REPUBLIC OF INDONESIA

THE FEASIBILITY STUDY ON THE VOLCANIC DEBRIS CONTROL AND WATER CONSERVATION PROJECT IN THE SOUTH EASTERN SLOPE OF MT. SEMERU

PROGRESS REPORT (I)

SEPTEMBER, 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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FOREWORD

It is our great pleasure to submit to the Directorate of Rivers, Directorate General of Water Resources Development, Ministry of Public Works of the Republic of Indonesia the " Progress Report I " September 1982, for the Feasibility Study on The Volcanic Debris Control and Water Conservation Project in the South Eastern Slope of Mt. Semeru in the Republic of Indonesia.

This feasibility study is a three - year study program, and the 1982 study falls on the first year.

This report prepared in Indonesia, is designed to give an outline of activities, findings and summary on review of the existing Master Plans and selection of the first priority project based on interim result of our field study performed from March 1982 to August 1982.

During this period the study was executed by ninteen study team members with Dr. Koichi Hirao as its team leader and advices were given by JICA Advisory Committee consisting of six members with Dr. Masayosi Mastubayasi as its chairman.

During the field study, we tried to find out the actual situation or real aspects of the study area through field surveys and discussions with the Indonesian counterparts.

In spite of the short period field study, we have gotten many interesting results and they were very fruitful and useful for us to deepen our recognation, we believe.

We would like to express our sincere gratitude to the Indonesian counterparts of the head quarter of the Department of Public Works and the project office who rendered us their harty cooperation during our discussion and field study in Indonesia.

PROGRESS REPORT (I)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. OUTLINE OF STUDY

(1) Objectives

The objectives of the study are :

① To conduct a feasibility study aimed at offering proposals from various points of view in order to prevent the frequent disaster on the southeastern slope of Mt. Semeru.

② To assess potential water utilixation volume which will result from the disaster prevention works.

③ To transfer technical knowledge relating to the disaster prevention plan and study methods, to technicians of the Indonesian Government.

(2) Study Area

Mt. Semeru, the highest mountain (3,676 m) and one of the most active volcano in Java Island, is located on the E. long. 113^{o} and S. Lati. 8^{o}, about 100 km S.E. of Surabaya City by straight line.

The south eastern area (730 km2) of Mt. Semeru is the study area, where three main rivers, K. Mujur, K. Rejali and K. Glidik, flow into the Indonesian Ocean. Refer to Fig. - 1.1.

(3) Study Process and Items

Basical study process and study items are shown in Fig.- 1.2 and 1.3 respectively.

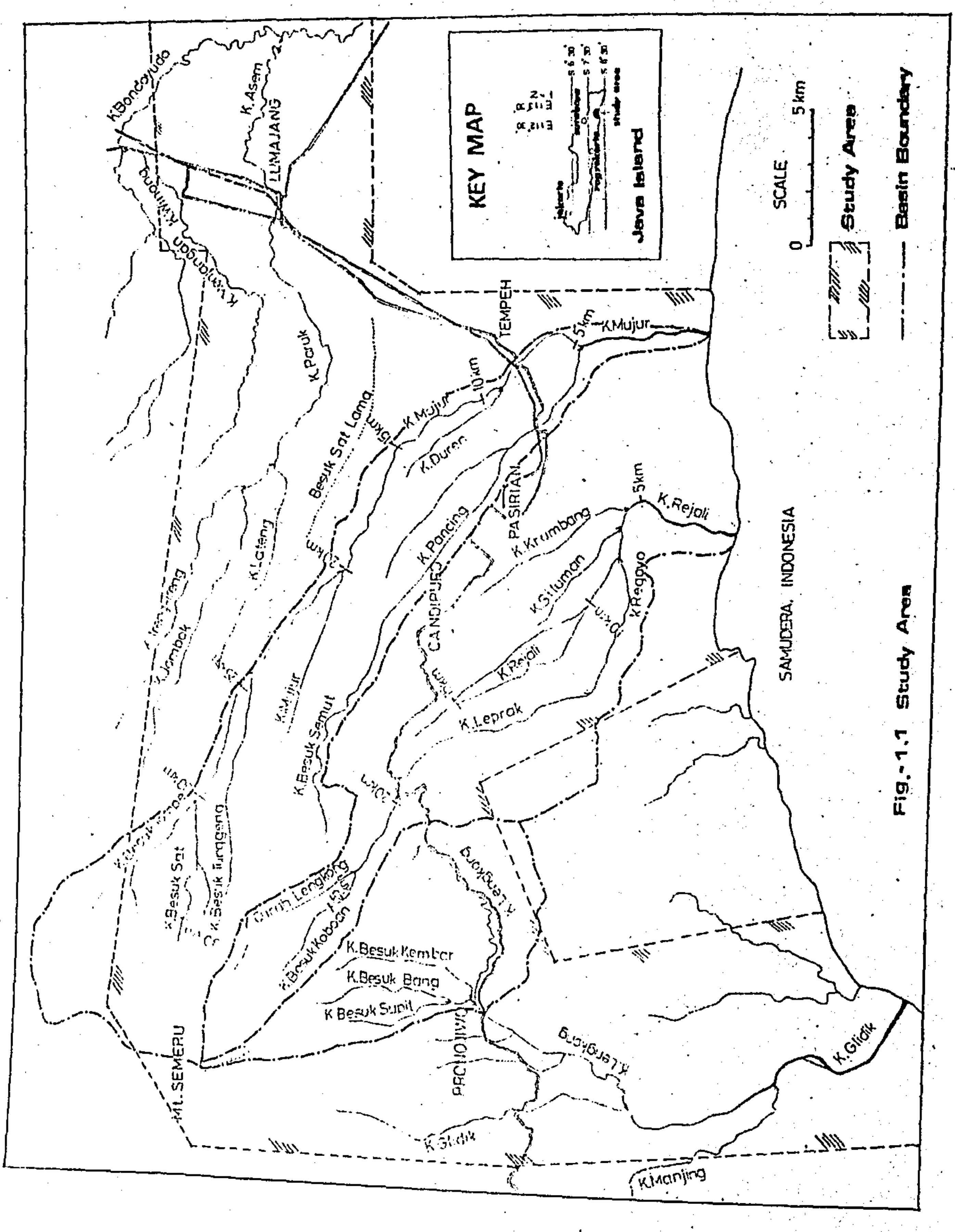


Fig.-1.1 Study Area

STAGE	YEAR MONTH	MAIN MEETING AND REPORT	STAGE TARGETS
1 st STAGE	MAR.		DECISION OF STUDY PLAN
	APR.	INCEPTION REPORT	
	MAY.		
2 nd STAGE	JUN.		① REVIEW OF EXISTING MASTER PLANS, AND SELECTION OF PRIORITY PROJECT
	JUL.	SELECTION OF 1 st	
	AUG.	PRIORITY PROJECT	
	SEP.	PROGRESS REPORT (I)	
	OCT.		② EXECUTION OF INVESTIGATION, STUDY AND ANALYSIS
	NOV.	I/F OUTLINE OF 1 st	
	DEC.	PRIORITY PROJECT	③ PLAN AND DESIGN OF 1 st PRIORITY PROJECT
	JAN.		
	FEB.		
	MAR.		
3 rd STAGE	APR.		① PROJECT EVALUATION ON 1 st PRIORITY PROJECT
	MAY.		
	JUN.	PROGRESS REPORT(II)	
	JUL.		② PROPOSAL FOR IMPLEMENTATION PROGRAM OF 1 st PRIORITY PROGRAM
	AUG.		
	SEP.		
	OCT.	INTERIM REPORT	
	NOV.		③ EXECUTION OF COMPLEMENTARY INVESTIGATIONS ON 2 nd PRIORITY PROJECT, IF NECESSARY
	DEC.		
	JAN.		
	FEB.		
	MAR.	PROGRESS REPORT(III)	
4 th STAGE	APR.		① PROJECT EVALUATION ON 2 nd PRIORITY PROJECT
	MAY.		
	JUN.		
	JUL.		② FINAL REPORT ON FEASIBILITY STUDY OF 1 st AND 2 nd PRIORITY PROJECT
	AUG.		
	SEP.	(DRAFT)	
	OCT.	FINAL REPORT	
	NOV.		
	DEC.	FINAL REPORT	

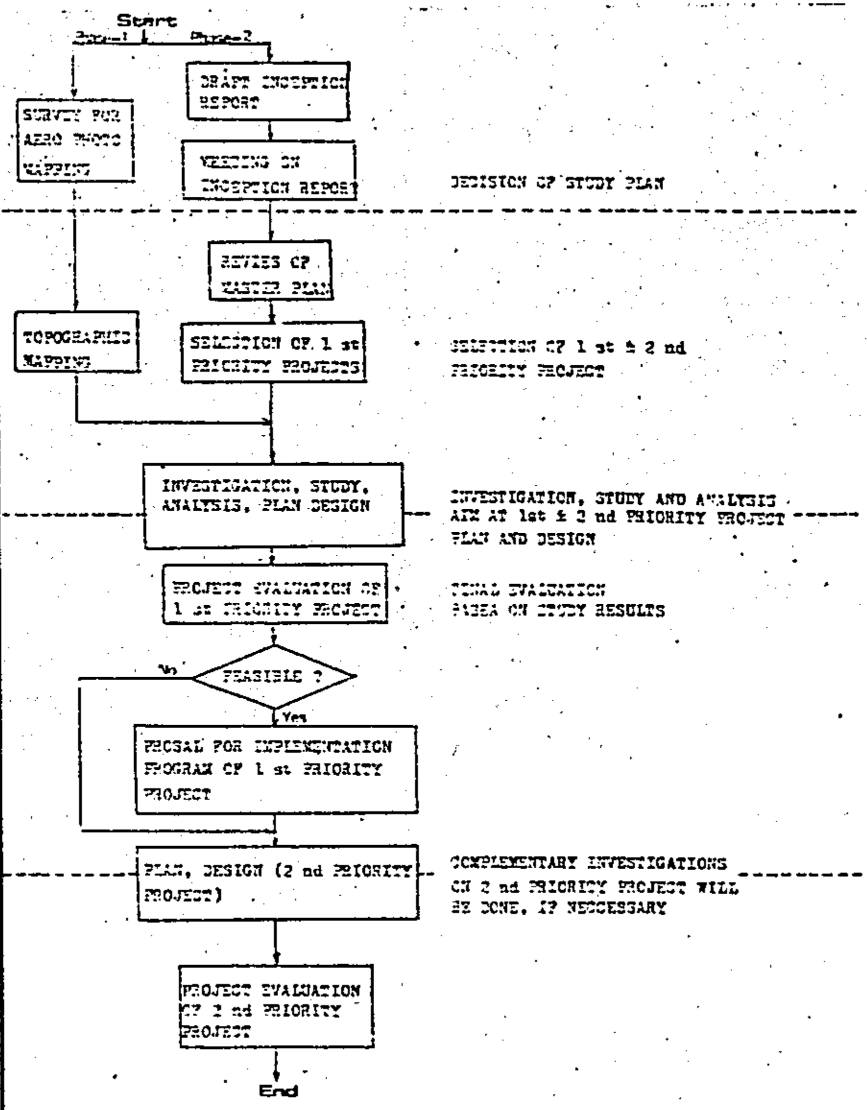
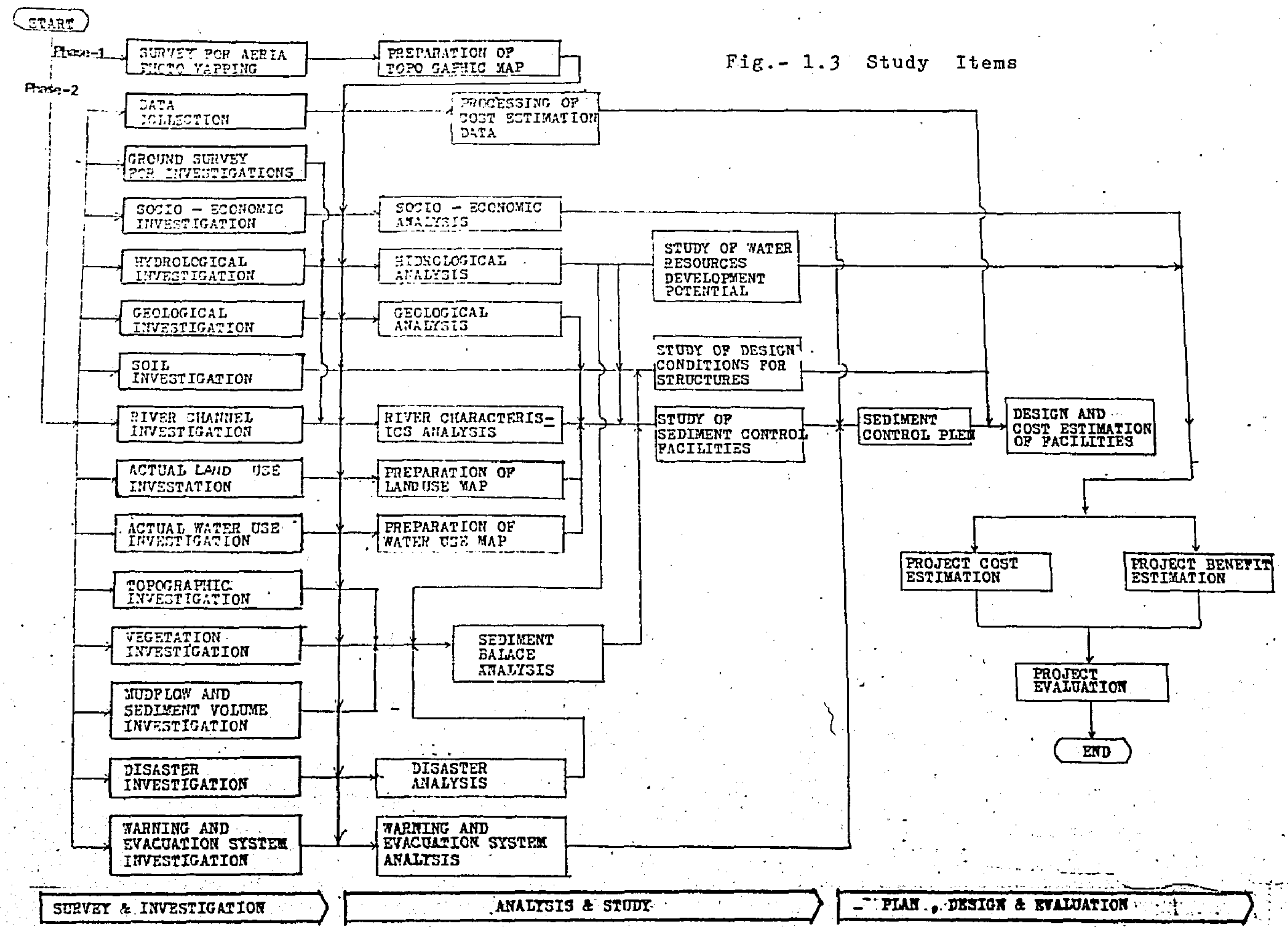


Fig.- 1.2 Study Process

Fig.- 1.3 Study Items



2. SUMMARY OF REPORT

2.1 ACTIVITIES

The main activities of the Study Team are summarized as follows:

Date	Summary of Main Activities
March 17 (1982)	Dr. K. Hirao, Team Leader, Mr. K. Mizue, Sub Team Leader, and Mr. H. Kanamura, Member of the Team arrived in Jakarta, and started explanation of Draft Inception Report to Directorate General of Water Resources Development (hereinafter referred to as "D.G.W.R.D.") of Departemen Pekerjaan Umum (hereinafter referred to as "D.P.U.")
April 6	Draft Inception Report was accepted by D.G.W.R.D. with the understandings as mentioned in the Minutes of Meeting.
May 11	Team Leader and 11 other Members arrived in Jakarta and thenceforth to Lumajang on May 14, and Topographical Maps Making and the field survey of the Main Study started thereafter.
May 12	The Study Team submitted Final Inception Report to D.G.W.R.D.
May 24	Five Topographical Map Making group finished their works and returned to Japan on May 25.
May 30-June 5	Submitted Specifications for the Geological Survey works to D.P.U.

July 12 — Geological Survey Works by the Government of the Republic of Indonesia (hereinafter referred to as "G.R.I.") started under the supervision of the Study Team.

August 25 — The Study Team explained to the Project Office the "Summary on Review of the Existing Master Plans and Selection of the First Priority Project".

August 30 — Meeting in Jakarta to discuss the above Summary with D.G.W.R.D. The Summary was accepted with some amendments as mentioned in the Minutes of Meeting.

2.2 REVIEW OF THE MASTER PLANS

In order to understand a basic idea of sediment control and to obtain an useful information for selection of priority projects, JICA Study Team reviewed two sets of master plan; for K. Mujur and K. Rejali.

Main comments and recommendation on both Master Plans are summarized as follows.

(1) Design Control Sediment Volume

It is necessary to review the method of probability evaluation in the process of obtaining the design control sediment value (which corresponds to the term "design excess sediment volume" according to the Technical Standard of River and Sabo Engineering, Ministry of Construction Japan) from the sediment volume of the deposits resulted from the past disasters.

(2) Classification of Sediment Transport Flow Type

In both Master Plans, classification of sediment transport flow type is not discussed. Its classification is essential to make a plan of sediment control works, therefore JICA

Study Team proposes the classification according to transportation system and sedimentation form.

(3) Basic Idea of Sediment Control Plan

The Storage system of sediment control works is the only effect evaluation system in the Master Plans. However, in the study area where distinctive amount of volcanic debris is yielded and flow out, effect evaluation at the time of flood using the control system also needs to be conducted simultaneously.

(4) Counter Measures

① It is favorable that the channel works plan is determined considering the capacity of sediment transport to river mouth and fluctuation of river bed.

② In selecting work execution method, it is desirable to investigate the relation between the order of work execution and the transition of river condition and sediment yield.

③ Selection of execution method and order of work execution is desired to be centered around the requirement that the disaster preventing effect will be secured immediately.

④ According to above mentioned comments and recommendations, JICA Study Team proposes the modifications of the Sediment Control Facility Plans for K. Mujur and K. Rejali. (Refer to chapter 4).

2.3 SELECTION OF PRIORITY PROJECTS

The Urgent Improvement Works of the highest priority is to start construction in 1983 and will give much effect to K. Mujur basin in the near future. Therefore, the first priority should be given to K. Rejali project and to the second priority to K. Mujur.

JICA Study Team selects the following priority projects from among the disaster prevention works which are planned in the existing Master Plans and recommended by the Team. Refer to Fig. - 5.4.

① The first priority project
(K. Rejali)

- Diversion Channel, 2 km long
  from Curah Kobo'an to K. Lengkong

- 2 check dams in Curah Kobo'an
  15m high, 155m wide, at elevation 820m
  15m high, 380m wide, at elevation 740m

- 2 sand pockets in K. Leprak
  900m long, at elevation 370m
  1,230m long, at elevation 330m

(K. Lengkong, main tributary of K. Glidik)

- Sand pocket in K. Lengkong
  300m long, at elevation 720m

- Check dam (Pronojiwo Dam)
  30m high, 450m wide, at elevation 630m

② The second priority project (tentative)
(K. Mujur)

- 5 check dams in K. Besuk Sat
  from elevation 764m to elevation 692m

- 3 sand pockets in K. Besuk Sat
  Bendo sand pocket
  Kertosari sand pocket
  Kloposawit sand pocket

- Leces Dike rehabilitation works

- 6 consolidation dams
  from elevation 428m to elevation 65m

- 10 river trainings
  from elevation 285m to elevation 65m

2.4 FIELD INVESTIGATIONS

Field investigation is being executed according to the Inception Report from March, 1981 in order to obtain useful information for sabo planning and project evaluation.

The main result and process of each Field Investigation is as follows:

(1) Topographic Map Presentation

- Leveling, traversing, field identification and procking have been finished.

- Mapping is now executed based on the above-mentioned data.

(2) Socio-economic Study

- Data collection is in progress now.

(3) Actual Water Use Investigation

- Study of low water during the dry season of this year has been almost finished.

- Field survey and additional data collection is underway.

(4) Actual Land Use Investigation

- Field study has been almost finished

- Data of field study has not yet been arranged.

(5) Hydrological Study

- Low water observation is executed continuously since April, 1982.

- Rainfall observation network has been provided for the study.

(6) Geological and Soil Investigation

- General geological survey has been finished

- Specifications for detail geological survey, soil investigation, and material testing have been submitted to the Indonesian Government.

- Those surveys are being done at present.

(7) Disaster Investigation

- Field work has been finished

- Possible disaster area map has been made.

(8) River Channel Investigation

- Existing facility investigation has been finished.

- Promising sabo facility location investigation has been finished.

- Field work for river channel characteristics has been almost finished except the lower reaches of the K. Glidik and the K. Rejali.

(9) Sediment Flow and Volume Investigation

- Field work has been finished.

- The sediment deposition volume and sediment production volume of flood in May, 1981 has been calculated.

- The sediment flow type classification has been finished.

(10) Sediment Control Facility Study

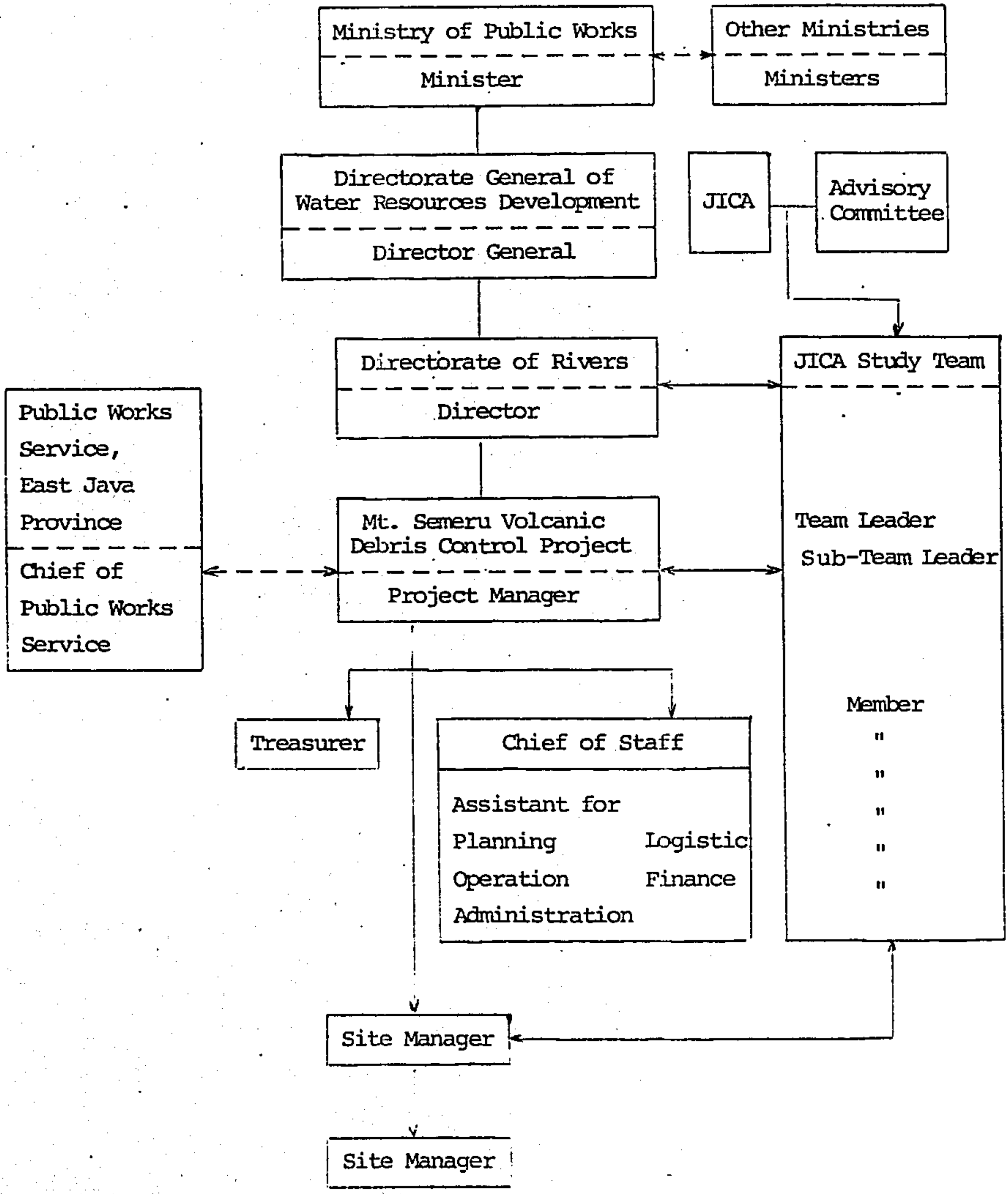
The sediment control facilities mentioned below in the K. Rejali and the K. Lengkong have been planned:

- Diversion channel,
- Increasing the height of Curah Koboan Dam I,
- Pronojiwo Dam,
- Leprak Sand Pocket.

3. ACTIVITIES OF THE STUDY TEAM

3.1 ORGANIZATION

① Execution System of Mt. Semeru Debris Control & Water Conservation Feasibility Study



② Assignment of JICA Study Team Member and Indonesian Counterparts

JICA Study Team			Counterpart
Title	Scope of Work in Charge	Name	Name
Team Leader	General Management & Sabo Plan	Koichi Hirao	Soeparman, B.I.E.
Sub-Team Leader	Sociology, Economy	Kazuo Mizue	Achmadie, Sukoharjo
Member	Economy	Masaki Kobayashi	Achmadie, Sudjatmiko, B.I.E.
"	Water Conservation	Toru Takahashi	Amron Siregar, B.I.E., Agus Siswantoro
"	Geology, Soil	Nobuhiko Uchiseto	Ir. CL. Sumartono, Suratno, Hrc. Parwono, B.I.E.
"	Land Condition	Yusuke Sasaki	- same as above -
"	Ground Water	Yoshiyuki Uemura	Amron Siregar, Bambang Priyono
"	River	Masatomo Watanabe	Amron Siregar, Suratno
"	Hydrology	Hidetoshi Kanamura	- same as above -
"	Sabo Facility	Yoshifumi Shimoda	Ir. Hoedhijatmoko, Manis Irawan, B.I.E.
"	Dam Engineering	Takashi Ishizaka	Djai, B.I.E., Djoko Suryo
"	Disaster Study, Land Use	Kazuo Ikeda	Ir. Hoedhijatmoko, Djoko Sukendro
"	Mud-Flow	Shuji Hamana	Ir. Heodhijatmoko, Bambang Priyono
"	Physical Exploration	Minoru Nakazawa	Ir. CL. Sumartono, Suratno, Hrc. Parwono, Abd. Manan
"	Survey	Hitoshi Koami	Ir. Hoedhijatmoko, Djoko Sukendro
"	"	Hiroyuki Koshikawa	- same as above -
"	"	Akito Yasuda	- same as above -
"	"	Masumi Ikuno	- same as above -
"	"		

3.2. MAIN ACTIVITIES OF THE STUDY TEAM

Date	Activities
March 17 (Wed.)	- Eight Members of the Study Team and one Coordinator arrived Jakarta. - Name of Members Dr. K. Hirao (Team Leader) Mr. H. Kanamura (Hydrology) Mr. H. Koami (Survey) Mr. H. Koshikawa (Survey) Mr. A. Yasuda (Survey) Mr. M. Ikuno (Survey) Mr. M. Matsuzaki (Survey) Mr. T. Watanabe (Coordinator)
March 18 (Thur.)	Paid a courtesy call to JICA, Jakarta Office and explained the outline of the Study. Also paid a courtesy call to D.G.W.R.D. and made a rough explanation of the draft Inception Report (Main Study and Topographical Maps Preparation) in the presence of Ir. Djoko Legowo, Chief of Sabo Section and six other staff.
March 19 (Fri.)	Discussed with Ir. Djoko Legowo of D.P.U. on the accommodations in Lumajang for the Study Team.
March 20 (Sat.)	The Study Team submitted 20 copies of Inception Reports to D.G.W.R.D., D.P.U.
March 23 (Tues.)	The Study Team left Jakarta for Lumajang. Paid a courtesy call to Consulate-General of Japan in Surabaya on the way to Lumajang.
March 24 (Wed.)	Had the first meeting with the Mt. Semeru Project Office (hereinafter referred to as "the Project Office") to explain the Inception Report and discuss the accommodations for the Team.

March 25 (Thur.)	Site Investigation
March 26 (Fri.)	Dr. Hirao and Mr. Mizue left Lumajang for Jakarta.
March 27 (Sat.)	Meeting with D.P.U. for accommodations. Topographical mapping group started survey work.
March 29 (Mon.)	Meeting with D.P.U. on the schedule of the main meeting slated for April 6.
March 30 (Tues.)	Dr. Masayoshi Matsubayashi (Chief of Advisory Committee) and Mr. Hitonori Ono (Coordinator from JICA, Tokyo) arrived Jakarta. Internal meeting for the Main Meeting of April 6 among Advisory Committee, the Study Team, Mr. A. Sakai (Colombo Plan Expert, D.P.U. and Mr. M. Fujiyoshi, First Secretary, Embassy of Japan).
March 31 (Wed.)	Courtesy call to JICA, Jakarta Office and Embassy of Japan with Dr. Matsubayashi and Mr. Ono.
April 1 (Thur.)- April 4 (Sun.)	Dr. Matsubayashi and Mr. Ono made site investigation together with Dr. Hirao, Mr. Mizue and Mr. Kanamura. Mr. Masao Kiyono (Member of Advisory Committee in charge of Ground Water) arrived Jakarta.
April 5 (Mon.)	Dr. Matsubayashi, Mr. Kiyono, Mr. Ono and the Study Members made a courtesy call to Ir. Y. Sudaryoko, General Director of G.D.W.R.D. and reported on the result of site investigation. Meeting in preparation for the Main Meeting of April 6.

April 6 (Tues.)	Courtesy call to Ir. Mardjono, Staff of Minister of Public Works (Expert in Dam and River). Main Meeting for the Inception Report and signing of the Minutes of Meeting. Dinner Party at President Hotel under the joint auspices of Dr. Masayoshi Matsubayashi, Chief of the Advisory Committee and Dr. Koichi Hirao, Leader of JICA Study Team in commemoration of the commencement of this Feasibility Study.
April 8 (Thurs.)	Dr. Matsubayashi and Mr. Ono left Jakarta for Tokyo, Japan. Mr. Kanamura left Jakarta for Lumajang.
April 10 (Sat.)	Mr. Kiyono, Dr. Hirao and Mr. Mizue left Jakarta for Tokyo.
April 23 (Fri.)	The First Advisory Committee Meeting was held in Tokyo.
May 3 (Mon.)	Mr. H. Kato was dispatched to Lumajang to assist the general administration works as a member of Yachiyo Engineering Co., Ltd. (not as an official JICA Team Member).
May 11 (Tues.)	Dr. Hirao, Leader of the Study Team, and six other members left Tokyo and arrived Jakarta.
May 12 (Wed.)	Made a courtesy call to JICA, Jakarta Office and Embassy of Japan. Visited D.P.U. and submitted the Inception Report (Final) with explanation thereof to Dr. Amir Muryadi (Chief of Sub-Directorate of River Planning & Design), Ir. Hamamori (JICA Expert on Rivers) and other officials.

May 14 (Fri.)	The seven Study Team Members left Jakarta for Lumajang.
May 15 (Sat.)	Meeting with the Project Office about the schedule of the Study Work, vehicles and counterparts.
May 17 (Mon.) - May 19 (Wed.)	Site Investigation of K. Lengkong, K. Mujur and K. Rejali with Mr. Soeparman, B.I.E. (Project Manager) and other staff.
May 23 (Sun.)	Five Study Team Members for topographical mapping, Messrs. Koami, Koshikawa, Yasuda, Ikuno and Matsuzaki returned to Tokyo.
May 24 (Mon.)	Ir. CL. Sumartono of Research and Survey Section, River Dept., D.G.W.R.D. (Counterpart in charge of Geology) arrived Lumajang.
May 24 (Mon.) - May 30 (Sun.)	Joint work with Ir. Sumartono for making specifications for Geological Survey Works to be undertaken by G.R.I.
June 1 (Tues.)	Dr. Hirao called on Prof. Suryo at Institute of Volcanology in Bandung to collect data on Volcanoes and lahar of Indonesia and to request his cooperation in the field survey of Mt. Semeru Feasibility Study.
June 8 (Tues.)	The Project Office requested Institut Teknologi Bandung (I.T.B.) to make an estimation of the geological survey works.
June 11 (Fri.)	Meeting with the Project Office to request arrangements of additional cars and office/mess furniture.
June 12 (Sat.)	The 5th Anniversary of the Project Office.

June 17 (Thurs.)	Meeting with the Project Office concerning: - explanation of the existing Master Plans by the Project Manager. - Lecture on the geological survey. - Making an appointment of Universitas Brawijaya, Malang, etc.
June 21 (Mon.)	The Project Office received from I.T.B. a quotation for the geological survey works.
June 22 (Tues.)	Prof. Suryo of Institute of Volcanology, Bandung, arrived Lumajang.
June 23 (Wed.)	Mr. Soeparman, B.I.E., the Project Manager made a presentation of the existing Master Plans to the Study Team.
June 23 (Wed.) - June 25 (Fri.)	Prof. Suryo gave the Study Team, in the field, explanation of sediment yield and transportation.
June 28 (Mon.)	Dr. Hirao visited D.G.W.R.D. and discussed the survey works to be undertaken by G.R.I. Concerning the geological survey works, the Project Office decided on the following: - Bandung Institute of Technology shall be nominated for the execution of the works in the total contract amount of RP. 50,290,250. - The survey works shall start within one week after June 28.
June 30 (Wed.)	Dr. Hirao reported on the present situation of this Feasibility Study to JICA, Jakarta Office.

July 1 (Thurs.)	Dr. Hirao talked with Ir. Amir Muryadi of D.G.W.R.D. to expedite G.R.I.'s procedures for the three Jeeps to be provided by JICA. Three Study Team Members, Mr. M. Watanabe (in charge of Rivers), Mr. M. Kobayashi (in charge of Economy) and Mr. T. Ishizaki (in charge of Dam Engineering) arrived Jakarta.
July 3 (Sat.)	The above three Members arrived Lumajang.
July 5 (Mon.)	Messrs. Uchiseto and Sasaki gave lectures on geology and the geological survey to the Indonesian Counterparts.
July 8 (Thurs.)	Meeting with the Project Office to explain the economic study and to request data collection and assignment of Indonesian Counterparts. Also discussed the geological survey works. Mr. Uchiseto left Lumajang for Jakarta. (Left Jakarta on July 9 for Tokyo).
July 9 (Fri.)	The execution staff of the survey boring works arrived Lumajang.
July 12 (Mon.)	Meeting was held concerning the geological survey works attended by: (JICA) Dr. Hirao and Mr. Sasaki (Project Office) Mr. Sihono, B.I.E., Chief of Staff, Ir. Hoedhijatmoko, Chief of Planning Section (I.T.B.) Ir. Yonti Arief - Dr. Hirao gave a lecture on technical and economical aids by JICA and OECF to the Project Manager and other main staff.

July 13 (Tues.)	Prof. Sukendar of I.T.B. arrived Lumajang. Project Manager, Mr. Soeparman, B.I.E. and Dr. Hirao explained and discussed with him the plan of the geological survey works. Ir. CL. Sumartono of D.G.W.R.D. arrived Lumajang. Received a reply from Universitas Brawijaya, Malang that the Professors can meet the Study Team on July 31.
July 14 (Wed.)	Professor Sukendar and Mr. Soeparman made arrangements for the geological survey works at Pronojiwo job site.
July 15 (Thurs.)	Mr. Nakazawa, Member of the Study Team in charge of Physical Exploration left Tokyo and arrived Jakarta on July 15 and Lumajang on July 16.
July 16 (Mon.)	Arrangements were made for River Bed Materials Testing at job site by: (I.T.B.) Mr. Bambang (G.D.W.R.D.) Ir. Sumartono (JICA) Dr. Hirao and Mr. Shimoda
July 27 (Tues.)	Mr. Kobayashi gave a lecture on socio-economic study to the staff of the Project Office and Study Team Members.
July 28 (Wed.)	Mr. Kobayashi left Lumajang for Jakarta.
July 29 (Thurs.)	Mr. Kobayashi left Jakarta for Tokyo.
July 31 (Fri.)	Dr. Hirao and Mr. Mizue met the Professors of Universitas Brawijaya to exchange views on economic and development problems of Indonesia, East Java and Lumajang area.

Aug. 3 (Tues.)- Aug. 6 (Fri.)	Advisory Committee Members, Mr. Yasue (in charge of Topography and Geology) and Mr. Miura (in charge of Disaster Prevention Plan) and JICA Coordinator, Mr. Suzuki visited Lumajang.
Aug. 9 (Mon.)	Meeting with the Project Office regarding the assignment of Indonesian Counterparts for Messrs. Watanabe, Uemura, Takahashi and Ishizaka.
Aug. 16 (Mon.) - Aug. 17 (Tues.)	The Study Team exhibited and demonstrated Radio-Type Current Meter and P.H. Meter at the exhibition held in Lumajang celebrating the Independence Day of Indonesia.
Aug. 24 (Tues.)	Mr. K. Tani was dispatched to Lumajang to assist the general administrative works as a member of Yachiyo Engineering Co., Ltd. (not as an official JICA Team Member).
Aug. 25 (Tues.)	Meeting with the Project Office to explain "Summary on Review of the Existing Master Plans and Selection of the First Priority Project".
Aug. 30 (Mon.)	JICA Study Team (Represented by Dr. Hirao, Team Leader) had a meeting in Jakarta with D.G.W.R.D. (Represented by Ir. Amir Muryadi, Chief of Sub-Directorate of River Planning & Design) concerning "Summary on Review of the Master Plans and Selection of the First Priority Project". This Summary was accepted by D.G.W.R.D. with some amendments which are mentioned in the Minutes of Meeting.

3.3 MAIN MEETINGS

The Main Meetings that the JICA Study Team had mainly with D.G.W.R.D. of D.P.U. of the Government of the Republic of Indonesia are as follows:

(Details are as per attached Minutes of Meeting)

Date	Brief Description of Meeting
March 18 (1982)	Meeting with D.G.W.R.D. of D.P.U. for rough explanation of Draft Inception Report.
19	Meeting with D.P.U. on accommodations.
22	Meeting with D.P.U. for explanation of Draft Inception Report.
23	Meeting with the Project Office on accommodations.
24	Meeting with the Project Office for explanation of Draft Inception Report.
31	Meeting with D.P.U. on training of Counterparts, timing of preparing Implementation Programme, etc.
April 5	Meeting with Ir. Sudaryoko, General Director of G.D.W.R.D. to report on the results of field investigation by Dr. Matsubayashi, Chief of Advisory Committee.
6	Final Meeting with D.G.W.R.D. on Draft Inception Report.
May 15	Meeting with the Project Office on assignment schedule, car and Counterparts.

Date	Brief Description of Meeting
June 11	Meeting with the Project Office on car and furnishing of office and mess.
17	Meeting with the Project Office requesting explanation by the Project Manager of the existing Master Plans, manning schedule & office space, etc.
23	Explanation of the Master Plans by the Project Manger, Mr. Soeparman, B.I.E.
July 8	Meeting with the Project Office on the Economic Study.
31	Meeting with Brawijaya University, Malang concerning economic and development problems of Indonesia, East Java and Lumajang area.
August 9	Meeting with the Project Office to request the assignment of Indonesian Counterparts for Messrs. Watanabe, Uemura, Takahashi and Ishizaka.
25	Meeting with the Project Office to explain "Summary on Review of the Existing Master Plans and Selection of the First Priority Project".
30	Meeting in Jakarta with D.G.W.R.D. concerning "Summary on Review of the Master Plans and Selection of the First Priority Project". This Summary was accepted by D.G.W.R.D. with some amendments as are mentioned in the Minutes of Meeting.

3.4 TECHNOLOGY TRANSFER

The following lectures were given by the Study Team as a means of Technical Transfer to the Indonesian Counterparts as well as on the job training. (Details as per Appendices)

Date	Lecturer	Subject
July 5 (1982	Mr. N. Uchiseto	Topography and Geology
- " -	Mr. Y. Sasaki	Geological Survey
July 12	Dr. K. Hirao	Technical and Economic Aids by JICA and OECF
July 27	Mr. M. Kobayashi	Socio-Economic Study

4. REVIEW OF THE MASTER PLANS

4.1 GENERAL

The objects of the review of the Master Plans for K. Mujur and K. Rejali are to understand a basic idea of sediment control and to obtain an useful information for selection of priority projects.

The Master Plans for K. Mujur and K. Rejali were prepared by Directorate of Rivers, Directorate General of Water Resources Development, Ministry of Public Works, in 1981. The Master Plan for entire basin of K. Glidik is not yet prepared. These Master Plans are reported in the following documents.

- Final Report on Investigation Survey and Master Plan Making of K. Besuk Sat, Kabupaten Lumajang, East Java, February 1981

- Final Report of Investigation Survey and Master Plan Making of K. Kobo'an and K. Leprak at Mt. Semeru Area, Kabupaten Lumajang, East Java, December 1981.

JICA Study Team reviewed the above Master Plans taking the following into consideration.

- Field investigation results obtained by JICA Study Team, including the existing sediment control, water use facilities and the disaster of flood in May 1981.

- Urgent Improvement Works to be started in 1983, are considered to be existing, not to be new projects.

4.2 SUMMARY OF EXISTING MASTER PLAN OF K. MUJUR

4.2.1 DESIGN CONTROL SEDIMENT VOLUME

As the design control sediment volume of K. Mujur, 10.14×10^6 m^3 (for 70 years) is estimated on the basis of the flood data from 1909 to 1980, especially on the basis of two floods sediment volume (1909, 1978). The specific value of the design control sediment of K. Mujur is: 2.100 m^3/km^2/year = 10×10^6 m3/69.19 km^2/70 years.

4.2.2 MAIN PRINCIPLES OF SEDIMENT CONTROL PLAN

The main principle of sediment control plan of K. Mujur is as follows:

① To store 100% of design control sediment volume (10.0×10^6 m^3) by check dams and sand pocket.

② To prevent channel erosion by consolidation dams, dike, revetment and river training.

4.2.3 SEDIMENT CONTROL FACILITIES

The sediment control works plan of K. Mujur, shown in Table - 4.1., Fig. - 4.1. composed of two groups of facilities:

① Facilities to store 100% of design control sediment (10.0×10^6 m^3):

- 22 check dams (4 dams have been constructed)
  Upstream of Munggir, PK 13 (EL 693 m)

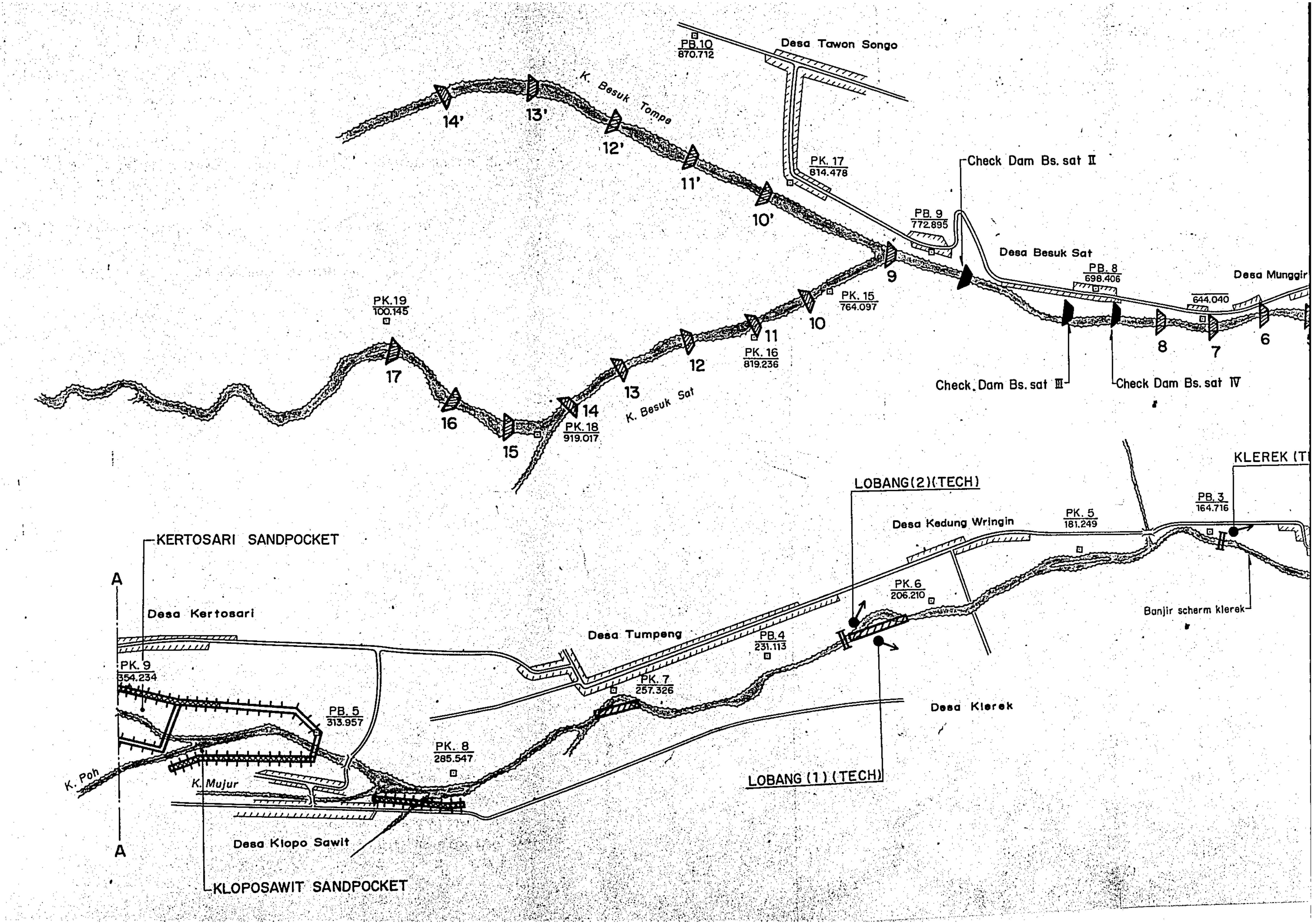
- 1 sand pocket
  at Bendo, PB 7 (EL 564 m)

② Facilities to prevent channel erosion:

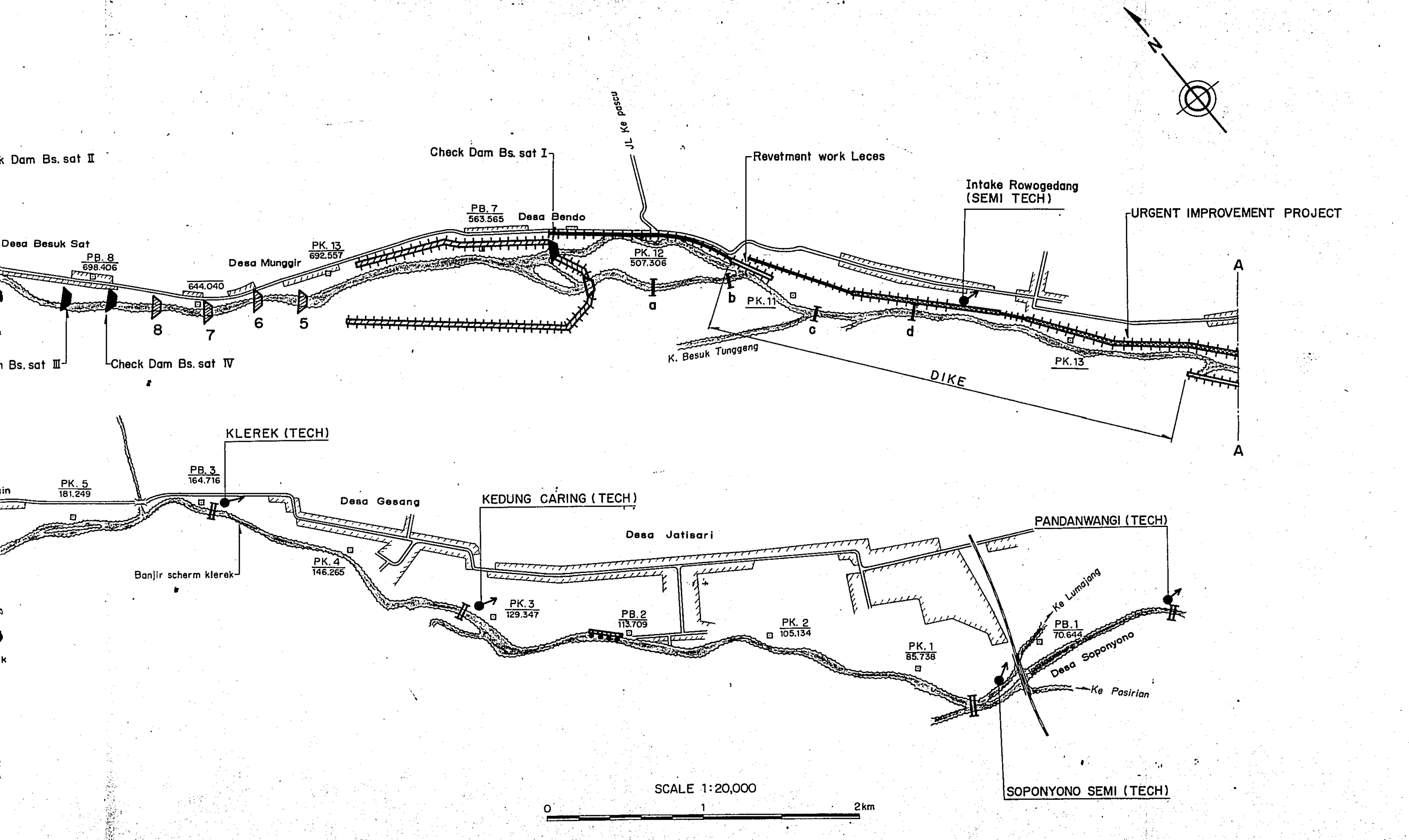
- 4 consolidation dams
  between PK 12 (EL 507 m) and PB 6 (EL 428 m)

Table - 4.1 Sediment Control Facility of Existing Master Plan in K. Mujur

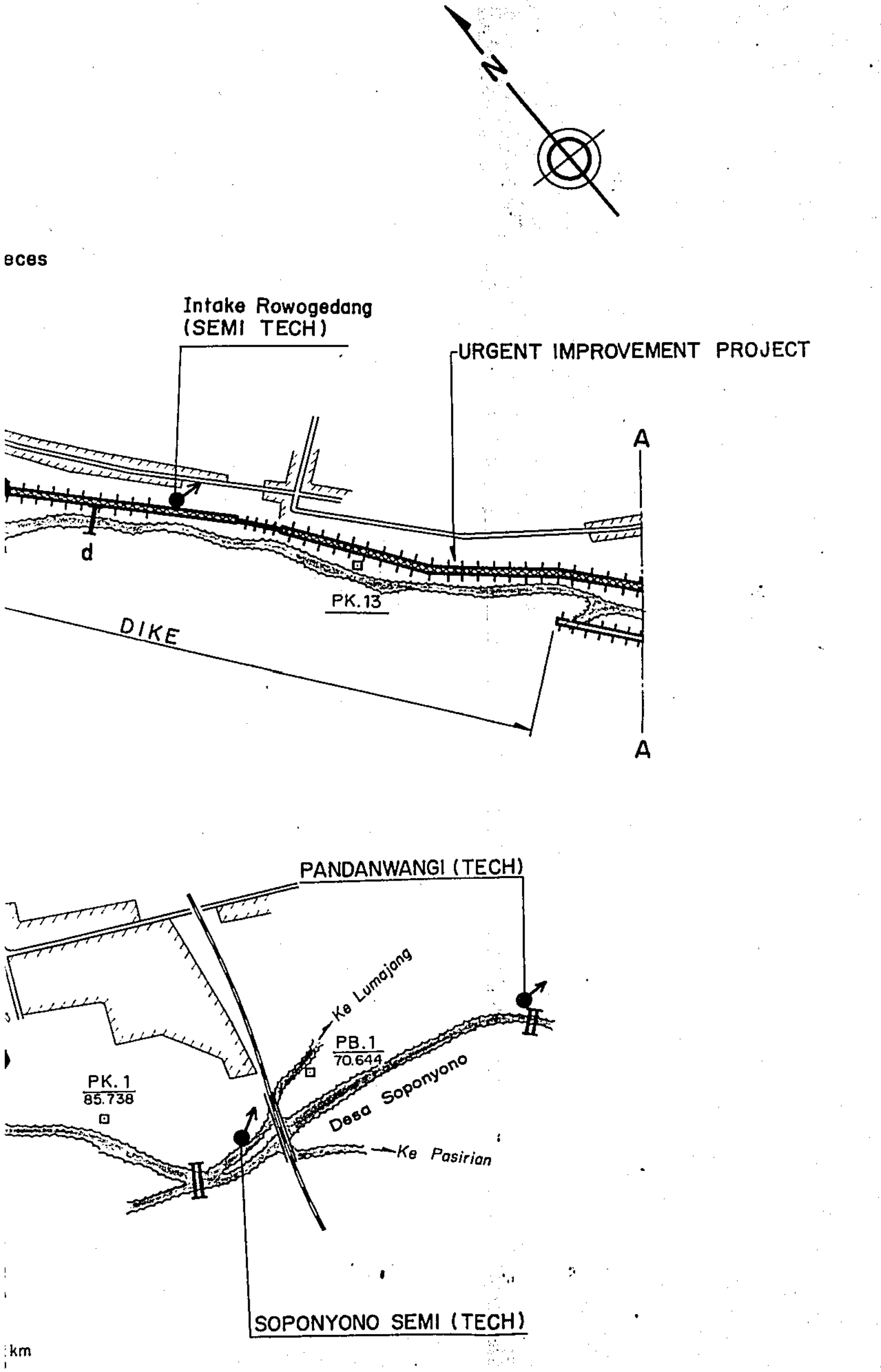
Facility	No.	Height (m)	Storage Volume (m3)	Remarks
Checkdam	II	10	300 000	Existing
	III	8	275 000	Existing
	IV	8	250 000	Existing
	5	7	200 000	
	6	7	200 000	
	7	7	200 000	
	8	7	200 000	
	9	15	900 000	
	10	12	250 000	
	10	15	350 000	
	11	12	250 000	
	11'	15	350 000	
	12	12	250 000	
	12'	15	350 000	
	13	10	200 000	
	13'	12	300 000	
	14	10	225 000	
	14'	10	300 000	
	15	10	225 000	
	16	10	200 000	
	17	10	200 000	
Sand pocket	I + I'	10	4 169 000	I : Existing
Consolidation dam	a			
	b			
	c			
	d			
Revetment				1 place
Dike				
Super dike				
River traning				
Bridge				2 places



PB.10
870.712
Desa Tawon Songo
K. Besuk Tompe
14'
13'
12'
11'
10'
PK. 17
814.478
Check Dam Bs. sat II
PB. 9
772.895
Desa Besuk Sat
9
PB. 8
698.406
644.040
Desa Munggir
PK. 15
764.097
10
11
PK. 16
819.236
12
13
14
PK.18
919.017
K. Besuk Sat
PK.19
100.145
17
16
15
8
7
6
Check. Dam Bs. sat III
Check Dam Bs. sat IV
KLEREK (T
LOBANG(2)(TECH)
PB. 3
164.716
PK. 5
181.249
Desa Kedung Wringin
PK.6
206.210
Banjir scherm klerek
KERTOSARI SANDPOCKET
A
Desa Kertosari
Desa Tumpeng
PB.4
231.113
PK. 9
354.234
PB. 5
313.957
PK. 7
257.326
Desa Klerek
K. Poh
K. Mujur
PK. 8
285.547
LOBANG (1) (TECH)
A
Desa Klopo Sawit
KLOPOSAWIT SANDPOCKET



k Dam Bs. sat II
Check Dam Bs. sat I
JL Ke pasca
Revetment work Leces
Intake Rowogedang
(SEMI TECH)
URGENT IMPROVEMENT PROJECT
Desa Besuk Sat
PB. 8
698.406
PB. 7
563.565
Desa Bendo
PK. 13
692.557
Desa Munggir
644.040
PK. 12
507.306
a
b
PK. 11
c
d
8
7
6
5
A
A
n Bs. sat III
Check Dam Bs. sat IV
K. Besuk Tunggeng
PK. 13
DIKE
KLEREK (TECH)
PB. 3
164.716
PK. 5
181.249
Desa Gesang
KEDUNG CARING (TECH)
Desa Jatisari
PANDANWANGI (TECH)
Banjir scherm klerek
PK. 4
146.265
PK. 3
129.347
PB. 2
113.709
PK. 2
105.134
PK. 1
85.738
Ke Lumajang
PB. 1
70.644
Desa Soponyono
Ke Pasirian
SOPONYONO SEMI (TECH)
SCALE 1:20,000
0
1
2km



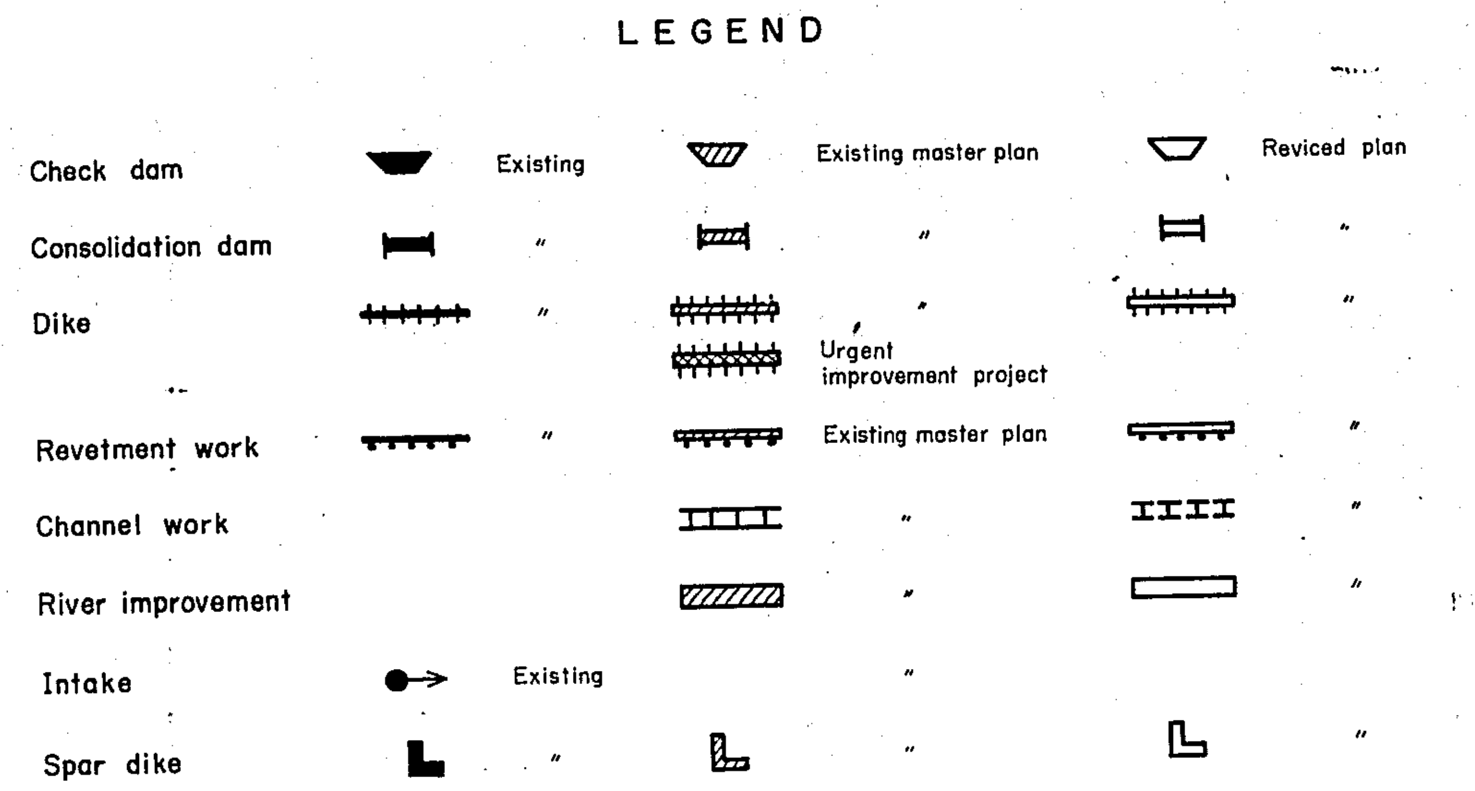


FIG.-4.1 Sediment Control Plan of Existing Master Plan in K. Mujur

- Revetment and dike at bending spots

- River training (including super dikes, revetment, consolidation dams short cut, excavation, etc.)

4.2.4 PROJECT EVALUATION

The project evaluation is as follows:

(1) Cost Estimation

Total Construction Cost	RP. $10,855.^{75} \times 10^6$
Construction Period	10 years
Interest	Nil
Mean Annual Cost	
$\frac{RP.\ 10,855.^{75} \times 10^6}{10} =$	RP. $1,085.575 \times 10^6$

(2) Benefit Estimation

Mean Annual Benefit of Divastage Land	RP. $716,^{07} \times 10^6$
Mean Annual Benefit of Crops Production	RP. $2,709.36 \times 10^6$
Total Mean Annual Benefit	RP. $3,425.43 \times 10^6$

(3) Economic Evaluation

Benefit- Cost Ratio

$$BCR = \frac{RP.\ 3425.43 \times 10^6}{RP.\ 1085.575 \times 10^6} = 3.16$$

(4) Conclusions

① Master Plan of sediment control of K. Mujur is feasible from the point of view of social and economical effects; it is not only to overcome the problem at a certain area, but in general, it can be a masterpiece of developing the area surrounding Mt. Semeru.

② Sediment control of this river will increase the crops production; it is not only to protect the lands from flood attacks but also to maintain the river for the water supply to irrigated lands.

③ Sediment control of this river is also to stabilize the river channel condition. After that it is hoped that some intakes can be constructed to take more irrigation water. The existing intakes can be improved to take water after rehabilitation those intakes. Moreover, they can be changed from the present condition into technical or semi technical intakes.

4.3 SUMMARY OF EXISTING MASTER PLAN OF K. REJALI

4.3.1 DESIGN CONTROL SEDIMENT VOLUME OF K. REJALI

The total sediment volume caused by two floods, 1976 and 1981, is calculated as 0.85×10^6 m3. This value is evaluated to be a mean total for five years. And the design control sediment volume of K. Rejali, 8.5×10^6 (for 50 years) is estimated on the basis of the above value.

The specific value of the design control sediment of K. Rejali is:

$$6{,}500\ m^3/km^2/year = 8.5 \times 10^6\ m^3/26.35\ km^2/50\ years$$

4.3.2 MAIN PRINCIPLE OF SEDIMENT CONTROL PLAN

The main principle of sediment control plan of K. Rejali is as follows:

① To store 30% of design control sediment ($30\% \times 8.5 \times 10^6\ m^3 = 2.55 \times 10^6\ m^3$) by check dams at upstream from the outlet of gulch.

② To transport 70% of design control sediment ($70\% \times 8.5 \times 10^6\ m^3 = 5.95 \times 10^6\ m^3$) by channel work at downstream from the outlet of gulch.

4.3.3 SEDIMENT CONTROL FACILITIES

The sediment control works plan of K. Rejali, shown in Table - 4.2. and Fig. - 4.2. is composed of the two groups of facilities:

① Facilities to store 30% of design control sediment ($30\% \times 8.5 \times 10^6\ m^3 = 2.55 \times 10^6\ m^3$):

- 7 check dams
  Upstream from the outlet of gulch

② Facilities to transport 70% of design control sediment ($70\% \times 8.5 \times 10^6\ m^3 = 5.95 \times 10^6\ m^3$) and to prevent channel erosion;

- Channel works (8.5 km), with consolidation dams embankments.
  From the outlet of gulch to Gondoroso

- River training
  Including embankment, shortcut, revetment, spur dike Downstream of Gondoroso.

4.3.4 PROJECT EVALUATION

The project evaluation is as follows:

(1) Cost Estimation

Total Construction Cost	RP. 10 860 x 10^6
Construction Period	10 years
Project Life	50 years
Interest	7% p.a.

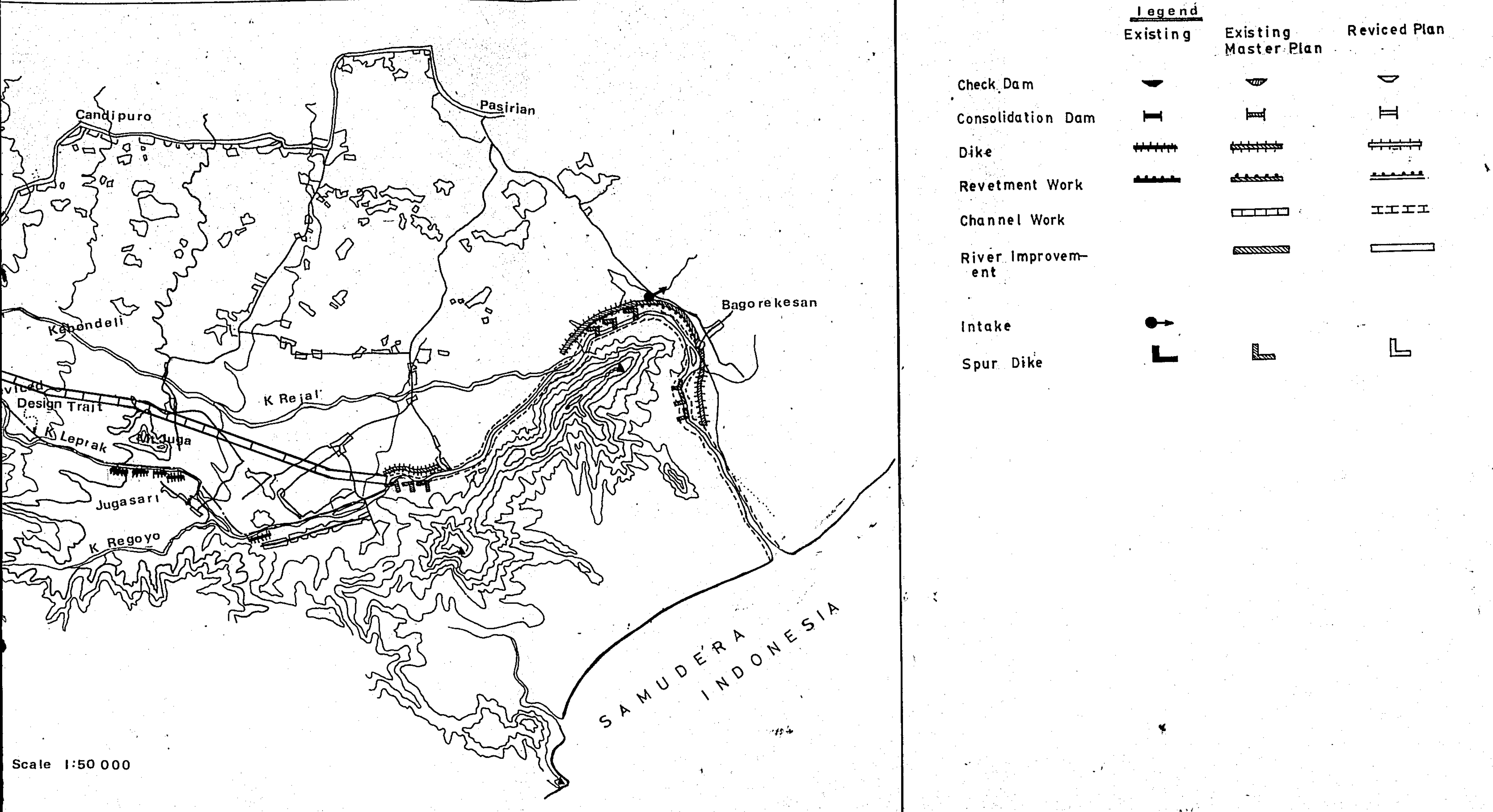
Mean Annual Cost

$$RP.\ 10860 \times 10^6 \times \frac{0.07\ (1 - 0.07)^{50}}{(1 - 0.07)^{50} - 1} = RP.\ 786.76356 \times 10^6$$

Table - 4.2 Sediment Control Facility of Existing Master Plan in Rejali River

Facility	No.	Quantity	Storage volume (m3)	Remarks
Checkdam	Curah Kobo'an I	-	400 000	Existing
	Leplak I	-	400 000	"
	Curah Kobo'an III-VII	5	400 000 x 5	
Consolida-tion dam	Curah Kobo'an II	-		Existing
Dike	Leplak I			Existing
	" II			"
	" III			"
	" IV			"
	" V			"
	" VI			"
	" VII			"
	" VIII			"
	" IX			"
	Jugosari I			"
	" II			"
	Gondoruso			"
	Ringin Pulih	0.6 km		
Super dike	Leplak			Existing
	Bagorekesan	12		
Channel works	Leplak	8.5 km		
Revetment	Bagorekesan	0.3 km		
Short cut		0.3 km		

Fig-4.2 Sediment Control Plan of Existing Master Plan in K.Rejali Scale 1:50 000


Candipuro
Pasirian
Bagorekesan
Kebondeli
K Rejali
Reviced
Design Trail
K Leprak
Mt Juga
Jugasari
K Regoyo
SAMUDERA INDONESIA
Scale 1:50 000
legend
Existing
Existing Master Plan
Reviced Plan
Check Dam
Consolidation Dam
Dike
Revetment Work
Channel Work
River Improvement
Intake
Spur Dike

Annual Operation and Maintenance Cost — RP. 50×10^6

(2) Benefit Estimation

Mean Annual Benefit of Devastage Land — RP. 20×10^6

Mean Annual Benefit of Rice Production — RP. 697.2×10^6

Total Mean Annual Benefit — RP. 717.2×10^6

(3) Economic Evaluation

Benefit-Cost Ratio

$$BCR = \frac{RP.\ 717.2 \times 10^6 - RP.\ 50 \times 10^6}{RP.\ 786.76356 \times 10^6} = 0.848$$

IRR — 5.93%

(4) Conclusions

From the calculation above where BCR < 1, or IRR = 5.93% per each year, it means that the project is not beneficial. However, the following must be given careful consideration.

- Disease prevention caused by lahar
- People life and others
- The quietude of people

Therefore, even though BCR   1, but control works must be constructed, especially that area is por and never be developed.

4.4 COMMENTS AND RECOMMENDATIONS

4.4.1 DESIGN CONTROL SEDIMENT VOLUME

(1) Sedimentation Volume of May 1981 Flood

There was a big flood in May, 1981. JICA Study Team had a field investigation on the sedimentation of May 1981 flood, and estimated its volume as follows:

- K. Mujur;

Total Sedimentation Volume	1.65×10^6 m^3
Specific Value of Sedimentation Volume	24000 m^3/km^2/Flood

- K. Rejali;

Total Sedimentation Volume	1.90×10^6 m^3
Specific Value of Sedimentation Volume	72000 m^3/km^2/Flood

The specific value of K. Rejali at May 1981 flood is three times as large as K. Mujur. This relation of K. Rejali and K. Mujur is the same with the specific value of design control sediment volumes which are used in existing Master Plans.

The reasons are:

- Because of the flank eruption, K. Rejali increased its catchment area, joining the upstream area of B. Semut
- K. Rejali has active tributaries that yield much sediment.

(2) Evaluation of Design Control Sediment Volume of K. Mujur and K. Rejali

It is necessary to review the method of probability evaluation in the process of obtaining the design control sediment value (which corresponds to the term "design excess sediment volume"* according to the Technical Standard of River and Sabo Engineering, Ministry of Construction, Japan) from the sediment volume of the deposits resulted from the past disaster.

* ... Design sediment volume, subject of the sediment control plan. Design excess sediment volume at the reference point = Design sediment runoff volume at the reference point - design allowable sediment runoff volume at the reference point.

But absolute value of design control sediment is not very relevant at this stage, because the main purpose at this stage is to select the First Priority Project. Therefore, JICA Study Team adopted these values for the time being for the purpose of selection of the First Priority Project. Detailed study of these values will be carried out during this Feasibility Study to be followed.

4.4.2 CLASSIFICATION OF SEDIMENT TRANSPORT FLOW TYPE

In both Master Plans, classification of sediment transport flow type is not discussed. Its classification is essential to make a plan of sediment control works.

On the basis of the field investigation result, JICA Study Team proposes the following classification according to transportation system and sedimentation form. This classification is aiming at an index of the sediment control works plan and the disaster due to its flow type.

① Pyroclastic Flow

Volcanic products flow due to the gravity (not due to the rain water), and consist of ash flow, pumice flow, scoria flow, nuee ardente.

② Debris Flow

Sediment transport flow at the upper stream, and shows the following characteristics of sedimentation.

- Semicylindrical cross section
- Bolder concentration at the front
- Banking along the water course

③ Mud Flow

Sediment transport flow at the middle stream, and transitional flow between debris flow and bed-load flow. Mud flow is divided into two types (mud flow (A), mud flow (B)). Mud flow (A) has much characteristics of bed-load flow.

④ Bed-Load Flow

Sediment transport flow at the lower stream.
Sediment with few bolder, uniform grain size and stratographical structure is widely distributed relatively.

Table - 4.3. shows the classification of sediment flow for K. Mujur and K. Rejali, and the suitable sediment control countermeasures according to the sediment flow types.

4.4.3 MAIN PRINCIPLE OF SEDIMENT CONTROL PLAN

The following must be taken into consideration in order to make the sediment control plans:

① The storage system of sediment control works is the only effect evaluation system in the Master Plans. However, in the study area where distinctive amount of volcanic debris is yielded and flow out, effect evaluation at the time of flood using the control system also needs to be conducted simultaneously.

② It is favorable that the channel works plan is determined considering the capacity of sediment transport to river mouth and fluctuation of riverbed.

Table - 4.3 Classification of Sediment Flow

Sediment Flow Types	Main Sections of Disaster		Counter-measures
	K. Rejali	K. Mujur	
Pyroclastic Flow (Nuee Ardente)*	Crater → Top of Leprak Fan	Crater → Confluence with B. Tompe and B. Sat	Checkdam
Debris Flow (Lahar)*	Top of Leprak Fan → Kebondeli	Confluence with B. Tompe and B. Sat → Confluence with K. Tunggeng	Checkdam
Mud Flow (A) (Lahar)*	Kebondeli → Gn. Jugo	Confluence with B. Tunggeng → Confluence with K. Mujur	Checkdam Sandpocket
Mud Flow (B) (lahar)*	Gn. Jugo → Bogorakasan	Confluence with K. Mujur → Confluence with K. Pancing	Sandpocket, dike Consolidation dam
Bed-load Flow (Banjir)*	Bogorakasan → Mouth	Confluence with K. Pancing → Mouth	Channel work consolidation dam, dike

* Technical Term, generally used in Republic of Indonesia

③ In selecting work execution method, it is desirable to investigate the relation between the order of work execution and the transition of river conditions and sediment yield.

④ Selection of work execution method and order of work execution is desired to be centered around the requirement that the disaster preventing effect will be secured immediately.

4.4.4 SEDIMENT CONTROL FACILITY

(1) Sediment Control Facility of K. Mujur

The sediment control facilities of existing Master Plan are basically reasonable enough to prevent flood disaster, with the following modifications:

① Kertosari Sand Pocket and Kloposawit Sand Pocket will be planned using the dikes to be constructed in the Mt. Semeru Urgent Improvement Project.

② 2 river trainings are planned in the Master Plan, 8 river trainings will be additionally planned at the point where the course is bended between PK-1 (5 km) and PK-8 (20 km).

③ The riverbeds at the existing technical intakes will be stabilized, by 6 consolidation dams.

④ The part of Leces Dike (constructed in 1913) which is destroyed in May 1981 will be reinforced with a concrete made strong structure. The other parts will be also reinforced considering the necessity.

(2) Sediment Control Facility of K. Rejali

① Debris flow deposits are currently settled in the upper part of the fan area where sand pocket method will be used in the early period of work execution. It is appropriate that channel work will be executed after the inflow of debris flow is eliminated and changed into the inflow of bed load or suspended load as the result of debris control works to be executed in the upper reach.

② Along Curah Koboan and Curah Lengkong, technically it is very difficult to execute the control work of sediment production to change the sediment flow system from debris flow to bed load flow by means of check dams, and to expect sufficient regulation effect of check dams, because of the geomorphological condition, or the river bed gradient, and the great amount of a flood sediment volume.

③ On the other hand, the record shows that a number of disasters occured in K. Rejali after 1942 when the area in the devastated mountains of the Besuk Semut was altered by the outflow of lava, due to flank volcanic eruption. This implied that at the lower reach of the Kali Rejali, the stream scale and the sedimental scale caused by sudden increase catchment area are remarkably large in comparison with the original river size. Famous geologist W.M. Davis called such a state with a term "Misfit". This seems to be the reasons why in the fan area of the K. Rejali, the state of the river becomes very unstable and the force to form a fan is very active at present.

④ Therefore, from technical standpoint, it is very difficult to provide a disaster prevention measures in the K. Rejali if the scope is limited to the K. Rejali only.

⑤ Considering the above background, JICA Study Team presents the following recommendations:

- A diversion channel will be planned connecting upstream of K. Rejali (1.1 km upstream of Curah Koboan No. 1 Check Dam) and K. Glidik (27.9 km, K. Lengkong, main tributary of K. Glidik).

- The structure of the check dam which has already been planned in the master plan at the diverted point of the river, will be determined taking the diversion into consideration.
- A part of the design trait of river channel in K. Rejali fan area will be altered by moving it to the right, or K. Leprak.
- For the channel work in K. Rejali fan area, the progress rate of work execution and the degree of devastated condition are to be considered. Namely, sand pocket in the early stage of work execution, spur dike, consolidation dam in the middle stage, and channel work in the later stage will mainly be used.
- Regarding the planning of the diversion channel, a sand pocket will be planned at the joint area of the K. Lengkong and the diversion channel, furthermore, Pronojiwa Dam will be planned.

4.4.5 PROJECT EVALUATION

The project evaluation in both existing Master Plans is summarized as Table - 4.4. As shown in the table, there are some differences in the Economic project evaluation of K. Mujur and K. Rejali. Therefore, the final economic project evaluation, or Benefit Cost Ratio (B/C) is not an index to give a priority to the project. More detail project evaluation (or feasibility study) for K. Mujur and K. Rejali will be executed by JICA Study Team in this study.

4.4.6 OTHER RECOMMENDATIONS

(1) Extended Study of K. Lengkong Fan

If the diversion channel, from the upstream of K. Rejali to K. Lengkong, is planned, the sediment control works to cope with the load from the diversion channel will also develop the diverted water and the ground water, making multi-purpose use of the reservoir (or the underground reservoir) that will be formed by the sediment control works in K. Lengkong fan.

(2) Master Plan of K. Glidik

At present, the Master Plan of the entire basin of K. Glidik is not yet made. It should be prepared immediately, because of the following reasons:

- It is now being planned to divert from the upstreams of K. Rejali to K. Lengkong that is the main tributary of K. Glidik.
- The main tributaries of K. Glidik, or B. Sarat, B. Kembar B. Bang, are active ones that have a large amount of sediment yielded by the direct inflow of volcanic products.
- In January 1982, there was a disaster at Wareng. The countermeasures are being undertaken now.

Table - 4.4 Project Evaluation for K. Mujur and K. Rejali

Items \ Project	K. Mujur	K. Rejali
A. Cost Estimation		
(1) Items to be estimated	Construction cost	Construction cost and maintenance cost
(2) Interest	Nil	7% p.a.
(3) Total Construction	Rp 10,855,750,000	Rp 10,860,000,000
(4) Mean Annual Cost	Rp 1,085,575,000 *1	Rp 786,763,560 *2
B. Benefit Estimation		
(1) Items to be estimated	Effect of decreasing disaster area effect on rice production	Effect of decreasing disaster area, effect on rice production
(2) Mean Annual Benefit	Rp 3,425,430,000 *3	Rp 717,000,000 *4
C. Economic Evaluation		
(1) Benefit - Cost Ratio	3.16	0.848
(2) IRR	-	5.93%

5. SELECTION OF PRIORITY PROJECTS

5.1 GENERAL

In selecting the priority projects to be effective in early stage among the projects schemed in the Master Plans of K. Mujur and K. Rejali, the followings are considered.

① Disaster Potentials
- Population
- Disaster Magnitude
- Disaster Frequency

② Socio-economic Potential in Disaster Area
- Population
- Agricultural Productivities
- Immovable Properties
- Public Facilities

③ Disaster Prevention Effect of Existing Works

5.2 DISASTER POTENTIAL

(1) Disaster Area

JICA Study Team has prepared a map of possible disaster area in the study area, on the basis of the field investigation results. (Details are discussed in chapter 6.8).

From the map (Fig. - 6.8.9), the possible disaster area in K. Mujur and K. Rejali Basin is compiled in Table - 5.1.

Table - 5.1 Possible Disaster Area

River system	Disaster area		Percentage
	Grade	Area (km^2)	%
K. Mujur	I	4.60	2
	II	7.58	3
	III	34.68	9
	IV	71.00	27
	V	132.03	51
	VI	21.56	8
	Total	261.45	100
K. Rejali	I	9.40	17
	II	1.75	3
	III	12.04	22
	IV	26.27	49
	V	3.00	6
	VI	1.73	3
	Total	54.19	100

Note:

Grade I : Pyroclastic flow disaster
" II : Debris flow disaster
" III : Mud flow (A) disaster
" IV : Mud flow (B) disaster
" V : Bed load flow disaster
" VI : Flood disaster

(2) Disaster Magnitude

As an index to imply a disaster magnitude, the following two sets of sediment volume are shown in Table - 5.2.

① Sediment deposits of May 1981 flood, estimated by JICA Study Team (Refer to Chapter 6.10).

② Design control sediment volume used in the Master Plans (Refer to Chapter 4)

From the table, it can be known that the specific sediment volume of K. Rejali is about three times larger than that of K. Mujur.

Table - 5.2 Sediment Volume

River System	Sediment Deposits in May '81		Master Plan	
	Total Sediment volume	Specific Sediment Volume*	Design Control Sediment Volume	Specific Sediment Volume*
K. Mujur	1,650,000 m^3	24,000 m^3/km^2/flood	10,140,000 m^3	2,100 m^3/km^2/year
K. Rejali	1,900,000 m^3	72,000 m^3/km^2/flood	8,500,000 m^3	6,500 m^3/km^2/year

* The used area is:

K. Mujur (A=69.19 km^2) ; Upper stream from confluence of K. Besuk Sat and K. Besuk Tunggeng

K. Rejali (A=26.35 km^2) ; Upper stream from Curah Kobo'an No. 1 Check Dam.

(3) Disaster Frequency

Fig. - 5.1 is an example to compare the disaster frequency of K. Mujur and K. Rejali. This figure is prepared on the basis of past disaster records described in both Master Plans.

This figure shows that the disaster frequency of K. Rejali is increasing after the drainage system alternation of K. Rejali (1942, because of the lava sedimentation caused by the flank eruption, B. Semut lost the upstream catchment area, meanwhile K. Rejali took the area and increased its catchment area. Details are discussed in Chapter 6.8).

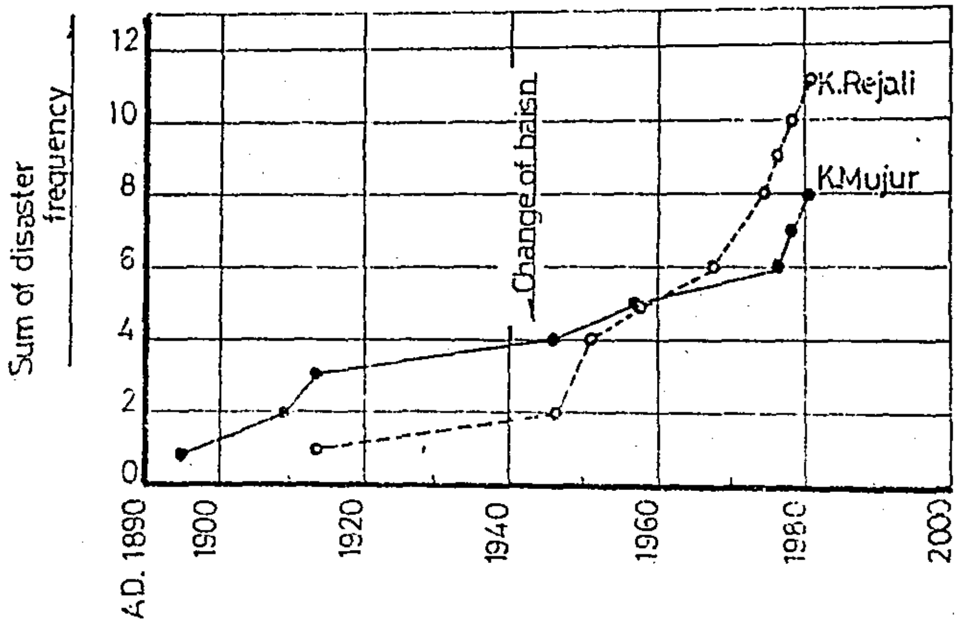


Fig. - 5.1 Disaster Frequency

5.3 SOCIO-ECONOMIC POTENTIAL

(1) Population

On the basis of Fig. - 5.2 (Administrative Division in Disaster Area) and Table - 5.5 (Disaster Area by Administrative Division), population in the disaster area is compiled in Table - 5.3.

Table - 5.3 Population in Disaster Area

River System	Population	Population Density
K. Mujur	160,000 persons	6.1 persons/ha
K. Rejali	23,000 persons	4.2 persons/ha

(2) Economic Potential

Agricultural productivity, immovable properties and public facilities in disaster area must be considered as economic potential. As the basic representative data of above items, area of rice fields, area of villages and number of households are shown in Table - 5.4. This table is prepared on the basis of Fig. - 5.3 (Land Use in Disaster Area) and Table - 5.6 (Land Use Classification and Area).

Table - 5.4 Economic Potential in Disaster Area

River System	Area of Rice fields (ha)	Area of Villages (ha)	Number of Households
K. Mujur	22,600	3,300	39,300
K. Rejali	4,400	400	5,300

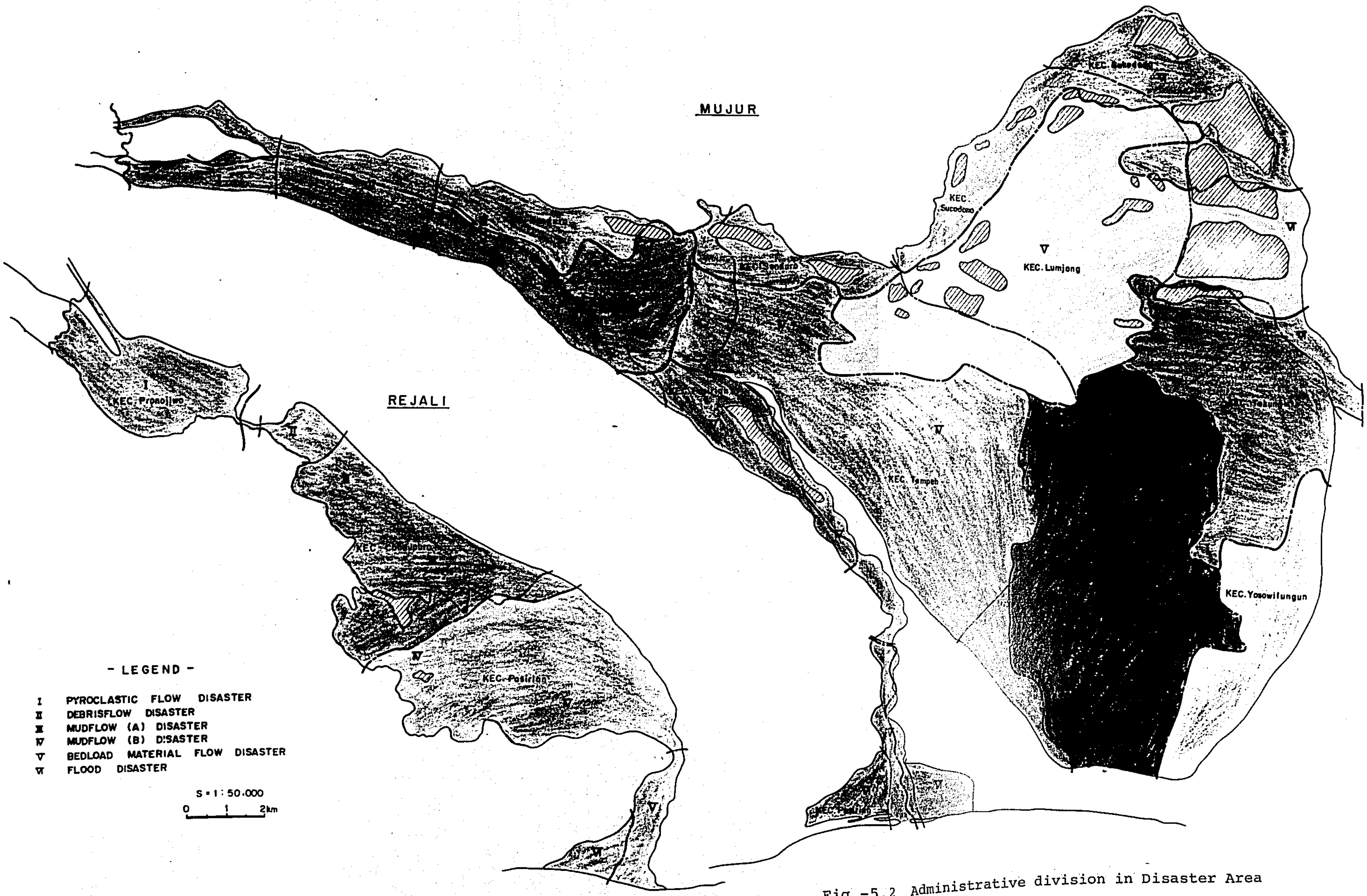


Fig.-5.2 Administrative division in Disaster Area

Table - 5.5 Disaster Area by Administrative Division

area km^2
(rate)

No.	KECAMATAN	MUJUR							REJALI						
		I	II	III	IV	V	VI	total	I	II	III	IV	V	VI	total
1.	Lumajang				11.85 (0.16)	32.12 (0.24)	4.40 (0.20	48.37 (0.81)							
2.	Sukodono					10.11 (0.08)	10.51 (0.49)	20.62 (0.08)							
3.	Senduro	1.67 (0.36)	2.95 (0.39)	7.15 (0.29)	4.15 (0.06)			15.92 (0.06)							
4.	Pasirian			0.40 (0.02)	5.60 (0.08)	2.05 (0.01)	2.30 (0.11)	10.35 (0.04)				21.67 (0.82)	3.00 (1.00)	1.73 (1.00)	26.40 (0.49)
5.	Tempeh			2.90 (0.12)	44.40 (0.63)	4.85 (0.04)	2.20 (0.10)	54.35 (0.21)							
6.	Candipuro	2.93 (0.64)	4.63 (0.61)	14.23 (0.57)				21.79 (0.08)		1.75 (1.00)	12.04 (1.00)	4.60 (0.13)			18.39 (0.34)
7.	Pronojiwo								9.40 (1.00)						9.40 (0.17)
8.	Yosowilungun					14.70 (0.11)		14.70 (0.06)							
9.	Kunir				5.00 (0.07)	44.95 (0.34)		49.95 (0.19)							
10.	Tekung					23.25 (0.18)	2.15 (0.10)	25.40 (0.10)							
	Total	4.60 (0.02)	7.58 (0.03)	24.68 (0.09)	71.00 (0.27)	132.03 (0.51)	21.56 (0.08)	261.45 (1.00)	9.40 (0.17)	1.75 (0.03)	12.04 (0.22)	26.27 (0.49)	3.00 (0.06)	1.73 (0.03)	54.19 (1.00)

Note:
I: Pyroclastic flow disaster
II: Debrisflow disaster
III: Madflow A disaster
IV: Mad flow B disaster
V: Bedload flow disaster
VI: Flood disaster

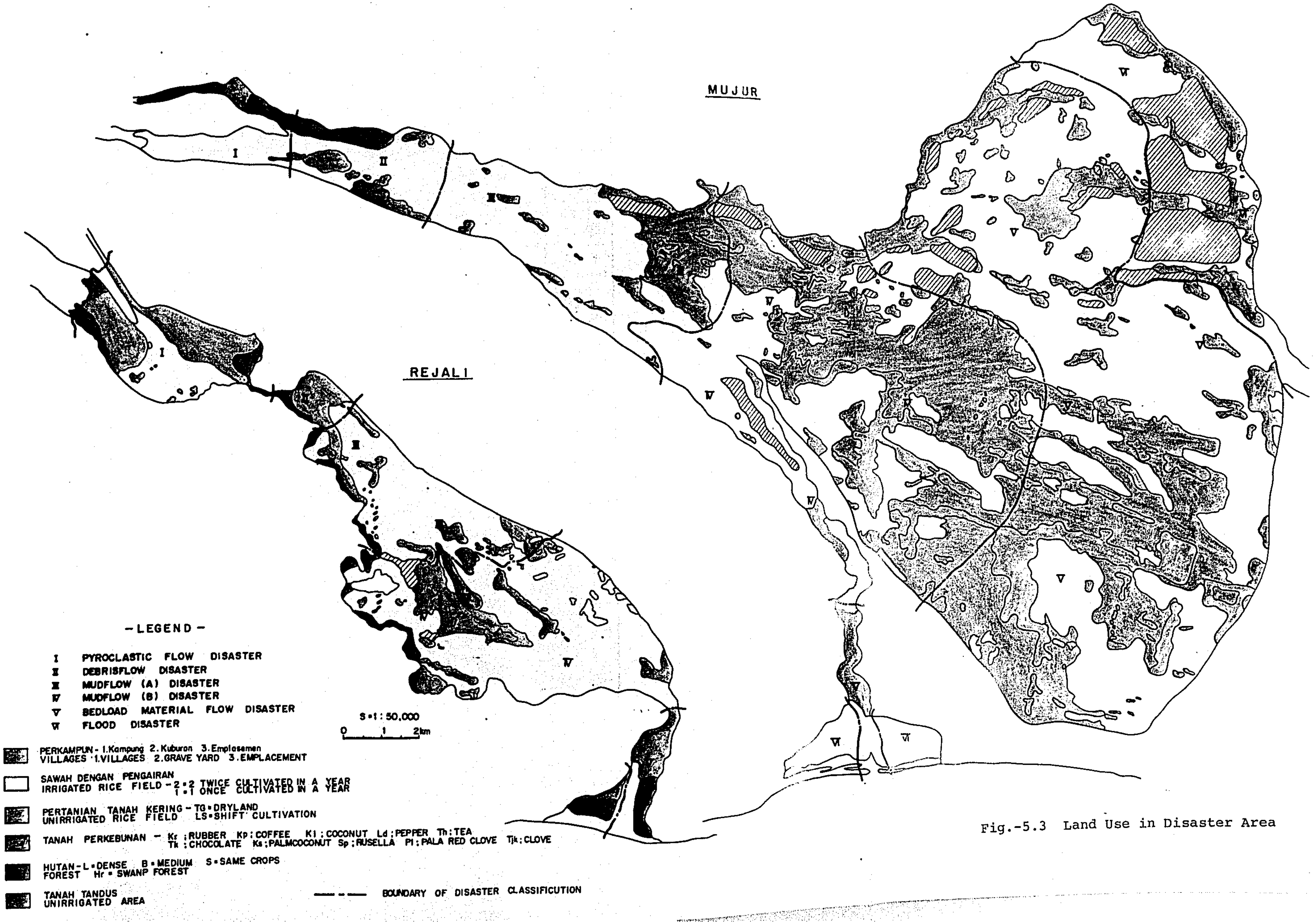


Fig.-5.3 Land Use in Disaster Area

Table - 5.6 Land Use Classification and Area area km^2 (rate)

River System	Disaster Classification	Classification of Land Use							Total
		Villages	Irrigated rice field	unirrigated rice field	estate	unirrigated area	forest	bush	
K. Mujur	I	0.06	3.06	0.40	–	–	1.08	–	4.60 (0.02)
	II	0.60	4.68	0.60	0.54	–	1.16	–	7.58 (0.03)
	III	1.30	17.88	5.50	–	–	–	–	24.68 (0.09)
	IV	10.24	28.38	32.38	–	–	–	–	71.00 (0.27)
	V	19.82	75.50	36.71	–	–	–	–	132.03 (0.51)
	VI	0.72	14.78	6.06	–	–	–	–	21.56 (0.08)
	Total	32.74 (0.13)	144.28 (0.55)	81.65 (0.31)	0.54 (–)	–	2.24 (0.01)	–	261.45 (1.00)
K. Rejali	I	0.20	3.28	5.00	–	–	0.92	–	9.40 (0.17)
	II	–	0.24	1.31	–	–	0.20	–	1.75 (0.03)
	III	1.08	9.14	0.84	0.24	0.50	0.24	–	12.04 (0.22)
	IV	2.44	19.18	3.33	–	0.44	0.88	–	26.27 (0.49)
	V	–	0.12	1.04	–	–	0.58	1.26	3.00 (0.06)
	VI	–	–	0.28	–	–	0.54	0.91	1.73 (0.03)
	Total	3.72 (0.07)	31.96 (0.59)	11.80 (0.22)	0.24 (–)	0.94 (0.02)	3.36 (0.06)	2.17 (0.04)	54.19 (1.00)

Note;
I: Pyroclastic flow disaster
II: Debris flow disaster
III: Madflow A disaster
IV: " B disaster
V: Bedload flow disaster
VI: Flood disaster

5.4 DISASTER PREVENTION EFFECT OF EXISTING WORKS

(1) Urgent Improvement Works Project

The Urgent Improvement Works Project with O.E.C.F. loan application is now being planned and scheduled to start construction in 1983. This project is planned to prevent such disaster as the same magnitude as that in May 1981.

- estimated damage; approximate Rp. 8,200 million
- 365 person dead
- 1,002 houses damaged

This project will give much effect to K. Mujur basin after the project completion (1985).

(2) Number of Sediment Control Works

As an index to know the disaster prevention effect of existing works, the number of existing sediment control works is shown in Table - 5.7.

Table - 5.7 Number of Existing Sediment Control Works

River System	Dam	Dike	Spur Dike	Excavation	Total
K. Mujur	5	26	0	4	35
K. Rejali	4	9	3	0	16

5.5 PRIORITY PROJECTS

The Urgent Improvement Works of the highest priority is to start construction in 1983 and will give much effect to K. Mujur basin in the near future. Therefore, the first priority should be given to K. Rejali project and the second priority to K. Mujur due to the following reason.

- K. Rejali is more disastrous than K. Mujur after the Urgent Improvement Works.

- The percentage of high grade disaster area of K. Rejali is larger than that of K. Mujur.

- In the Master Plans, specific sediment volume of K. Rejali is about 3 times as large as K. Mujur.

- The disaster frequency of K. Rejali after 1942 (alternation of catchment area) is 1.6 times as often as K. Mujur.

- The total capacity of existing sediment control works of K. Rejali is considered to be lower than that of K. Mujur.

JICA Study Team selects the following priority projects from among the disaster prevention works which are planned in the existing Master Plans and recommended by the Team.

Refer to Fig. - 5.4

1 The first priority project

(K. Rejali)

- <u>Diversion channel (2 km long) from Curah Kobo'an to K. Lengkong</u>

- <u>2 check dams in Curah Kobo'an</u>

  15 m high, 155 m wide, at elevation 820 m
  15 m high, 380 m wide, at elevation 740 m

- <u>2 Sand pockets in K. Leprak</u>

  900 m long, at elevation 370 m
  1,230 m long, at elevation 330 m

(K. Lengkong, main tributary of K. Glidik)

- Sand pocket in K. Lengkong

  300 m long, at elevation 720 m

- Check dam (Pronojiwo Dam)

  30 m high, 450 wide, at elevation 630 m

② The second priority project (tentative)
(K. Mujur)

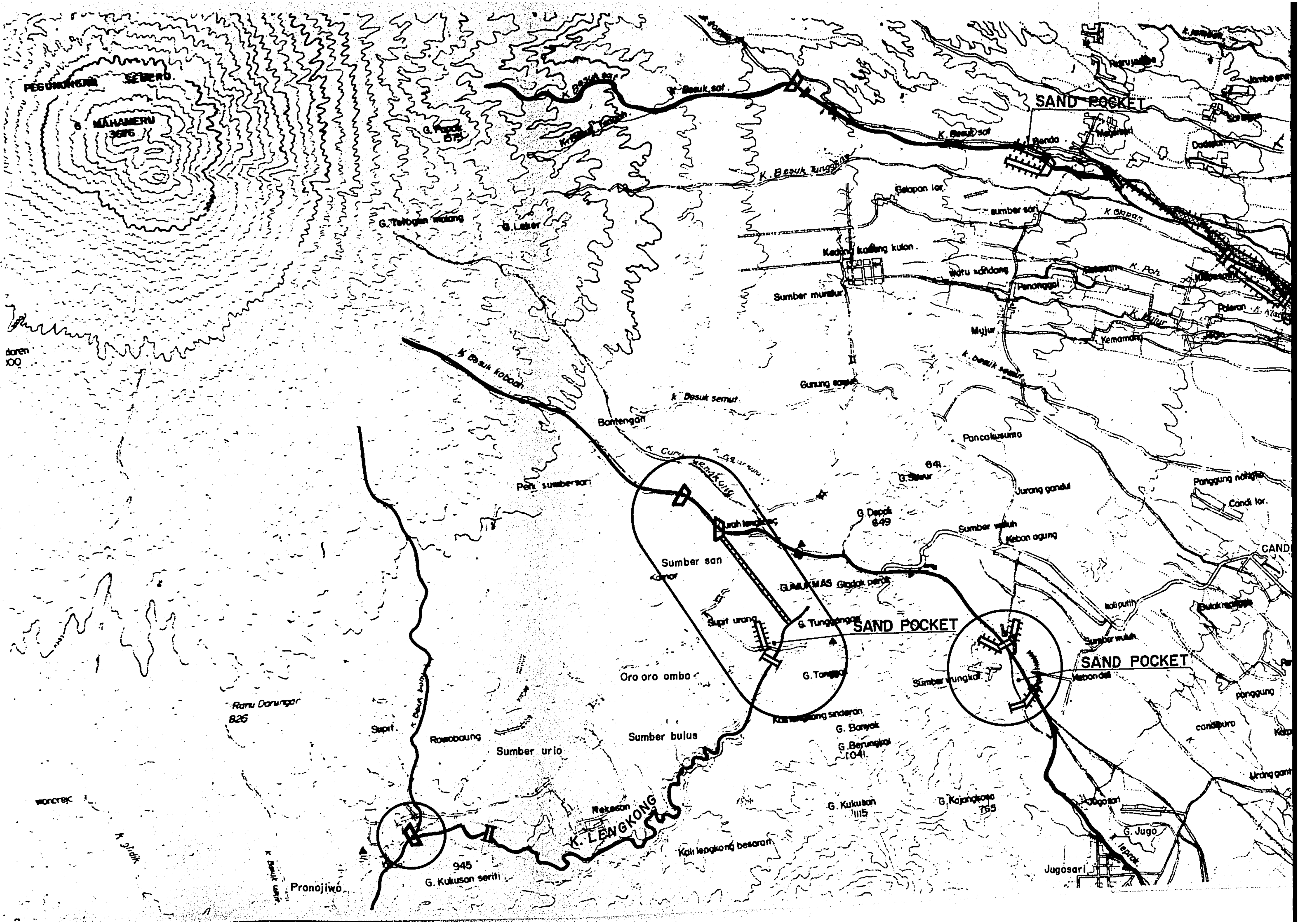
- 5 check dams in K. Besuk Sat
  From elevation 764 m to elevation 692 m

- 3 sand pockets in K. Besuk Sat
  Bendo sand pocket
  Kertosari sand pocket
  Kloposawit sand pocket

- Leces Dike rehabilitation works

- 6 consolidation dams
  From elevation 428 m to elevation 65 m

- 10 river trainings
  From elevation 285 m to elevation 65 m


PEGUNUNGAN SEMERU
G. MAHAMERU
3676
G. Lekar
K. Besuk sat
K. Besuk Tunggeng
SAND POCKET
Benda
Gelapan lor.
sumber sari
K. Glapan
Sumber mundur
Penanggal
K. Poh
K. Mujur
Mujur
Kemamang
Gunung sawur
K. Besuk kobokan
Bantengan
k. Besuk semut
Pancakusuma
Pert. sumbersari
G. Sawur
641
G. Dempil
649
Jurang gandul
Panggung nongko
Candi lor.
Sumber wuluh
Kebon agung
Sumber san
Kamar
GUMUKMAS
Supit urang
G. Tunggangan
SAND POCKET
G. Tanggol
Oro oro ombo
Sumber wungkal
SAND POCKET
Kebon deli
Sumber wuluh
Panggung
Ranu Darungan
826
Rowobaung
Sumber urio
Sumber bulus
G. Banyak
G. Berungkal
1.041
Rekesan
K. LENGKONG
G. Kukusan
1115
G. Kojangkoso
765
Jugosari
G. Jugo
Jugosari
Kali lengkong besaran
945
G. Kukuson seriti
Pronojiwo
woncrejo

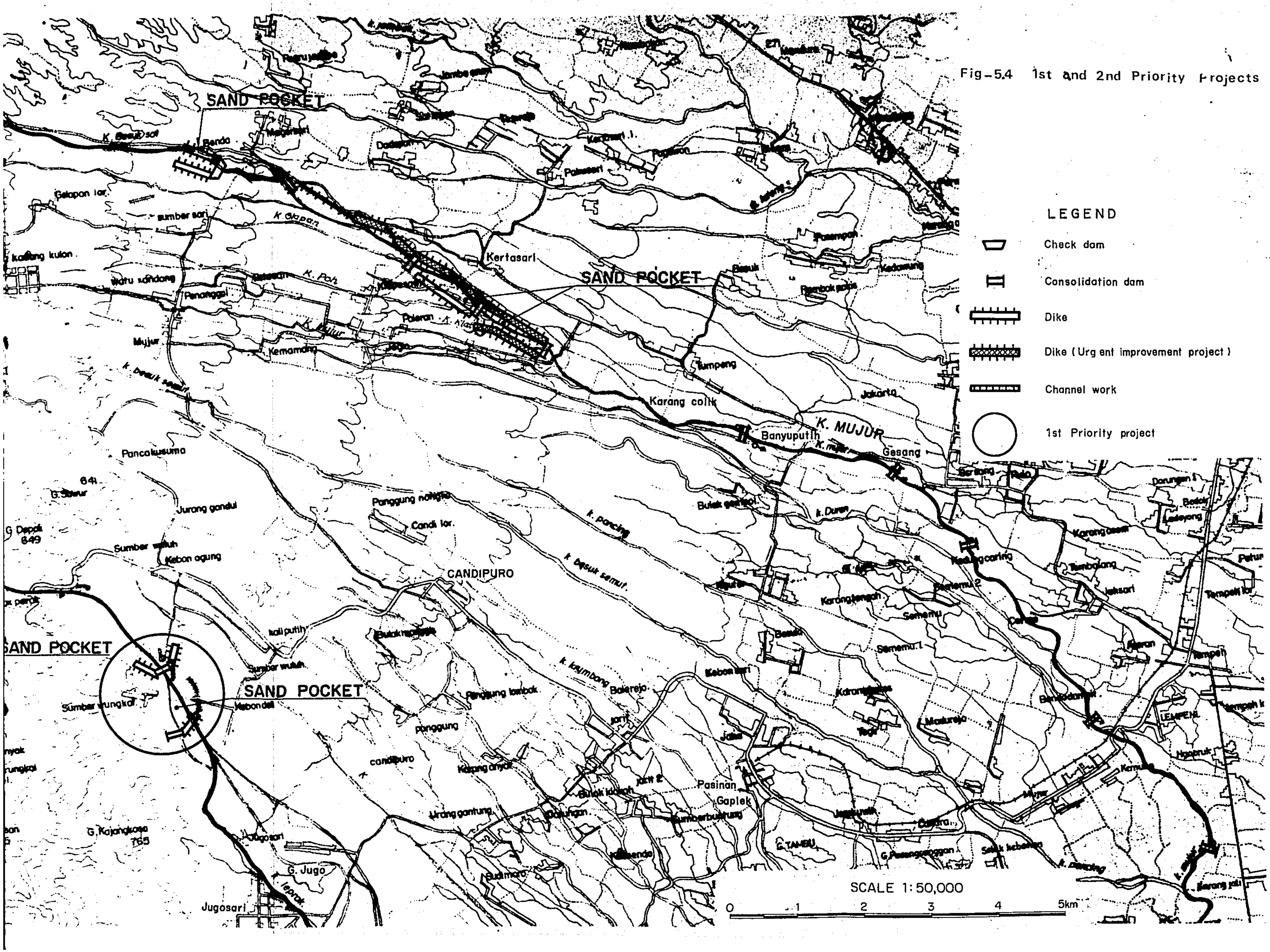


Fig-5.4 1st and 2nd Priority Projects

6. STUDY CONTENTS

6.1 GENERAL

This study consists of Field Investigation, Analysis, Planning (including Design and Cost Estimation) and Project Evaluation.

The Items executed up to present (August 1981) are as follows:

(1) Field Investigation
- Topographic Map Preparation
- Socio-Economic Study
- Actual Water Use Investigation
- Actual Land Use Investigation
- Hydrological Study
- Geological and Soil Investigation
- Topographical Investigation
- Disaster Investigation
- River Channel Investigation
- Sediment Flow and Volume Investigation

(Warning and Evaculation System Investigation and Vegetation Study are not yet executed)

(2) Sediment control facility study.

It was partially executed based on the interim results of the field investigation for Project Evaluation and Selection of Priority Projects.

In the field investigation, some work items are executed in association with the Indonesian Government and the JICA Team according to the following allocation.

Table - 6.1.1 Allocation of Field Investigation

Work Item		Indonesian Government	JICA Team
Topographical Survey		Execution of field work	Selection of the location for the survey, the observation and test.
Geological Survey	Survey Boring		
	Seismic Survey	Sampling and each test	
	Electrical Sounding		
	Site Permeability Testing	Collection and arrangement of materials.	Determination of method
Materials and Soil Characteristics Testing.			Technical guidance
River Bad Materials Testing			
Economic Status Survey			
Hydrological Survey	Water Quality Survey		
	Hydrological Observation		

6.2 TOPOGRAPHIC MAP

Using the existing aerial photo:

- Scale; 1 : 10,000.
- Focal length camera; 150 mm.
- Date of aerial photo taken; July 1981, April 1982.

to prepare the topographic map of the study area (scale 1 : 10,000, Area to be covered = 730 km^2), JICA survey team (of five surveyors) carried out the following surveys, during 17 March and 25 May.

(1) Leveling

- Leveling was conducted along the main roads so as to keep the accuracy of elevation, using the equipment of level and staff.
- Original points of leveling were selected among existing Bench Marks and used as the original points of elevation for the survey work.
- According to the topographic conditions, direct method and/or Indirect method (trigonometric leveling) were employed.
- Length of leveling route: approx. 70 km
- Accuracy of leveling route; closure error less than 10 cm + 1 cm S

S = survey length (km) measured on the existing 1 : 50,000 topographic map.

(2) Traversing

- Traversing was conducted along main roads so as to keep the accuracy of horizontal position on the topographic map, using the equipment of theodolite.
- Original points of traversing were selected among existing triangulation points and used as the original points of horizontal coordination for the survey work.
- Accuracy of traversing route; closure error less than 1 : 10,000.

(3) Field Identification

- Photo interpretation keys were determined for each classified area and major facilities in the area were checked.
- Area identified;
  Area along main roads, major villages, major topographic features.

(4) Pricking

- Pricking of existing triangulation points, control points and leveling points was done for aerial triangulation.
- Number of pricked points; 100 points.

K. MIZUE
M. KOBAYASHI

6.3 SOCIO-ECONOMIC STUDY

Data collected by the end of August, 1982 are listed below. Data collection is still under way and the data to be further collected are also listed under item (6) hereof.

(1) Survey - Social and Economical Situations at the Circumference of Mt. Semeru in Lumajang Prefecture - Brawijaya University, Malang.

(2) PROSIDA Report (Report on Irrigation Rehabilitation Programme)

Summary :

① Water Users Association (HIPPA) in Pekalen Sampean Sub Project.
② O & M Budget Provided by Provincial Public Work (Lumajang, Bondowoso, Banyuwangi Irrigation Region).
③ O & M Staffing (Lumajang, Bondowoso, Banyuwangi Irrigation Region).
④ Tertiary Development Programme (Construction).
⑤ Target and Realize of Ipeda per District in Pekalen Sampean Sub Project.
⑥ Area and Yield of Paddy (Probolinggo, Lumajang, Jember, Bondowoso, Situbondo and Banyuwangi District).

(a) Directorate General of Water Resources Development
I.D.A. Irrigation Rehabilitation Programme
Pekalen Sampean Sub Project, East Java

<u>AGRICULTURE DATA WET SEASON</u> (1980/Nov. - 1982/Apr.)

Contents ......

1 Area, Yield and Production of Rice.

2 Cost and Value of Production of Rice under Bimas Programme.

(3) Cost and Value of Production of Rice under Inmas Programme.
(4) Cost and Value of Non Intensification Programme.
(5) Area, Yield and Production of Secondary Crops.
(6) Number of BUUD's and Village Unit BRI and other Support Service.
(7) Number of Agriculture Extension Personnel and Demonstration Unit.
(8) Specification on Bimas Paddy with high Yielding Variety Package per Ha.
(9) Target and Realized of Ipeda.
(10) Area affected and damaged by pest and natural disasters.

(b) Agriculture Semi Annual Report (1981/May - 1981/Oct. - Dry Season)

Contents .... Same As (a)

(c) Irrigation Rehabilitation Programme (1980/Nov. - 1981/Apr. - Wet Season)

Contents .... Same As (a)

(d) Directorate General of Water Resources Development
I.D.A. Irrigation Rehabilitation Programme
Pekalen Sampean Sub Project, East Java
AGROECONOMIC - DATA (1980/May - 1980/Oct. - Dry Season)

Contents .... Same As (a)

(e) Directorate General of Water Resources Development
I.D.A. Irrigation Rehabilitation Programme
Pekalen Sampean Sub Project, East Java
AGROECONOMIC - DATA (1979/Nov. - 1980/Apr.)

Contents .... Same As (a)

(3) Statistics for East Java, 1980 - Statistics Office for Province, East Java

(4) Statistics for East-Java, 1976-1980

(5) List of Other Data

(a) Present Facilities for each Kecamatan

① Pronojiwa
② Senduro
③ Candipuro
④ Pasirian
⑤ Tempeh
⑥ Lumajang
⑦ Kunir
⑧ Tekung
⑨ Yosowilangun

Table 1. Mosque, Church, Clinic, Market, School
Table 2. Irrigation Facilities (Well, Dam, Intake)
Table 3. Cultivation Area for each Crops (Rice, Corn, Peanuts, Soybean) Yield for each area (same as above)
Table 4. Number of Households
Table 5. Historic Place, Ruins and Others (including other Kecamatan)
Table 6. Irrigation Area (Technical - Non Technical)
Table 7. Cultivation Area for each Crops (Crops by Plantation such as coffee etc.)
Yield for each Crops (by unit-area)
Table 8. Cattle (Horse, Cow, Water Buffalo, Pig, Sheep, Duck, Hen)
Table 9. Unit Price for Major Yield
Table 10. Timber Yield and Products from Forest (for 4 Kecamatan including Nos. 1, 2, 4 as above and Klakar)
Table 11. Plantation Area (Coconuts Palm, Pepper, Areca Palm, Tobacco etc.)
Yield by Plantation (same as above)

(b) Market Prices (August, 1981)

- Farm Crops - Rice, Corn, Cassava, Peanuts, Soybean, Coffee, Coconuts, Clove, Pepper, Tobacco

- Cattle - Water Buffalo, Milch, Horse, Sheep, Goat, Duck, Hen, Pig

- House - Brick, Brick-Bamboo, Wood, Bamboo

(c) List of Budget for Semeru Project

(d) Population (Kabupaten Lumajang) - by each age and sex

(e) Record of Disaster

(f) Statistics for East Java - Summary

Table 1. Regional Gross Domestic Products
Table 2. Transition of Population and Forecast
Table 3. Population of Farmers (by each cultivation area)
Table 4. Cultivation Area and Yield for Major Crops (1978 and 1979)
Table 5. Employed Population for each Industry
Table 6. GDP Composition for each Industry

(g) Statistics of East Java

Table 1. Population for each Kabupaten
Table 2. Population for each Work (1976)
Table 3. Planted Area and Yield for each Vegetables
Table 4. Gross Regional Product (1976 - 1980)
Table 5. Income for each Person
Table 6. Planted Area and Yield for each Crops (Rice, Corn, Sweet Potato, Cassava, Peanuts, Soybean)
Table 7. Production-Conditions for Plantation (Rubber, Coffee, Tea, Cocoa, Clove, Coconuts, Sugar Cane)
Table 8. Transition of Demands and Yield of Rice (1976 - 1980)
Table 9. Forecast of Demands and Yield of Rice (1981 - 1985)

Table 10. Number of Farmers for each Kabupaten

(h) Statistic of Lumajang
Statistic of 7 Kecamatan (Lumajang, Tempeh, Pasirian, Candipuro, Senduro, Pronowijo, Sukodono)

Table 1. Gross Regional Product (1979 and 1980)
Table 2. Planted Area and Yield for each Crops (1978 - 1980)

(6) List of Data as Required

(a) Statistics for each Desa are required for the followings:

① Area
② Population
③ Number of Households
④ Cultivation Area for each Crops
⑤ Yield for each Crops

(b) The following data for each Desa are required for the area to be studied:

① Spread of Houses, Stores, Factories and Hospitals (detailed data for Stores are required)
② Scale of Stores and Evaluation of Commodities
③ Number of Cattle (for each kind)

(c) Data by Basic Unit

- Agriculture

① Consumption of Service Water by each Crops/Yield by Unit
② Consumption of Fertilizer by each Crops/Yield by Unit
③ Consumption of Insecticide by each Crops/Yield by Unit
④ Market Prices of Crops
⑤ Costs for Fertilizer
⑥ Costs for Insecticide

⑦ Production-Efficiency for Irrigation Agriculture (Yield/Unit Area)
⑧ Production-Efficiency for Non-Irrigation Agriculture (Yield/Unit Area)

- Assessment of Assets (Movable Property + Immovable Property)

① Housing (Upper Stream, Middle Stream, Lower Stream)
② Stores (classified in detail)
③ Offices
④ Hospitals
⑤ Factories
⑥ Schools

- Unit Price for Construction

① Housing (Upper Stream, Middle Stream, Lower Stream)
② Stores (classified in detail)
③ Hospitals
④ Factories
⑤ Schools

- Scale of Stores and Factories

① Stores' Amount of Sales (classified in detail)
② Factories' Scale of Production (classified in detail)

(d) General Data for Agriculture Production

① Cropping Pattern by each Region
② Cropping Pattern by each Crops
③ Damages upon Agriculture at the Time of the Disaster in May, 1981
④ Transition of Production/Month by each Crops
⑤ Ratio of Irrigation Area (by each Kecamatan)
⑥ Water System for Irrigation (Location of Intake)
⑦ Sectional Map of Agriculture Land to be Irrigated

General Data

- Restoration Cost for Flood Disaster
  1. Medical Costs
  2. Foods Costs
  3. Personnel Expenses
  4. Construction Costs for Restoration
  5. Emergency Housing
  6. Costs for Migration

- Period for Restoration
  1. Agricultural (Agriculture Land and Irrigation Facilities)
  2. Infrastructures (Road, Bridge, Electricity etc.)
  3. Buildings (Housing, Stores, Factories etc.)

- Budget

- Data for Development Planning

- The Budget Statement of President
  1. January, 1981 as already issued - in Indonesian and English
  2. January, 1982 scheduled to be issued in August - in Indonesian and English

(f) Sectional Map by each Kecamatan and Desa

6.4 ACTUAL WATER USE INVESTIGATION

T. TAKAHASHI

6.4.1 GENERAL

Actual water use investigation is carried out to give a basic data for calculating the economic effect of this project.

In the dry season, there are some cases which is not easy to take the water from river because of riverbed degradation at the intakes along the Kali Mujur (Mujur River) and Kali Rejali (Rejali River). In order to investigate these conditions, low water observation have been carried out once a month since April, 1982 (this observation is planned until June 1984). Flow regime of the Kali Mujur and the Kali Rejali intake rate at each intakes during both the rainy season and the dry season, ratio of the intake rate, at intakes to the discharge of the river will be made clear by data obtained from observation.

As there is the relation between the water use and the land use in the irrigated area, further investigation is carried out about the following items:

- Investigation on the relation between the intake rate and the irrigated area during both rainy season and the dry season at each intakes.

- Investigation of kinds of main crops cultivated in the non-irrigated area, harvested area, production, and production cost by each crop.

- Investigation of paddy field regarding the following points:

  ① Periods of cultivation

  ② Times of cultivation per year
  (once a year, twice a year, etc.)

  ③ Water requirement
  (mm/day/Ha, liter/month/Ha, etc.).

At present (end of August, 1982), these items are under investigation.

This report mainly deals with the investigation of intakes and a result of low water analysis such as flow regime of river, ratio of the intake rate to the discharge of river during first dry season (*) of this year.

6.4.2 OUTLINE OF INTAKES

There are about 20 intakes along the Kali Mujur and the Kali Rejali as shown in Fig. - 6.4.1. Table - 6.4.1 shows the controlling public body, types of irrigation, covered area, design intake rate, etc. In these items, there are three types of irrigation as follows:
the technical irrigation, the semi-technical irrigation, the non-technical irrigation, depending on construction and management of irrigation facilities.

(a) Technical irrigation

The government (D.P.U.) constructs and manages intakes, primary, and secondary channels. The village (desa) constructs and manages the tertiary and subsequent channels.

(b) Semi-technical irrigation

The government only constructs and maintains intakes and all other work is done by the villages.

(c) Non-technical irrigation

The villages carry out all the construction and management of irrigation facilities.

(*) From May to October

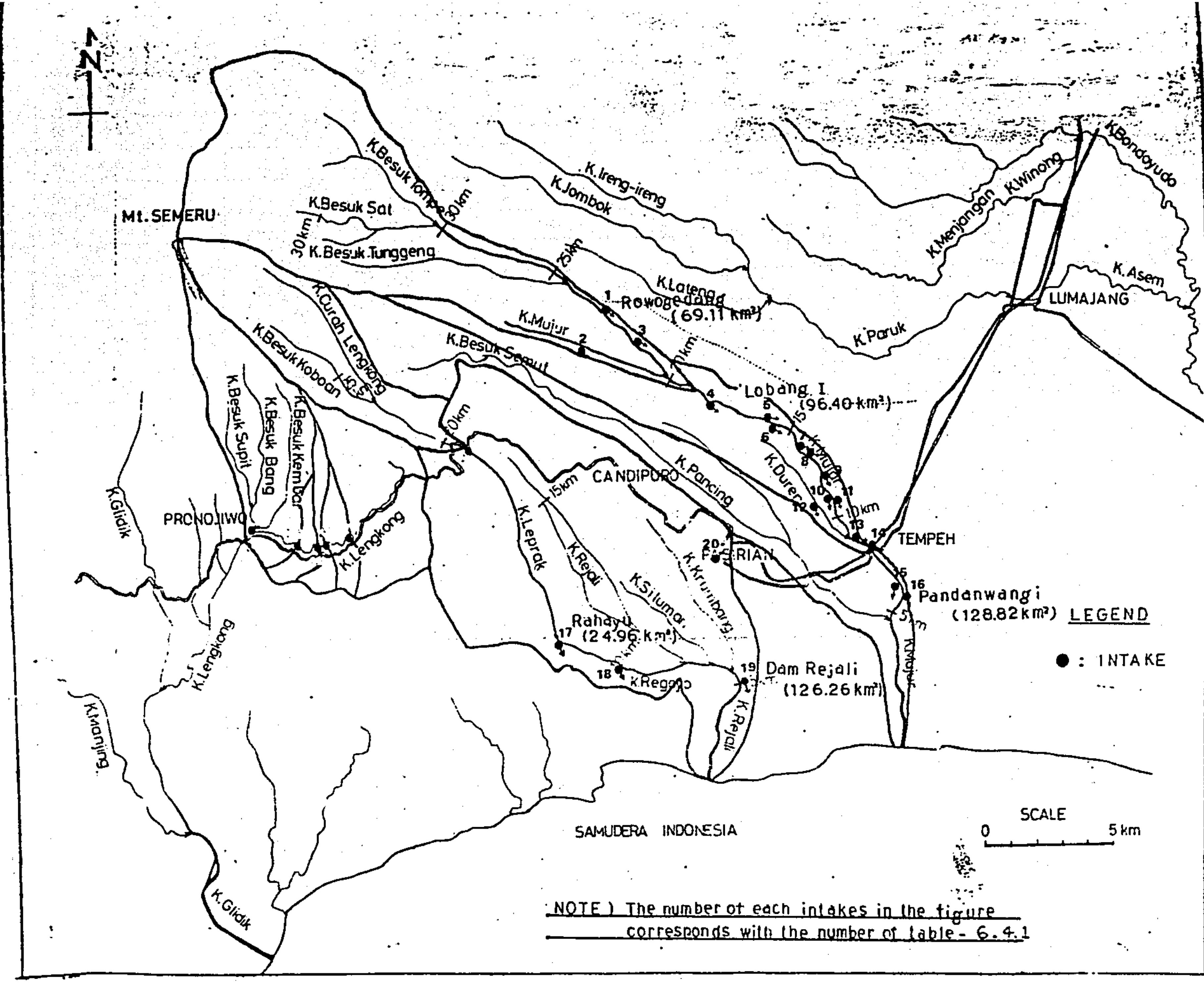


Fig.- 6.4.1

STUDY AREA

(Actual Water Use Investigation)

Table - 6.4.1 List of Intakes along the Kali Mujur and Kali Rejali

No.	Name of Intake	Location	Controling Public Body	Type of Irrigation	Covered Area (ha)	Design Intake rate (m^3/s) Wet season Max.	Wet season Min.	Dry season Max.	Dry season Min.	Year Constructed	Village (Desa)
1	Rowogedang	K.B.Tunggeng 22K 300	Irrigation office —— I.O	Semi-technical	573	1.15		4.25		1980	Kertosari
2	Dam Juranggegur	-	Kantor Desa Kloposawit	Non-technical	45						"
3	Dam Pancut	K.B.Tunggeng 20K 600	"	"	85						"
4	Dam Karan colik	K.Mujur 17 K 700	"	"	65					1978	Karan colik
5	Loban I	K.Mujur 16 K 800	I.O.	technical	899	1.70		5.83		1980	Banyuputih
6	Loban II	K.Mujur 16 K 300	"	"	201	0.96		3.99		1980	"
7	Klerek I	K.Mujur 14 K 500	"	"	412	1.35		4.80		1979	Gesang
8	Klerek II	K.Mujur 14 K 400	"	"							"
9	Kedung Caring	K.Mujur 12 K 400	I.O.	"	317	0.83		3.96		1978	Jatisari
10	Juweni	K.Mujur 10 K 600	KANTOR DESA JATISARI	Non-technical	17						"
11	Sapari	K.Mujur 10 K 600	"	"	40						"
12	Carik	K.Duren 9 K 700	KANTOR DESA LEMPENI	"	200						Lempeni
13	Soponyono	K.Mujur 9 K 000	I.O.	technical	66	0.94		0.77		1980	"
14	Ponco	K.Mujur 8 K 700	KANTOR DESA LEMPENI	Non-technical	15						"
15	Dawuhan Kerti	K.Mujur 6 K 400	"	"	30						Tempeh Kidul
16	Pandanwangi	K.Mujur 5 K 900	I.O.	technical	1,070	2.00				1979	"
17	Rahayu	K.Regoyo 11 K 500	KANTOR DESA GONDO RUSO	Non-technical							Gondoruso
18	Dawhan Marso	K.Regoyo 9 K 200	KANTOR DESA GONDO RUSO	Non-technical	30						Gondoruso
19	Dam Rejali	K.Rejali 3 K 500	I.O.	technical	455						Bago
20	Talang	spring	I.O.	"	294						Pasirian

Table - 6.4.2 shows the number and areas by irrigation type.

Table - 6.4.2 Number, Areas by Type of Irrigation

Type of Irrigation \ River	Kali Mujur (*)		Kali Rejali (**)		Total	
	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)
Technical	6	2,965	1	455	7	3,420 (489 ha/p.c.)
Semi-technical	1	573	-	-	1	573 (573 ha/p.c.)
Non-technical	8	497	1	30	9	527 (59 ha/ p.c.)
T o t a l	15	4,035	2	485	17	4,520 (266 ha/p.c.)

(*) Excluding "Klerek II"
(**) Excluding "Rahayu" and "Talang"

The technical irrigated area have a large area compared with the non-technical area. This difference influences not only a stable supply of water (*) but yield of crops.

Location map of intakes are shown in the Fig. - 6.4.2.

There were some intakes injured by debris flow on May 14, 1981. But most of these intakes were rehabilitated by D.P.U.

(*) There is a man called "Juru Pengairan (irrigation expert)". He controls quantity of water by measuring water level three times a day at the main channel.

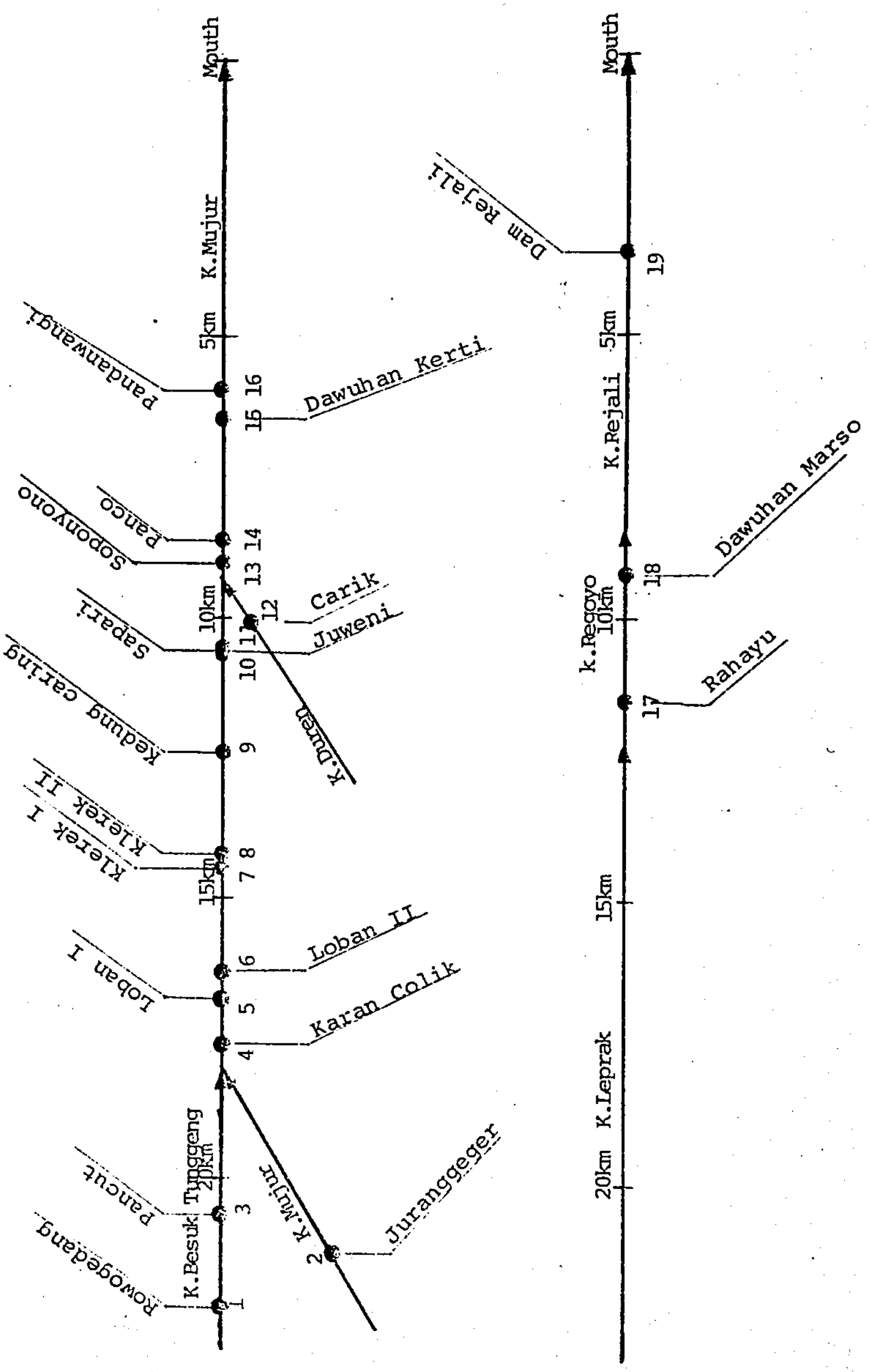


Fig.-6.4.2 Outline Map of The Intakes

6.4.3 INVESTIGATION OF RELATION BETWEEN DISCHARGE OF RIVER AND INTAKE RATE

(1) Flow Regime in the Mujur River Basin and Rejali River Basin

Table - 6.4.3 shows the flow regime from April to August in the Kali Mujur basin and Kali Rejali basin and the discharge per one-hundred square kilometers (100 Km^2). Also, Fig. - 6.4.3 shows the variation of discharge and discharge per 100 Km^2.

These data leads to the following:

- The discharge of river decreased suddenly during the period from April (end of rainy season) to May (beginning of dry season).

- The Flow regime of Kali Rejali basin is superior to the flow regime of Kali Mujur basin (refer to Fig. - 6.4.3 below). As the discharge of "Rowogedang" located in the upper basin of the Kali Mujur and the discharge of "Rahayu" located in the middle basin of the Kali Rejali are looked upon as the "natural flow" by reason of no intakes in the upper area from these points the flow rate former is smaller than the latter by 2 m^3/s in each month.

- The discharge per 100 Km2 varies 1.0-2.0 $m^3/s/100$ Km^2 at Rowogedang in Kali Mujur basin. In Kali Rejali basin, this value varies 2.0-4.0 $m^3/s/100$ Km^2 at Rahayu.

- It is said that the flow regime of Mujur basin is similar to the flow regime of Rejali basin judging from a tendency of the discharge at Rowogedang and the discharge at Rahayu.

Further investigation will be carried out in May, 1983 when one year's observation is completed.

Table - 6.4.3 Flow Regime, Discharge per 100 Km^2

Station \ Catchment area (Km^2) \ Year, Month		1982.4	1982.5	1982.6	1982.7	1982.8
Rowogedang	69.11	2.16	1.41	0.85	0.88	0.65
		(3.13)	(2.04)	(1.23)	(1.27)	(0.94)
Laban I	96.40	3.13	0.67	0.59	0.38	0.02
		(3.25)	(0.70)	(0.61)	(0.39)	(0.02)
Pandanwangi	126.82	2.11	0.46	0.96	0.83	0.73
		(1.64)	(0.36)	(0.75)	(0.64)	(0.57)

Kali Rejali

Station \ Catchment area (Km^2) \ Year, Month		1982.4	1982.5	1982.6	1982.7	1982.8
Rahayu	24.96	1.05	0.67	0.57	0.55	0.42
		(4.21)	(2.68)	(2.28)	(2.20)	(1.68)
Dam Rejali	126.26	4.00	3.81	1.91	1.65	1.34
		(3.17)	(3.01)	(1.51)	(1.31)	(1.06)

Note

Upper : Discharge observed once a month (m^3/s)

Below : Discharge per 100 Km ($m^3/s/100\ Km^2$)

$$q = \frac{Q}{A} \times 100$$

q : Discharge per 100 Km^2 ($m^3/s/100Km^2$)

Q : Discharge (m^3/s)

A : Catchment area (Km^2)

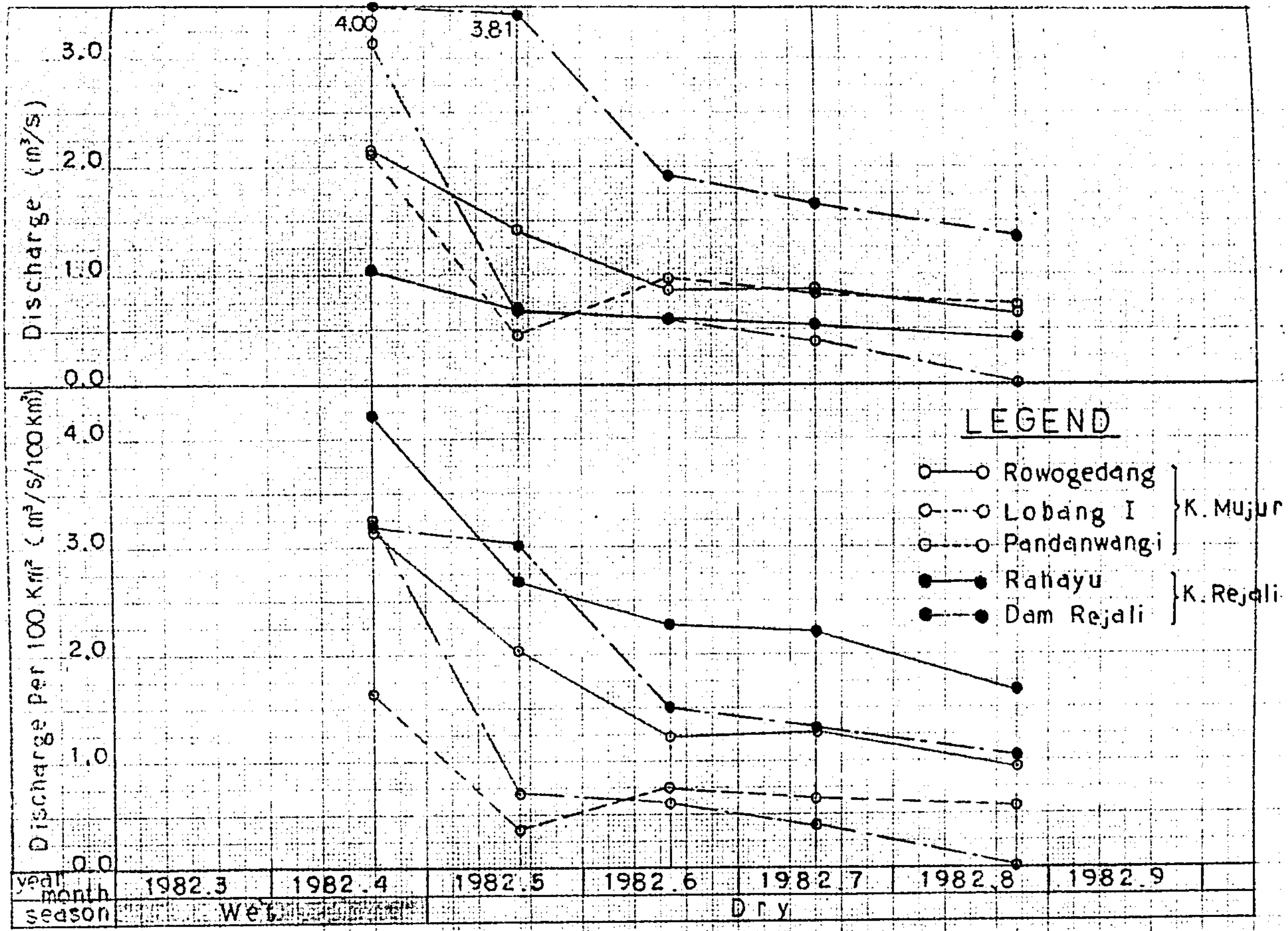


Fig.- 6.4.3 Variation of Discharge and Discharge per 100 km²

(2) Relation Between the Discharge of the River and the Intake Rate

In this study, the relation between the discharge of the river and the intake rate will be made clear in the dry season of this year.

Table - 6.4.4 shows the observed discharge at each intake and the "intake ratio" in the Kali Mujur and Kali Rejali. The intake ratio is defined as the ratio of the intake rate to the discharge of river in this case. The variation of intake rate and intake ratio are shown in Fig. - 6.4.4.

Table - 6.4.4, Fig. - 6.4.4 lead to the following:

- Intake rate has gradually decreased since April or May in Kali Mujur. On the other hand, in the Kali Rejali, these tendency is not so evident.

- Calculating intake rate per hectare from the Table - 6.4.4, these rates are generally classified by the irrigated area as follows:

①	Less than 100 (ha)	2.0 - 4.0 (l/s/ha)
②	100 - 500	0.5 - 2.0
③	more than 500	0.3 - 1.5

- Intake ratio has been increasing since May in the upper and middle reaches of the Kali Mujur. In these areas, the intake ratio are 60 - 90%. In the lower area, it is around 50%.

- In the Kali Rejali, the intake ratio registers 70 - 80% in the middle reaches and around 50% in the lower reaches.

It seems that intake rate has relations with cultivated area and season of paddy in the irrigated area.

Further investigation will be carried out until the end of September, 1982.

Table - 6.4.4 Observed discharge at each intakes in the Kali Mujur and Kali Rejali

Kali Mujur

(m^3/s)

No.	Name of Intake	Location	1982.4 up ①	1982.4 down ②	1982.4 channel ③	1982.4 ratio ③/①	1982.5 up ①	1982.5 down ②	1982.5 channel ③	1982.5 ratio ③/①	1982.6 up ①	1982.6 down ②	1982.6 channel ③	1982.6 ratio ③/①	1982.7 up ①	1982.7 down ②	1982.7 channel ③	1982.7 ratio ③/①	1982.8 up ①	1982.8 down ②	1982.8 channel ③	1982.8 ratio ③/①
1.	Rowogedang	K 22 300	2.16	1.67	0.34	0.16	1.41	0.50	1.03	0.73	0.85	0.29	0.74	0.89	0.88	0.49	0.62	0.71	0.65	0.20	0.34	0.53
2.	Juranggeger	-	-	-	-	-	-	-	-	-	0.18	0.06	0.10	0.56	0.22	0.06	0.12	0.55	0.17	0.03	0.19	1.12
3.	Pancut	20 600	-	-	-	-	-	-	-	-	0.24	0.18	0.13	0.56	0.30	0.14	0.16	0.54	0.32	0.14	0.21	0.65
4.	Karangolik	17 600	-	-	-	-	-	-	-	-	0.31	0.12	0.15	0.49	0.73	0.16	0.19	0.27	0.52	0.10	0.19	0.37
5.	Lobang I	16 800	3.13	3.37	0.56	0.17	0.67	0.05	0.70	1.04	0.59	0.05	0.48	0.83	0.41	0.04	0.40	0.98	0.38	0.28	0.33	0.87
6.	Lobang II	16 300	2.48	-	0.00	-	0.00	1.05	0.67	-	0.79	0.59	0.24	0.31	0.56	0.38	0.32	0.56	0.16	0.03	0.13	0.82
7.	Klerek I	14 500	2.68	-	0.28	0.10	0.28	0.38	-	-	0.42	-	0.18	0.44	-	-	0.11	-	0.51	-	0.23	0.46
8.	Klerek II	14 400	-	-	-	-	-	-	-	-	0.52	0.10	0.39	0.76	0.47	0.03	0.43	0.92	0.35	0.07	0.39	1.12
9.	Kedung-caring	12 400	2.12	1.57	0.47	0.22	0.48	0.10	0.38	0.79	0.32	0.16	0.24	0.77	0.31	0.19	0.18	0.59	0.19	0.08	0.15	0.79
10.	Juweni	10 600	-	-	-	-	-	-	-	-	0.47	0.40	0.07	0.15	0.32	0.27	0.05	0.16	0.24	0.14	0.10	0.42
11.	Sapari	10 600	-	-	-	-	-	-	-	-	0.40	0.42	0.02	0.06	0.33	0.31	0.02	0.06	0.23	0.14	0.09	0.39
12.	Carik	9 700	-	-	-	-	-	-	-	-	0.60	0.48	0.07	0.13	0.60	0.51	0.15	0.26	0.53	0.46	0.15	0.28
13.	Soponyono	9 000	1.69	0.73	0.93	0.55	1.18	0.64	0.64	0.54	1.20	0.79	0.50	0.42	0.83	0.63	0.36	0.43	0.91	0.47	0.57	0.63
14.	Ponco	8 700	-	-	-	-	-	-	-	-	0.79	0.89	0.18	0.23	0.70	0.55	0.14	0.20	0.47	0.35	0.11	0.24
15.	Dawuhan-kerti	6 400	2.06	2.11	0.20	0.09	0.71	0.46	0.15	0.21	1.20	0.96	0.10	0.50	0.74	0.61	0.13	0.18	0.62	0.48	0.14	0.23
16.	Pandan-wangi	5 900	2.11	0.23	1.60	0.75	0.46	0.33	0.32	0.69	0.96	0.55	0.52	0.57	0.83	0.46	0.37	0.45	0.73	0.44	0.29	0.39

Kali Rejali

No.	Intake	Location	1982.4 up ①	1982.4 down ②	1982.4 channel ③	1982.4 ratio ③/①	1982.5 up ①	1982.5 down ②	1982.5 channel ③	1982.5 ratio ③/①	1982.6 up ①	1982.6 down ②	1982.6 channel ③	1982.6 ratio ③/①	1982.7 up ①	1982.7 down ②	1982.7 channel ③	1982.7 ratio ③/①	1982.8 up ①	1982.8 down ②	1982.8 channel ③	1982.8 ratio ③/①
17.	Pahayu	K 11 500	1.05	0.44	0.50	0.47	0.50	0.67	0.17	0.34	0.57	0.14	0.14	0.25	0.55	0.08	0.40	0.73	0.42	0.04	0.33	0.79
18.	Dawuhan Marso	9 200	-	-	-	-	-	-	-	-	0.95	0.87	0.07	0.08	0.68	0.61	0.07	0.10	0.73	0.64	0.19	0.27
19.	Dam Rejali	3 500	4.00	2.94	1.01	0.25	3.81	1.63	0.77	0.20	1.91	0.69	0.99	0.52	1.65	0.93	0.74	0.45	1.34	0.62	0.67	0.50
20.	Talang (*)	-	-	-	0.46	-	-	-	0.45	-	-	-	0.43	-	-	-	0.35	-	-	-	0.57	-

(*)_ take a water from spring

① up : discharge in the upstream of the intake

② down : discharge in the downstream of the intake

③ channel : discharge in the channel

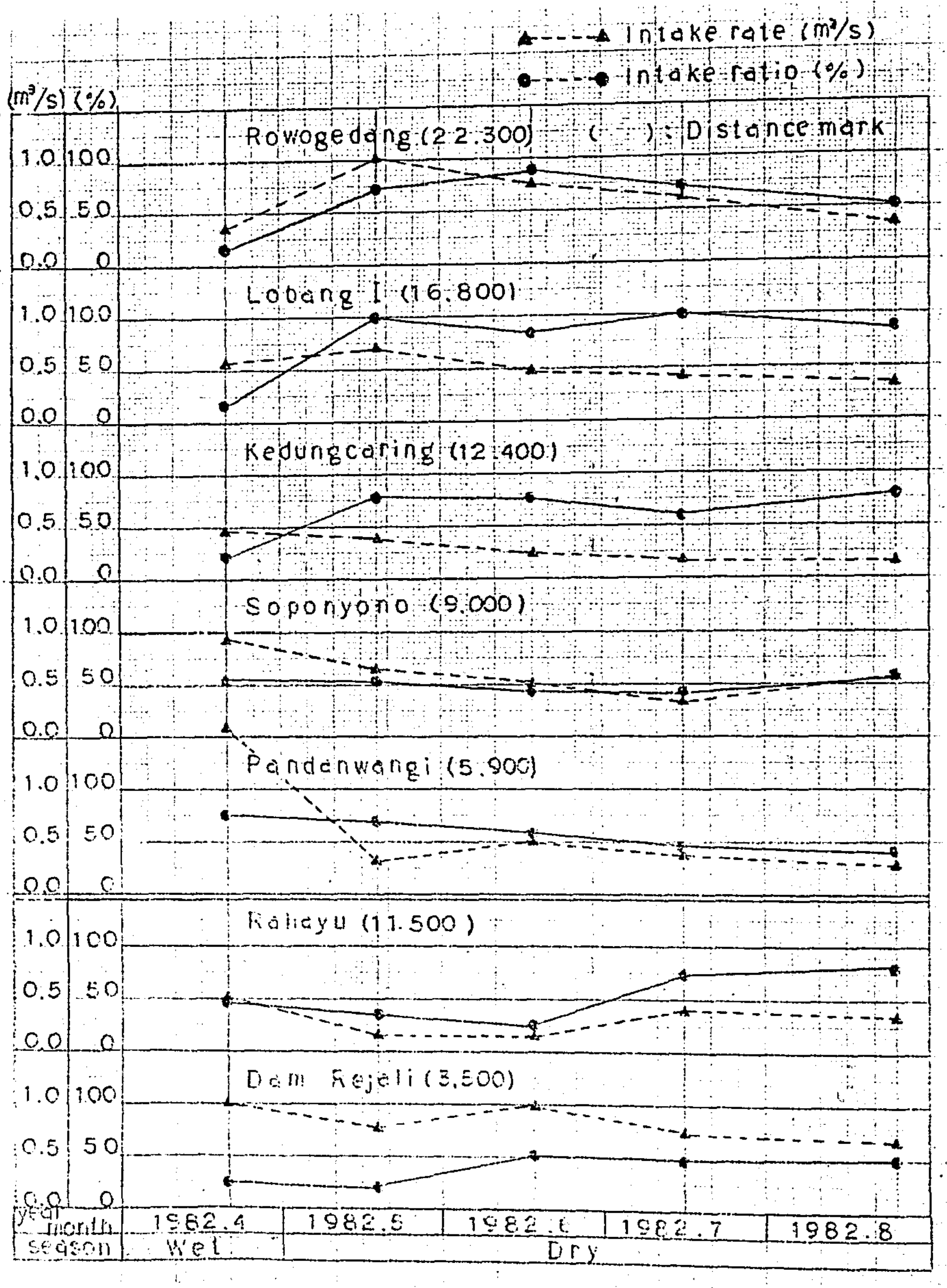


Fig - 6.4.4 Variation of intake rate and intake ratio

6.5 ACTUAL LAND USE INVESTIGATION

K. IKEDA

(1) OBJECTIVES

The purpose of this study is to understand the actual land use condition and to revise the existing land use map (SCALE = 1 : 50,000) in the study area.
The results of the actual land use investigation and land use map shall be used to analyze the influence of the disaster on land and estimate the economic benefit.

(2) METHODS

The field survey by means of questionnaire and observation of land use at sampling points is carried out. Kinds of crops and combination of crops before disaster and after disaster are investigated. The irrigation condition is also investigated. Now, the field survey is underway and the field data have not been arranged.

The sampling points are selected by means of aero-photo interpretation and existing land use map. The sampling points distributed on the disaster area and different land use area.

The arrangement of field survey data is to provide interpretation keys. After providing the interpretation key, aero-photo interpretation of land use shall be carried out and the existing land use map shall be revised. The work processes are shown in Fig.-6.5.1 and the questionnaire is shown in Table 6.5.1.

(3) FIELD SURVEY RESULTS AT PRESENT

It seems that the land use corresponds to landform classification as follows:

- Main part of the volcanic cone:
  Forest, Plantation

- Steep slope volcanic fan:
  Disaster area --- Paddy field, field, Waste lands
  Non-disaster area --- Paddy field
- Gentle slope volcanic fan:
  Disaster area --- Paddy field, Field
  Non-disaster area --- Paddy field, Field
- Peripheral plain:
  Paddy field
- Alluvial plain:
  Paddy field
- Old volcanic piedmont:
  Field, Plantation
- Tertiary mountainous area:
  Plantation

The influence of disaster to land use is as follows:

① The area frequently damaged by lahar still remains under an undeveloped condition in terms of land use. These condition can be observed in the K. Mujur fan area.

② Coaser materials prevent recultivation. These condition can be seen in the 1909 disaster area and K. Rejali fan area.

Land use is also closely related to the irrigation. For example, in the B. Semut and the K. Pancing basin, waste land and forest can be observed, because of lack of water. On the gentle slope volcanic fan area and peripheral plain, the crop combinations are decided by irrigation condition.

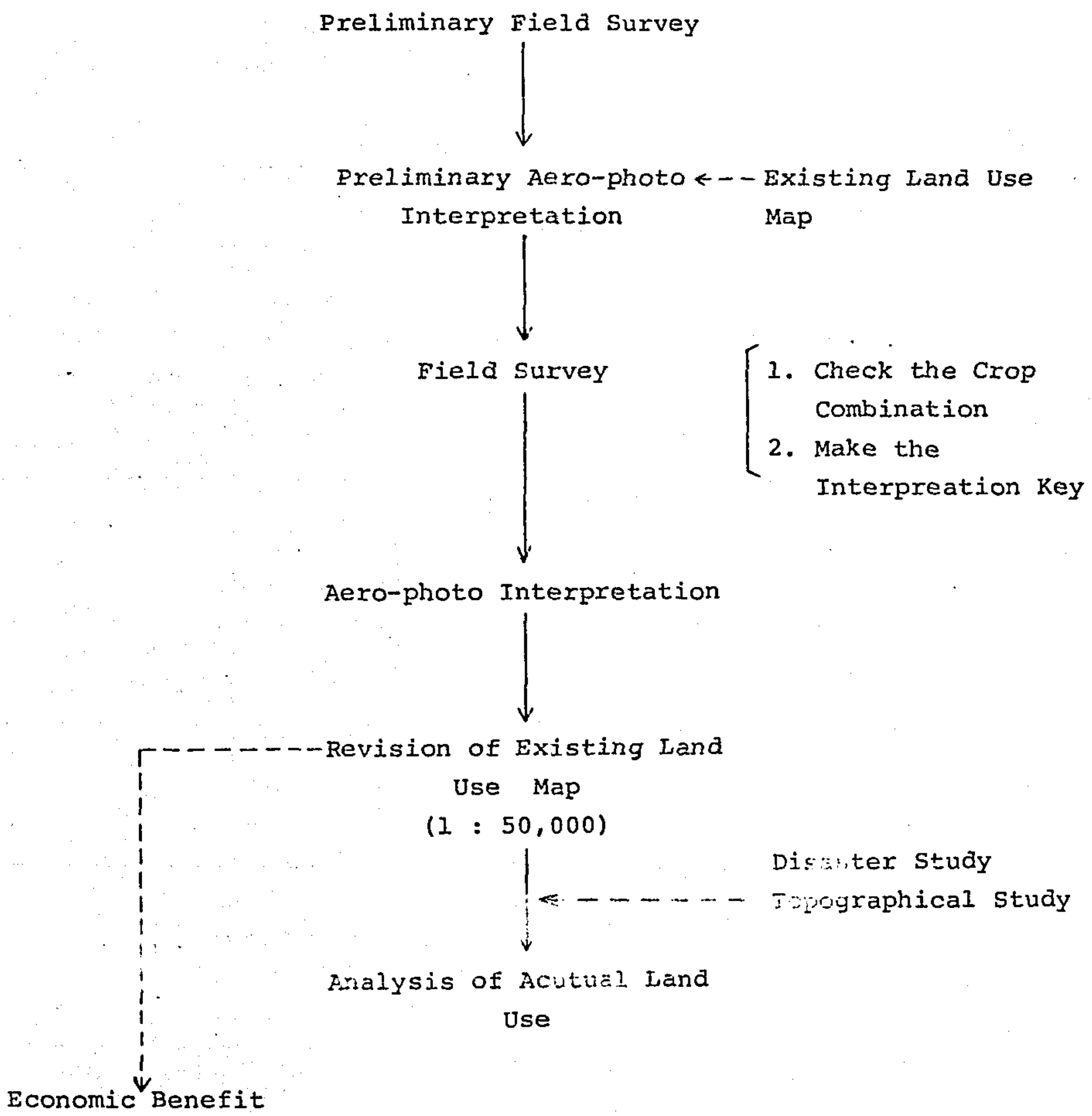


Fig.-6.5.1 Work Processes

Table-6.5.1 Questionnaire of Land Use

What crop did you plant around July, 1981													
Table of Crops Planted During One Year													
Month	1	2	3	4	5	6	7	8	9	10	11	12	Comments
Kind of Crops													Before or After Disaster
Irrigation Condition													
Kind of Crops													Before or After Disaster
Irrigation Condition													
Factors Preventing Planting of Rice	1. No water 2. Not permitted taking water 3. Cannot obtain of water 4. Unknown factor												
Factors Preventing Irrigation Water	1. Because river course and water height are changable 2. Because the land is too height 3. Because water source is too far												
Production of Primary Crops for per Ha.													

6.6 HYDROLOGICAL STUDY

6.6.1 HYDROLOGICAL OBSERVATION

(1) Rainfall Observation

H. KANAMURA

For the purpose of putting the rainfall observation stations in order, the following matters were carried out.

- Installation of New Rainfall Observation Stations
- Inspection of Existing Rainfall Observation Stations

(a) Installation of New Rainfall Observation Stations

1) Summary

There are many rain observation stations installed in the study area, but almost of those stations are located at flat area.

The sparse area have been undercontrolled in the observation network by this installation of new observation stations.

At around 1500 meters height, automatic rain gauges surround the east-south part of Mt. Semeru. So, it can be said that the observation network has been ready for the study.

2) General description

At the beginning of April '82, 5 automatic rain gauges were sent from Japan International Cooperation Agency (hereinafter called JICA). The location plan for the above rain gauges was shown by Proyek Semeru.

The recommendation for the installation of the above new rain gauges was submitted after considering the thiessen polygon and the elevation of those stations by JICA study team.

The recommendation is attached in Appendix - 6 .
Table - 6.6.1 shows the detail of rainfall observation stations.
Fig. - 6.6.1 shows the location of rainfall observation stations and the thiessen polygon.

3) Description of Rain Gauge

a) No. of Rain Gauge ....5 units

b) Type of Rain Gauge ... NAKAASA Remote Recording Rain Gauge

c) Specifications

- Detector .... Tipping-bucket
- Rainfall per one tipping .... 0.5 mm
- Recording period .... 1 month.

4) Description of new observation stations

a) Pos Vulkanologi Argosuko (XI)

This station covers the western part of Mt. Semeru, as the sparse area.

b) Pos Pendakian Panupane (XII)

At first, this station was planned to install at the eastern part of this study area.
But, finally, this station was selected by Proyek Semeru's offer to use this station for the K. Bondoyudo investigation.

c) Supit Urang (XIII)

This station had an automatic rain gauge once, but, when a gauge in the station, Kamar A (III) was out of order, the gauge of this station was moved and installed there.

The western part of the study area is covered by this new stations again.

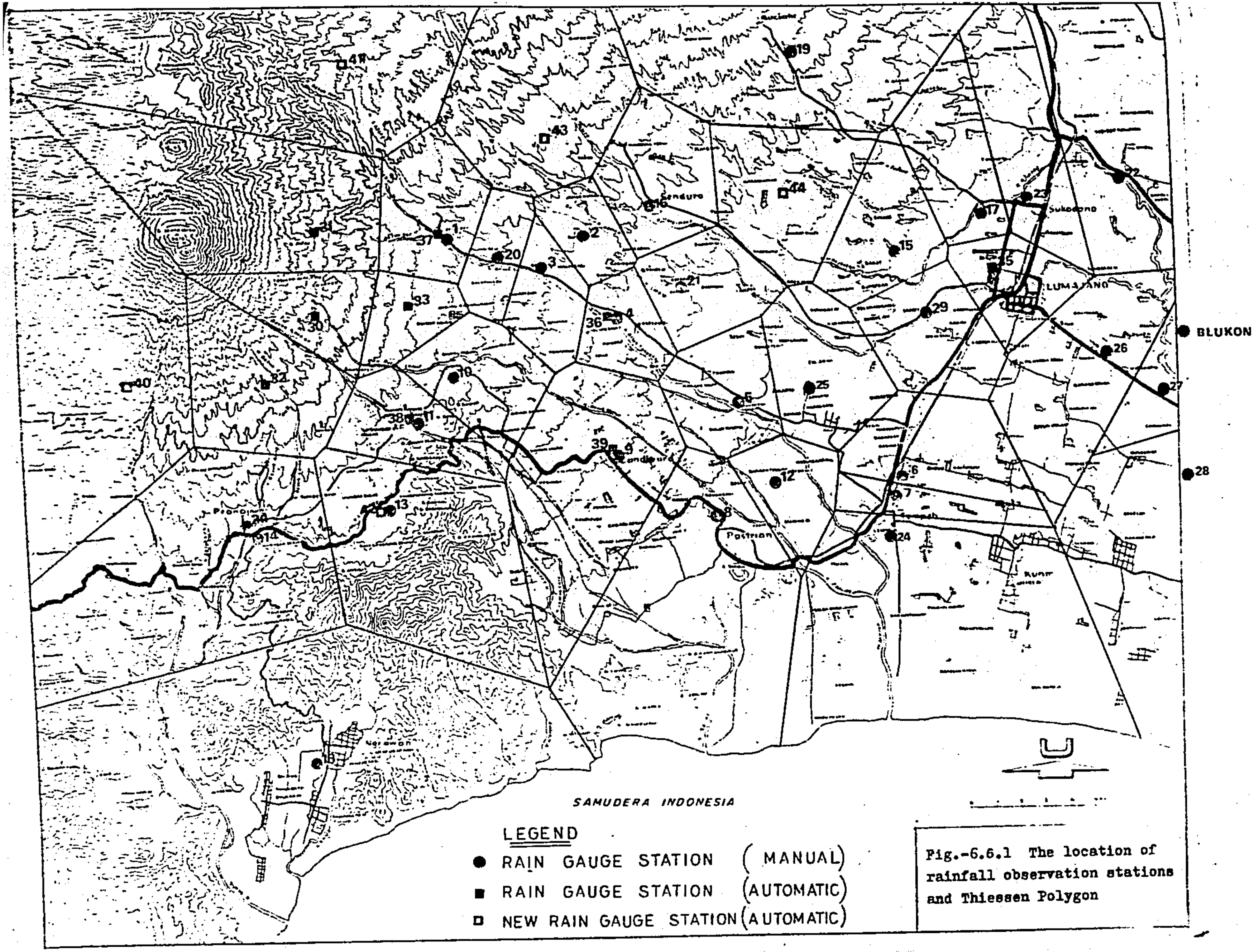


Fig.-6.6.1 The location of rainfall observation stations and Thiessen Polygon

Table- 6.6.1 (1) Rainfall Observation Stations

NO	OBS. NO	STATION	LOCATION LATITUDE	LOCATION LONGITUDE	EL. (m)	RANK	BELONGING	TYPE OF EQUIP.	AVAILABLE DATA	INSTALLED DAY	REMARKS
1	158a	BESUK SAT	S8°6'37"	E113°1'0"	+795	B	DEP IRRIGASI	MANUAL	1951 – 1982	—	
2	161	PASRU JAMBE	S8°6'50"	E113°3'36"	+481	D	— DITTO —	— DITTO —	1951 – 1982	—	
3	162	BENDO	S8°2'40"	E113°2'51"	+510	C	— DITTO —	— DITTO —	1951 – 1982	—	SUMBER DUREN
4	160	KERTOSARI	S8°8'30"	E113°5'1"	+345	C	— DITTO —	— DITTO —	1951 – 1982	1974/1975	
5	186	KEDUNG WRINGIN	S8°10'19"	E113°7'44"	+103	C	— DITTO —	— DITTO —	1952–59, 62–1982	1974/1975	
6	190a	BESUK	S8°10'8"	E113°11'4"	+93	B	— DITTO —	— DITTO —	1978 – 1982	—	
7	190b	BEDOG	S8°11'56"	E113°10'38"	+93	B	DITTO —	DITTO —	1980 – 1982	1974/1975	
8	189	PASIRIAN	S8°12'30"	E113°6'53"	+155	C	— DITTO —	— DITTO —	1952 – 1982	1974/1975	
9	188a	CANDIPURO	S8°11'13"	E113°4'6"	+322	C	— DITTO —	— DITTO —	1951 – 1982	1974/1975	
10	188b	GUNUNG SAWUR	S8°10'0"	E113°0'24"	+682	B	— DITTO —	— DITTO —	1952 – 1982	—	
11	164a	CURAH KOBOAN	S8°10'16"	E113°0'10"	+734	C	— DITTO —	— DITTO —	1952 – 1982	—	
12		SEMEMU	S8°11'55"	E113°7'54"	+38	B	— DITTO —	— DITTO —	1977 – 1982	—	
13	166	SUPIT URANG	S8°13'9"	E112°58'4"	+675	C	— DITTO —	— DITTO —	1971 – 1982	—	SUMBER BADANG
14	167	SUMBER ROWO	S8°12'45"	E112°56'37"	+600	C	— DITTO —	— DITTO —	1974 – 1982	1975/1976	PRONOJIWO
15	89	KEDUNG SANGKU	S8°7'12"	E113°11'1"	+60	B	— DITTO —	— DITTO —	1952–59, 62–1982	—	
16	159	SENDURO	S8°5'55"	E113°5'26"	+435	C	— DITTO —	— DITTO —	1952–59, 62–1982	—	
17	183	DAWUHAN LOR	S8°5'47"	E113°13'6"	+97	C	— DITTO —	— DITTO —	1949 – 1982	—	
18	167a	TEMPUR SARI	S8°16'56"	E112°58'48"	+5	D	— DITTO —	— DITTO —	1952–59, 62–1982	—	RAWAAN
19	157	GUCIALIT	S8°2'27"	E113°7'57"	+600	C	— DITTO —	— DITTO —	1951 – 1982	—	

Table- 6.6.1 (2) Rainfall Observation Stations

NO	OBS. NO	STATION	LOCATION LATITUDE	LOCATION LONGITUDE	EL. (m)	RANK	BELONGING	TYPE OF EQUIP.	AVAILABLE DATA	INSTALLED DAY	REMARKS
20		MUNGGIR	S8° 7' 32"	E 113° 3' 15"	+600	C	DEP IRRIGASI	MANUAL	1953–59, 62–1982	1974·1975	
21		PAGOWAN	S8° 7' 53"	E 113° 6' 22"	+115	C	– DIT. TO –	– DITTO –	1969 – 1982		
22		UMBUL	S8° 5' 42"	E 113° 15' 41"	+40	A	– DITTO –	– DITTO –	1972 – 1982	—	
23		SUKODONO	S8° 6' 16"	E 113° 13' 39"	+45	D	– DITTO –	– DITTO –	1976 – 1982	—	
24		TEMPEH KIDUL	S8° 13' 14"	E113° 10' 36"	+93	C	– DITTO –	– DITTO –	1954–68, 78–1982	—	
25		JOKARTO	S8° 9' 52"	E113° 6' 8"	+161	C	– DITTO –	– DITTO –	1976 – 1982	—	
26	222	WONOKERTO	S8° 10' 0"	E113° 16' 21"	+34	D	– DITTO –	– DITTO –	1952–59, 62–1982	—	
27	223	TEKUNG	S8° 10' 32"	E113° 17' 2"	+22	B	– DITTO –	– DITTO –	1952 – 1982	—	
28		NOGOSARI	S8° 11' 9"	E113° 17' 22"	+17	D	– DITTO –	– DITTO –	1952–59, 62–1982	1974/1975	
29	185	BRUG PURWO	S8° 8' 36"	E113° 11' 15"	+50	B	– DITTO –	– DITTO –	1951– 80, 1982	—	LUMAJANG
30	I	GUNUNG LEKER	S8° 7' 42"	E112° 58' 2"	+1400	C	PROYEK G. SEMERU	AUTOMATIC		26 JAN '82	
31	II	GUNUNG PAKIS	S8° 5' 34"	E112° 58' 50"	+1600	C	– DITTO –	– DITTO –	1982	11 FEB '82	
32	III	KAMAR A	S8° 8' 56"	E112° 57' 10"	+1300	B	– DITTO –	– DITTO –	1982	2 FEB '82	
33	IV	WONORENGGO	S8° 8' 9"	E113° 0' 11"	+800	A	– DITTO –	– DITTO –	1982	22 JAN '82	
34	V	PRONOJIWO	S8° 12' 47"	E112° 56' 18"	+600	A	– DITTO –	– DITTO –	1979 – 1982	JAN '79	
35	VI	PROYEK SEMERU	S8° 7' 0"	E113° 12' 50"	+52	D	– DITTO –	MANUAL/AUTOMATIC		MAY '82.	
36	VII	KERTOSARI	S8° 8' 30"	E113° 5' 2"	+345	C	– DITTO –	AUTOMATIC	1980 – 1982	JAN '80	
37	VIII	BESUK SAT	S8° 6' 39"	E113° 1' 0"	+795	B	– DITTO –	– DITTO –	1978–79, 80–1982	DEC. '77	
38	IX	CURAH KOBOAN	S10° 0' 16"	E113° 0' 10"	+734	C	– DITTO –	– DITTO –	1978 – 1982	JAN. '78	

Table- 6.6.1 (3) Rainfall Observation Stations

NO	OBS. NO	STATION	LOCATION LATITUDE	LOCATION LONGITUDE	EL. (m)	RANK	BELONGING	TYPE OF EQUIP.	AVAILABLE DATA	INSTALLED DAY	REMARKS
39	X	CANDIPURO	S9°25'45"	E113°19'31"	322	A	PROYEK G SEMERU	AUTOMATIC	1980 – 1982	NOV '79	
40	XI	POS VULKANOLOGY ARGOSUKO	S8°11'0"	E112°53'0"	900		— DITTO —	— DITTO —		13 JUL '82	NEW
41	XII	POS PENDAKIAN RANUPANE	S8°0'0"	E112°56'0"	2300		— DITTO —	— DITTO —		14 JUL '82	NEW
42	XIII	SUPIT URANG	S8°13'11"	E112°58'6"	675		— DITTO —	— DITTO —	1980 – 1981	21 JUN '82	NEW
43	XIV	DESAKANDANGTEPUS	S8°5'25"	E113°4'33"	1000		— DITTO —	— DITTO —		27 JUN '82	NEW
44	XV	DESA BOPANG	S8°6'27"	E113°10'8"	875		— DITTO —	— DITTO —		28 JUN '82	NEW

d) Desa Kandangtepus (XIV)

This was installed in the middle-course of K. Bondoyudo for the investigation of that river.

e) Desa Bopang (XV)

This was installed in the downstream of K. Bondo-yudo for the investigation of that river.

(b) Inspection of Existing Rainfall Observation Stations

1) Summary

This inspection were carried out from the end of April '82 to the beginning of May '82 by visiting each existing observation stations.

This consideration shall give some help on picking out the data for analysis in the collection data.

The evaluation of all stations are shown as follows:

RANK	No. of Station
RANK A (Excellent)	4
RANK B (Good)	10
RANK C (Need for improvement)	19
RANK D (Data are unreliable)	6
T O T A L	39

2) Objective

In this feasibility study, Rainfall Data is indispensable and one of the basic data.

But, some stations sometimes give the doubtful rainfall data when making an analysis of those data.

The reason are shown as follows;

a) The phenomena of nature beyond mankind's reach occurs.

b) The place where the station is located in is not suitable for an observation station.

c) There is something wrong with the observation way or the observation equipment.

d) There occurs an easy mistake when making an analysis of data.

In this consideration, all existing observation stations are evaluated on item b) and c).

3) Inspection Items

The inspection items are as follows:

a) Suitability of the place for the observation station. (This inspection was done on a just local point of view.)

To put it concretely, it was inspected that the following items were contented or not.

- An area, has more than 100 square meters, and of which rainfall conditions are stable.

- A flood-free zone.

- An area has no fears of serving damage to gauge.

- A point of easy access and easy get a man for the observer around there.

4) Evaluation

The evaluation was done as follows;

- RANK A : Excellent
- RANK B : Good
- RANK C : Need for improvement
- RANK D : Bad, the data are unreliable

5) Location

Location and details of existing rainfall observation stations are shown in Table - 6.6.1 and Fig. - 6.6.1.

6) Description of stations

Description of stations is attached in Appendix - 7 .

7) Collection of rainfall data

The list of collected rainfall data are shown in Table - 6.6.2 and Table - 6.6.3.

Table- 6.6.2 The List of Collected Rainfall Data (Manual Type)

STATION	NO	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
KEDUNG SANGKU	89				○	○	○	○	○	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
ALASBESUKI	154					△11	△3	△3		△1	○	○	○	△7	△6	○	○	△2	○	○	○	○	○	○	○	○	△5								
GUCIALIT	157			○	○	○	○	○	○	○	△1	△1	○	○	○	○	○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
BESUKSAT	158a			△1	○	○	○	○	○	○	○	○	○	○	△8	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
SENDURO	159				○	○	○	○	△4	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
KERTOSARI	160			△1	○	○	○	○	○	○	○	○	○	○	△1	○	○	△1	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
PASRUJAMBE	161			△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△3	△1	○	○	○	△2	○	○	○	○	○	△4
SUMBER DUREN (BENDO)	162			△1	○	○	○	○	○	○	○	○	△1	△1	○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△1
CURAH KOBO'AN	164a			△8	○	○	○	○	○	○	○	○	○	○	○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
SUMBER SARI	165						△2	○	○	△1	○	○	○	○	○	△3	△4																		
SUPIT URANG (SUMBER BADANG)	166																						△4	○	○	○	○	○	○	○	○	○	○	○	△4
KOBON DERI (PERK)	166a					△8	○	△1	○	○	○	△4	△1	△3	△1	△7																			△6
SUMBER ROWO (PRONOJIWO)	167																										○	○	○	○	○	○	○	○	△4
TEMPUR SARI (RAWAAN)	167a				○	○	○	○	○	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
RANU KLAKAH	180				○	○	○	○	○	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
DAWUHAN LOR	183	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
LUMAJANG (LABRUK LOR)	185a			○	○	○	○	○	○	○	○	○	△1	○	△1	△1	△1	△2	△4	△1	△1	△1	△1	△9	○	△1	○	○	△1	○	○	○	○		△4
KEDUNG WRINGIN	186				○	○	○	○	○	○	○	○			○	△1		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
CANDIPURO	188a			○	○	○	○	○	○	○	○	○	○	○	○	△1	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
GUNUNG SAWUR	188b				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
PASIRIAN	189				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
TEMPEH TENGAH	190				○	○	○	○	○	○	○	○	○	○	○	○	○			○	○	○	○	○	○		○	○	○	○	○	○			
BESUK	190a																														○	○	○	○	△4
BEDOG (TEMPEH LOR)	190b																																○	○	△4
SUKOSARI (TEMPEH KIDUL)	192a						○	○	○	○	○	○	○	○	○	△1	△1	△1	○	○	○	△3	△4								○	○	○	○	△4
WONOKERTO					○	○	○	○	○	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
TEKUNG	223				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
BLUKON	224			○	○	○	○	○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
MELEMAN	226			○	○	○	○	○	△1	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
SEMEMU																														△6	○	○	○	○	△1
MUNGGIR						○	○	○	○	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4
PAGOWAN																						○	○	○	○	○	○	○	○	○	○	○	○	○	△4
UMBUL																									○	○	○	○	○	○	○	○	○	○	△4
SUKODONO																													△6	○	○	○	○	○	△1
JOKARTO																													○	○	○	○	○	○	△4
NOGOSARI					○	○	○	○	○	○	○	○			○	△1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△4

LEGEND;

○ : Available for the whole year

△ : Not available for the whole year (the figure means the number of unobserved months)

TABLE – 6.6.3 THE LIST OF COLLECTED RAINFALL DATA (AUTOMATIC TYPE)

STATION	OBS NO	1978 J	F	M	A	M	J	J	A	S	O	N	D	1979 J	F	M	A	M	J	J	A	S	O	N	D
GUNUNG LEKER	I																								
GUNUNG PAKIS	II																								
KAMAR A	III																								
WONORENGGO	IV																								
PRONOJIWO	V															O	O	O		O	O		O	O	
PROYEK G. SEMERU	VI																								
KERTOSARI -	VII																								
BESUK SAT	VIII	O	O	O	O	O	O	O	O	O	O	O	O	O		O		O	O	O	O		O		
CURAH KOBO'AN	IX	O	O	O	O	O	O	O	O	O	O	O	O		O		O	O		O	O		O	O	O
CANDIPURO	X																							O	
POS VULKANOLOGY ARGOSUKO	XI																								
POS PENDAKIAN RANUPANE	XII																								
SUPIT URANG	XIII																								O
DESA KANDANGTEPUS	XIV																								
DESA BOPANG	XV																								

STATION	OBS NO	1980 J	F	M	A	M	J	J	A	S	O	N	D	1981 J	F	M	A	M	J	J	A	S	O	N	D
GUNUNG LEKER	I																								
GUNUNG PAKIS	II																								
KAMAR A	III																								
WONORENGGO	IV																								
PRONOJIWO	V		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
PROYEK G. SEMERU	VI																								
KERTOSARI -	VII	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
BESUK SAT	VIII													O	O	O	O	O	O	O	O		O	O	O
CURAH KOBO'AN	IX			O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
CANDIPURO	X	O	O		O	O	O		O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O
POS VULKANOLOGY ARGOSUKO	XI																								
POS PENDAKIAN RANUPANE	XII																								
SUPIT URANG	XIII	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
DESA KANDANGTEPUS	XIV																								
DESA BOPANG	XV																								

STATION	OBS NO	1982 J	F	M	A	M	J	J	A	S	O	N	D
GUNUNG LEKER	I		O	O			O	O					
GUNUNG PAKIS	II		O	O	O	O	O	O					
KAMAR A	III		O	O	O	O	O	O					
WONORENGGO	IV		O	O	O	O	O	O					
PRONOJIWO	V	O	O	O	O	O	O	O					
PROYEK G. SEMERU	VI												
KERTOSARI -	VII	O	O	O	O	O	O	O					
BESUK SAT	VIII	O	O	O	O	O	O	O					
CURAH KOBO'AN	IX	O	O	O	O	O	O	O					
CANDIPURO	X	O	O	O	O	O	O	O					
POS VULKANOLOGY ARGOSUKO	XI							O					
POS PENDAKIAN RANUPANE	XII												
SUPIT URANG	XIII							O					
DESA KANDANGTEPUS	XIV							O					
DESA BOPANG	XV							O					

LEGEND:

O : AVAILABLE

(2) Runoff Observation

H. KANAMURA

Actually, no runoff record exist at all.
So, the data taken from this observation shall have a big influence on this study.

- High Water Observation
- Low Water Observation

(a) High Water Observation

This observation will start this rainy season for two years. The flood in the study area seem to occur in the evening. Therefore, among the suitable points for analysis, the following matters were taken into consideration in the selection of the high water observation stations.

- Choose a point of easy access
- Choose a point of safe measurement
- Choose a point of easy getting an observer

As a result, for the high water observation stations, 2 stations in K. Mujur, 1 station in K. Rejali and 1 station in K. Lengkong come out.

Location of them are shown in Table - 6.6.4 and Fig. - 6.6.2.

Details of the observation method are still planning. But, basically, the staff gauge will be installed in each high water observation station.

When floods occur, the water level of those floods will be recorded by reading the scale on the staff gauge at intervals of a few hours.

Under the good conditions, the flow measurement will be carried out by using the Radio-type Current Meter and the surface float.

In the case of the above equipments cannot be used for the flow measurement, the discharge will be estimated by measuring the trace of the maximum stage of those floods.

Table - 6.6.4 High Water Observation Stations

STATION	LOCATION	CATCHMENT AREA (Km2)	REMARKS
HSM 1 (KLOPOSAWIT BRIDGE)	+ 19,929 Km (K. Besuk Tunggeng)	82.56	
HSM 2 (MUJUR BRIDGE)	+ 8,653 Km (K. MUJUR)	126.22	
HSR 1 (CHECK DAM LEPRAK NO.1)	+ 20,337 Km (K. LEPRAK)	26.32	
HSL 1 (PRONOJIWO DAM SITE)	+ 19.300 Km (K. LENGKONG)	54.77	

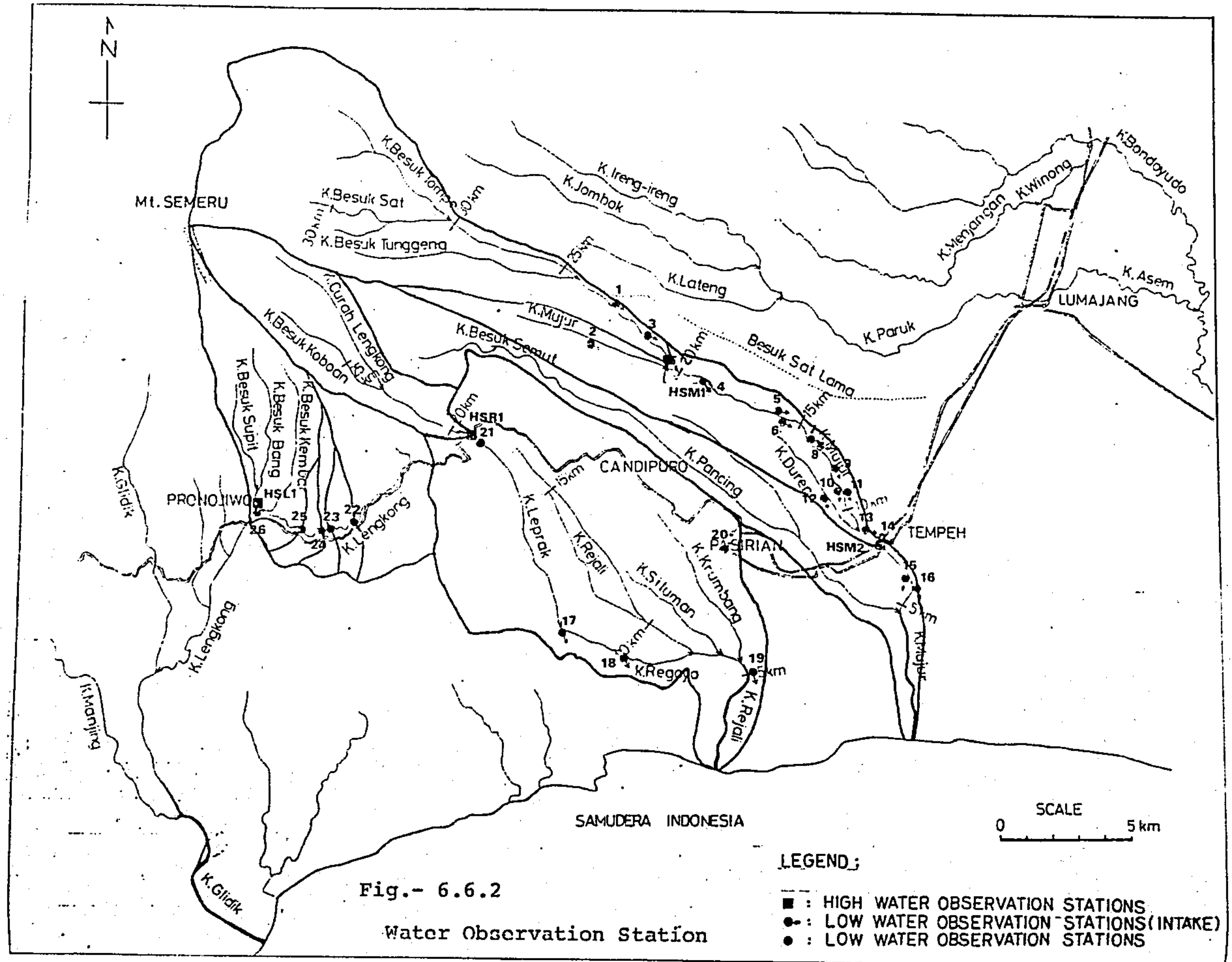


Fig.- 6.6.2

Water Observation Station

(b) Low Water Observation

1) Summary

Low water observation is carried on the up-stream and down-stream of the water intake points, in the water intake channels and the planned points for the main sabo dams to provide the basis for long-term runoff analysis and economic effect estimation. The observation has been done since April '82, and carried out every month.
It will last up to June '84.

The observation data up to Aug. '82 are shown in Table - 6.6.7.

2) Objectives

This observation is to obtain the discharge at the up-stream and down-stream of the water intake points, in the water intake channels and the planned points for the main sabo dams to provide the basis for long-term runoff analysis and economic effect estimation.

3) Location

The location of observation stations are shwon in Fig. - 6.6.2.

4) Observation Schedule

- Period: April '82 - June '84
- Times : Once per month
- Days : 5 days in the middle of month

5) Observation stations

Table - 6.6.5 shows the water intake and Table - 6.6.6 shows the other observation stations including the planned main sabo dams points.

Table-6.6.5 The list of intakes along K. Mujur and K. Rejali

NO.	INTAKES	LOCATION	TYPE	BELONGING	COVERED AREA (ha)
1.	ROWOGEDANG	+ 23.10 Km (K. Besuk Tunggeng)	SEMI-TECH.	IRRIGATION OFFICE	573
2.	DAM JURANGGEGER	(K. Mujur)	NON-TECH,	KANTOR DESA KLOPOSAWIT	45
3.	DAM PANCUT	+ 20.55 Km (K. Besuk Tunggeng)	- ditto -	- ditto -	85
4.	DAM KARAN COLIK	+ 19.17 Km (K. Mujur)	- ditto -	- ditto -	65
5.	LOBANG I	+ 16.77 Km (K. Mujur)	TECHNICAL	IRRIGATION OFFICE	899
6.	LOBANG II	+ 16.29 Km (K. Mujur)	- ditto -	- ditto -	201
7.	KLEREK I	+ 14.52 Km (K. Mujur)	- ditto -	- ditto -	412
8.	KLEREK II	+ 14.40 Km (K. Mujur)	NON-TECH		
9.	KEDUNG CARING	+ 12.43 Km (K. Mujur)	TECHNICAL	IRRIGATION OFFICE	317
10.	JUWENI	+ 10.65 Km (K. Mujur)	NON-TECH.	KANTOR DESA JATISARI	17
11.	SAPARI	+ 10.57 Km (K. Mujur)	- ditto -	- ditto -	40
12.	CARIK	+ 9.70 Km (K. Duren)	- ditto -	KANTOR DESA LEMPENI	200
13.	SOPONYONO	+ 9.00 Km (K. Mujur)	SEMI-TECH.	IRRIGATION OFFICE	66
14.	PONCO	+ 8.73 Km (K. Mujur)	NON-TECH.	KANTOR DESA LEMPENI	15
15.	DAWUHAN KERTI	+ 6.435 Km (K. Mujur)	- ditto -	- ditto -	30
16.	PANDANWANGI	+ 5.88 Km (K. Mujur)	TECHNICAL	IRRIGATION OFFICE	1,070
17.	RAHAYU	+ 11.50 Km (K. Regoyo)	SEMI-TECH.	IRRIGATION OFFICE	
18.	DAWUHAN MARSO	+ 9.20 Km (K. Regoyo)	NON-TECH.	KANTOR DESA GONDORUSO	30
19.	DAM REJALI	+ 3.50 Km (K. Rejali)	TECHNICAL	IRRIGATION OFFICE	455
20.	TALANG	Spring Water	- ditto -	- ditto -	294

Note; The location shows the distance from the river mouth.

Table - 6.6.6 The list of other water observation points

NO.	POINT	LOCATION	CATCHMENT AREA (Km^2)	REMARKS
21.	K. Leprak	+ 20.20 Km (K. Leprak)	26.35	K. Leprak Check Dam No.1
22.	K. Lengkong No.1	+ 23.40 Km (K. Lengkong)	20.39	
23.	K. Lengkong No.2	+ 22.28 Km (K. Lengkong)	23.83	Mouth of the pond
24.	K. Lengkong No.3	+ 22.05 Km (K. Lengkong)	26.99	Exit of the pond
25.	K. Lengkong No.4	+ 21.15 Km (K. Lengkong)	29.53	Planned NANAS DAM SITE
26.	K. Lengkong No.5	+ 19.30 Km (K. Lengkong)	54.77	Planned PRONOJIWO DAM SITE

6) Method

This observation is carried out at the up-stream and down-stream of the water intake points, and also at the water intake channels, at planned main sabo dam points.

The price type current meter is used in this observation. Specifications of this observation are as follows:

a) Establish one reference section every time (done in cross-section survey)

b) Interval between the vertical measuring-lines is 10% of the river width

c) Measuring point per a line is two; at 20% and 80% of water depth on a line. In case water depth is less than 50 cm, measuring point is one at 60% of water depth.

d) Measuring is made twice for each point. The velocity of that point is indicated by arithmetically calculated average value. Date and time of measurement is recorded.

e) Average velocity at one measuring line is indicated: in a case of two measuring points, by arithmetically calculated average value, in case of one point, by its measured value.

f) Cross-section area one measuring line dominates extends up to the centering line between the neighbouring lines and the line in question

g) Total discharge is a sum of individual discharge which is obtained by multiplying average velocity at a line by its area.

7) Discharge data

The discharge data from April '82 to August '82 are shown in Table - 6.6.7.

As the transfer of knowledge to the Counterpart is almost finished, that table will be filled with the data continuously.

8) Collection of data

The list of collected water level data in K. BONDOYUDO are shown in Table - 6.6.8.
Fig. - 6.6.3 shows the location of the observation stations.

The list of collected climatological data are shown in Table - 6.6.9.
Fig. - 6.6.4 shows the location of those observation stations.

Table 6.6.7 ⓐ observed Discharge 1981 / 1982

( ) : Estimation unit : m^3/s

NO.	STATION	DATE	TIME	M.STREAM (UP)	M.STREAM (DOWN)	INTAKE	REMARKS
1	ROWOGEDANG	20/APR	9:20 - 9:50	2.16	1.67	0.34	
2	DAM JURANGGEGER	-	-	-	-	-	
3	DAM PANCUT	-	-	-	-	-	
4	DAM KARAN COLIK	-	-	-	-	-	
5	LOBANG I	20/APR	10:48 -11:33	3.13	3.37	0.56	
6	LOBANG II	20/APR	12:06 -12:11	2.48	-	0	
7	KLEREK I	20/APR	13:57 -14:13	2.68	-	0.28	
8	KLEREK II	-	-	-	-	-	
9	KEDUNG CARING	21/APR	8:48 - 9:35	2.12	1.57	0.47	
10	JUWENI	-	-	-	-	-	
11	SAPARI	-	-	-	-	-	
12	CARIK	-	-	-	-	-	
13	SOPONYONO	21/APR	10:31 -11:15	1.69	0.73	0.93	
14	PONCO	-	-	-	-	-	
15	DAWUHAN KERTI	21/APR	12:40 -13:10	2.06	2.11	0.20	
16	PANDAN WANGI	21/APR	13:25 -13:53	2.11	0.23	1.60	
17	RAHAYU	22/APR	11:04 -11:37	1.05	0.44	0.50	
18	DAWUHAN MARSO	-	-	-	-	-	
19	DAM REJALI	22/APR	8:53 - 9:58	4.00	2.94	1.01	
20	TALANG	22/APR	13:00 -13:08			0.46	SPRING WATER
21	K.LEPRAK	-	-	-			K.LEPRAK CHECK DAM NO.1
22	K.LENGKONG NO.1	-	-	-			NEAR THE BRIDGE
23	K.LENGKONG NO.2	-	-	-			MOUTH OF THE POND
24	K.LENGKONG NO.3	-	-	-			EXIT OF THE POND
25	K.LENGKONG NO.4	-	-	-			PLANNED NANAS DAM SITE
26	K.LENGKONG NO.5	-	-	-			PLANNED PRONOJIWO DAM SITE

Table- 6.6.7. ⓑ observed Discharge 1981 / 1982

( ) : Estimation unit : m^3/s

NO.	STATION	DATE	TIME	M.STREAM (UP)	M.STREAM (DOWN)	INTAKE	REMARKS
1	BOWOGEDANG	17/MAY	9:40 -10:12	1.41	0.50	1.03	
2	DAM JURANGGEGER	-	-	-	-	-	
3	DAM PANCUT	-	-	-	-	-	
4	DAM KARAN COLIK	-	-	-	-	-	
5	LOBANG I	17/MAY	11:45 -11:58	0.67	0.05	0.70	
6	LOBANG II	17/MAY	11:04 -11:38	1.05	0.67	0.24	
7	KLEREK I	17/MAY	12:30 -12:48	0.38	-	0.32	
8	KLEREK II	-	-	-	-	-	
9	KEDUNG CAPING	18/MAY	8:40 - 9:08	0.48	0.10	0.38	
10	JUWENI	-	-	-	-	-	
11	SAPARI	-	-	-	-	-	
12	CARIK	-	-	-	-	-	
13	SOBONYONO	18/MAY	9:52 -11:03	1.18	0.64	0.68	
14	PONCO	-	-	-	-	-	
15	DAWUHAN KERTI	18/MAY	11:53 -12:17	0.71	0.46	0.15	
16	PANDAN WANGI	18/MAY	12:26 -12:41	0.46	0.33	0.32	
17	RAHAYU	19/MAY	11:26 -11:57	0.67	0.17	0.52	
18	DAWUHAN MARSO	-	-	-	-	-	
19	DAM REJALI	19/MAY	9:17 -10:15	3.81	1.63	0.77	
20	TALANG	18/MAY	13:16 -13:19			0.45	SPRING WATER
21	K.LEPRAK	-	-	-			K.LEPRAK CHECK DAM NO.1
22	K.LENGKONG NO.1	-	-	-			NEAR THE BRIDGE
23	K.LENGKONG NO.2	-	-	-			MOUTH OF THE POND
24	K.LENGKONG NO.3	-	-	-			EXIT OF THE POND
25	K.LENGKONG NO.4	-	-	-			PLANNED NANAS DAM SITE
26	K.LENGKONG NO.5	-	-	-			PLANNED PRONOJIWO DAM SITE

Table- 6.6.7. © observed Discharge 1981 / 1982

( ) : Estimation unit : m^3/s

NO.	STATION	DATE	TIME	M.STREAM (UP)	M.STREAM (DOWN)	INTAKE	REMARKS
1	ROWOGEDANG	15/JUN	9:48 -10:15	0.85	0.29	0.74	
2	DAM JURANGGEGER	15/JUN	10:43 -11:09	0.18	0.06	0.10	
3	DAM PANCUT	15/JUN	12:22 -12:39	0.24	0.18	0.13	
4	DAM KARAN COLIK	15/JUN	11:25 -11:45	0.31	0.12	0.15	
5	LOBANG I	15/JUN	13:57 -14:13	0.59	0.05	0.48	
6	LOBANG II	15/JUN	13:37 -13:50	0.79	0.59	0.24	
7	KLEREK I	16/JUN	9:55 -10:13	0.42	-	0.18	
8	KLEREK II	16/JUN	10:25 -10:43	0.52	0.10	0.39	
9	KEDUNG CARING	16/JUN	13:04 -13:24	0.32	0.16	0.24	
10	JUWENI	16/JUN	9:17 - 9:37	0.47	0.40	0.07	
11	SAPARI	17/JUN	9:38 - 9:56	0.40	0.42	0.02	
12	CARIK	17/JUN	10:39 -11:08	0.60	0.48	0.07	
13	SOPONYONO	17/JUN	12:12 -13:00	[0.64] 0.56	0.79	0.50	[ ] : K. DUREN.
14	PONCO	17/JUN	13:17 -13:28	0.79	0.89	0.18	
15	DAWUHAN KERTI	17/JUN	13:42 -14:03	1.20	0.96	0.10	
16	PANDAN WANGI	17/JUN	14:07 -14:33	0.96	0.55	0.52	
17	RAHAYU	18/JUN	11:23 -11:53	0.57	0.14	0.42	
18	DAWUHAN MARSO	18/JUN	12:11 -12:36	0.95	0.87	0.07	
19	DAM REJALI	18/JUN	8:27 - 9:50	1.91	0.69	0.99	
20	TALANG	18/JUN	13:12 -13:16			0.43	SPRING WATER
21	K.LEPRAK	-	-	-			K.LEPRAK CHECK DAM NO.1
22	K.LENGKONG NO.1	-	-	-			NEAR THE BRIDGE
23	K.LENGKONG NO.2	-	-	-			MOUTH OF THE POND
24	K.LENGKONG NO.3	-	-	-			EXIT OF THE POND
25	K.LENGKONG NO.4	-	-	-			PLANNED NANAS DAM SITE
26	K.LENGKONG NO.5	-	-	-			PLANNED PRONOJIWO DAM SITE

Table- 6.6.7. ⓓ observed Discharge 1981 / 1982

( ) : Estimation unit : m^3/s

NO.	STATION	DATE	TIME	M.STREAM (UP)	M.STREAM (DOWN)	INTAKE	REMARKS
1	ROWOGEDANG	13/JUL	8:50 - 9:30	0.88	0.49	0.62	
2	DAM JURANGGEGER	13/JUL	10:02 -10:30	0.22	0.06	0.12	
3	DAM PANCUT	13/JUL	12:19 -12:36	0.30	(0.14)	0.16	
4	DAM KARAN COLIK	13/JUL	10:47 -11:25	0.73	0.16	0.19	
5	LOBANG I	13/JUL	13:54 -14:23	[0.03] 0.38	0.04	0.40	▭ : inflow from the rice field
6	LOBANG II	13/JUL	13:25 -13:48	0.56	0.38	0.32	
7	KLEREK I	14/JUL	9:22 - 9:37	-	-	0.11	
8	KLEREK II	14/JUL	9:43 -10:05	0.47	0.03	0.43	
9	KEDUNG CARING	14/JUL	10:32 -11:02	0.31	0.19	0.18	
10	JUWENI	14/JUL	11:45 -12:08	0.32	(0.27)	0.05	
11	SAPARI	14/JUL	12:15 -12:27	0.33	0.31	0.02	
12	CARIK	14/JUL	13:22 -14:05	0.60	0.61	0.15	
13	SOPONYONO	15/JUL	9:04 - 9:59	[0.20] 0.63	0.63	0.36	▭ : K. DUREN.
14	PONCO	15/JUL	10:07 -10:40	0.70	0.55	0.14	
15	DAWUHAN KERTI	15/JUL	11:00 -11:18	0.74	(0.61)	0.13	
16	PANDAN WANGI	15/JUL	11:32 -11:43	(0.83)	0.46	0.37	
17	RAHAYU	17/JUL	11:14 -11:44	0.55	0.08	0.40	
18	DAWUHAN MARSO	17/JUL	12:03 -12:50	0.68	(0.61)	0.07	
19	DAM REJALI	17/JUL	9:11 -10:16	1.65	0.93	0.74	
20	TALANG	15/JUL	12:13 -12:18			0.35	SPRING WATER
21	K.LEPRAK	16/JUL	9:07 - 9:14	0.37			K.LEPRAK CHECK DAM NO.1
22	K.LENGKONG NO.1	16/JUL	9:55 -10:03	0.42			NEAR THE BRIDGE
23	K.LENGKONG NO.2	16/JUL	10:20 -10:27	0.48			MOUTH OF THE POND
24	K.LENGKONG NO.3	16/JUL	10:41 -10:49	0.46			EXIT OF THE POND
25	K.LENGKONG NO.4	16/JUL	11:07 -11:17	0.45			PLANNED NANAS DAM SITE
26	K.LENGKONG NO.5	16/JUL	11:37 -12:00	1.47			PLANNED PRONOJIWO DAM SITE

Table- 6.6.7. ⓔ observed Discharge 1981 / 1982

( ) : Estimation unit : m^3/s

NO.	STATION	DATE	TIME	M.STREAM (UP)	M.STREAM (DOWN)	INTAKE	REMARKS
1	ROWOGEDANG	21/AUG	8:44 - 9:35	0.65	0.30	0.34	
2	DAM JURANGGEGER	21/AUG	10:05 - 10:48	0.17	0.03	0.19	
3	DAM PANCUT	21/AUG	12:30 - 13:16	0.32	0.14	0.21	
4	DAM KARAN COLIK	21/AUG	10:20 - 11:57	0.52	0.10	0.19	
5	LOBANG I	23/AUG	8:58 - 9:45	[0.38] 0.02	0.28	0.33	[ ] : inflow from the rice field
6	LOBANG II	21/AUG	14:13 - 14:32	0.16	0.03	0.13	
7	KLEREK I	23/AUG	10:14 - 10:40	0.51	-	0.23	
8	KLEREK II	23/AUG	10:45 - 11:12	0.35	0.07	0.39	
9	KEDUNG CARING	23/AUG	11:39 - 12:15	0.19	0.08	0.15	
10	JUWENI	23/AUG	12:59 - 13:20	0.24	(0.14)	0.10	
11	SAFARI	23/AUG	13:24 - 13:39	(0.23)	0.14	0.09	
12	CARIK	24/AUG	9:03 - 9:59	0.53	0.46	0.15	
13	SOPONYONO	24/AUG	10:27 - 11:06	[0.46] 0.45	0.47	0.57	[ ] : K. DUREN
14	PONCO	24/AUG	11:13 - 11:25	0.47	0.35	0.11	
15	DAWUHAN KERTI	24/AUG	11:56 - 12:14	0.62	(0.48)	0.14	
16	PANDAN WANGI	24/AUG	12:16 - 12:36	(0.73)	0.44	0.29	
17	RAHAYU	26/AUG	11:46 - 12:16	0.42	0.04	0.33	
18	DAWUHAN MARSO	26/AUG	12:34 - 13:11	0.73	0.64	0.19	
19	DAM REJALI	26/AUG	9:30 - 10:49	1:34	0.62	0.67	
20	TALANG	24/AUG	13:10 - 13:16			0.57	SPRING WATER
21	K.LEPRAK	25/AUG	10:00 - 10:09	0.36			K.LEPRAK CHECK DAM NO.1
22	K.LENGKONG NO.1	25/AUG	12:50 - 13:00	0.30			NEAR THE BRIDGE
23	K.LENGKONG NO.2	25/AUG	10:45 - 10:55	0.47			MOUTH OF THE POND
24	K.LENGKONG NO.3	25/AUG	11:05 - 11:15	0.39			EXIT OF THE POND
25	K.LENGKONG NO.4	25/AUG	11:30 - 11:42	0.39			PLANNED NANAS DAM SITE
26	K.LENGKONG NO.5	25/AUG	12:02 - 12:25	1.23			PLANNED PRONOJIWO DAM SITE

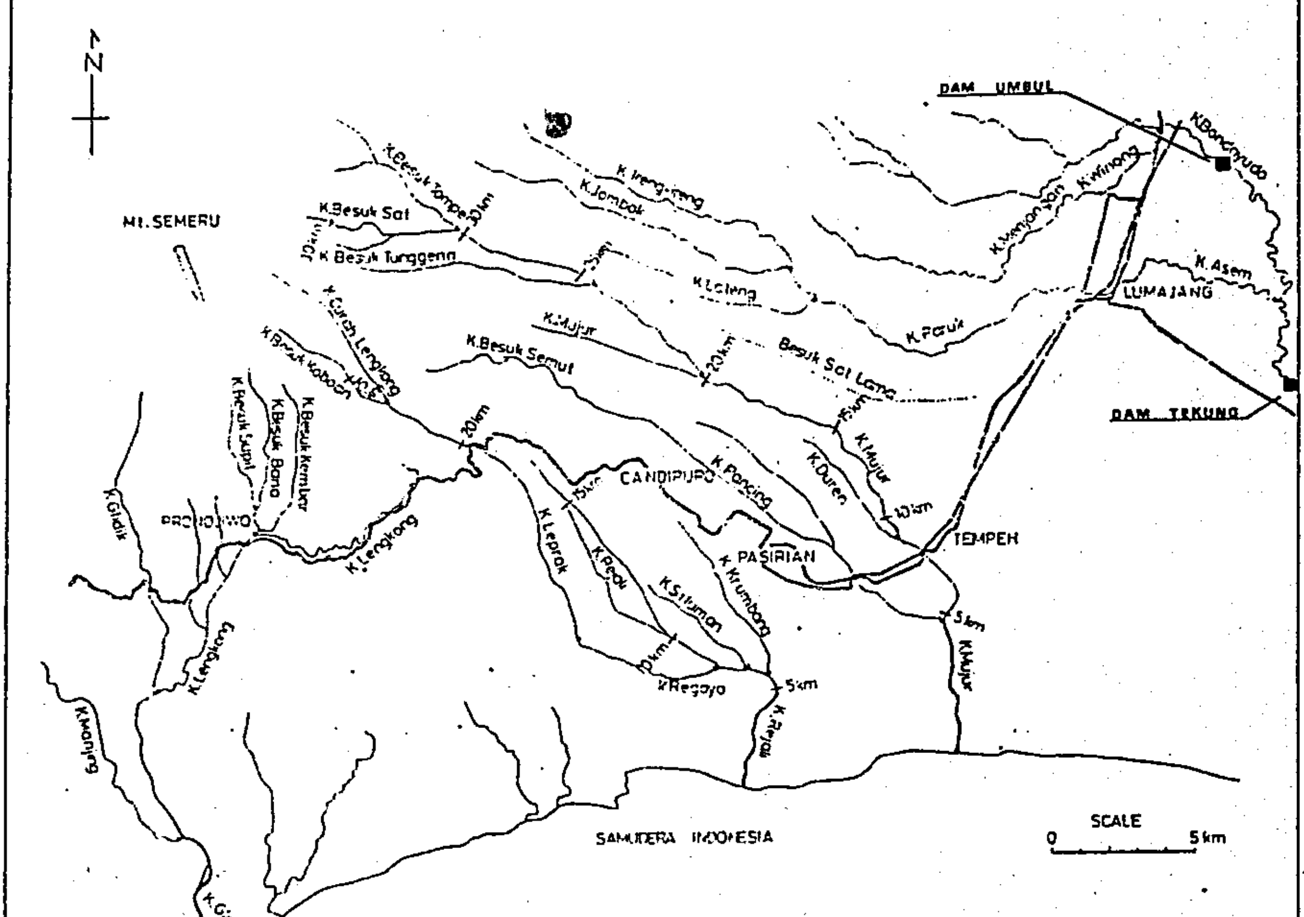


Fig.-6.6.3 THE LOCATION OF WATER OBSERVATION STATIONS IN K.BONDOYUDO

Table-6.6.8 The list of collected Water Level Data in K. BONDOYUDO

STATION	CATCHMENT AREA	76	77	78	79	80	81
DAM UMBUL	412.75 km^2		△	△	△	○	○
DAM TEKUNG	677.50 km^2	△	△	△	△	△	△

LEGEND;

○ : Available for the whole year
△ : Not available for the whole year

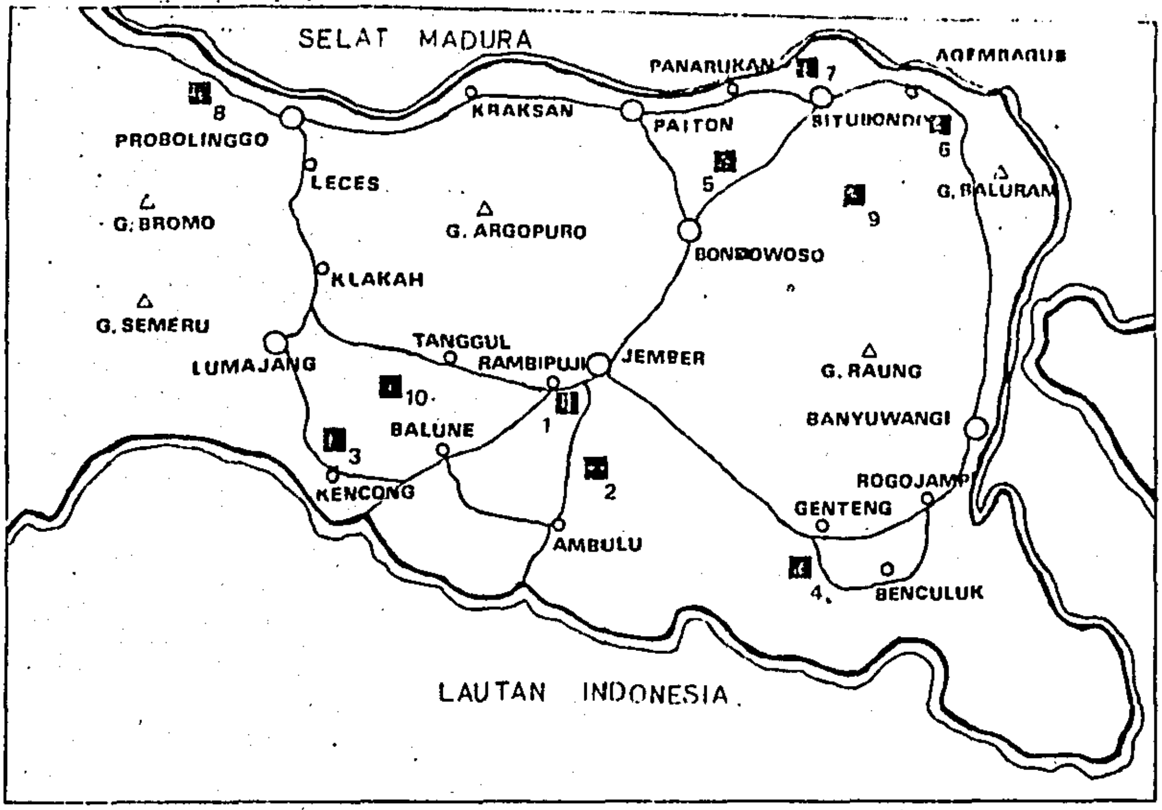


Fig.-6.6.4 The location of the climatological observation stations

Table - 6.6.9 (a) The location & period of climatological data (Temperature)

NO	STATION	LOCATION		EL (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11'	E 113° 36'	35.85		△	△	○	○
2	JENGGAWAH/K.LOMP	S 8° 13'	E 113° 40'	63.90	△	△	△	△	○
3	GUBUNG DOMAS HILIR	S 8° 14'	E 113° 26'	11.80	△	△	△	○	○
4	DAM SANPEAN BARU	S 7° 47'	E 113° 57'	125.00	△	△	△	△	○
5	LP3. GENTENG	S 8° 21'	E 114° 13'	168.00	△	△	△	○	○
6	LPT I. ASEMBAGUS	S 7° 39'	E 114° 12'	5.50		△	△	○	○
7	PG. WRINGIN ANOM	S 7° 47'	E 113° 44'	14.00		△	△	○	△
8	PG. WONOLANGAN	S 7° 14'	E 113° 12'	20.00		△	△	△	○
9	JATISARI	S 7° 45'	E 114° 06'	[illegible]		△	△	○	○
10	PG. SEMBORO	S 8° 17'	E 113° 37'	29.00				△	○

LEGEND;

○: Available for the whole year

△: Not available for the whole year

Table - 6.6.9 (b) The location & period of climatological data (Solar Radiation)

NO	STATION	LOCATION		EL (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11'	F 113° 36'	35.85		△	△		
2	JENGGAWAH/K.LOMP	S 8° 13'	E 113° 40'	63.90	△	△	△		
3	GUBUNG DOMAS HILIR	S 8° 14'	E 113° 26'	11.80	△	△	△		
4	DAM SANPEAN BARU	S 7° 47'	E 113° 57'	125.00	△	△	△		
5	LP3. GENTENG	S 8° 21'	E 114° 13'	168.00	△	△	△		
6	LPT I. ASEMBAGUS	S 7° 39'	E 114° 12'	5.50		△	△		
7	PG.WRINGIN ANOM	S 7° 47'	E 113° 44'	13.00		△	△		
8	PG.WONOLANGAN	S 7° 14'	E 113° 12'	20.00		△	△		
9	JATISARI	S 7° 45'	E 114° 06'	119.00		△	△		
10	PG.SEMBORO	S 8° 17'	E 113° 37'	29.00					

LEGEND;
○ : Available for the whole year
△ : Not available for the whole year

Table - 6.6.9 (c) The location & period of climatological data (Wind Speed)

NO	STATION	LOCATION		EL (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11'	E 113° 36'	35.85		△	△	△	○
2	JENGGAWAH/K.LOMP	S 8° 13'	E 113° 40'	63.90	△	△	△	△	△
3	GUBUNG DOMAS HILIR	S 8° 14'	E 113° 26'	11.80	△	△	△	○	○
4	DAM SANPEAN BARU	S 7° 47'	E 113° 57'	125.00	△	△	△	△	○
5	LP3. GENTENG	S 8° 21'	E 114° 13'	168.00	△	△	△	○	○
6	LPT I. ASEMBAGUS	S 7° 39'	E 114° 12'	5.50		△	△	○	○
7	PG.WRINGIN ANOM	S 7° 47'	E 113° 44'	13.00		△	△	○	△
8	PG.WONOLANGAN	S 7° 14'	E 113° 12'	20.00		△	△	△	△
9	JATISARI	S 7° 45'	E 114° 06'	119.00		△	△	△	
10	PG.SEMBORO	S 8° 17'	E 113° 37'	29.00				○	○

LEGEND ;
○ : Available for the whole year
△ : Not available for the whole year

Table - 6.6.9 (d) The location & period of climatological data (Relative Humidity)

NO	STATION	LOCATION		EL. (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11′	E 113° 36′	35.85		△	△	○	○
2	JENGGAWAH/K.LOMP	S 8° 13′	E 113° 40′	63.90	△	△	△	△	○
3	GUBUNG DOMAS HILIR	S 8° 14′	E 113° 26′	11.80	△	△	△	○	○
4	DAM SANPEAN BARU	S 7° 47′	E 113° 57′	125.00	△	△	△	△	○
5	LP3. GENTENG	S 8° 21′	E 114° 13′	168.00	△	△	△	○	○
6	LPT I. ASEMBAGUS	S 7° 39′	E 114° 12′	5.50		△	△	○	○
7	PG.WRINGIN ANOM	S 7° 47′	E 113° 44′	13.00		△	△	○	△
8	PG.WONOLANGAN	S 7° 14′	E 113° 12′	20.00		△	△	△	○
9	JATISARI	S 7° 45′	E 114° 06′	119.00		△	△	○	○
10	PG.SEMBORO	S 8° 17′	E 113° 37′	29.00				△	○

LEGEND ;
○ : Available for the whole year
△ : Not available for the whole year

Table - 6.6.9 (e) The location & period of climatological data (Evaporation)

NO	STATION	LOCATION		EL. (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11′	E 113° 36′	35.85		△	△	○	○
2	JENGGAWAH/K.LOMP	S 8° 13′	E 113° 40′	63.90	△	△	△	△	○
3	GUBUNG DOMAS HILIR	S 8° 14′	E 113° 26′	11.80	△	△	△	○	○
4	DAM SANPEAN BARU	S 7° 47′	E 113° 57′	125.00	△	△	△	△	○
5	LP3. GENTENG	S 8° 21′	E 114° 13′	168.00	△	△	△	○	○
6	LPT I. ASEMBAGUS	S 7° 39′	E 114° 12′	5.50		△	△	○	○
7	PG.WRINGIN ANOM	S 7° 47′	E 113° 44′	13.00		△	△	○	△
8	PG.WONOLANGAN	S 7° 14′	E 113° 12′	20.00		△	△	○	○
9	JATISARI	S 7° 45′	E 114° 06′	119.00		△	△	○	○
10	PG.SEMBORO	S 8° 17′	E 113° 37′	29.00				○	○

LEGEND ;
○ : Available for the whole year
△ : Not available for the whole year

Table - 6.6.9 ⓕ The location & period of climatological data (Rainfall)

NO	STATION	LOCATION		EL (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11′	E 113° 36′	35.85		△	△	○	○
2	JENGGAWAH/K.LOMP	S 8° 13′	E 113° 40′	63.90	△	△	△	△	○
3	GUBUNG DOMAS HILIR	S 8° 14′	E 113° 26′	11.80	△	△	△	○	○
4	DAM SANPEAN BARU	S 7° 47′	E 113° 57′	125.00	△	△	△	○	○
5	LP3. GENTENG	S 8° 21′	E 114° 13′	168.00	△	△	△	○	○
6	LPT I. ASEMBAGUS	S 7° 39′	E 114° 12′	5.50		△	△	○	○
7	PG.WRINGIN ANOM	S 7° 47′	E 113° 44′	13.00		△	△	○	○
8	PG.WONOLANGAN	S 7° 14′	E 113° 12′	20.00		△	△	○	○
9	JATISARI	S 7° 45′	E 114° 06′	119.00		△	△	○	○
10	PG.SEMBORO	S 8° 17′	E 113° 37′	29.00				○	○

LEGEND;
○: Available for the whole year
△: Not available for the whole year

Table - 6.6.9 ⓖ The location & period of climatological data (Sunshine Hours)

NO	STATION	LOCATION		EL (m)	77	78	79	80	81
		LATITUDE	LONGITUDE						
1	JUBUNG	S 8° 11′	E 113° 36′	35.85				○	○
2	JENGGAWAH/K.LOMP	S 8° 13′	E 113° 40′	63.90				○	○
3	GUBUNG DOMAS HILIR	S 8° 14′	E 113° 26′	11.80				△	○
4	DAM SANPEAN BARU	S 7° 47′	E 113° 57′	125.00				△	○
5	LP3. GENTENG	S 8° 21′	E 114° 13′	168.00				○	○
6	LPT I. ASEMBAGUS	S 7° 39′	E 114° 12′	5.50				○	○
7	PG.WRINGIN ANOM	S 7° 47′	E 113° 44′	13.00				○	△
8	PG.WONOLANGAN	S 7° 14′	E 113° 12′	20.00				○	○
9	JATISARI	S 7° 45′	E 114° 06′	119.00				△	
10	PG.SEMBORO	S 8° 17′	E 113° 37′	29.00				○	○

LEGEND;
○: Available for the whole year
△: Not available for the whole year

(3) Ground Water Observation

Y. UEMURA

Based on the request of the Government of Indonesia, JICA provided 11 automatic recording water level gauges in December 1981 and 6 same gauges in March 1982.

Under the technical guidance given by Mr. Sakai in February 1982, the Mt. Semeru Project Office installed these equipments.

The location of piezometric observation wells is as shwon in Fig. - 6.6.5.

(i) Well Inventory

According to the hydrogeological survey plan submitted on 9 Aug. 1982, the inspection of piezometric observation was carried out and these results in first step is compiled in Appendix - 8 .

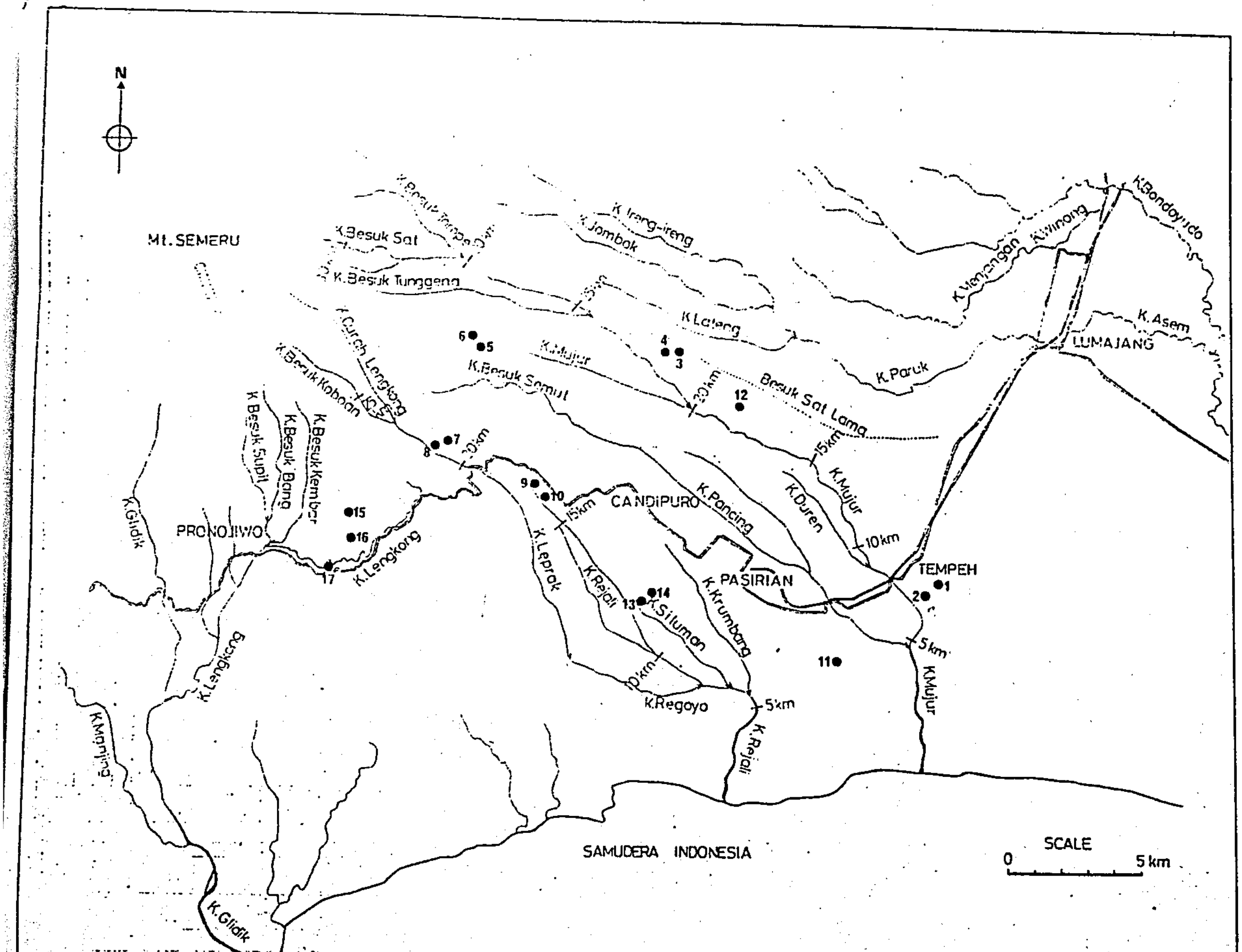
(ii) Piezometric Observation

Piezometric observation is fully executed by Mt. Semeru Project Office and the frequency to change the recording sheet is once a week.

Observation period up to August at each well is as indicated in Table - 6.6.10.

(iii) Installation of Equipment

The schematic representation of automatic water level gauge is as shown in Fig. - 6.6.6.

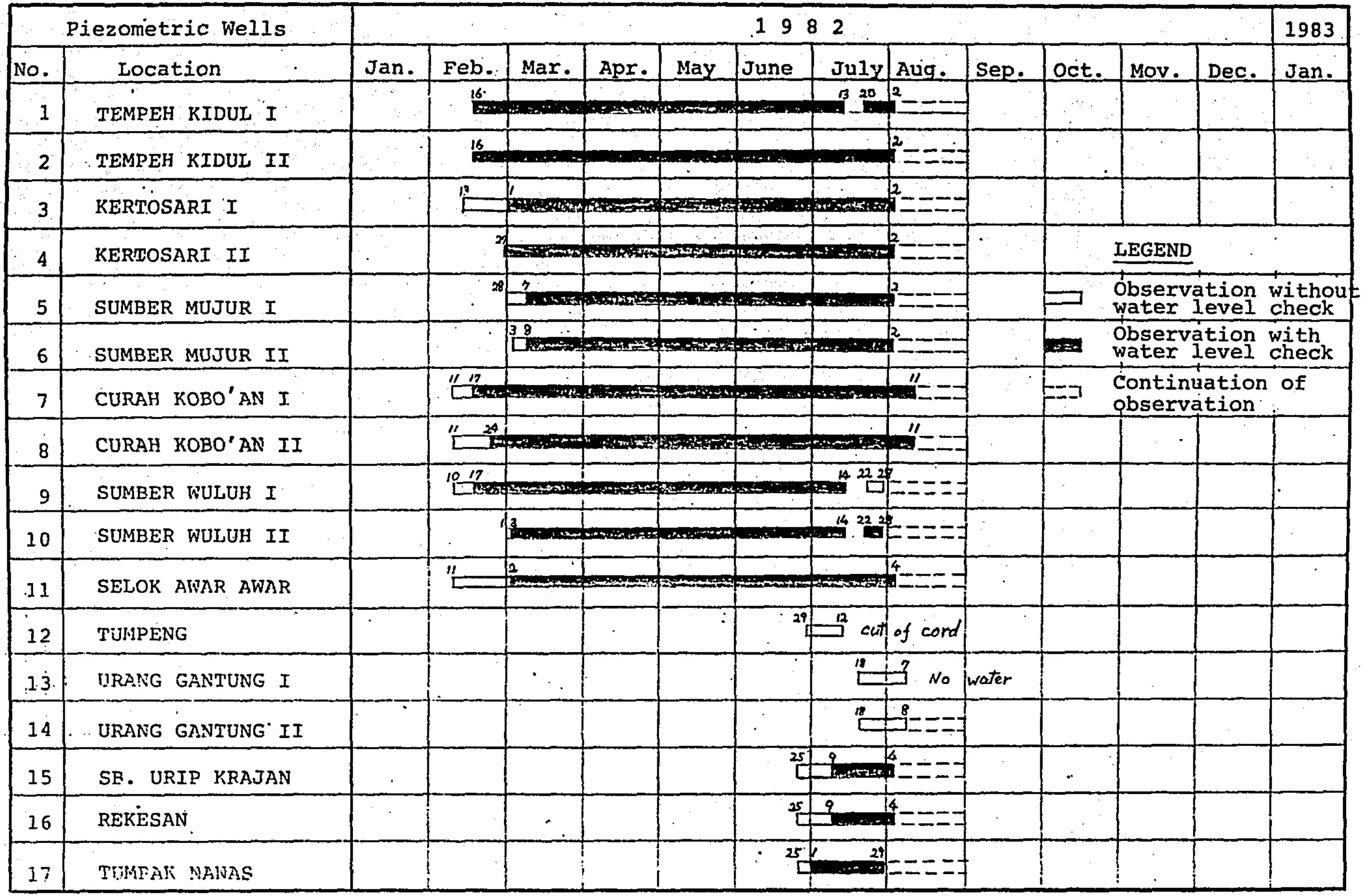


LOCATION

1 TEMPEH KIDUL I
2 TEMPEH KIDUL II
3 KERTOSARI I
4 KERTOSARI II
5 SUMBER MUJUR I
6 SUMBER MUJUR II
7 CURAH KOBO'AN I
8 CURAH KOBO'AN II
9 SUMBER WULUH I
10 SUMBER WULUH II
11 SELOK AWAR AWAR
12 TUMPENG
13 URANG GANTUNG I
14 URANG GANTUNG II
15 SB. URIP KRAJAN
16 REKESAN
17 TUMPAK NANAS

Fig.-6.6.5 Location of Piezometric Observation Wells

Table- 6.6.10 Observation Period of Piezometric Wells



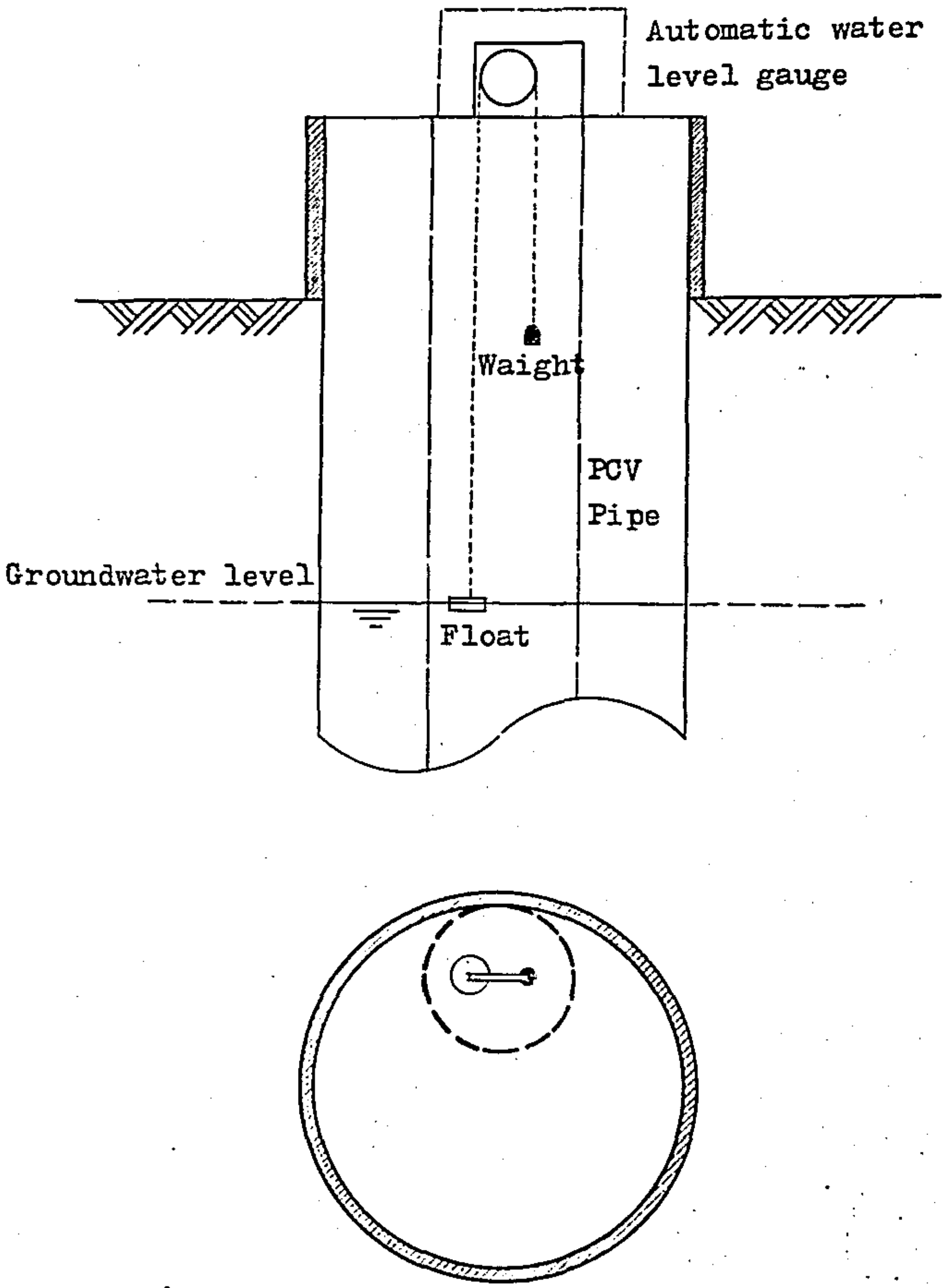


Fig.- 6.6.6 Schematic Representation of Automatic Water Level Gauge

6.6.2 WATER QUALITY INVESTIGATION

Y. UEMURA

(I) General

Water quality investigation aims to obtain one of the fundamental information on the delineation of groundwater system.

The work allocation for the Indonesian Government and JICA Study Team, mentioned in the final inception report, as follows;

(i) Indonesian Government

- Sampling of water
- Water quality survey material
- Partial water quality investigation

(ii) JICA Study Team

- Selection of sampling points
- Determination of time and method of sampling collection
- pH meter measurement
- Technical guidance in data arrangement

(2) Investigation Plan

The investigation plan of water quality is in accordance with the explanation sheet of hydrogeological survey submitted in the meeting with Mt. Semeru Project Office members on 9 Aug. 1982.

The flowchart of investigation is as shown in Fig. - 6.6.7.

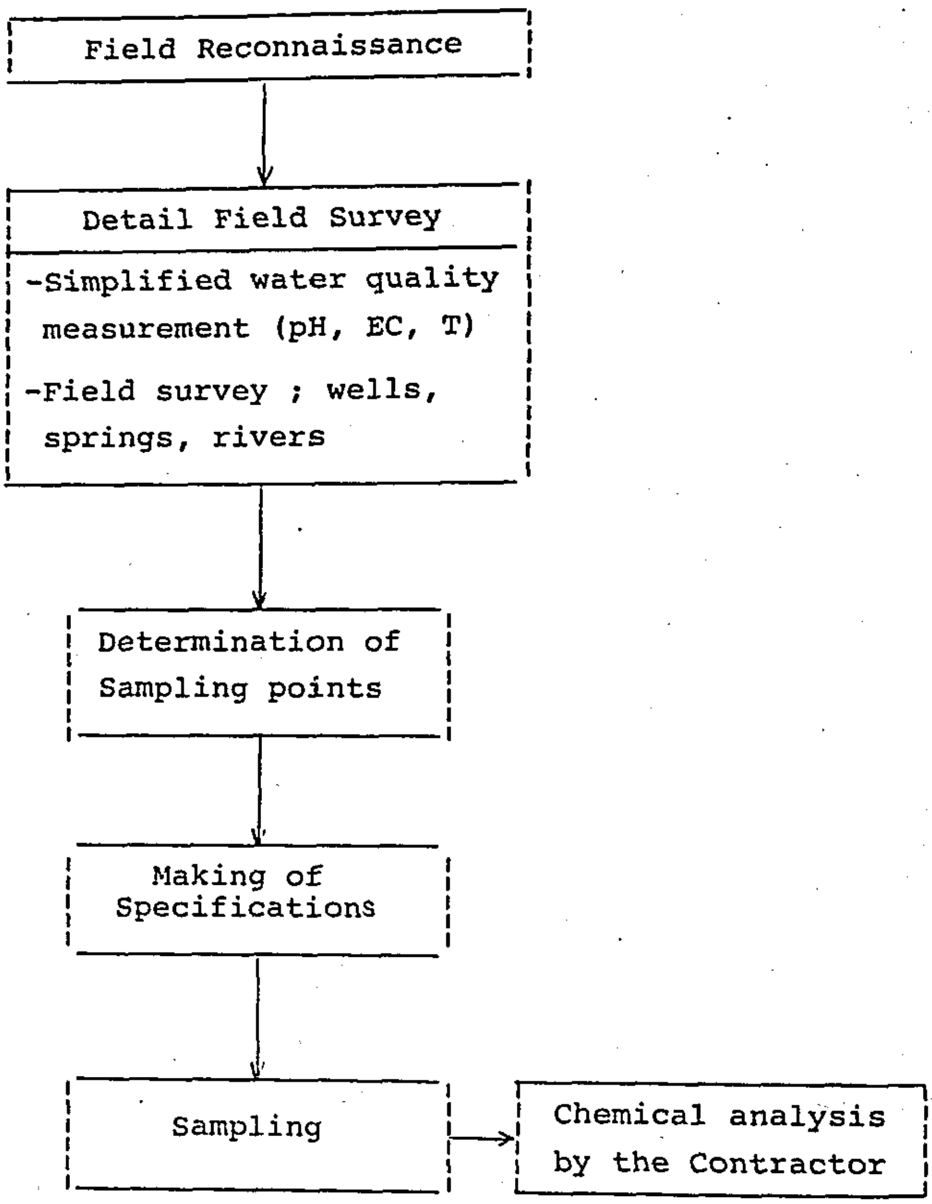


Fig.- 6.6.7 Flowchart of Water Quality Invstigation

(3) Work Progress

(i) Field Reconnaissance

From the field reconnaissance carried out from 10 Aug. to 13 Aug. 1982, observation results can be summarized as follows:

- Spring water found in the K. Lengkong fan is thought to contain iron ion, because iron oxide deposits is often observed along streams originated from springs.

- As river water is used for washing, bathing doing one's need, etc., nitrogeous compounds and phrosphate are expected to dissolve in the part of river water.

- River water and irrigation water are generally sourced by groundwater which also appears to the surface in the form of spring and seepage during dry season (May to Oct.).

- In many cases, each farm has its own well which is used for drinking and other domestic use.

- Well type is shallow dug well tapped in the shallow aquifer. Pump installation are very rare.

(ii) Simplified Water Quality Measurement

Simplified water quality measurement was executed two times;

- First measurement : 26 Aug. to 27 Aug. 1982, 22 points.
- Second measurement: 1 Sep. to 3 Sep. 1982, 40 points.

Measurement items consist of pH, temperature (°C), conductance (mS/cm), dissolved oxygen (ppm) and turbidity (ppm), using HORIBA water quality checker.

From the first measurement results, the sensibility of the above-mentioned equipment in conductance was not satisfying in accuracy. Therefore, EC meter having micro mho/cm in accuracy was employed at the second time.

Concerning turbidity measurement, values can easily vary with the arrangement conditions and show only relative tendency.
The results of measurement at sampling points for the chemical analysis are as shown in Table - 6.6.11.

(iii) Determination of Sampling Points

Sampling points were determinated, taking into consideration;

- Field survey (springs, rivers, wells)
- Inspection of piezometric observation wells.
- Prospective sites of sabo facilities

and are shown in Fig. - 6.6.8.

(iv) Specifications of Chemical Analysis

After the execution of field reconnaissance, a draft on the specifications of chemical analysis was submitted on Aug. 1982 and modified into practicable form, taking into account of the information given by Mt. Semeru Project Office.

The specifications submitted on 30 Aug. 1982 are as shown in Appendix - 9 .

Table- 6.6.11 Sampling List For Patial Water Quality Investigation

Sampling			Nature	Measurement at Sampling Point				Chemical Analisis Items		
No.	Location	Date		pH	T (°C)	DO (ppm)	EC (/cm)	Fe	NH_4, NO_2 NO_3, PO_4	Principal Composition
1.	K. Lengkong (Up st.)	1 Sep.	R	7.4	22.5	6.8	205		o	o
2.	Oro- oro Ombo A	,,	G	5.9	24.8	3.7	100		o	o
3.	Oro- oro Ombo B	,,	G	6.0	21.6	2.8	70		o	o
4.	Oro- oro Ombo C	,,	R	7.1	21.0	4.6	100		o	o
5.	Tumpak Nanas	,,	G	6.6	22.9	1.8	207			o
6.	Sb. Tumpak Nanas (Left B.)	,,	S	6.3	24.9	0.4	230	o		o
7.	K.Lengkong (Dam Site)	,,	R	8.4	29.3	6.3	260	o	o	o
8.	B. Kembar (Dam Site)	,,	R	8.1	26.0	6.5	300	o	o	o
9.	B. Koban (Dam Site)	,,	R	8.1	25.4	6.7	410	o	o	o
10.	Sb. Tumpak Nanas (Rigth B.)	,,	S	6.8	24.7	0.0	280	o		o
11.	Rekasan	2 Sep	G	6.9	22.8	3.2	230		o	o
12.	Sb. Urip Krajan	,,	G	7.0	21.2	1.4	200		o	o
13.	Sb. Kembar	,,	S	7.8	23.8	6.7	220	o		o
14.	Sb. Raharan	,,	S	7.0	21.3	6.1	92	o	o	o
15.	Oro- oro Ombo D	,,	G	6.8	22.3	3.4	270		o	o
16.	Sb. Kamar A	,,	S	5.6	19.7	8.2	110	o	o	o
17.	Curah Kobo'an I	,,	G	6.9	22.7	6.8	179			o
18.	K. Besuk Kobo'an	,,	R	8.4	23.9	8.4	190	o	o	o
19.	Curah Kobo'an II	,,	G	7.1	21.4	6.8	130			o
20.	B. Semut	,,	R	7.0	22.1	8.6	180		o	o
21.	K. Kali Panching (Up.)	,,	R	5.9	21.2	8.4	110	o	o	o
22.	K. Mujur (Up.)	,,	R	7.6	21.2	8.3	120		o	o
23.	Sumber Mujur I	,,	G	7.1	19.9	6.8	120			o
24.	B. Sat (Ketosari)	,,	R	7.8	23,9	7.8	220		o	o
25.	Kertosari II	,,	G	6.6	23.3	6.6	190		o	o
26.	Kertosari I	,,	G	6.6	23.3	5.2	180		o	o
27.	Sb. Gesang (Left B.)	3 Sep.	S	8.1	23.8	8.5	300			o
28.	K. Mujur (Gesang)	,,	R	8.1	28.4	7.6	270		o	o
29.	Gesang Streem	,,	G	6.8	26.8	4.4	320			o
30.	Kedung Wringin	,,	G	6.9	26.6	2.4	390			o
31.	Kali Putih	,,	G	7.0	25.8	2.1	360			o
32.	Tumpeng	,,	G	6.8	27.1	5.1	300		o	o
33.	Umbulsari ,Pulo	,,	S	6.8	27.6	1.4	370			o
34.	Sumber Wuluh II	,,	G	7.0	25.2	4.0	170		o	o
35.	Sumber Wuluh I	,,	G	6.9	24.5	5.1	180		o	o
36.	Sb. Sumber Wuluh	,,	S	6.8	25.0	3.6	190			o
37.	Urang Gantung II	,,	G	7.1	25.6	2.3	430		o	o
38.	K. Leprak (J gosari)	,,	R	8.5	26.0	6.8	230			o
39.	Tempeh Kidul I	,,	G	7.2	27.1	3.9	330		o	o
40.	Tempeh Kidul II	,,	G	7.1	26.9	3.3	320			o
				Total Quantities				10	25	

Note ; R : River Water
G : Groundwater
S : Spring Water

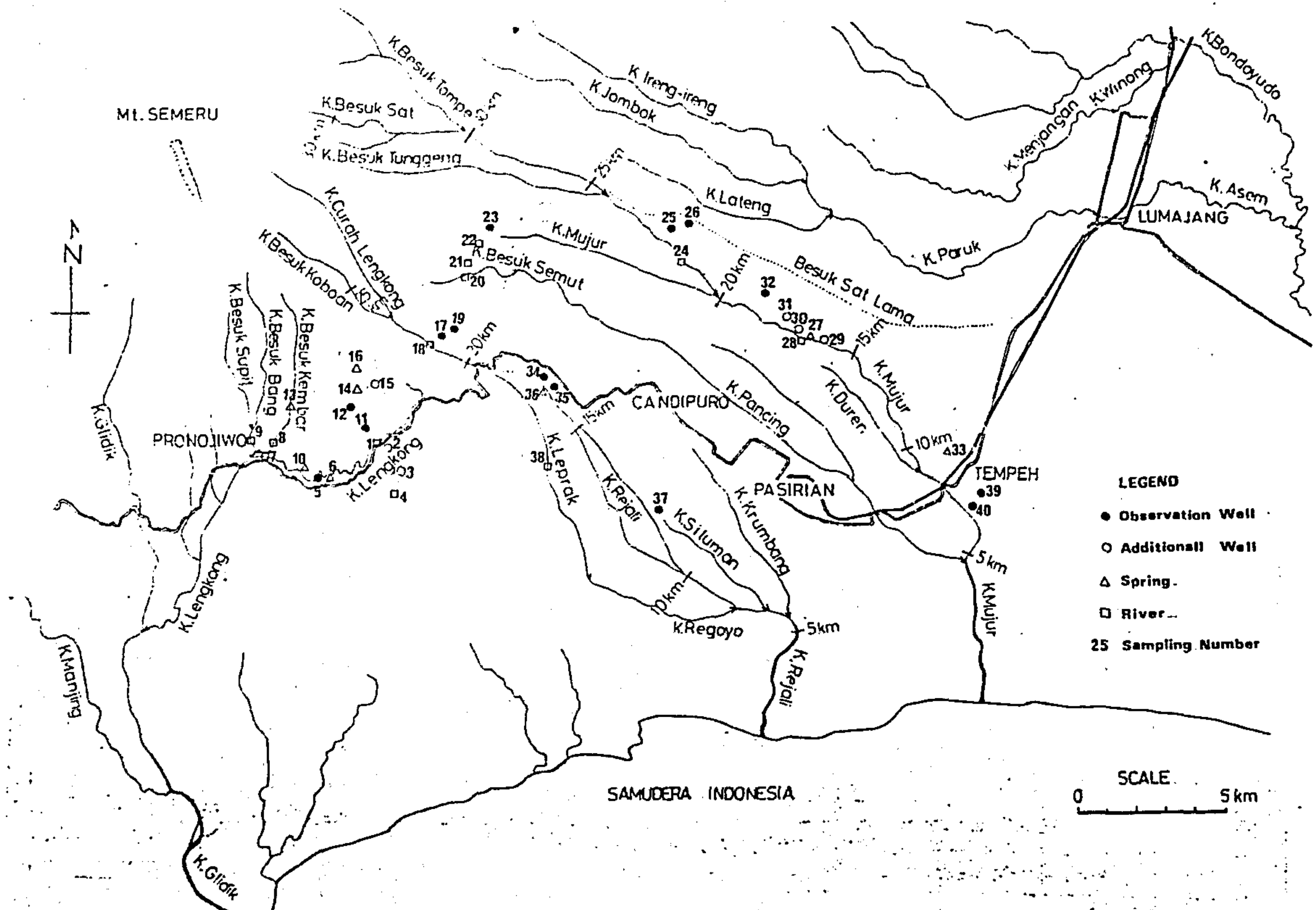


Fig.- 6.6.8 . **LOCATION OF SAMPLING POINT**

6.6.3 RAINFALL STUDY

M. WATANABE

In order to comprehend the general rainfall characteristics in the study area, preliminary rainfall study was carried out using the original daily rainfall data (see Table - 6.6.12) collected in the first stage (Mar. - May, 1982).

An additional data collection (of automatic recording data, or other existing data) is being made, and more detail study to serve a volcanic debris control planning and a water conservation research, will be performed successively and will be reported in the next volume.

In this article, the main results of the first rainfall study are described as follows.

(1) Annual Isohyetal Map

Annual Isohyetal Lines (A.I.L.) are down, approximately parallel to and along the contour line (C.L.) of Mt. Semeru: (Refer to Fig. - 6.6.9).

- A.I.L. 2,000 mm on C.L. 200 m
- A.I.L. 3,000 mm on C.L. 500 m
- A.I.L. 4,600 mm on C.L. 1,000 m
- A.I.L. 5,000 mm on C.L. 2,000 m

This means annual isohyetal map was prepared on the basis of the followings.

① Used station and period;
11 stations, 29 years (hydrological year 1951/52 - 1979/80).

Table- 6.6.12 List of Collected Daily Rainfall Data

STATION	No.	EL.	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
ALASBESUKI	154						x10	x3	x3		x1	o	o	o	x7	x6	o	o	x2	o	o	o	o	o	o	o	o	x5								
GUTJILIT	157				o	o	o	o	o	o	o	x1	x1	o	o	o	o	o	x1	o	o	o	o	o	o	o	o									
BESUKSAT	158	795m			x1	o	o	o	o	o	o	o	o	o	o	x3	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x3		
SENDURO	159																																o	x3		
KERTOSARI	160	345m			x1	o	o	o	o	o	o	o	o	o	o	x1	o	o	x1	x1	o	o	o	o	o	o	o	o	o	o	o	o	o	o		
PASRUDJAMBE	161	481m			x1	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x3	x1	o	o	o	x2	o	o	o	x3		
SUMBERDUREN	162	510m			x2	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	x1	o	o	o	o	o	o	o	o	o	x3		
CURAHKOBOAN	164A	734m			x8	o	o	o	o	o	o	o	o	o	o	x6	x10	o	x	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x3		
SUMBERSARI	165							x2	o	o	x1	o	o	o	o	o	x3	x11																		
SUMBERRAPANG	166																																o	x3		
KEBONDERI	166A						x10	o	x9	o	o	o	x3	x1	x5	x1	x7																			
SUMBERROWO	167																																o	x3		
RANUKLAKAH	180																															o	o	x5		
DAWUHANLOR	183	97m	o	o	o	o	o	o	o	o	o	o	o	o	o	x1	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		
LUMAJANG	185	50m			o	o	o	o	o	o	o	o	o	x1	o	x1	x1	x1	x2	x2	x1	x1	x1	x1	x9	o	x1	o	o	x1	o	o	o	o		
CANDIPURO	188				o	o	o	o	o	o	o	o	o	o	o	x1	x1	x1	x5	o	x1	x8					o	x1	o	o	o	o	o	o		
GUNUNGSAWUR	188B	632m				o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x3		
PASIRIAN	189	155m				o	o	o	o	o	o	o	o	o	o	o	o	o	x	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		
TEMPEHTENGAH	190	95m				o	o	o	o	o	o	o	o	o	o	o	o	o			o	o	o	o	o	o		o	o	o	o		o	o		
SUKOSARI	190A							o	o	o	o	o	o	o	o	o	x1	x1	x1	o	o	o	x4	x11									o	o		
TEMPEHBESUK	190B																																o	x3		
TEKUNG	223							x8	x9		x2	x1	x3	o	o	o	o		x7	x3	x11	x7	o	x4	x10	o	o	x1	x1	o			o	x3		
BLUKON	224	30m			o	o	o	o	o	x1	o	o	o	o	o	o	o	o	x1	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		
MELEMAN	226				o	o	o	o	o	x1	x2	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o				
WONOKERTO	247																																o	o		

Note: o = All data is available
x = Some months data (suffix figure) is not available

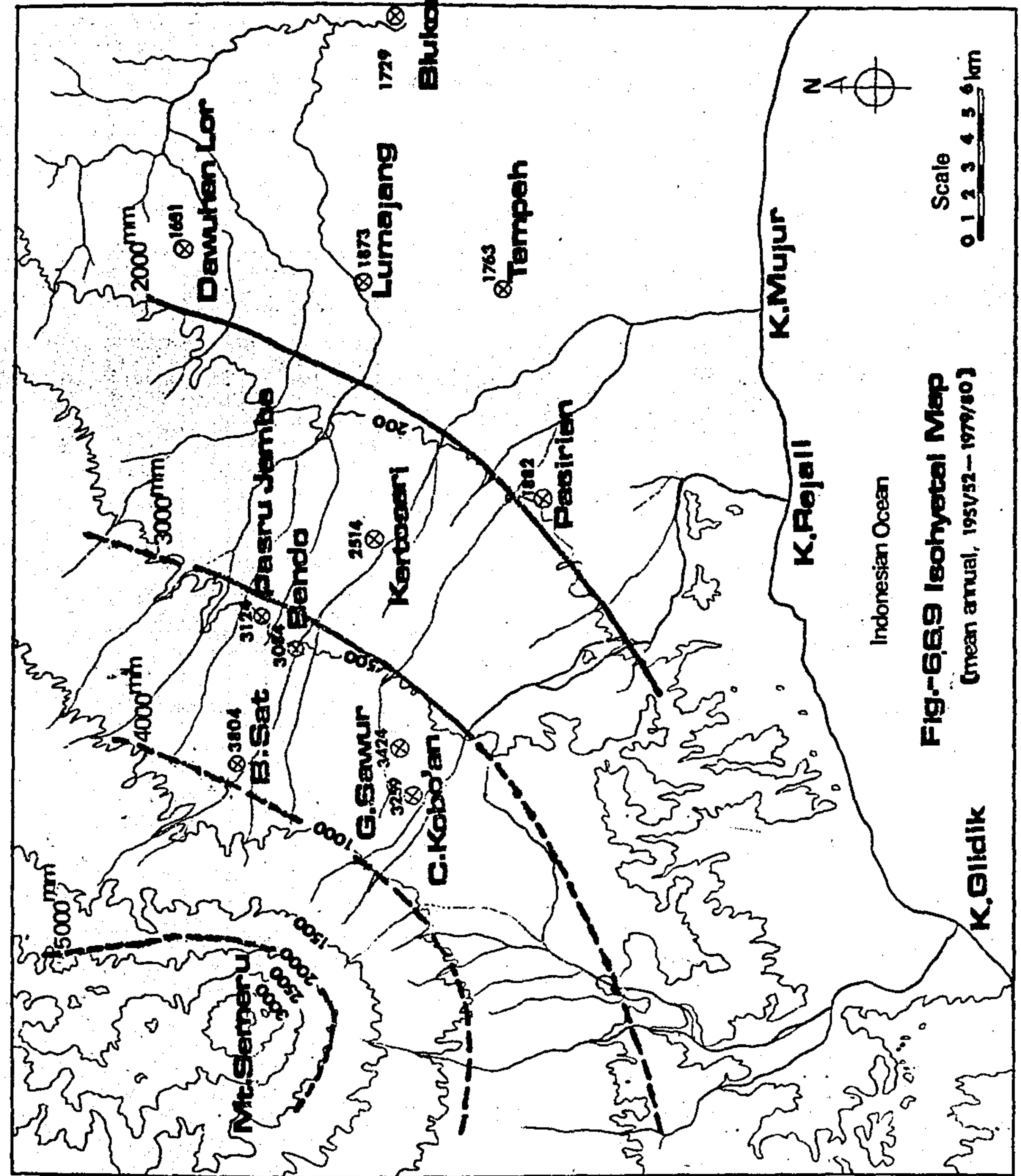


Fig.-6.6.9 Isohyetal Map
(mean annual, 1951/52—1979/80)

- Lumajang (EL. 50 m)
- Pasru Jambe (EL. 481 m)
- Dawuhan Lor (EL. 97 m)
- Tempeh Bedog (EL. 95 m)
- Pasirian (EL. 155 m)
- Kertosari (EL. 345 m)
- Besuk Sat (EL. 795 m)
- Bendo (Sumber Duren) (EL. 510 m)
- Gunung Sawur (EL. 632 m)
- Curah Kobo'an (EL. 734 m)
- Bulkon (EL. 30 m)

② Annual rainfall of the area over the elevation 1,000 m is sought from the regression curve (Altitude - Annual rainfall, Fig. 6.6.10).

(2) Fluctuation of Annual Rainfall

The annual rainfall fluctuation of two stations:

- Lumajang (EL. 50 m), as a representative for lower area
- Besuk Sat (EL. 795 m), as a representative for higher area

is shown in Fig. - 6.6.11.

The figure reveals the followings

① Approximate mean annual rainfall ($\overline{R}$), standard deviation (SD) and fluctuation coefficient (Cf = SD/R) are:

For Lumajang:

$\overline{R}$ = 1,890 mm
SD = 440 mm
Cf = 0.24

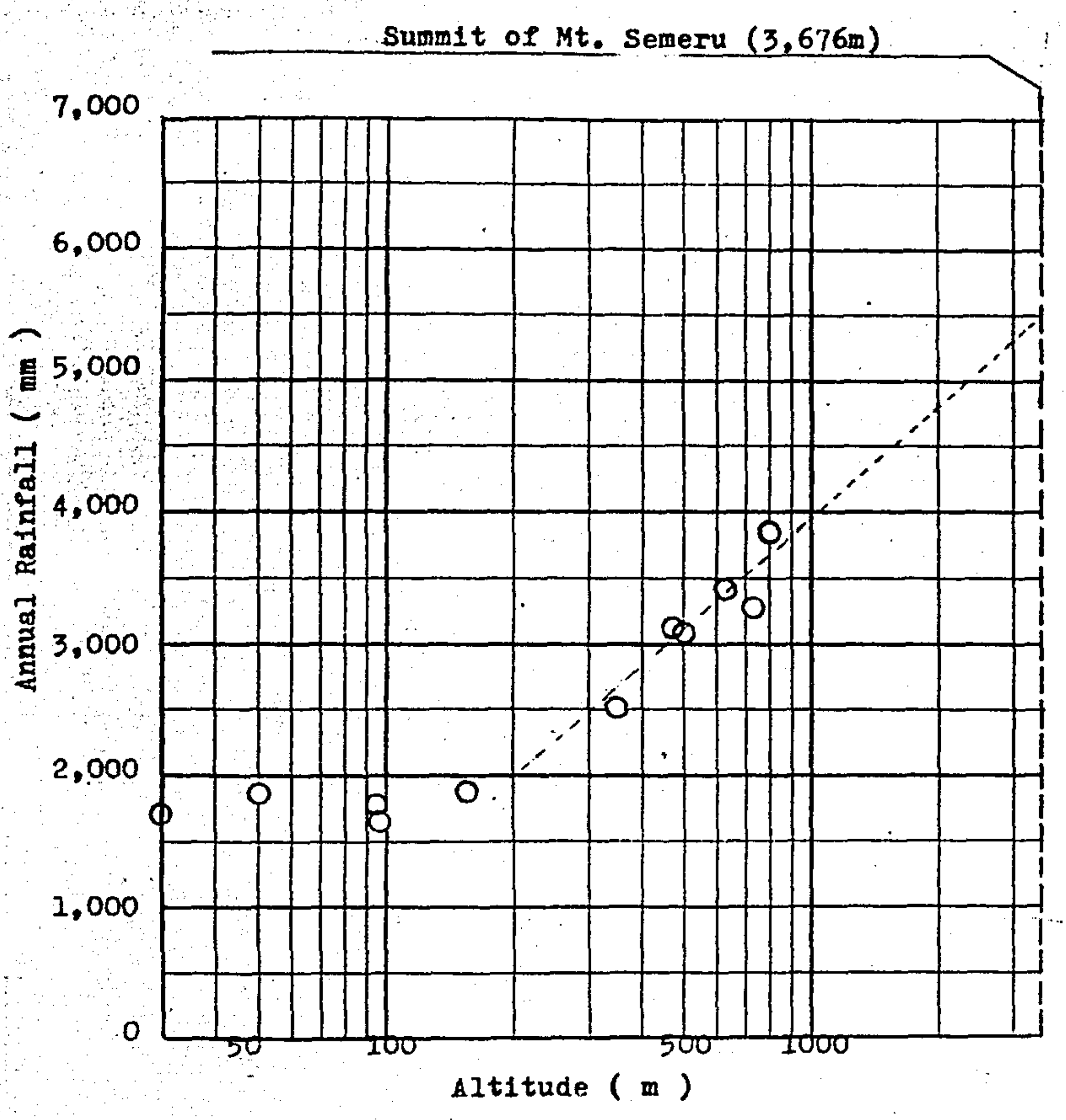


Fig.- 6.6.10 Relationship between Altitude and Annual Rainfall

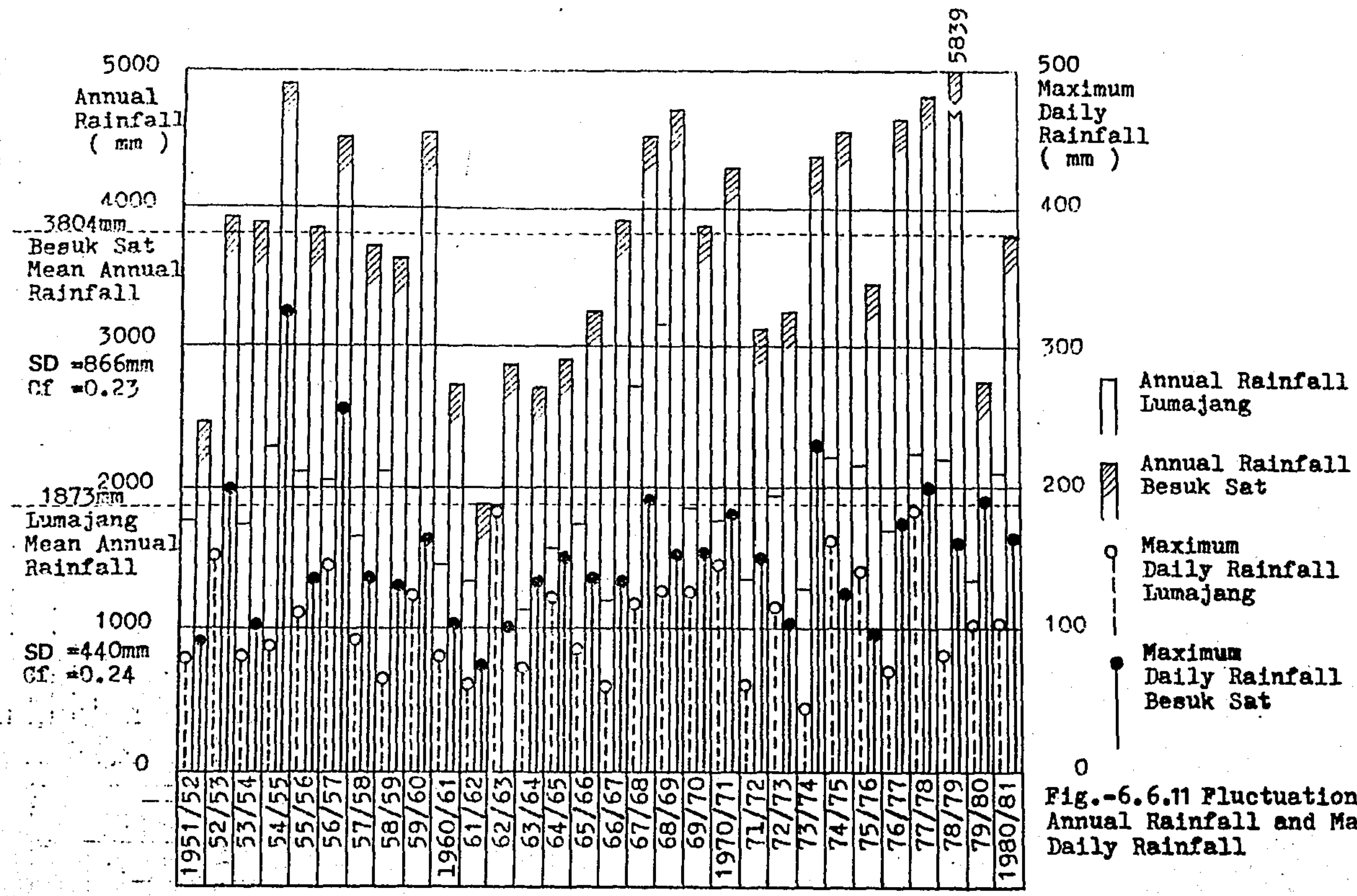


Fig.-6.6.11 Fluctuation of Annual Rainfall and Maximum Daily Rainfall

For Besuk Sat:

$\bar{R}$ = 3,800 mm

SD = 866 mm

Cf = 0.23

② The higher the altitude is, the bigger the fluctuation of annual rainfall becomes.

③ The fluctuation ratio of annual rainfall (or fluctuation coefficient) is nearly constant, having no relation to altitude.

(3) Monthly Rainfall

Fig. - 6.6.12 shows the monthly rainfall patterns of Lumajang (as a representative of lower area), and of Besuk Sat (as a representative of higher area).

It can be seen that the variation of monthly rainfall of lower area is bigger than that of higher land, or the distinction between rainy and dry season of lower area is more clear than that of higher area.

In Fig. - 6.6.13, relationship between altitude and the fluctuation coefficient of monthly rainfall in a year is shown. The figure distincly shows that the monthly rainfall fluctuation of lower area is bigger than that of higher area.

(4) Correlation Analysis

Using rainfall data of eleven stations employed in preparation of the annual isohyetal map (fig. - 6.6.9), the following correlation analysis is done.

① Correlation of daily rainfall (over 50 mm)
② Correlation of annual rainfall

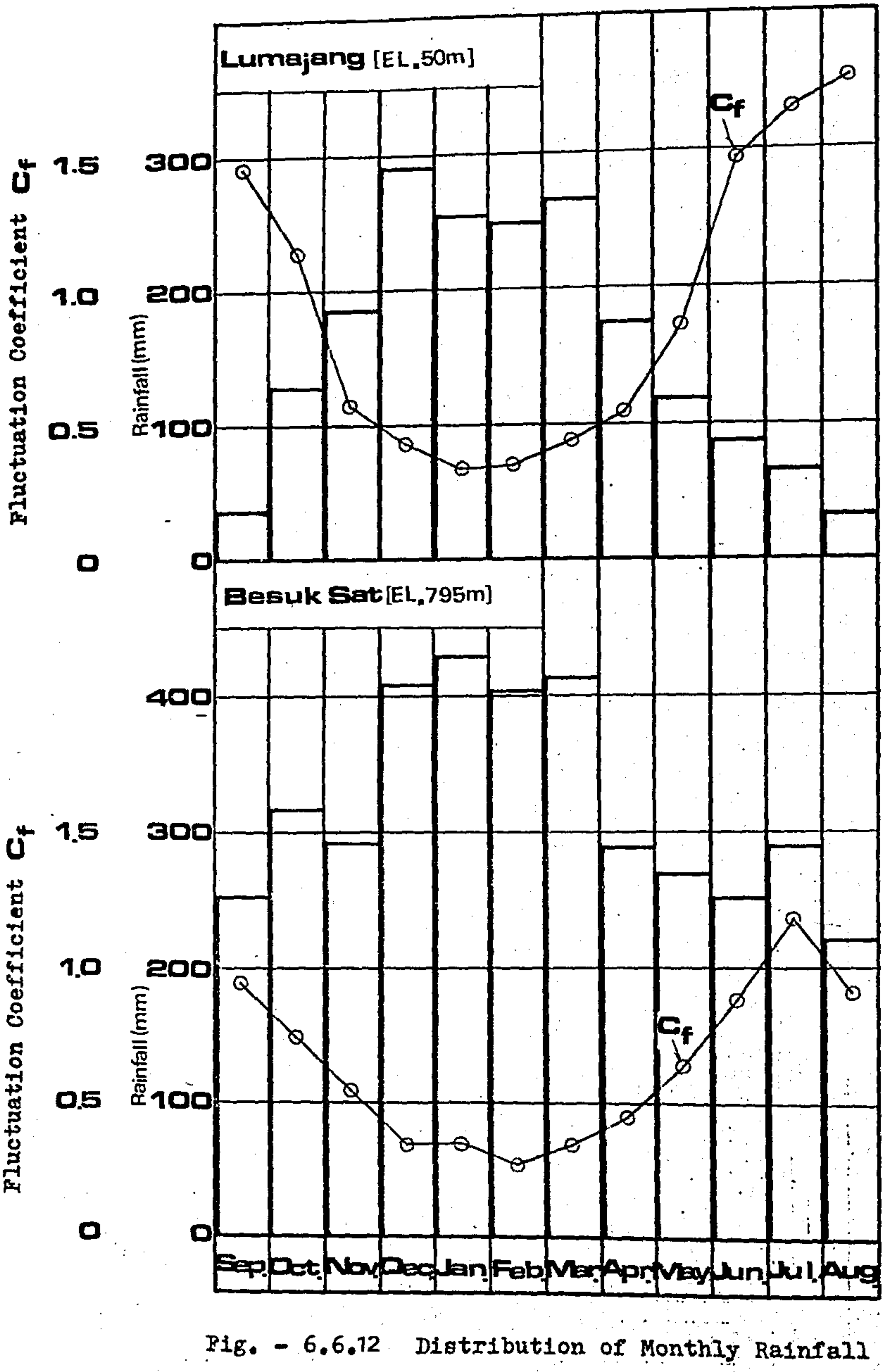


Fig. - 6.6.12 Distribution of Monthly Rainfall

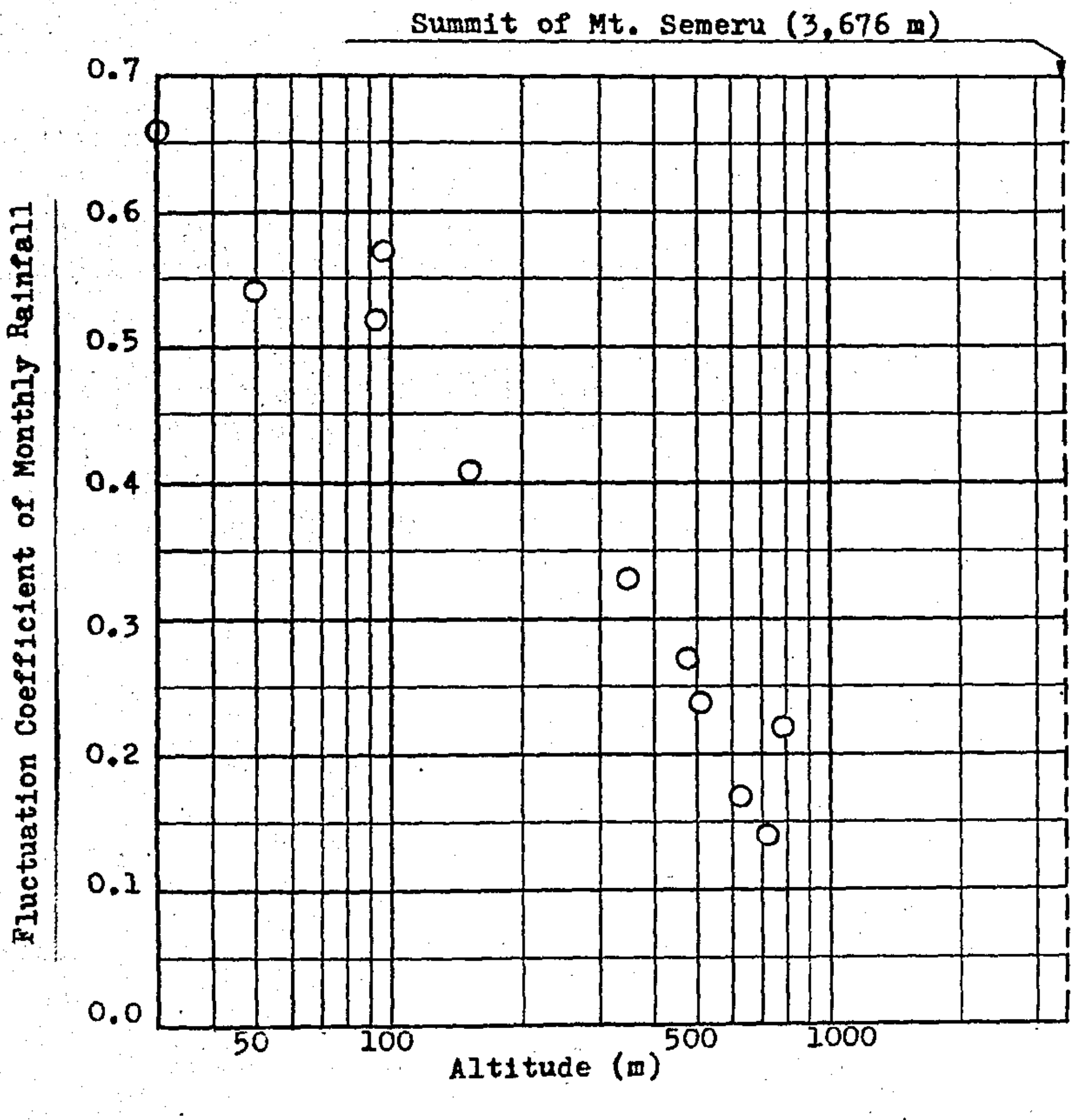


Fig.-6.6.13 Relationship between Altitude and Fluctuation Coefficient of Monthly Rainfall

Results of the analysis are shown in Table-6.6.13 and Table -6.6.14 respectively.

From these tables, the followings can be known.

① The correlation of daily rainfall(over 50 mm) is low.

② The correlation of annual rainfall is rather higher than that of daily rainfall.
The correlation coefficient is in inverse proprtion to the distance between the stations (See Fig.-6.6.14)

(5) Probable Rainfall

Probable annual rainfall and probable daily rainfall of Besuk Sat are sought Iwai Method, and shown in Fig.-6.6.15 and Fig.- 6.6.16 respectively.

Table-6.6.13 Correlation Analysis (Daily Rainfall > 50 mm)

Y / X	1 Besuk Sat 158	2 Kert Sari 160	3 Pasur Jambe 161	4 Sumber Duren 162	5 Curah Kobo'an 164A	6 Dawuhan Lor 183	7 Lum-jang 185	8 Gunung Sawur 188B	9 Pasiri-an 189	10 Tempeh Tengah 190	11 Bulkon 224
Besuk Sat 158	① ② ③ ④	-0.36 40.99 0.033 (643)	0.168 40.09 0.161 (685)	0.281 30.05 0.275 (647)	0.230 36.98 0.269 (679)	0.467 48.69 0.364 (664)	0.388 49.74 o.344 (602)	0.090 53.72 0.037 (725)	-0.323 46.70 -0.285 (633)	-432 60.26 -0.367 (599)	-0.495 96.790 -.0874 (781)
Kerto Sari 160			0.152 56.75 0.160 (466)	0.032 58.255 0.035 (446)	0.008 66.84 0.010 (485)	0.473 60.42 0.419 (401)	-0.332 60.70 -0.341 (351)	0.001 65.50 0.001 (559)	-0.275 60.05 -0.284 (362)	-.0391 62.32 -0.392 (348)	-0.475 112.07 -1.042 (509)
Pasru Jambe 161				0.363 34.83 0.367 (475)	0.074 54.03 0.091 (580)	-0.497 55.71 -0.420 (510)	-0.368 54.85 -0.361 (460)	0.130 52.86 0.142 (629)	-0.351 54.91 -0.336 (490)	-0.418 56.26 -0.387 (447)	-0.475 104.60 -0.938 (623)
Sumberduren 162					0.159 52.49 0.200 (543)	-0.551 58.90 -0.466 (483)	-0.432 59.65 -0.429 (435)	0.227 52.11 0.249 (584)	-0.391 58.95 -0.386 (458)	-0.445 59.92 -0.434 (420)	-0.502 106.44 -1.011 (598)
Curahkobo'an 164						-0.476 49.08 -0.326 (521)	-0.358 49.98 -0.274 (449)	0.443 43.11 0.387 (529)	-0.243 46.80 -0.193 (481)	-0.438 53.54 -0.329 (450)	-0.451 95.22 -0.737 (621)
Dawuhanlor 183							0.223 64.902 -0.267 (283)	-0.500 80.00 -0.642 (592)	-0.685 76.15 -0.693 (344)	-0.499 69.66 -0.562 (322)	-0.402 112.44 -1.036 (465)
Lumajang 185								-0.388 78.25 -0.441 (524)	0.760 70.16 -0.464 (283)	-0.382 65.65 -0.378 (284)	-0.444 117.54 -1.018 (415)
Gunungsawur 188									-0.292 49.28 -0.260 (548)	-0.455 53.98 -0.384 (533)	-0.478 97.73 -0.85 (699)
Pasirian 189										-0.299 65.59 -0.288 (282)	-0.363 109.95 -0.833 (445)
Tempehtengah 190											-0.333 108.97 -0.779 (427)
Blukon 224											

Note : ① = Correlation Coefficient
② = a (Y = a + b)
③ = b
④ = Number of Data

Table-6.6.14 Correlation Analysis (Annual Rainfall)

y / x	1 Besuk Sat 158	2 Kert Sari 160	3 Pasur Jambe 161	4 Sumber Duren 162	5 Curah Koboa'n 164A	6 Dawuhan Lor 183	7 Luma-jang 185	8 Gunung Sawur 188B	9 Pasiri-an 189	10 Tempeh Tengah 190	11 Bulkon
Besuk Sat 158	1 2 3 4	0.720 538.51 0.519 23	0.807 609.33 0.648 24	0.843 64.19 0.733 27	0.743 780.04 0.628 24	0.318 913.62 0.193 27	0.608 975.31 0.229 14	0.770 956.61 0.765 26	0.628 629.53 0.316 26	0.773 1026.40 0.202 16	0.198 372.08 0.512 25
Kert Sari 160	5 10.0 km		0.833 975.70 0.872 30	0.774 579.40 0.939 23	0.735 1293.82 0.768 20	0.613 330.46 0.525 23	0.668 1026.63 0.316 11	0.750 728.80 1.058 22	0.694 763.13 0.443 22	0.285 1472.85 0.137 14	0.373 -1224.08 1.399 22
Pasurjambe 161	6.9	3.9		0.802 83.10 0.899 25	0.891 718.71 0.812 21	0.643 255.23 0.445 25	0.660 945.62 0.293 14	0.897 36.43 1.094 24	0.658 546.85 0.418 24	0.740 558.65 0.358 13	0.370 -1544.05 1.256 23
Sumberduren 162	5.3	4.6	2.9		0.824 990.78 0.754 24	0.389 891.02 0.264 29	0.462 1283.94 0,202 14	0.773 893.31 0.873 28	0.669 805.52 0.369 28	0.509 1013.92 0.269 17	0.222 407.94 0.659 27
Curahkobo'an 164A	7.4	10.0	10.0	7.1		0.440 441.69 0.378 24	0.622 780.30 0.334 13	0.804 20.75 1.071 23	0.676 411.17 0.951 24	0.467 982.32 0.263 14	0.159 495.61 0.617 22
Dawuhanlor 183	22.1	14.7	15.4	17.7	24.3		0.836 829.01 0.602 14	0.498 2142.50 0.779 28	0.645 1041.73 0.508 28	0.354 1398.23 0.230 17	0.245 237.68 1.248 27
Lumajang 185	24.5	16.9	18.7	20.7	26.0	6.6		0.688 564.23 1.651 18	0.759 37.09 1.004 13	0.908 -423.07 1.092 8	0.440 -3567.20 3.522 13
Gunungsawur 188B	7.6	7.9	9.9	5.0	2.1	22.4	26.4		0.601 932.01 0.281 27	0.418 1187.01 0.177 16	0.405 -1501.28 1.114 26
Pasirian 189	16.4	7.9	11.7	11.7	12.9	17.4	16.3	11.9		0.628 765.67 0.540 17	0.256 -314.02 1.398 26
Tempehtengah 190	22.4	12.5	16.0	17.0	21.0	12.5	9.0	19.3	8.6		0.393 -2164.63 2.657 17
Bulkon 224	32.9	22.1	25.7	26.5	33.4	11.9	6.1	30.1	20.9	8.7	

Note: (1) = Correlation Coefficient
(2) = a (y = a + bx)
(3) = b
(4) = Number of Data
(5) = Distance between Stations

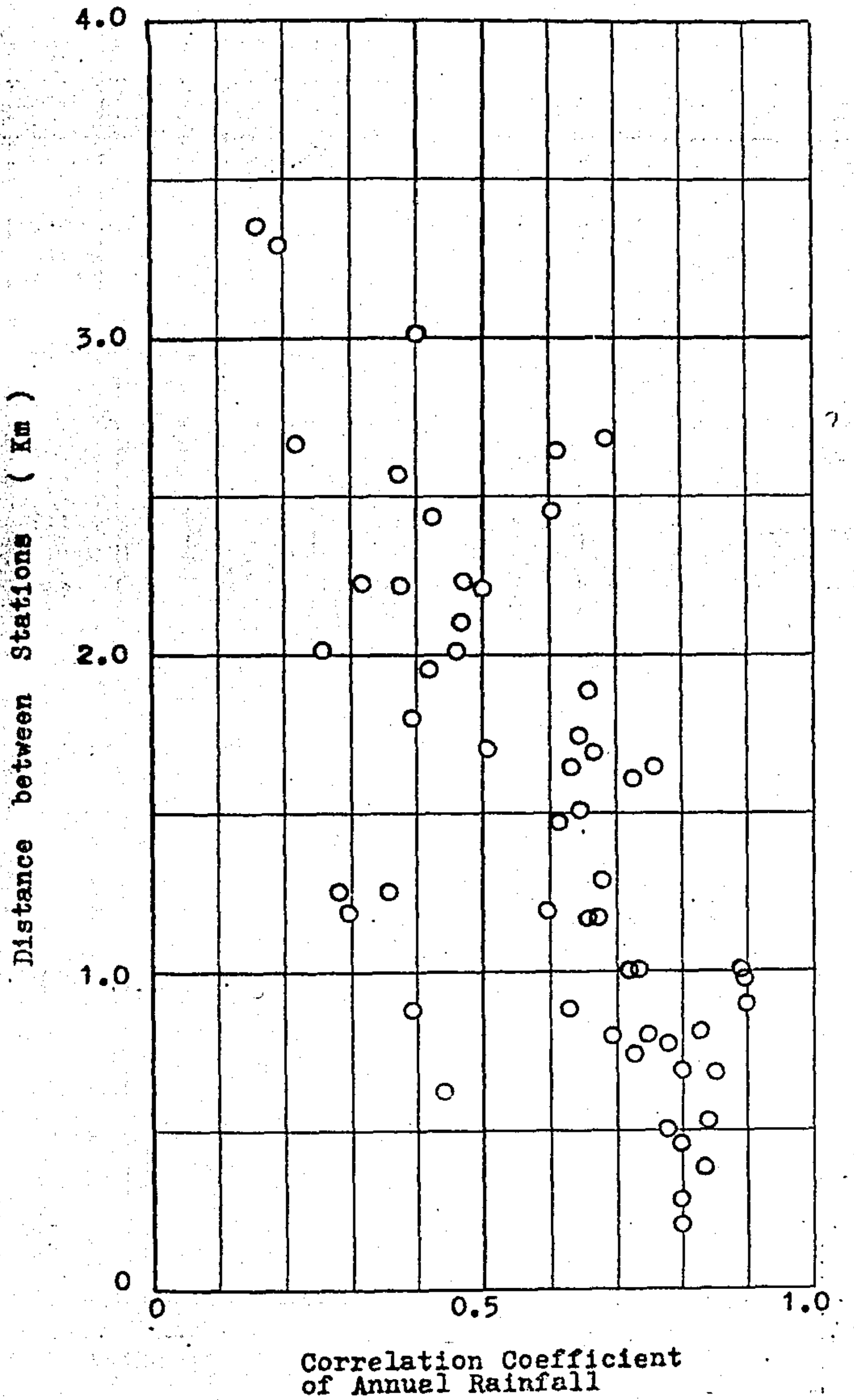
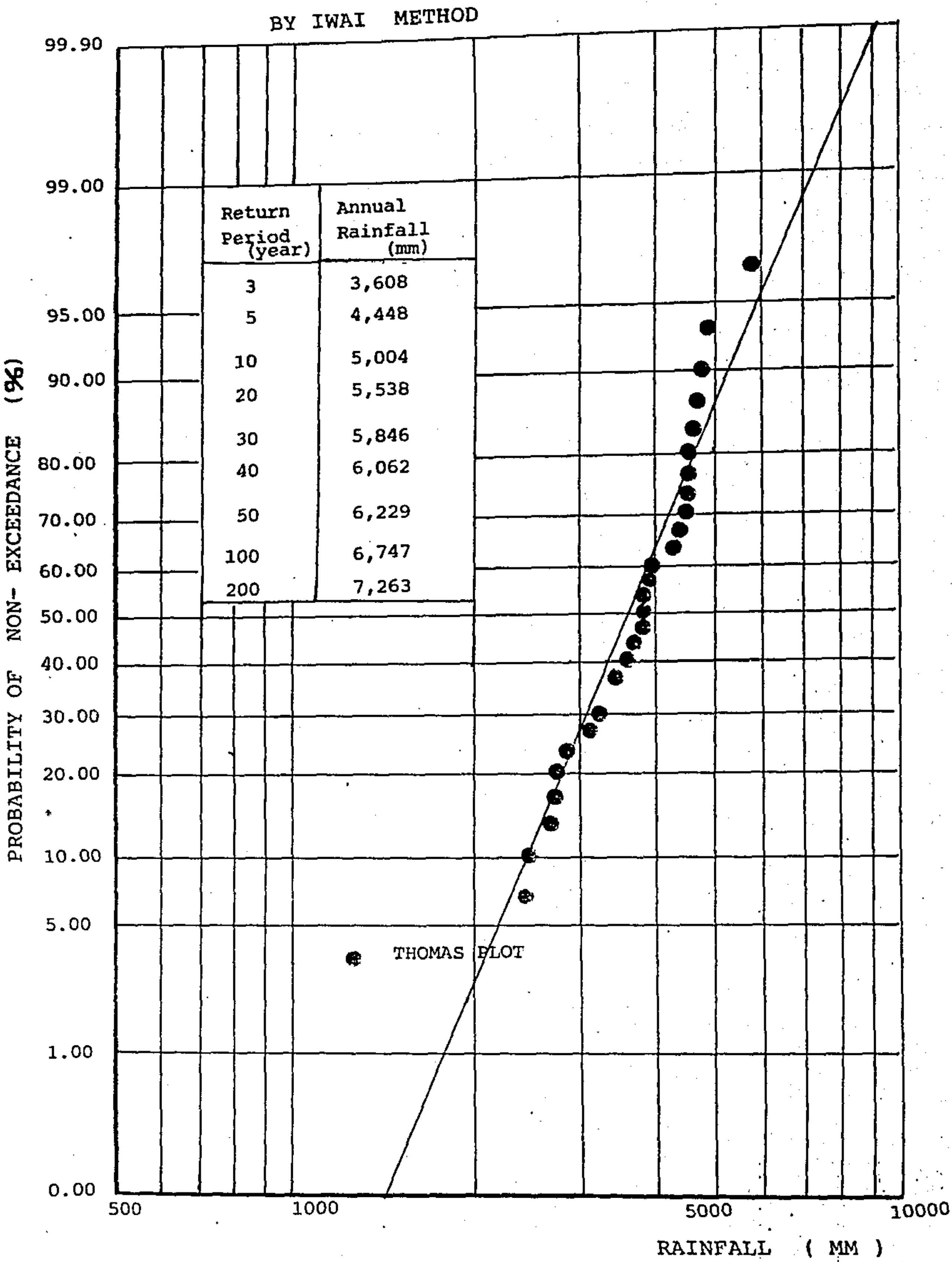


Fig.-6.6.14 Distance between Stations and Correlation Coefficient of Annual Rainfall

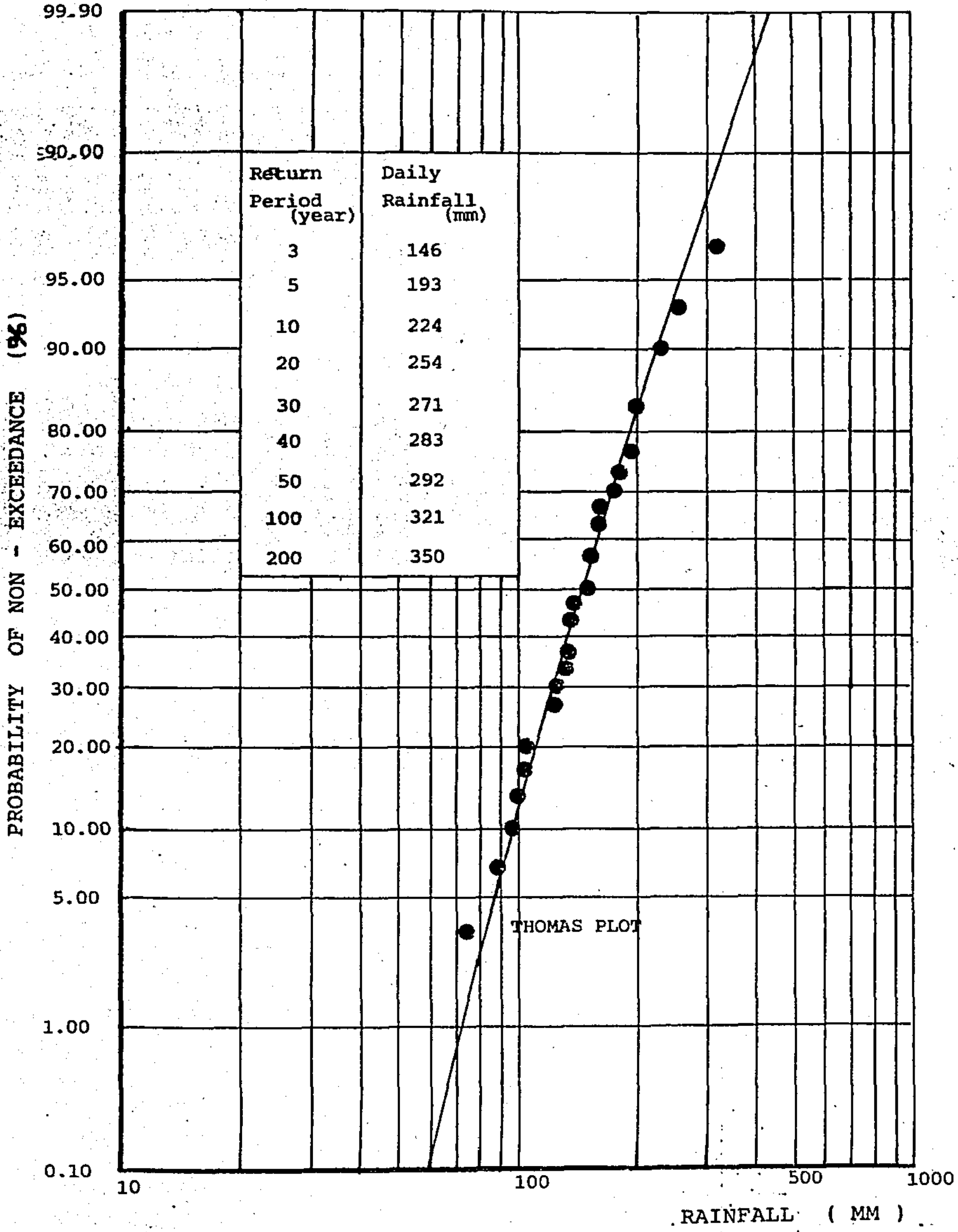


Return Period (year)	Annual Rainfall (mm)
3	3,608
5	4,448
10	5,004
20	5,538
30	5,846
40	6,062
50	6,229
100	6,747
200	7,263

ANNUAL RAINFALL (STATION : BESUKSAT . 158)

Fig.-6.6.15 Probable Annual Rainfall of Besuksat

BY IWAI METHOD



Return Period (year)	Daily Rainfall (mm)
3	146
5	193
10	224
20	254
30	271
40	283
50	292
100	321
200	350

MAXIMUM DAILY RAINFALL (STATION : BESUKSAT .158)

Fig.-6.6.16 Probable Daily Rainfall of Besuksat

6.7 GEOLOGICAL & SOIL INVESTIGATION

N. UCHISETO
Y. SASAKI

6.7.1 CIRCUMSTANCES OF INVESTIGATION WORKS

Mr. Uchiseto and Mr. Sasaki, who are the geological survey staff members of JICA Study Team. arrived at the Project Site on May 11, 1982, and conducted geological field survey of the study area until the end of May, 1982.

Based on this geological reconnaissance, 6 specifications for geological investigation works were prepared in English, and submitted to Dept. of Public Works (DPU) in the beginning of June, 1982.

The specifications were translated into the Indonesian by DPU staff members and the geological investigation works are ordered to the contractor in the middle of June.

The local geological survey was started again in the middle of June, 1982, and the interim results of the geological field survey and the plan of geological survey works were completed and reported to DPU staff members at the meeting held on July, 1982.

In the beginning of July, the contractors of the geological investigation works started their jobs (Drilling, Electric Sounding, Sampling of soil and rock materials, and In-situ permeability test). At that time, Mr. Uchiseto returned to Japand and Mr. Nakazawa, a geophysist of JICA team came to the Project site from Japan.

As to the seismic exploration, permission to use explosive material took a great deal of time. For this reason, this work started from the end of August, 1982.

Up to the present time, Mr. Nakazawa and Mr. Sasaki have controlled these works giving technical advises for the works through DPU supervisors.

As for the future schedule, both Nakazawa and Mr. Sasaki will continue the controlling works for geological investigations moreover Mr. Sasaki will carry out the geological reconnaissance in his spare time based on the results of aerial photo interpretation.

6.7.2 GENERAL TOPOGRAPHY AND GEOLOGY

(1) Topography

Mt. Semeru is the highest volcano (EL. 3675,7 m) in the Java Island and a member of the Volcanic chain trending in the north - south direction between the plains of Malang - Banggil and Lumajang - Probolinggo.

The volcanic chain can be divided into 3 morphological units as follows (SAKAI, SURYO, 1980):

a) The Tengger Mountain Range
b) The Jambangan Volcano Complex
c) Semeru Volcano

The oldest units is the Jambangan Volcanic Complex and the youngest is the Semery Volcano.

i) The Tengger Mountain Range.

In the western part of this unit the non-volcanic sediments are distributed as the basement and the volcanic materials overlie the basement in the western part. Bromo volcano in the western part is the only one active volcano in this unit.

ii) The Jambangan Volcano Complex

The Jambangan Volcano Complex is located between the Tengger Mountain Range and the Semeru Volcano. And, this volcano complex consist of Ayeg-ayeg volcano, Ranu Kembolo and Gunung Kepala.

iii) Semeru Volcano

Semeru Volcano is a strato Volcano and the youngest of these 3 units. It is located about 100 km south of Surabaya City in the East Java.

The summit of Mt. Semeru is called Mahameru which is the older crater. The present active crater is situated on south east side of Mahameru, and this active crater is called "Jonggring Seloko Crater".

The slope of Mt. Semeru smoothly extends eastward to the Lumajang Plain. On the contrary, the western slopes further southward extension ends at the foot of the tertiary mountain range.

Morphologically, the southern foot of the Semeru Volcano is younger than the east and the southeast side of mountain foot. This is because the eastern area borded by K. Glidik belongs to the Jambangan Volcano Complex and the southeastern area borded by Besuk Sat belongs to the Tengger Mountain Range. The study area is located in the southern foot of Mt. Semeru.

The study area can be topographically divided into 3 parts namely, they are the main part of the cone, the volcanic piedmont slope and the peripheral area.

The main part of the cone is located at the elevation between 1.000 m and the summit, and it receives the direct influence from the present volcanic activity. In this area, the primary volcanic materials from the crater, andesite lava and pyroclastic materials, are deposited.

The volcanic piedmont slope is situated between EL 25 m and EL 1.000 m and widely extend with gentle inclination toward east and southeast direction. This slope is characterized as volcanic fan consisting mainly of lahar deposits.

The peripheral area is situated between EL. 35 m and the sea level which widely spreads surroudning the volcanic piedmont slope with very gentle inclination. Thick alluvial deposits cover this area.

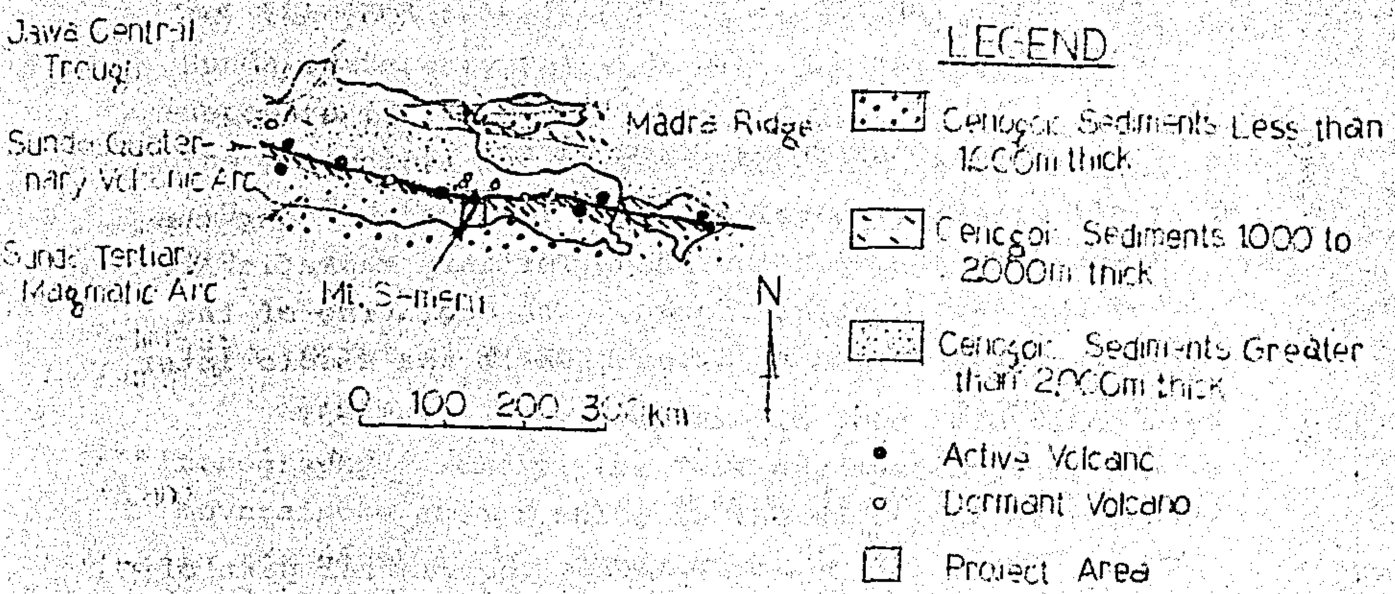
As for the detailed discussion on the topography the readers are requested to refer to Item 6.9 "TOPOGRAPHICAL INVESTIGATION".

(2) GEOLOGY

i) General Geology of East Java

Generally, in the eastern part of Jawa Island, the 4 geological provinces are recognised, namely from south to north, Sunda Tertiary Magmatic Arc , Sunda Quaternary Vocalnic Arc , Jawa Central Through and Madura Ridge as shown Fig. 6.7.1.

Fig-6.7.1 Schematic Geologic Province
Of East Java



-: Sunda Tertiary Magmatic Arc

The pre-tertiary basement rock (Metamorphic rocks, Upper Cretaceous deposits) are exposed in some place in the West and Central Java. The cenogoic sequence consists mainly of the so-called "Old Andesite" and carbonate rocks. Volcanic activity was relatively active from Oligocene to Middle Miocene. Therefore, the arc is called Tertiary magmatic arc (Katili, 1973).

-: Sunda Quaternary Volcanic Arc

This active volcanic arc is located along the hinges zone between the Sunda Tertiary Magmatic Arc and the Java Central Trough. The beginning of the quarternary volcanism dates back to the Middle later Pleistocene.

-: Java Central Trough

The trough which occupies the central part of Java Island. It is composed of a chain of sedimentary basins filled up with cenozoic deposits whose thickness reaches 6.000 m. The deposits mainly consist of clastic and carbonate materials accumulated during the Middle Eocene to the Pleistocene.

-: Madura Ridge

The ridge which is a shallow basement belt is covered with a relatively thin cenozoic sequence which is mainly consisting of the oligocene to the pleistocene clastic. The ridge exhibits an anticlinorium of weakly folded structures which plunges westwards.

ii) General Geology of the Study Area

The project site is located on both the Sunda Magmatic Volcanic Arc and the Sunda Quaternary Volcanic Arc. The investigation area is roughly divided into 4 geological units.
They are the tertiary system belonging to: (a) Sunda Tertiary Magmatic Arc, (b) the Older volcanic products, (c) the younger volcanic products belonging to the Sunda Quaternary Volcanic Arc, and (d) Alluvial deposits indicated in table 6.7.1.
The geological map of the study area is shown in Fig.-6.7.3. and the schematic geological profile is in Fig. - 6.7.3.

-: Tertiary System

The Tertiary system are in good accordance with topography. Namely, the Tertiary system forms the mountainous area running in the east-west direction in the south of the study area.

The Tertiary system, furthermore, is subdivided into 4 members, i.e. the limestone the green tuff patiary welded tuff, the alternation of tuff, tuff breccia, mudstone and andesite lava and the volcanic breccia. The alternation member unconformably overlies the green tuff member.

° Green Tuff Member

The green tuff member is the basement rock of the tertiary system in the study area.
It consists of green tuff, volcanic breccia, andesite and welded tuff which changes its lifthofacies like liparite in some place. The rocks of the green tuff member are hard and strong. Many faults are distributed in this member.

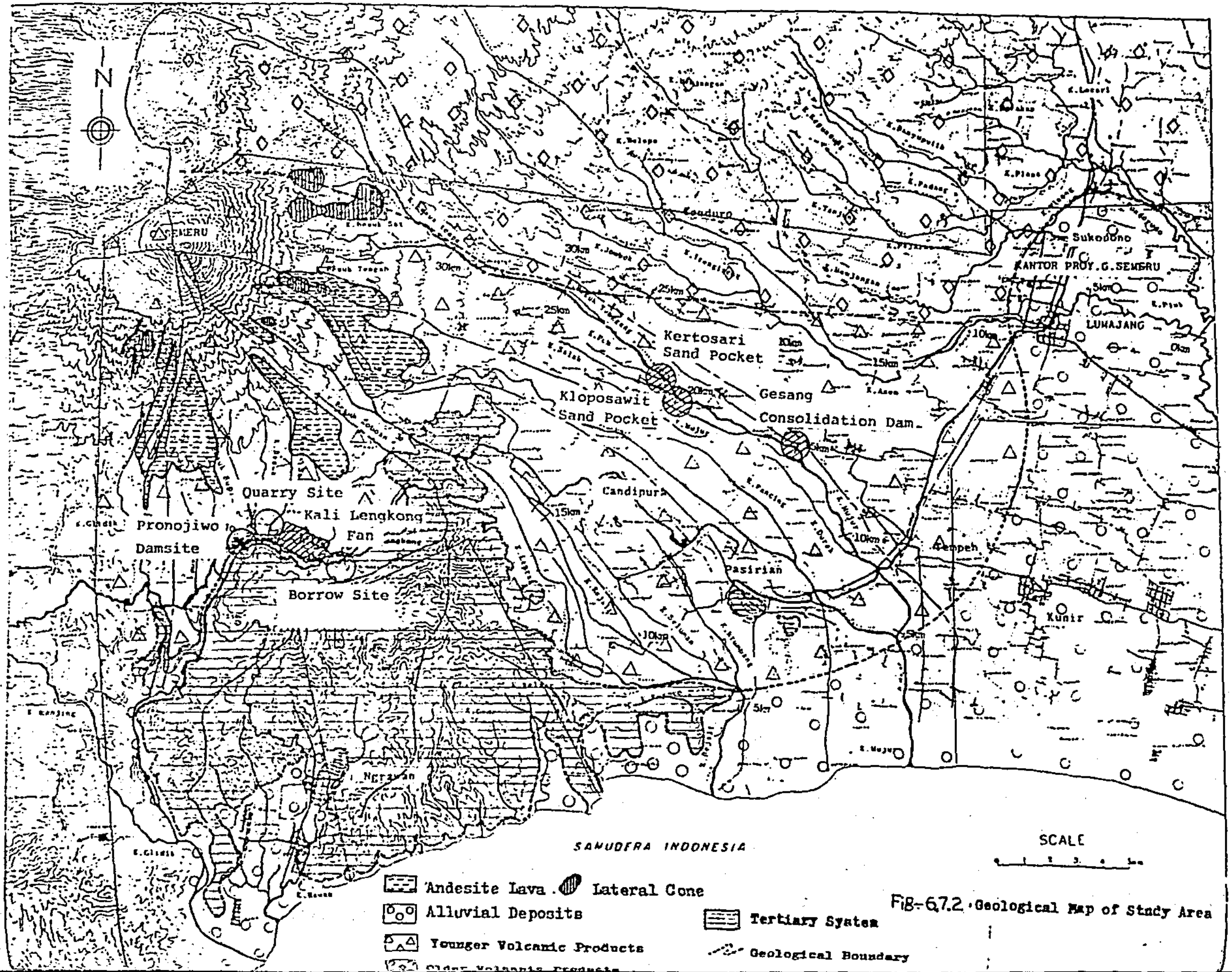
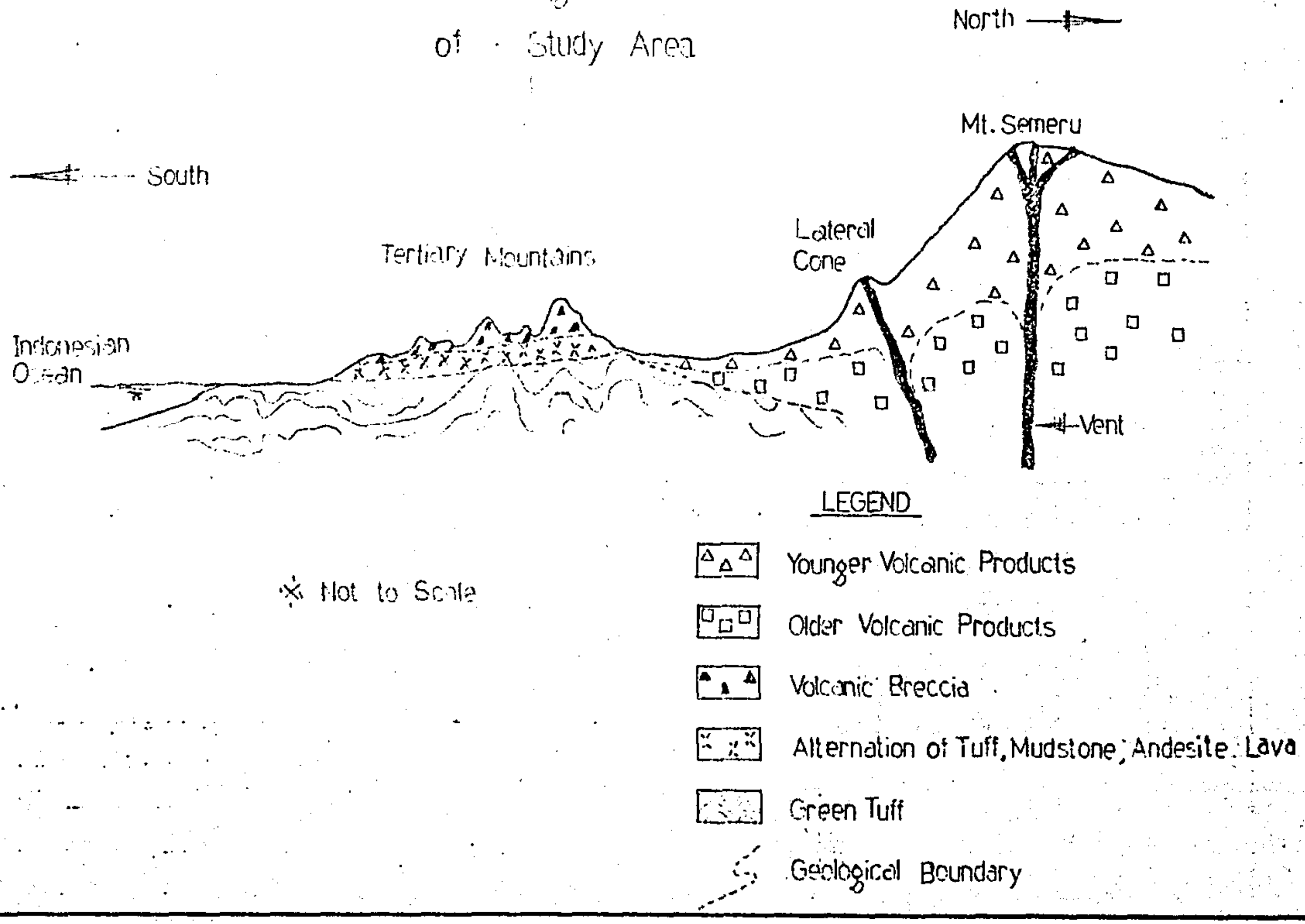


Fig-6.7.2 Geological Map of Study Area

Table-6.7.1 Stratigraphy of study area

Geological age		Formation	Rock Pacies
Quaternary	Holocene	Alluvial deposits	sand, clay, gravel.
		Younger volcanic Products	ash, lappili andesite lava, ledu lahar — younger lahar / Older lahar
	Pleistcene	Older volcanic products	ash, lappilli andesite lahar
Tertiary	Pliocene	Volcanic Breccia	Andesite lava, auto breccia, Volcanic breccia, tuff breccia
		Alternation of tuff, Mudstone and Andesite lava	tuff, tuff breccia, mudstone, andesite
		Limestone	limestone
	Oligocene	Green tuff, Andesite and Liparite	sandstone, tuff breccia Andesite liparite

Fig-6.7.3 Schematic Geological Profile of Study Area



° Limestone Member

The limestone cropped out at the downstream of K. Glidik which runs in the west end of the study area. This member widely distributes in the western area from the study area. The limestone in the study area is chalky, fossiliferous, and porous.

° Alternation Member

The alternation member unconformably overlies the green tuff member. This member consists of the alternation of tuff, tuff breccia, andesite lava and clay. This formation forms a gentle slope because it does not sustain against the weathering.

° Volcanic Breccia Member

This member conformably overlies the alternation member. It mainly consist of volcanic breccia, and some andesite lavas are intercalated within the volcanic breccia. This member is resistant against the erosion, and it shapes precipitous parts in the upper part of mountains.

- : Quarternary System

The Quarternary system in the study area can be subdivided into 3 members, the older volcanic products, the younger volcanic products, and the alluvial deposits.

° Older Volcanic Products Member

These are restricted in distribution in the north eastern and western part of the study area.
The older volcanic products were derived from old quaternary volcanos on the north of Mt. Semeru, that is, R. Kumbolo volcano, R. Hegeolo volcano and so on, these volcanos consist mainly of the pyroclastic rocks which are andesite lavas (partly basaltic), nuées andentes, ladu, lahar deposits, etc. These termes are

explained later. The older volcanic products are commonly compact and the nuées ardentes, ladu and lahar deposits turned their colour into light brown or brown as weathering progresses. The older products form a very steep and high bluffs in the rivers.

- Younger Volcanic Products Member

The younger volcanic products widely spread in the south-eastern slope of Mt. Semeru.
The boundary between the old volcanic products and the younger volcanic products can be assumed along the Besuk Sat in the study area. The topographic shapes of western part from the Besuk Sat and eastern part from the Besuk Sat are greatly different in the mountainous area. In the western part where the older volcanic products are distributed, rivers deeply dissects in the mountainous area. On the contrary, the western part where the younger volcanic prouducts overlies the older volcanic products shows relatively gentle topographic shape.

The younger volcanic products are also composed of andesite lavas (partly basaltic), nuées ardentes, ladu and lahar deposits etc. The lavas are emitted from the crater and the lateral cones which exists at the foot of Mt. Semeru in circular arrangement at approx. EL. 1500 m above sea level.

The lahar deposits of the younger volcanic products furthermore are divided into older lahar deposits and younger lahar deposits. The older lahar deposits are compact and hard. They cropped out narrowly and spottedly along the rivers.
The younger lahar deposits widely covers the older lahar deposits and they are very loose, weak and very soluble to water.

° Alluvial Deposits Member

Alluvial sedimentary deposits widely spread on the Lumajang plain. They are mainly consists of sand and gravels in the mode of unconsolidated and very loose.

iii) Geological Structure of the Study Area

As shwon in a schematic geological profile of the study area, the alternation formation and the volcanic breccia formation gently incline southward (toward the Indonesian Ocean) in general. These formations are gently folded and rarely faulted in some places.

The green tuff formation unconformably underlies the both formations mentioned above. This formation is complicatedly deformed and suffers the alteration to produce the clay, pyrite and so on.

The older volcanic products and the younger volcanic products unconformably cover the Tertiary system.

iv) Classification of Volcanic Products

In this study, the terminology is based on the following classification:

Fig.- 6.7.4 and Fig. - 6.7.5 show 2 types of nuees ardentes and volcanic products.

-: Nuée Ardentes (Avalanche Type)

When the lava flows over the rim of the creater, the tips of the unstable lava flow tongue may be brecciated and collapse.
And, the burning lava blocks will fall down the slope. When falling down, the burning lava blocks break into numerous pyroclastic fragments producing hot sand and

Classification of Volcanic Products

Fig-6.7.4 **Nuées Ardentes of the Avalanche type (lava type)**

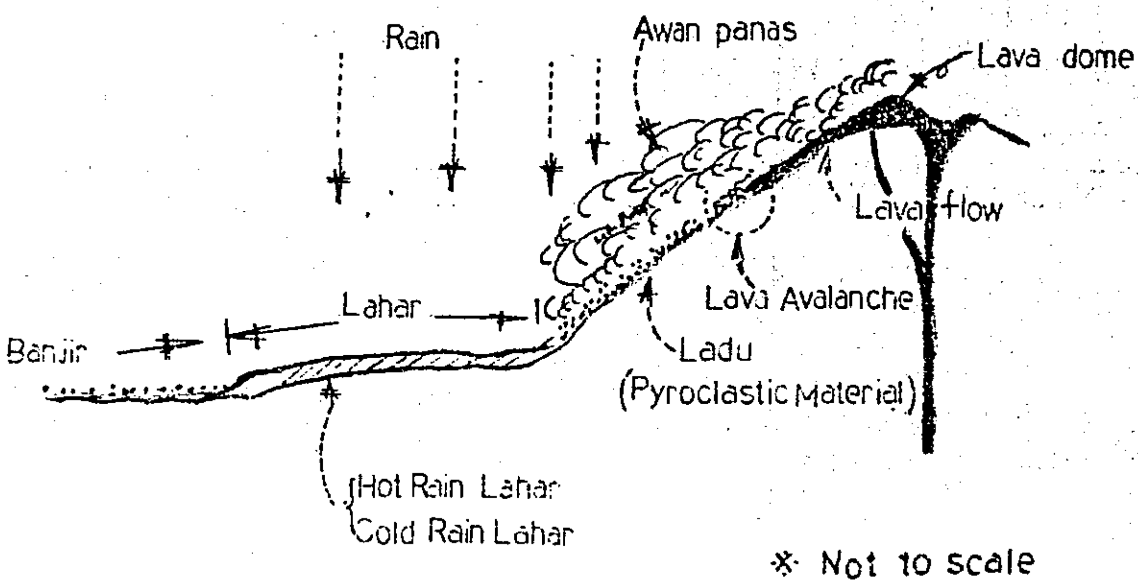
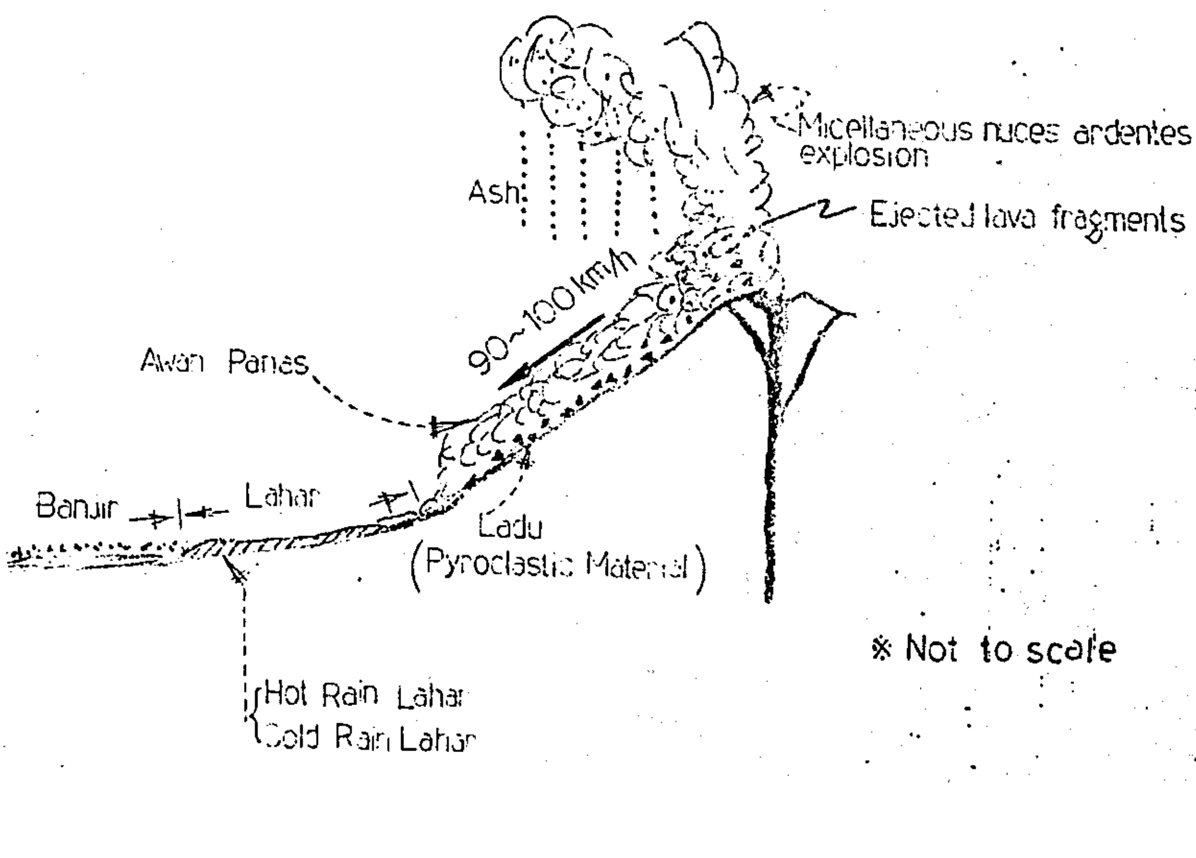


Fig-6.7.5 **Nuées Ardentes of the explosion type (eruption type)**



ash. They will be suspended in the hot air and volcanic gases, and will go down the mountain slope with far high velocity (90-100 km/hour) to reach 4-5 km far from the summit. Also, the relatively coarse hot materials produced from lava avalanche may rush down along the mountain slope with ash. This incandescent flow of volcanic debris is called "ladu" in the Indonesian language.

-: Nuée Ardente (Explosion Type)

The explosion type nuée ardente is directly ejected from the volcano. The composition of this type of nuée ardentes is the same as that of the Avalanche type. However, the difference is that the explosion type is always accompanied with rising cloud of ash. In the explosion type nuée ardentes, "ladu" also accompanies. The travelling distance of this type is usually 6-7 km in the study area and its velocity is 90-100 km/hour.

-: Lahar

When the loose volcanic materials are mixed with water, they may change from solid condition to very dense muddy mass, and descend downstream increasing their velocity.
When the "lahar" is caused by the intense rainfall, it is called "rain lahar".
When the lahar originated from hot volcanic materials is still hot when descending, it is called "hot lahar".

The "lahar" deposits consist of rocks whose sizes range from big rock blocks to pebble-sized gravels and sand whose grain sizes range from coarse sand to silt. They are sediments poorly sorted and not stratified.

-: Banjir

"Banjir" is an Indonesian term meaning floods caused by rains. The flood mainly consists of water containing clay, silt, sand and medium-sized gravels. "Banjir" deposits show clear bedding and lamination.

v) Eruption History of Mt. Semeru.

The data on eruption of Mt. Semeru can date back to 1818. According to the data, the active period and dormant period have been repeated alternately. Even in an active period eruptive phase continued for a few days to a few months.

Table - 6.7.2 shows Mt. Semeru's active and dormant periods since 1818.

vi) Distribution of Semeru Volcanic Materials.

Formerly, Mt. Semeru supplied volcanic materials over older volcanic products around its summit and grew higher and higher. The past eruption are assumed to be not very large judging from certain evidences. Namely, considerably thick ash from Mt. Semeru has not been found, and volcanic bombs and lapilli were not blown off too far, i.e. Their distribution was restricted to the upper of the volcanic slope.

The nuées ardentes and the lava flows have deposits of loose materials. As an important fact, the distribution of these materials is restricted to the south and east slope of Mt. Semeru and borded by the K. Glidik in the east and the Besuk Sat in the west. A more important fact is that the "lahar" and the nuées ardentes were also restricted to above mentioned area. This area generally coincides with the study area.

Table 6.7.2 Periods of activity and dormancy of Mt.Semeru after 1818.

Period of dormancy (years)	Period of activity (years)	number of
1818 - 1829		11
	1829 - 1848	20
1848 - 1856		8
	1856 - 1865	9
1865 - 1872		7
	1872 - 1879	7
1879 - 1885		6
	1885 - 1913	28
1913 - 1941		28
	1941 - 1942	1
1942 - 1945		3
	1945 - 1947	2
1947 - 1950		3
	1950 - 1980	30

The eastern area from the K. Glidik is presumed to be composed of the older volcanic products from Mt. Jambangan and Mt. Tengger in the western area from the Besuk Sat, the wide-spread older volcanic products are prsumed to be the materials from Mt. Tengger.

6.7.3 GEOLOGICAL INVESTIGATION WORKS

The general geological reconnaissance was carried out to make the plan of proceeding geological investigations based on the Inception Report submitted in April, 1982 during from the beginning of May to the end of May.

Based on this reconnaissance results, the following 6 specifications were prepared for the several geological investigation works which would be ordered to the contractors by DPU.

a) Specification of Drilling Works

b) Specification of Seimic Exploration

c) Specification of Electric Sounding

d) Specification of In-situ Permeability Teast

e) Specification of Materials and Soil Characteristics Test

f) Specification of River Materials Characteristics Test

As for the detailed description, the readers are requested to refer to the specifications attached to this report as appendixes.

Table 6.7.3 Schedule Quantity of Geological Investigation

Location	Survey Item		Quantity
Pronojiwo damsite	Field geological survey in Scale 1 : 2,000		Approx. 0,5 km^2
	Drilling		Total 3 holes 80m, Lugeon test 11 times
	Seismic survey		Total 5 lines, 3 km
Gesong damsite	Field geological survey in scale 1 : 5,000		Approx. 0,2 km^2
	Electric Sounding		16 points
Kloposawit sand pocket	Field geological survey in scale 1 : 5,000		Approx. 0,2 km^2
	Electric Sounding		8 points
Kertosari sand pocket	Field geological survey in scale 1 : 5,000		Approx.0,1km^2
	Electric sounding		6 points
Kali Lengkong Fan	Field geological survey in scale 1 : 10,000		Approx. 3 km^2
	Drilling work		Total 7 holes, 50 m
	Electrical sounding		50 points
	In - situ permeability		5 tests
	Field density test		5 tests
	Laboratory material test	Natural water contents	5 tests
		Grain size analysis	5 tests
		Specific gravity	5 tests
Borrow site	Laboratory soil test	Grain size analysis	2 tests
		Natural water contents	2 tests
		Specific gravity	2 tests
		Consistency test	2 tests
		Compaction test	2 tests
		Permeability test	2 tests
Quarry site	Laboratory material test	Natural water contents	5 tests
		Specific gravity	5 tests
		Grain size analysis	5 tests
Whole study area	Aerial photo interpretation, Field geological survey		Approx. 250 km^2

Field Geological Survey ------------------- Total approx 250 km^2
Drilling Work ------------------- Total 10 holes, 130 m
Seismic Exploration ------------------- Total 5 lines, 3 km
Electrical Sounding ------------------- Tatal 80 points
In - situ Permeability Test ------------------- Total 5 tests
Field Density Test ------------------- Total 5 tests
Soil and Material Test ------------------- Total 42 tests

* As for the River Materials Testing, readers are requested to refer to Table 6.7.5.

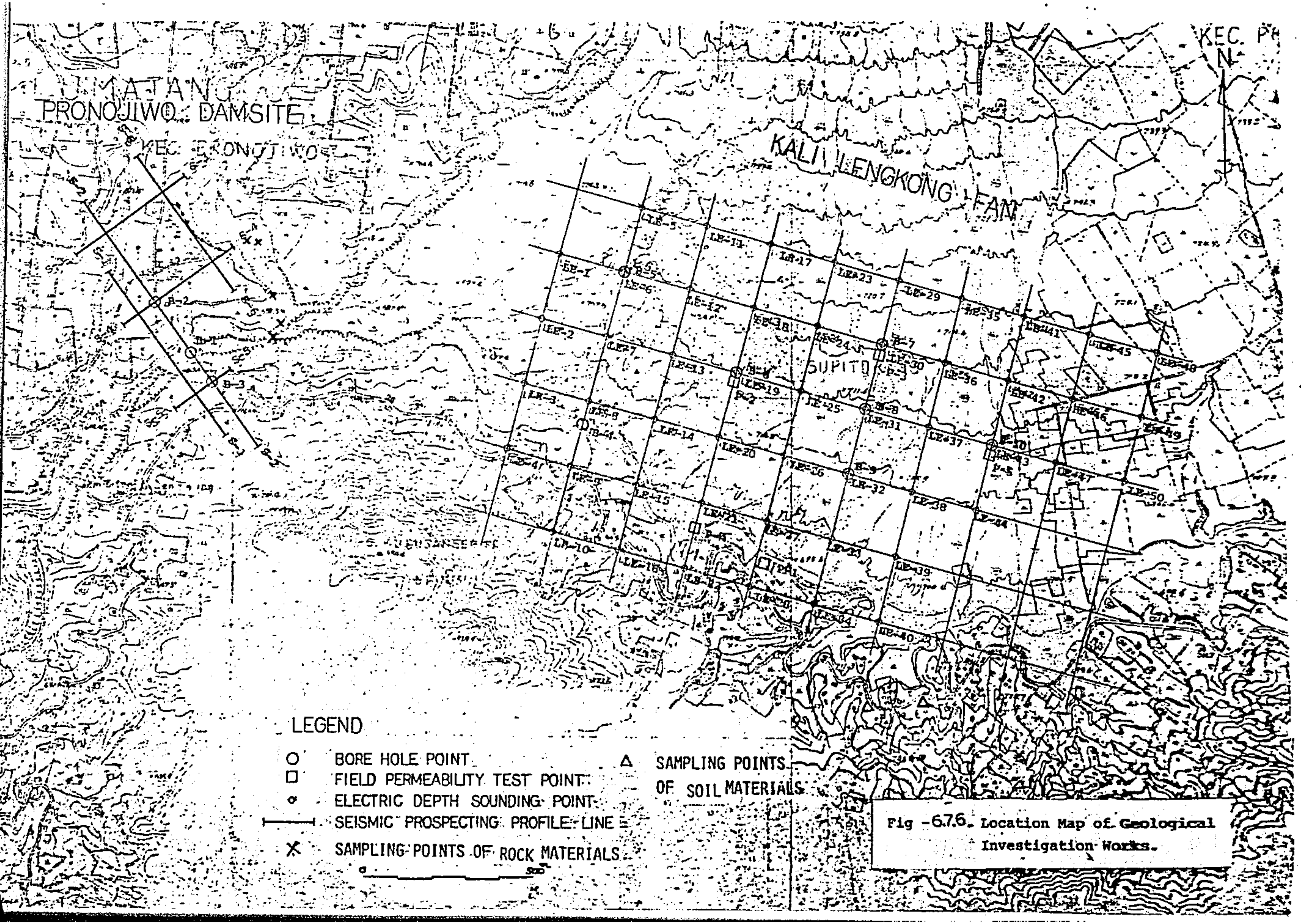
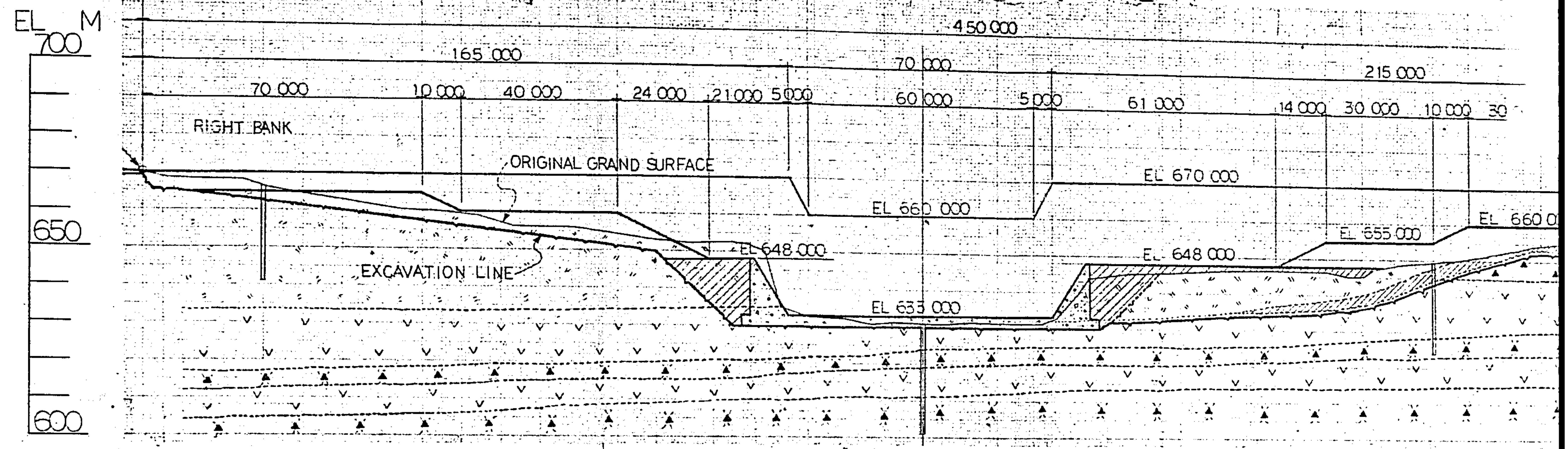


Fig -6.7.6. Location Map of Geological Investigation Works.

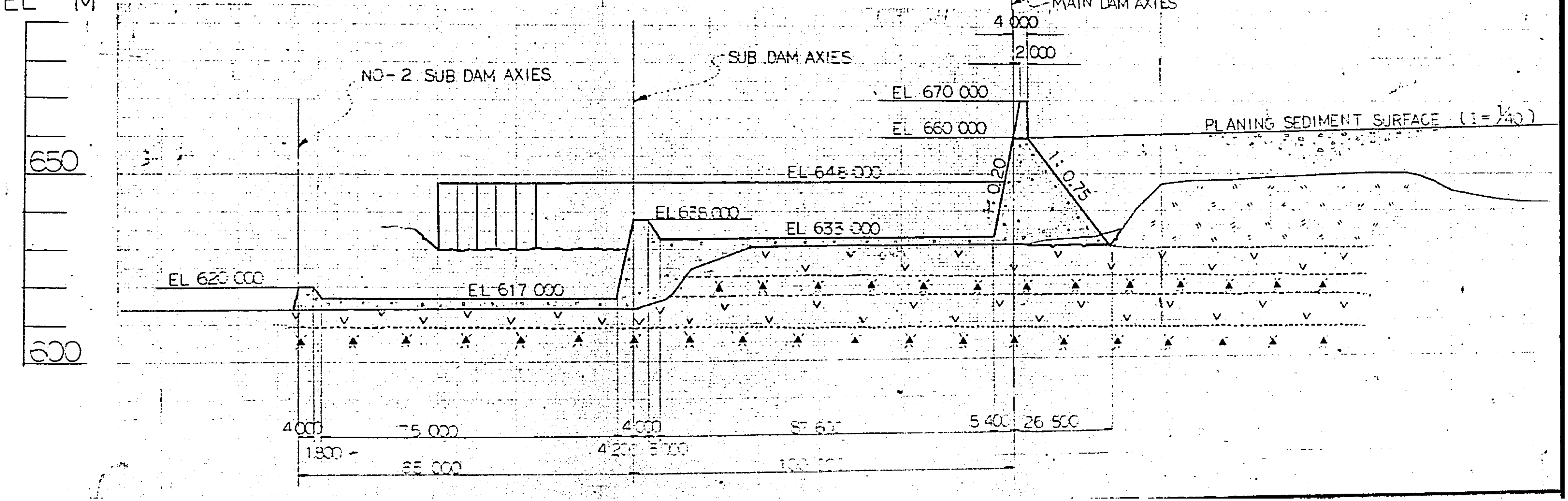
Table-6.7.4 Items of Sscheduled Geological Investigation

Item	Necessity	Methodology	Results	Location
Regional geological survey	General geological information for the scheduled structure's foundation and analysis of each catchment basin's characteristics.	Aerial photo - interpretation. Field geological survey in scale 1 : 50,000.	Regional geological map covering whole project area and profiles in scale 1 : 50,000.	Whole study area.
Hydrogeological survey	Assessing the potential water utilization volume of Kali Lengkong Fan.	Drilling works. Electric Sounding. In - situ permeability test. Field geological survey in scale 1 : 10,000.	Hydrogeological model of Kali Lengkong Fan.	Kali Lengkong Fan.
Engineering geology of the foundation	Planning and designing of structures	Drilling work. Seismic exploration. Electric Sounding. Field geological survey	Engineering geological maps and profiles of scheduled structure sites.	Pronojiwo dam site. Gesong damsite Kloposawit Sand pocket. Kertasari Sand pocket.
Materials and soil charae teristics testing.	Quarry and Borrow Plan. Sabo plan. Material characteristics of Kali Lengkong fan for hydrogeological analysis.	Laborat ry material test. Laboratory Soil Test. Field density test.	Quality of quarry, borrow and river materials. Relationship between Permeability and material characteristics.	Surrounding area of Pronojiwo damsite. Kali Lengkong Fan. Kali Mujur, Kali Rejali.

PROFIL ALONG AXIS OF DAM (DOWNSTREAM)



TIPICAL CROSS SECTION



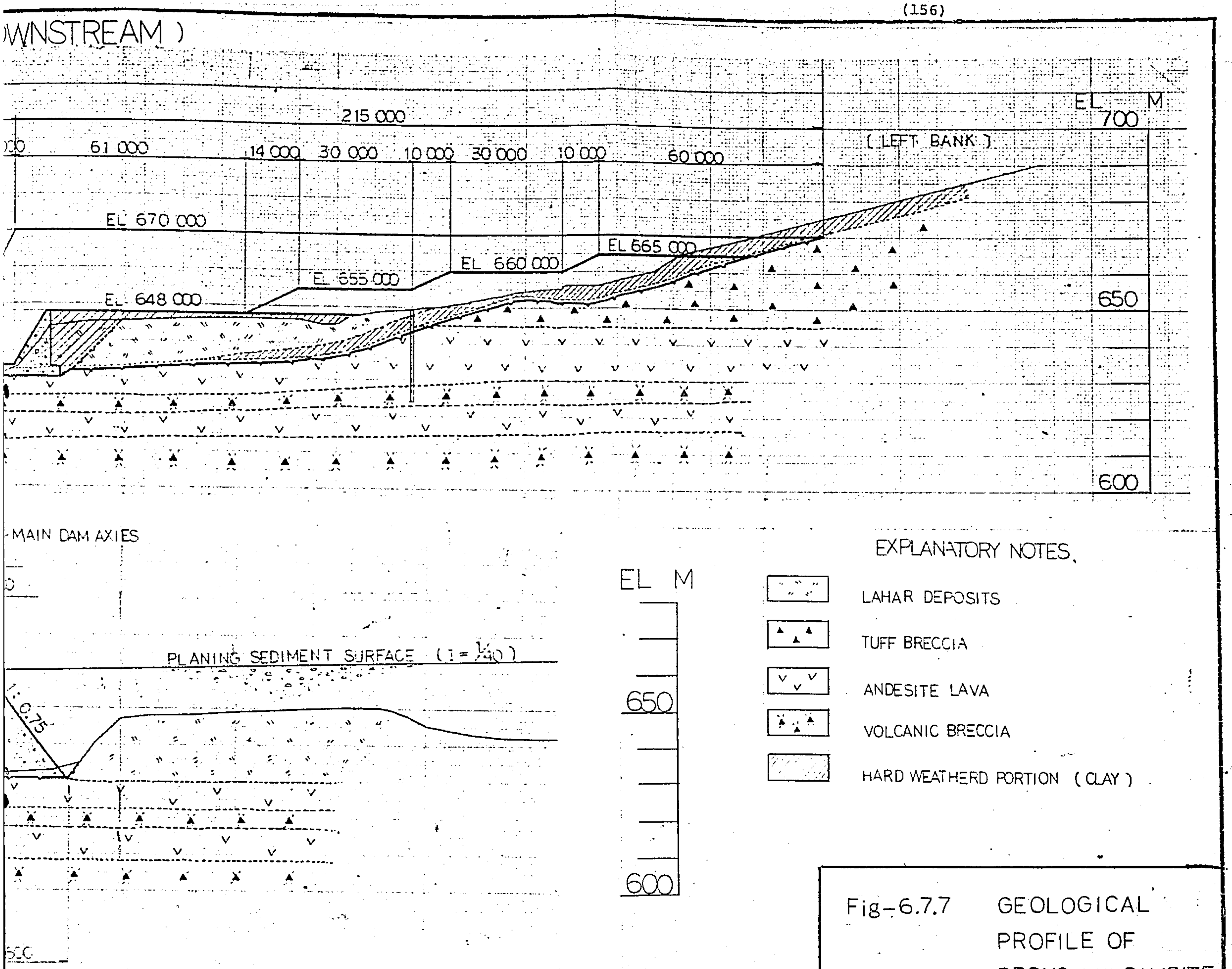


Fig-6.7.7 GEOLOGICAL PROFILE OF PRONOJIWO DAMSITE
S=1:1000

The items, necessities, methodology, these results and locations of geological investigations are arranged in Table-6.7.3. These quantities in each survey site are briefly given in Table-6.7.4 and the locations of the geological investigation works are shown in Fig.-6.7.2 and Fig.-6.7.6.

As mentioned above, the geological investigation plan was prepared on the beginning of June and the actual works are in process now.

The progress of each investigation work up to now (the end of August) and site condition based on the present data will be described in following items.

(1) Regional Field Geological Survey

The results of regional field geological survey are discussed in detail in Item 6.7.2.

The progress of the regional geological survey is judged to be completed by 90% at the end of August. From now on, the supplementary geological field survey will be done on the peculier points which is detected by the aerial photo interpretation.

(2) Pronojiwo Damsite

i) Topography and Geology

-: Topography

Pronojiwo damsite is located in the middle reaches of the K. Lengkong and this point is the junction of the K. Lengkong and the Besuk Sat.

The width of the K. Lengkong in the damsite is about 70 m and the bluff's relative height is 10-15 m on both banks. About 80 m downstream from the dam axis, the water height drops by about 15 m because of a waterfall, and the K. Lengkong is dissected to form a deep and steep valley on the downstream side of the waterfall.

The left bank of the damsite is situated at the foot of Mt. Kukusanseriti. In this location, deep valleys do not exist. The left bank is judged to have no important topographical problem as the dam foundation which is 30-40 m high.

The right bank of the damsite forms a gentle hill slope increasing its elevation toward Mt. Semeru's summit. The right bank is dissected deeply by the Besuk Bang in the upper reaches and the K. Urung Urung in the down reaches. As the distance between the 2 rivers is short, the right bank consists of a thin mountain ridge.

Topographically, the thin ridge forming the right bank renders a topographical problem, and it will be assumed to be one of the important factors for the dam designing.

-: Geology

Based on the data obtained from the 2 boreholdes (B-1 & B-2) and geological field survey, the geological porfiles as indicated in Fig.-6.7.7. has been made.

The bedrock of Pronojiwo damsite consists of the alternating andesite lava and volcanic breccia. The older and the younger lahar deposits, ladu and talus deposits cover the bedrock. The andesite lava is exposed in the riverbed.

The fault or fractured zone cannot be found in the damsite and the alternation inclined very gently in parallel with the riverbed.

The thickness of the andesite lava which crops out in the riverbed is 6-10 m, and volcanic breccia lies under the andesite lava.

The lahar deposits on the left bank seem to be thin and narrowly distributed. However, on the right bank, thick lahar deposits accumulate widely. According to the B-2 hole data, the boundary plain between the lahar deposits and the andesite lava is more or less horizontal as shown in Fig.-6.7.7.

The lahar deposits and the ladu in the damsite can be judged to possess almost the same nature geotechnically.

There are geological problems as follows:

a) Whether the shearing strength (τ_0) and the thickness of the andesite lava in the riverbed are sufficient to bear the concrete dam body with 30-40 m high or not,

b) Whether or not the shearing strength (τ_0) of the boundary between the andesite lava and the volcanic breccia is sufficient to bear the concrete dam body with 30-40 m in height.

c) Whether or not the bearing strength is sufficient to bear the large structure.

The shearing strength of the andesite lava is assumed to be more than τ_o = 120 tons/m2. And, the boundary between the andesite lava and the volcanic breccia is assumed to be at least τ_o = 30-50 tons/m2 as the result of field observation.

The lahar deposits are not assumed to be strong enough to bear the structure of more than 15 m in height, because the lahar deposits consist of loose sand and gravels.

ii) Progress of the Investigation Works

In Pronojiwo damsite, the 30-35 m high consolidation dam has been planned and the following geological investigation works were scheduled:

- Geological field survey
- Drilling
- Seismic exploration

-: Geological Field Survey

The geological mapping work (Scale: 1/2,000) will be done in September, 1982 by an Indonesian contractor under the supervision of DPU staff members and JICA Study Team members. The JICA Study Team are giving technical instructions and advises through the DPU staff members to the contractor.

-: Drilling Work

The 3 boreholes were planned in Pronojiwo damsite. Packer tests were also scheduled in the 3 boreholes. The boreholes B-1 and B-2 have been completed in 1 borehole, B-3 was being drilled at the end of August.

The location of the boreholes were changed according to the change of dam design, and the changed locations are shown in Fig.-6.7.6. The B-1 hole was deepened by 10 m because the lahar deposits were very thick.

The drilling work in Pronojiwo damsite will be finished until the beginning of September.

-: Seismic Exploration

Seismic exploration (Total: 3 km, 6 exploration lines) was scheduled in Pronojiwo damsite. The arrangement of the exploration lines was adjusted according to the revision of dam designing as shown in Fig.-6.7.6. The S-2 line indicated in Fig.-6.7.7. is almost identical with the dam axis. At the end of August, the exploration of S-1, S-3, S-4, and S-6 (Total: 1.9 km, 4 lines) has been completed. On the S-2 line, the work is still in process.

The seismic exploration work in Pronojiwo damsite will be completed in the beginning of September, and the analysis will be finished until the end of September.

(3) Gesang Consolidation Dam & Sand Pockets in Kloposawit & Kertosari

The 3 sites -- Gesang consolidation dam, Kloposawit Sand Pocket and Kertosari Sand Pocket are located in upper and middle reaches of the K. Mujur -- which suffered the lahar disaster of 1981.

The purposes of the geological investigation are to assume the depth of the compact and older lahar deposits' surface and ground water condition in the loose and younger lahar deposits.

i) Topography & Geology

\- Topography

The area surrounding these 3 sites is very gently inclined south-east ward.

-: Geology

The geology of the 3 sites are composed of the relatively compact and older lahar deposits as the basement, and the loose and younger lahar deposits as overburden. The older lahar deposits are exposed on both flanks of the river and spotedly exposed on the riverbed as outcrops.

The more detailed geological analysis will be done based on the results of the electrical sounding.

(4) K. Lengkong Fan

K. Lengkong Fan is situated on the southern slope of Mt. Semeru and this area suffered the 1978 disaster.

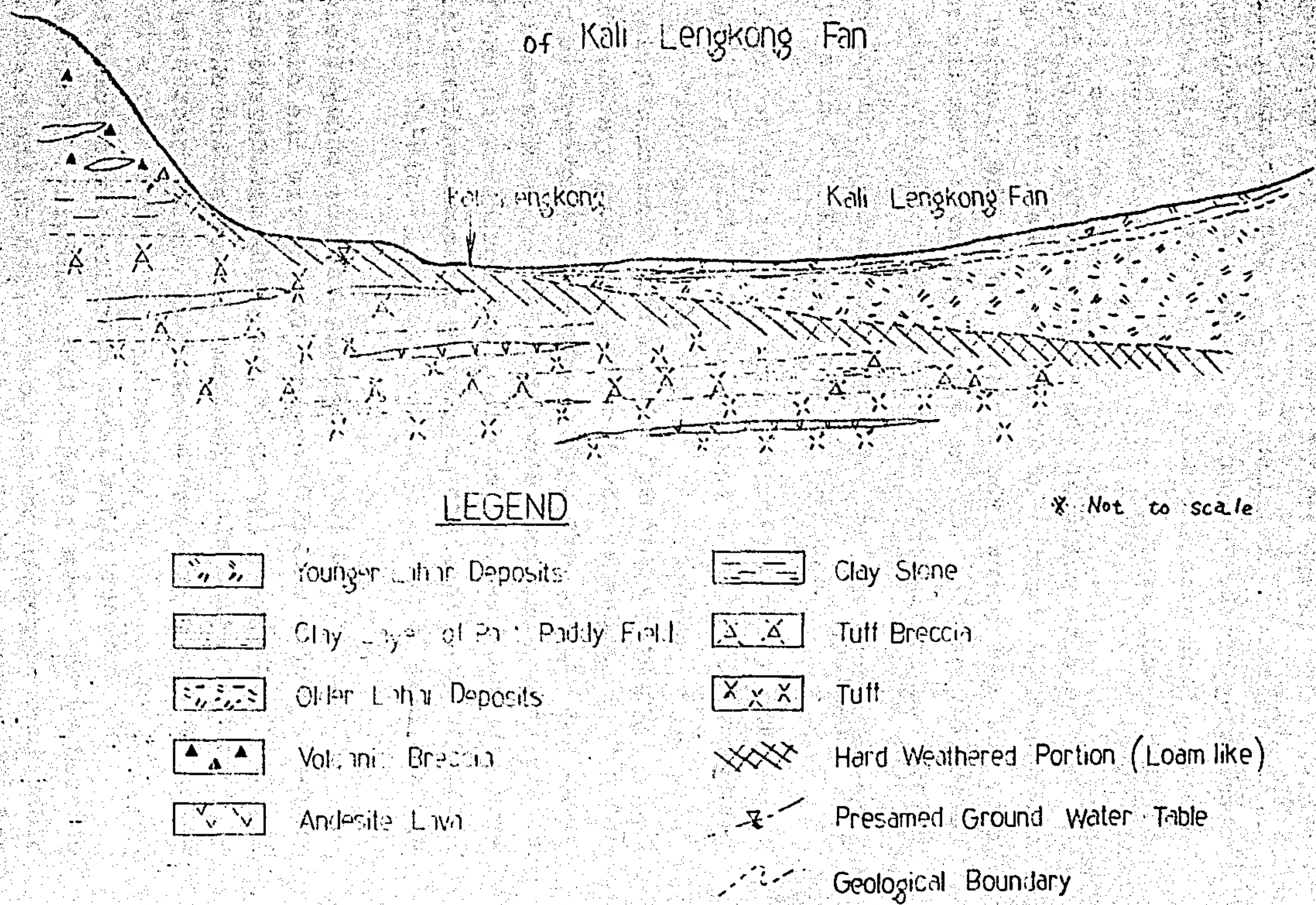
Along the K. Lengkong Fan, the consolidation dam whose height is nearly 10 m is scheduled to be constructed at Tumpak Nanas. The main goal of Tumpak Nanas consolidation dam is to store the volcanic products from Mt. Semeru and to stabilize the riverbed.

As the next step, water is planned to be taken from the reservoir area and K. Lengkong Fan. The water will be reserved in the dam reservoir as pore water among the volcanic material particles. When the water level in the reservoir will go down, the ground water in Kali Lengkong Fan will flow into the reservoir. Thus, not only the reservoir but also Kali Lengkong Fan can be used as water resources by constructing Tumpak Nanas Dam.

i) Topography and Geology

-: Topography

Fig-6.7.8 Schematic Geological Profile of Kali Lengkong Fan



Kali Lengkong Fan with the gentle slope is located in the southern slope of Mt. Semeru's mountain foot as shown in Fig.-6.7.2. In the toe of the fan, the Kali Lengkong runs in the westward direction, and the steep mountain range consisting of the Tertiary volcanic rocks is located in the opposite bank side extending in the east-west direction forming a wide arc.

The nick point of the Kali Lengkong can be found at the scheduled damsite of Tumpak Nanas Dam. In the upstream from the nick point, the inclination of the riverbed is relatively gentle. On the downstream side from the nick point, the inclination of the riverbed abruptly goes steeper.

-: Geology

The field geological survey gives the geological preassumption of Kali Lengkong Fan as shown in Fig.-6.7.8.

The hard weathered alternation formation (clay, tuff, and partial andesite lava) of the Tertiary system, which crops out on the left bank of the Kali Lengkong, is presumed to lie under the lahar deposits (fine-to-coarse sand mixed with pebbles, gravels, cobbles, and boulders) in the Kali Lengkong Fan. The hard weathered alternation formation appears like "loam".

According to local information, the paddy field spreaded widely on Kali Lengkong Fan before the disasters. Therefore, the clay layers of the paddy fields are assumed to be intercalated with the lahar deposits, and one of these layers occurs on the eastern area of the Project Site.

The compact older lahar deposits are assumed to be covered by the loose younger lahar deposits. However, the older lahar deposits are not outcropped on the electric sounding and the drilling site.

As mentioned above, the geology of Kali Lengkong Fan is presumed to be composed of 4 layers which are hard weathered loam-like alternation formation of Tertiary system, older lahar deposits, clay layers of past paddy fields, and younger lahar deposits.

The more detailed geological condition of Kali Lengkong Fan will be made clear after the completion of the geological investigation works.

ii) Progress of the Investigation Works

The several geological investigation works were planned to obtain the hydrogeological data for the ground water analysis in Kali Lengkong Fan as follows:

Item	Quantity
- Field geological survey	Approx. 3 km
- Borehole	Total 7 holes, 50 m
- Electric sounding	50 points
- In-situ permeability test	5 tests
- Material test	5 tests

The locations of the geological investigation works are shown in Fig.-6.7.2 and Fig.-6.7.6.

-: Field Geological Survey

The geological mapping work (in scale 1:10,000) has not yet been done by the Indonesian contractor. This work will be carried out in September. The JICA team member will give the instruction and advise to DPU staff members.

-: Drilling Work

The drilling work has not started at present (the end of August) in Kali Lengkong Fan. It will be commenced from the beginning of September and completed at the middle of September. Each boreholes will be completed at the piezometric observation well with the hole protection work.

-: Electric Sounding

The electric sounding is in process in the Kali Lengkong Fan. The field work of the electric sounding will be finished by the mid September, and the results of the analysis will be submitted by the end of September by the Indonesian contractor.

The electric sounding data will be useful for hydro-geological analysis covering ground water table, distribution of previous and unprevious layers, etc.

-: In-situ Permeability Test

In-situ permeability tests were conducted in 5 test pits during the period 19-30 July, 1982 on the following materials:

Test Pit	Materials
P-2, P-3	Lahar deposits (sand and gravels)
P-1, P-4	Weathered portion of bedrock (reddish brown clay)
P-5	Dark brown stiff clay of old paddy field

The test results are as follows:

Material	Permeability Coefficient K
Lahar deposits	5×10^{-4} cm/sec.
Weathered bedrock, Clay	8×10^{-3} cm/sec. (2×10^{-3} cm/sec.)
Clay of old paddy field	8×10^{-5} cm/sec.

As for the testing method in the lahar deposits and the old paddy-field clay, the constant head method was applied. In the weathered bedrock, both the constant head and the ground water recovery method were applied. The bracketed K value was gainged with the ground water recovery method, and this test was conducted on 23 and 24 August as an on-the-job training for DPU staffers.

The test results should be reconsidered together with the material test results.

-: Material Test

The field density test and laboratory material tests (grain size analysis, natural water contents test, and specific gravity test) will be done in parallel with the in-situ permeability test.

The purpose of these tests is to study the relation between the permeability and the material characteristics, such as void ratio, porosity, grain size distribution, etc.

The samples were taken from each in-situ permeability test pits and the laboratory testing are in progress now.

The test results will be submitted by the mid September by the Indonesian contractor.

(5) Materials and Soil Characteristics Testing

The materials and soil characteristics testing have 3 objectives as follows:

a. Soil characteristics testing for borrow planning,

b. Aggregate characteristics testing for quarry planning,

c. River material characteristics testing for the sediment flow analysis.

i) Soil Characteristics Testing

The soil samples were taken from the 2 locations in the foot of the mountain range of Tertiary system which is located on the opposite side of Kali Lengkong Fan.

The samples were the hard weathered portion of the Tertiary rock or talus deposits composed of brown, very fine, soft clay without gravels and they look like loam.

The testing items are as follows:

Item	Quantity
Grain size analysis	2 tests
Natural water contents test	2 tests
Specific gravity test	2 tests
Consistency test	2 tests
Compaction test	2 tests
Permeability test	2 tests

The laboratory tests are in progress now and the testing results will be submitted by the mid September by the Indonesian contractor.

ii) Aggregate Characteristics Testing

Aggregate characteristics testing is carried out in order to obtain information on rock material qualities for quarry planning.

The test samples were taken from 5 points located around the junction of the K. Lengkong and the Besuk Sat. Three samples of younger lahar deposits, 1 sample of older lahar deposits, and 1 sample of river deposits were taken.

The testing items are as follows:

Item	Quantity
Natural water contents test	5 tests
Specific gravity test	5 tests
Grain size analysis	5 tests

The testing is in progress and the testing results will be known by the mid September.

iii). River Material Characteristics Testing

The purpose of this testings is to find information on characteristics of river materials taken from the K. Mujur and the K. Rejali for the sediment flow analysis.

The testing items and quantity are shown in Table - 6.7.5.

The laboratory testings have not been completed yet now (the end of August) and the results of test will be known by the middle of September.

Table-6.7.5 Testing Items and Quantity of The River Materials Tests

River Name	Point No.	Quantity of Tests			
		Grain size	Specific gravity	Field dens. test	Grain size by photo
Kali Mujur	1	2	-	-	5-10 photo pieces
	2	2	-	-	"
	4	2	-	-	"
	5	2	-	-	"
	7	2	-	-	"
	8	2	-	-	"
Kali Rejali	3	2	2	2	"
	1	2	-	-	"
	5	2	-	-	"
	7	2	-	-	"
	8	2	2	2	"
	10	2	2	2	"
Total	12	24	6	6	60-120

6.8 DISASTER AND TOPOGRAPHICAL INVESTIGATION

K. IKEDA

6.8.1 INTRODUCTION

(1) Topography

Mt. Semeru (3,676 m), is located on about 100 km south east of Surabaya City and 30 km west of Lumajang City (the E. long 113° and S. Lati. 8°). The investigation covers an area of approximately 730 km2 on the south and south east slopes of Mt. Semeru (Fig. - 6.8.1).

Mt. Semeru, one of the most active volcanoes in Indonesia, is a volcanologically very young Quaternary stratovolcano forming a part of a volcanic row which runs from north to south. This volcanic row is divided into 3 morphological units (A. SAKAI, I. SURYO, 1980).
They are from north to south:

① The Tengget Mountain Range
② The Jambangan Volcano Complex
③ The Semeru Volcano

The Semeru volcano is the youngest and formed on the south slope of the Jambangan Volcano complex of the oldest. Among these volcanos, Mt. Semeru and Mt. Bromo situated in the Tengget caldera are still active.

The Semeru volcano has been active for decades. An active crater in the south of Mahameru an old crater forming the summit of Mt. Semeru is called Jonggring Seloko Crater. The magma, which formerly came out through Mahameru Crater has been shifting its exit southwards and now blows out from Jonggring Seloko Crater.

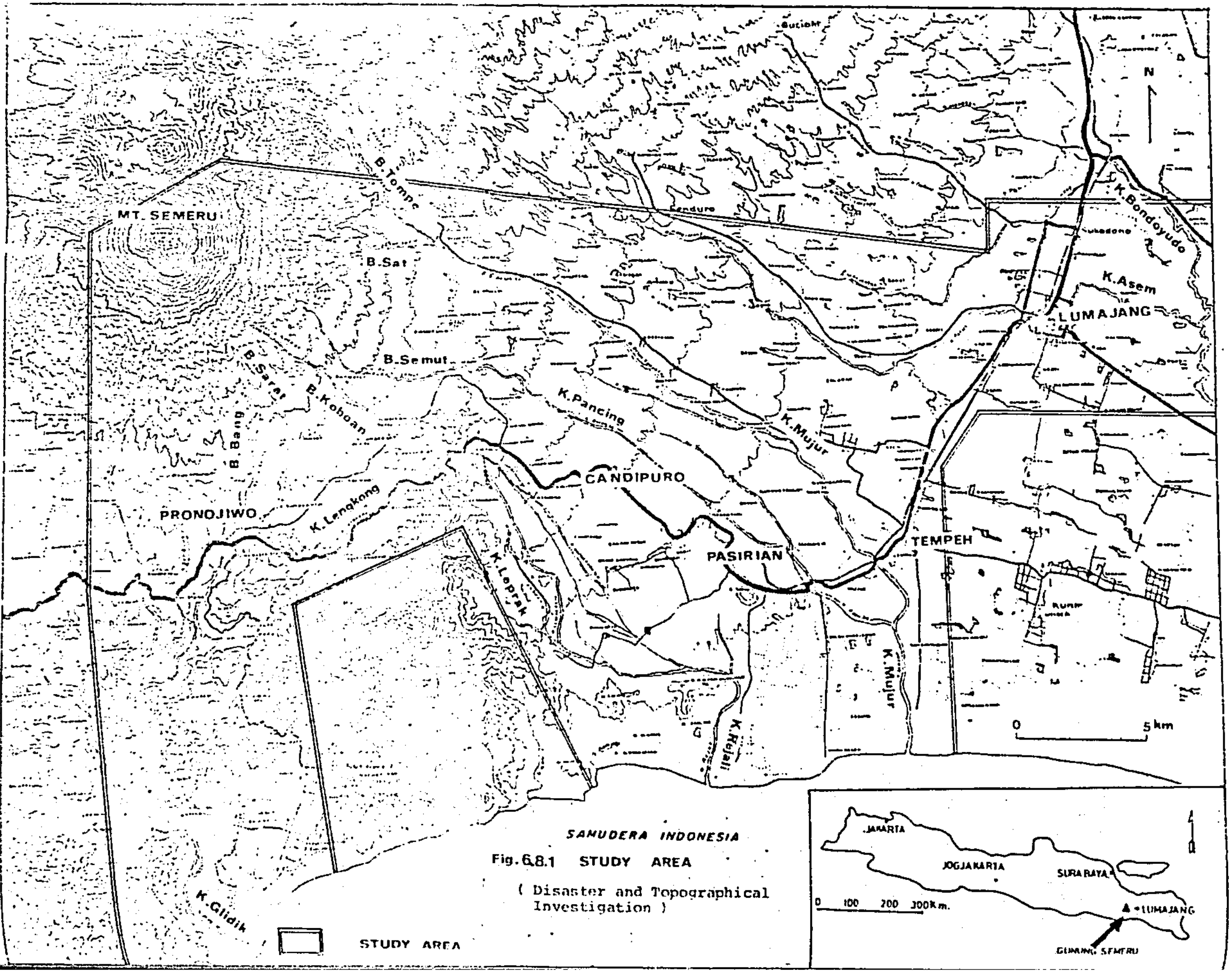


Fig. 6.8.1 STUDY AREA

(Disaster and Topographical Investigation)

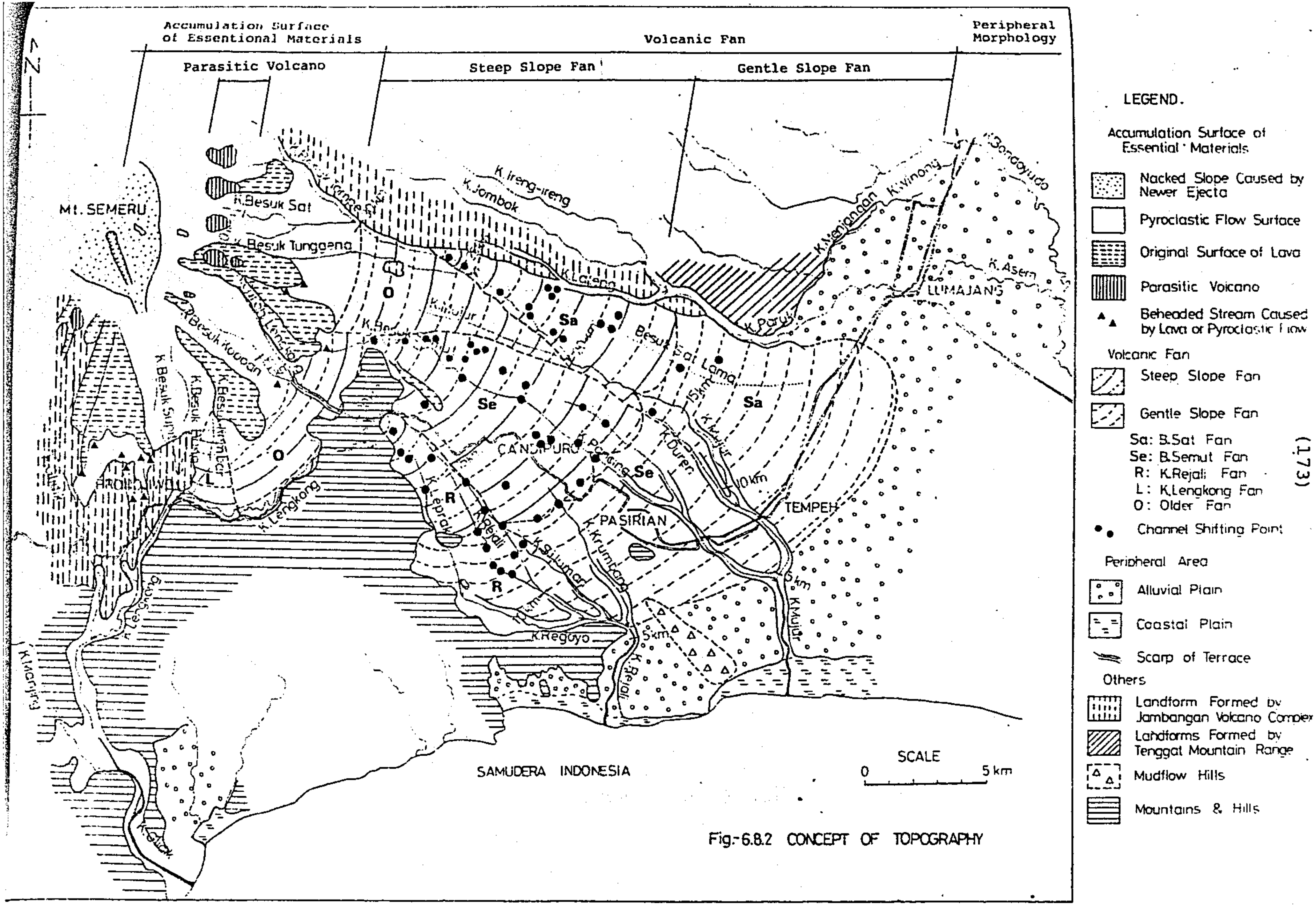


Fig.-6.8.2 CONCEPT OF TOPOGRAPHY

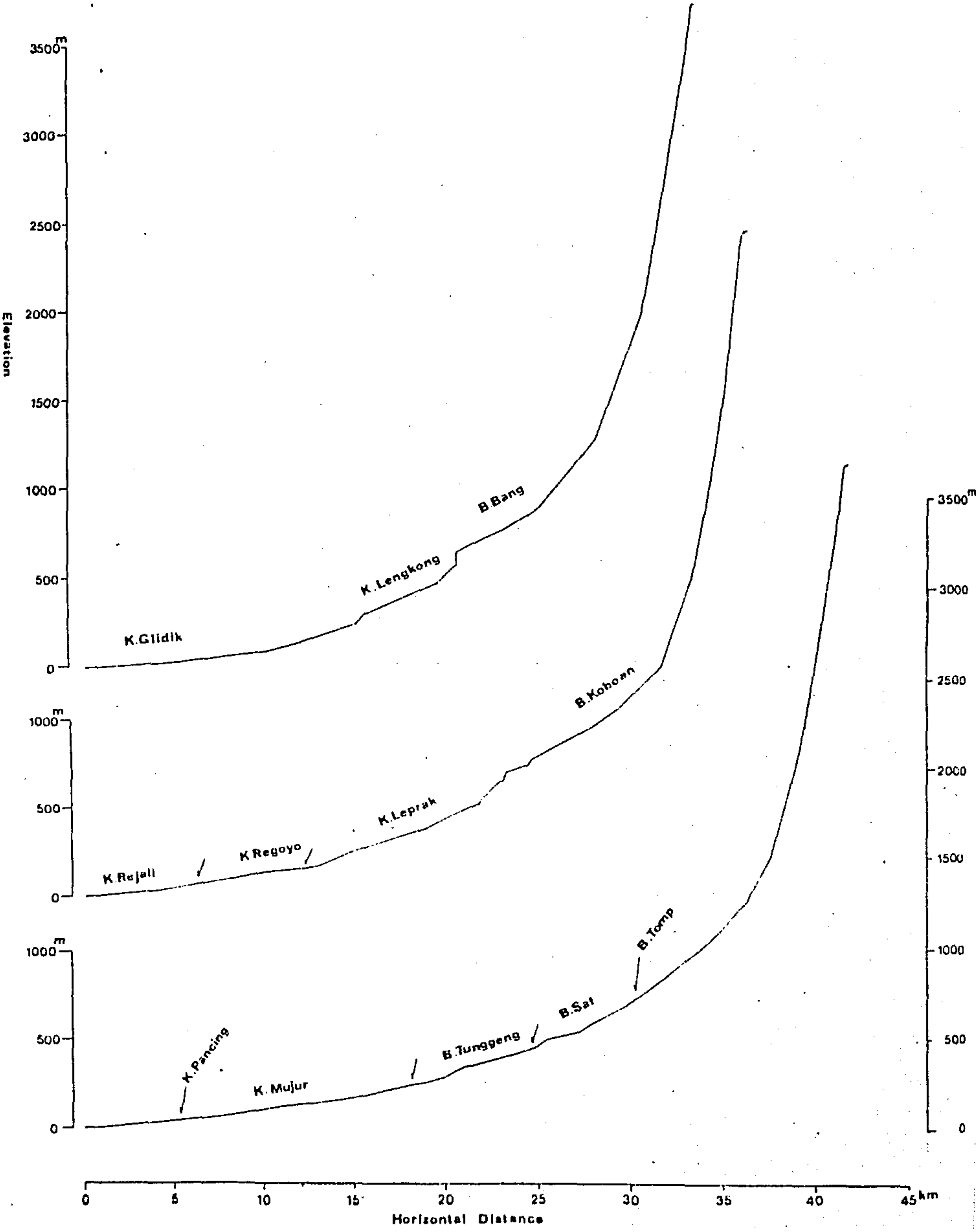


Fig. 6.8.3 CONCEPT OF LONGITUDINAL CROSS SECTIONS ALONG MAIN RIVERS

It is considered that Semeru Volcano overlaps the Jambangan basement which is exposed in some mountain ridge on the west slope of Mt. Semeru.

Many rivers flowing down radially from south to east dissect Mt. Semeru's body. Three main rivers, the K. Mujur, K. Rejali and K. Glidik River, flow into the Indonesian Ocean. The B. Tompe, B. Sat, B. Tunggeng, K. Poh and K. Duren are tributaries of the K. Mujur. The K. Curah Lengkong, B. Kobo'an, K. Leprak, K. Regoyo and K. Siluman are the tributaries of the K. Rejali. The K. Lengkong, B. Sarat, B. Kembar, B. Bang, B. Supit, K. Bening, B. Cukit and K. Manjing are the tributaries of the K. Glidik.

The K. Mujur and the K. Rejali flow down to south-east and form an extensive volcanic piedmont slope which reaches Lumajang City and Indonesian Ocean. The southern tertiary hills prevent the further development of the piedmont slope in the direction of south, where K. Glidik flows down. To the north, the Mt. Semeru's slope goes over the Jambangan Volcano complex at a height of 2,600 m above the sea level.

The investigation area in the direction of east and south-east can be divided into 3 parts as shown in Fig. - 6.8.2 according to its geomorphological characteristics.

All areas are described in detail as follows:

(a) Main Part of the Cone

1) Upper part

This area is higher than 2,100 - 3,000 m, and is always affected directly by the present volcanic activity accompanied with ejecta.

Therefore, the vegetation boundary is about 2,100 - 3,000 m high. Average inclination is more than 33 degrees.

2) Lower Part

This area is located in the range of the elevation 1,000 m - 2,500 m and covered with forests. Many tributaries in the form of gully or gorge dissect the volcanic body in this area. This area is also morphologically characterized by the existence of parasitic volcano and deposit of lava flow on pyroclastics flow.

Average inclination is between about 10° in the lower part and 30° in the upper part.

(b) The Volcanic Piedmont Slope

This area is from 50 m to 1,000 m and divided into three zones according to their inclination of slopes and geomorphological characteristics. This area develops in the direction of east and south-east extensively.

- Steep Slope of Volcanic Fan:

The upper part is from 200 m to 1000 m and characterized as steep slope volcanic fan which mainly consists of lahar deposits. The inclination of this area is about 2.5°.

- Gentle Slope of Volcanic Fan:

This zone is between 50 m and 200 m which is characterized as gentle slope volcanic fan which also consists mainly of lahar deposits. The inclination of this area is about 1°.

(c) Peripheral Area:

- Peripheral Area:

This part is characterized as peripheral area of volcano whose height is between 20 m and 50 m. This part has become low terrace along the main river as the results of fluvial erosion.

- Alluvial Plain:

This part has been formed on the outlying area of the volcanic piedmont slope and is divided into the following three parts:

. Alluvial plain along K. Bondoyudo:
. Valley bottom plain along K. Glidik:
. Coastal Plain:

The investigation area along K. Glidik lacks the marked topographical characteristics because of K. Glidik dissects tertiary mountainous area deeply until the river mouth. This area is characterized by the deep valleys, steep valley wall and narrow valley bottom plain.

(2) Problems

The investigation area incurred violent disaster due to some types of volcanic activities and volcanic debris flow. Generally, violent disaster caused by volcanic activities and volcanic debris flow are divided into 2 types by Indonesian people. The first type is called nuée ardente, the second type is Lahar or Banjir.

Nuée ardente occurs as the result of eruption. Lahar or Banjir as the result of heavy rainfall which comes of land slide. Generally, lahar includes more boulders and gravels than Banjir. However, there is no clear distinction between them.

(3) Objectives of Study

The purpose of this study is to determine the geomorphological land conditions in order to forecast the area exposed to the danger of debris flow and to design the facilities to control sediment and erosion.

The main work of this study is to understand the landform in order to estimate the dangerous area and design the Sabo facilities.

(4) Method and Work Process

In order to seize the geomorphological characteristics and the relationship between the landforms and the disaster area, aero-photo interpretation and field survey were carried out. The aero-photographs taken by EXSA in July 1981 (after disaster in May 1981) was used. The aero-photo interpretation was carried out with field survey to prepare the main field survey. In the field survey, the observation of topography and outcrops were carried out. After that, a landform classification map was prepared.

About disaster study, preliminary aero-photo interpretation was carried out. After that field survey by questionnaire was carried out. On the basis of this study, the existing data about disaster area was partly revised and the consideration of the relation between the past disaster areas and landform classification was carried out.

From these studies, the possible disaster area map was prepared.

The questionnaire is shown in Table - 6.8.1.

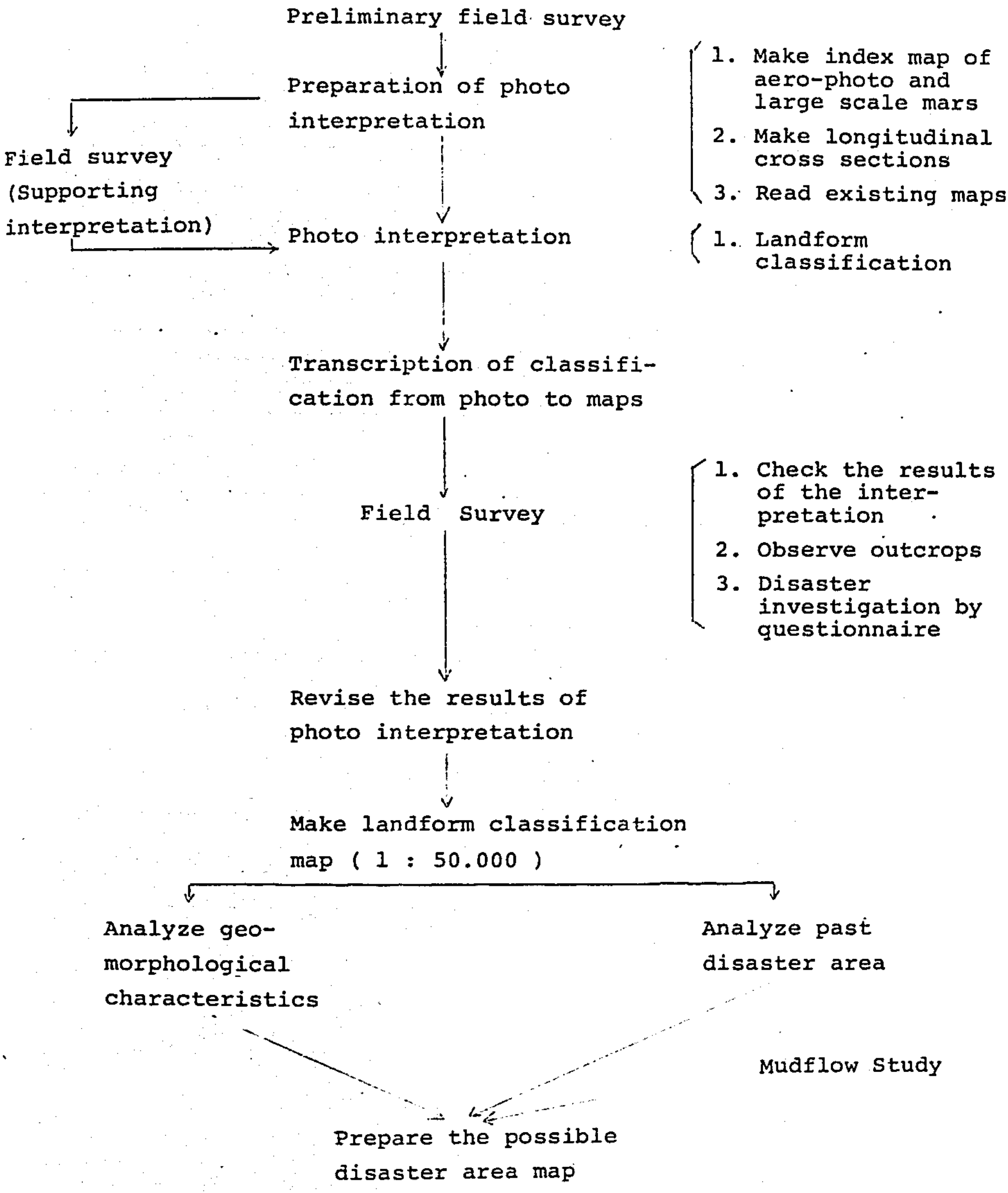


Fig. - 6.8.4 Work Process

Table - 6.8.1 Questionnaire on Past Disaster

Date/Month/Year			Name of Surveyor			
Name of Village						
Respondent	Men/Women	Age	How Long Have You Been Living Here			
Did You Ever Experience Lahar	Ever Never		Did Your Village Ever Attack By Lahar Before Your Born		Yes No	
Did You Ever Experience Floods	Ever Never		Did Your Village Ever Attack By Floods Before Your Born		Yes No	
Occurrence Of Lahars And Floods	Deposit Depth	Composition	Water Height	Losses		
				Household	Person	
Date/Month/Year. How Many Years Ago	M.	Clay, Sand Gravels, Stones	M.			
		Clay, Sand Gravels, Stones	M.			
		Clay, Sand Gravels, Stones	M.			
		Clay, Sand Gravels, Stones	M.			
Losses in 1981	Some Losses None	Date/Month/Time	Deposit Depth	M.		

6.8.2 GEOMORPHOLOGICAL STUDY

(1) Landform Classification

The landform classification map was prepared using a base map of 1 / 50,000 scale. Aero-photo interpretation techniques and field survey are employed for this study.

Geomorphological units and their explanations used in this map are described as follows:

(a) Items of Geomorphological Classification

① Mountains and hills consisting of tertiary rokcs

② Landforms formed by the Jambangan Volcano complex

ⓐ Dissected volcanic piedmont and volcanic slope
ⓑ Mudflow hills

③ Landforms formed by the Tenggat Mountain Range

ⓐ Dissected volcanic piedmont

④ Landforms formed by the Semeru Volcano

ⓐ Accumulation surface of essential materials
- Original surface of lava
- Pyroclastic flow surface
- Parasitic volcano
- Naked slope formed by newer ejecta and gully erosion.

ⓑ Landforms formed by volcanic activities
- Crater wall (Jonggring Seloko crater)
- Former crater wall
- Crater wall on the parasitic volcano

ⓒ Landforms formed by epigenetic processes
- Wall and floor of erosional valley
  . The valley which is certainly influenced directly by eruption at main crater.
  . The valley which may be directly influenced

by eruption at main crater.
. The valley which is rarefly influenced by eruption at main crater.
- Beheaded stream or under fit valley caused by lava or pyroclastic flow deposition.
- Volcanic fan
  . Volcanic fan (steep slope)
  . Volcanic fan (gentle slope)
  . Unit of fan (unit of braided stream)
  . Former river course
  . Channel shifting point
- Land slide
  . Large scale land slide or large gully on the valley head.
  . Land slide in May 1981
  . Slumps caused by lateral erosion
- Peripheral morphology on the volcanic piedmont
  . Alluvial plain

⑤ Others

ⓐ Alluvial plain
- Alluvial plain and valley bottom plain
- Coastal plain
  . Backmarsh
  . Beach ridge
- River terrace
- Scarp
  . High scarp
  . Scarp
- Talus and alluvial cone

(2) Explanations of units of landform classification

① Mountains and hills consist of tertiary rocks.

On the west side of the K. Leprak and on the south side of the K. Lengkong, mountains, whose elevation is about 1,000 m in the north part and about 200 m above the

the sea level in the south part and whose stage has reached maturity, protect further development of the volcanic piedmont in the direction of south. This mountain consists of tertiary rocks. The slope of this mountainous area is very steep and dissected by many small valleys. The K. Glidik cut a deep V-shaped valley in this area. The hills which distributed on the east side of K. Leprak also consist of tertiary rocks.

(2) Landforms formed by the Jambangan volcano complex

(a) Dissected volcanic piedmont and volcanic slope

In the study area, this unit is situated on the north side of B. Sat Fan and on the south and west slope of Mt. Semeru. The volcanic slope of Jambangan Complex, which is the oldest volcano in the volcanic row, has been dissected by many valleys, resulting in the planeze.

(b) Mudflow hills

A large number of small hills were independently formed in the south of Pasirian on the periphery of the Semeru volcanic piedmont. These hills consist of volcanic breccia. It is guessed, from weathering and from geomorphological characteristics, that these hills are formed by big scale volcanic mudflow related to Jambangan volcanic activities. However, the origin of these hills remains unknown.

(3) Landforms formed by the Tenggat Mountain Range.

In the north west of Lumajang Plain, undulated plateau which was formed by the Tenggat Mountain Range is located.

(4) Landforms formed by the Semeru Volcano

(a) Accumulation surface of essential materials

The surface of the main part of the volcanic cone consists of lava flow, pyroclastic flow and parasitic volcanic cones. The surface of lava flows which have many topographical characteristics such as frontal scarp of lava flow, lava levee and lava wrinkles which are clearly interpreted by means of aero-photographs.

On the other hand the surface of pyroclastic flows are less easy to distinguish from the volcanic fan surface. However, the breaking point on the longitudinal section gives information on boundary between this unit and volcanic fan.

Lava and pyroclastics flow through the valleys and fill up them. Alternation of catchment area and river system occur in such an area. Some missfit river (underfit) or beheaded river can be observed lower part of this unit.

The parasitic volcanic cones can be seen at the elevation of about 1,000 m to 1,500 m. The parasitic volcanic cone has a crater from where lava flowed down. The lateral eruption also changed the topography of the volcanic slope.

In the upper part (from 2,500 m to 3,000 m or more) of this unit, forest cannot grow on the surface. This is because of successive supply of newer loose ejecta and violent erosion and dissection.

(b) Landforms formed by volcanic activities

We can distinguish the main crater called Jonggring Seloko, the former main crater on the top of Mt. Semeru and the parasitic crater on the top of parasitic cones.

From the interrelation of the position of the main crater, it is considered that the main crater has gradually shifted southwards.

Ⓒ Landforms formed by epigenetic processes

- Wall and floor of erosional valley.

Many erosional valleys have been formed on the main part of the cone radially. Generally, each valley has steeply inclined valley wall, with the height of 30-50 m from valley bottom to the valley's upper edge.

Lava flow, pyroclastic flow and debris flow down into these valleys. These valleys are classified into the following 3 types according to the degree of sediment yield and the presence of direct inflow of volcanic products from the viewpoint of erosion and sediment control engineering.

. Stable valley;

Having small sediment yield and no direct inflow of volcanic products.

. Active Valley (1);

Having a large amount of sediment yield mainly due to the direct inflow of volcanic products.

. Active Valley (2);

Having a large amount of sediment yield mainly due to the land slide at the valley head.

The classification of each main valley is shwon in Table - 6.8.2.

Table - 6.8.2 Classification of characteristics of main valleys

River system	K. Mujur	K. Rejali	K. Glidik
Active valley (1)	-	B. Kobo'an	B. Bang B. Kembar B. Sarat
Active valley (2)	B. Tompe B. Sat B. Tengah	K. Curah Lengkong	B. Supit B. Cukit B. Glidik
Stable valley	B. Tunggeng K. Poh K. Mujur (upper reach) K. Pancing B. Semut	—	K. Bening K. Lengkong

At present, the crater faces the B. Bang. Therefore, the area along the B. Bang suffer the most frequent influence of eruption.

From the geomorphological viewpoint, the direction of crater will shift, and after that, the characteristics may be changed.

- Volcanic Fan

The Semeru Volcano has formed extensive volcanic fan in the direction of east and south east peidmont.

In the south, mountains protect the development of a broad volcanic fan.

The debris flow and mudflow called lahar left materials on the volcanic fan.

The volcanic fan is composed of fan deposit, consisting of boulders, gravels and sand. At the top of the fan area, however, it is difficult to distinguish the fan deposit from the pyroclastic materials (ladu deposits).

The volcanic fan could be classified into 2 parts longitudinally, and 4 or more parts cross-sectionally as follows:

- Longitudinal classification
  - Volcanic fan (steep slope);

    This unit has been formed at the elevation from 200 m to 1,000 m. The slope gradient is about 2.5°

  - Volcanic fan (gentle slope);

    This unit has been formed on the peripheral zone of the steep-slope volcanic fan.
    The slope inclination is about 1°.

  - It seems that the clear difference in their inclination is due to the difference types of flow which bring materials into the fan area. Some water springs can be observed on the border between the steep-slope fan and the gentle-slope fan.

- Cross-sectional classification.
  - B. Sat fan
  - B. Semut fan
  - K. Rejali fan
  - K. Lengkong fan
  - Another dissected fan

The B. Semut fan is the largest and the K. Lengkong fan is limited in a small area. The K. Rejali fan is a relatively narrow fan formed between the B. Semut fan and the tertiary mountainous area. The B. Sat fan is formed between the K. Lateng, a tributary of the K. Bondoyudo and the K. Mujur. The K. Mujur flows down along the boundary of the B. Semut fan and the B. Sat fan.

In the upper part of the volcanic fan area, where Sumber Mujur or Sumber Sari Village is located, there exist other units of volcanic fans. The river which formed them, no longer exist because of the development of the Semeru Volcano.

Meanwhile, the fan area along the B. Kobo'an had the similar condition as the present K. Lengkong fan, before the depth of Curah Kobo'an increased.

On the fan area, many short and shallow valleys were distinguished. These shallow valleys considered to be formed by rivers frequently shifting their courses through the fan.

The river course shifting points were found in the upper part of the steep-slope fan and gentle-slope fan. This is due to the coarser debris transported by lahar deposited rapidly at the breaking point of the gradient.
The past shifting of the main river channel will be described in Section (5).

- Landslide

There are many landslides along and at the higher end of the valleys which dissect the volcanic body. Usually, the landslides on the valley are the fall type. They seem to be the result of lateral erosion because they exist on the majority of the undercut slopes. Among them, the slump type landslide are larger in scale in terms of sliding depth and has the flat bottom. They are also the product of the lateral erosion of the rivers.

On the other hand, there are many traces of large-scale landslides or big gullies at the valley head of main valleys. They have been formed by headward erosion of the main valleys. The area in which headward erosion advance violently has necked steep volcanic slopes located higher than 2,500 m. However, it seems that some of them were formed by volcanic activities observable in the upper reach of B. Bang gully which connects the present main crater. In the upper reach of Curah Lengkong Gully, such slopes are observed.

- Peripheral morphology on the volcanic piedment.

On the outside of the gentle-slope volcanic fan, a plain having inclination of 0.5° and flat surface was formed. This unit is not so clearly distinguished from the gentle-slope fan. In this area, the main rivers, the K. Mujur and the K. Rejali deepened where the relative height between valley floor to upper of valley wall is 5 - 10 m.

In the outcrops of this with lamina and gravel layers is observed.

⑤ Others

ⓐ Alluvial plain

The alluvial plain is distinguished into 4 units. They are plains formed by the K. Bondoyudo river sytem, coastal plain on the outside of the peripheral plain, alluvial plain along K. Rawan which flows Temple Sari and valley-bottom plain along the K. Glidik river system.

In 1909, alluvial plain of the K. Bondoyudo where Lumajang city is situated suffered violent "Banjir". The coastal plain consists of back marsh and beach ridges. This back marsh area is to suffer "Banjir".

ⓑ River terrace

River terraces, whose relative height between the riverbed and the terrace surface is not so high, have been formed in the main valleys. These terraces are formed in the area where the increase in depth dominates over the recent sedimentation.

ⓒ Scarp

The river terraces consist of the terrace surface and the terrace scarps. Especially, a high scarp is formed along the lower reach of the K. Lengkong and some tributaries.

ⓓ Talus and alluvial cone

On the piedmont of the tertiary rock mountains, morphologies of piedmont sedimentations are formed. These are talus which was formed by rockfall or land-slides on the upper part of slopes and alluvial cones.

(3) Summary of historical development of landforms.

Fig. - 6.8.5 summarized the historical development of land-forms in the study area.

Semeru is a very young volcano. Therefore, its slope is not much dissected, and its activities are continuous. The distribution of the materials from the Semeru volcano is limited to the mountain's south and east slope at present the Semeru volcano is quickly growing and developing geomorphologically.

The gorge of the Curah Lengkong shows that a violent topo-graphical changed occurred.

The B. Semut fan seems to be formed at first, and then, Curah Kobo'an deepend and formed the K. Rejali fan. If the age of volcanic deposits could be determined, we could estimate the speed of topographical development.

(4) Geomorphological characteristics of main rivers

(a) K. Mujur

The K. Mujur river system has many tributaries and extensive catchment area. Before 1909, the B. Sat a main tributary of the present K. Mujur, was not the K. Mujur's tributary. After the 1909 disaster, which was the most severe disaster in recent years, the stream channel of the B. Sat was diversed artificially into the B. Tunggeng, a tributary of the K. Mujur. As the result, the catchment

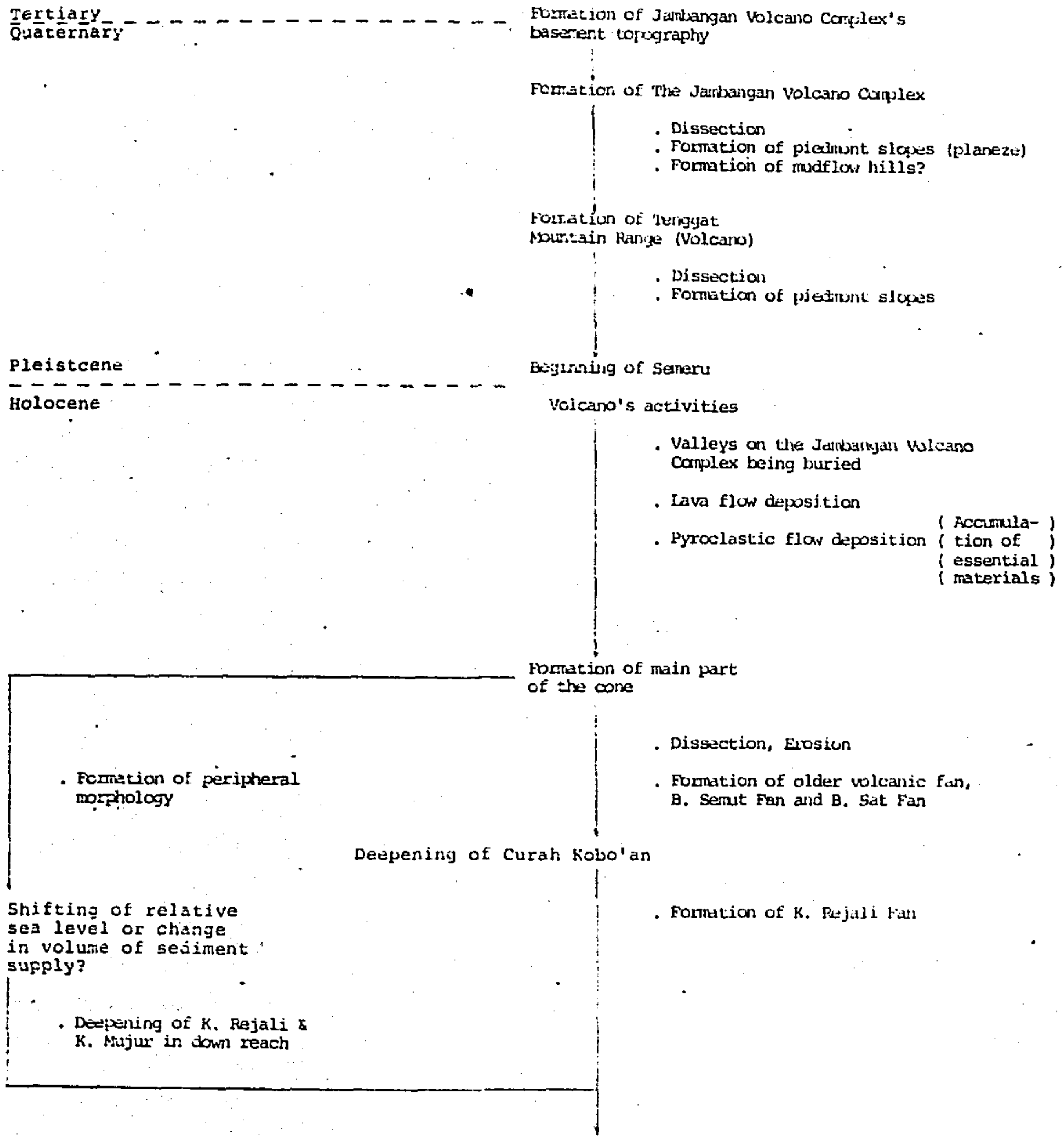


Fig. - 6.8.5 Summary of Historical Development of Topography in the Study Area.

area of the K. Mujur has become extensive while the middle and lower reach of the B. Sat have become under-fit condition and stable.

As had already been mentioned, longitudinally, the Semeru Volcano can be divided into 3 parts. The upper part, i.e. the main part of the cone, is formed by accumulation of essential materials, and it has a steep slope. The middle part is volcanic fan and the lower part is a peripheral area.

The boundary between the upper and the middle part lies at the confluence of the B. Tompe and the B. Sat (750 m above the sea). Another boundary between the middle and the lower part is situated at the confluence of the K. Mujur and the K. Pancing. At present in the upper part of the fan area a fanhead trench has been formed. Another, newer, fan unit has been formed at more lower point along the B. Sat.

Overflow of the 1909 lahar began at the lower fan top, and the 1981 lahar also gave some damage at this point. It appears that occurrence of an overflow at this point will cause the wide spread disaster in this area. Therefore, the main channel shifting points exist here. For this reason, topographically it is easy for lahar to flow into K. Lateng which is a tributary of the K. Asem and former river channel of the B. Sat (B. Sat Lama).

As Jonggring Seloko crater faces to the B. Bang at present, it seems that the direct influence of eruption of it is rare. If a lahar occurred in K. Mujur basin, the origin of it due to lateral eruption or occurrence of large scale land slide in the main part of cone. The cause of 1981 lahar due to later.

As the K. Mujur cut deep into the general surface of the volcanic piedmont in the area between Kertosari and Klumpangan, it is thought that in the lower reach of the K. Mujur, lahar on banjir rarely overflow onto the general surface.

(b) B. Semut and K. Pancing

The B. Semut or the K. Pancing, the largest tributary of the K. Mujur shows the typical missfit river morphology.

In 1941-1942, lava flow flowed down into the B. Semut until 800 m high above the sea level and filled up the valley.

As the result, alternation of catchment area occurred. The B. Semut lost the upper catchment area and become an under-fit river. In the down reach of the K. Pancing, a narrow valley-in-valley has been formed deepening the former wide river-bed. The former river-bed of the K. Pancing was wider than at present.

And the relative height between the former river-bed which is the present terrace surface and the general fan surface was a few meter high. it seems that the former K. Pancing transported much material before 1942.

(c) K. Rejali

The K. Rejali basin can be roughly divided into two parts according to the existence of tertiary hill in the middle part. The upper part of the K. Rejali is called the B. Kobo'an. Along the K. Rejali, different names are given to this stream. This is due to river's channel shifting in the fan area. From upper reach to the sea, the name of the K. Rejali is changed as follows;

K. Besuk Kobo'an → K. Leprak → K. Regoyo → K. Rejali

Before 1976, the direction of Jonggring Seloko, the main crater, faced the B. Kobo'an. From 1941 to 1942, lava flow flowed down into the B. Semut and filled up the valley. As the result, the upper reach of the B. Semut basin was added to the K. Rejali Basin.

These facts caused the frequent lahar disasters in recent years. The main crater products consist of much unstable material. They come into the basin and made the K. Rejali a geomorphologically overfit river. As mentioned before, the B. Semut became an under-fit river and stable. In contrast to this, the K. Rejali become an overfit river and unstable because of the transportation capacity of water and materials was too small.

Frequent occurrence of lahar caused the frequent channel shifting with the rapid deposition of coarser materials in the fan area. The K. Rejali fan is divided into 2 parts, i.e. the upper and the lower parts. The upper part, steep-slope volcanic fan, has been formed until Mt. Jugo.

The main channel shifting points exist at the top of these fans.

(d) K. Glidik

The catchment area of the K. Glidik is most extensive among the main rivers in the study area has different topographical characteristics. The landform of the upper part of the K. Glidik basin is formed by the Semeru Volcano. The middle part is characterized by the existence of the topography of the Jambangan volcanic complex.
The lower reach of the K. Glidik basin is characterized by tertiary mountains and hills.

Andesite lava, which crops out at the Pronojiwo Water Fall prevents the further deepening of the K. Lengkong. The same condition can be observed on the K. Bening, the B. Cukit and the middle reach of the K. Glidik.

The east side of the B. Kembar, a volcanic fan has been formed by the B. Kembar and the B. Sarat. Meanwhile, from the west side of the B. Kembar to the right side of the K. Glidik, the fan has not been formed, and the materials from the Semeru Volcano is restricted to the valley side.

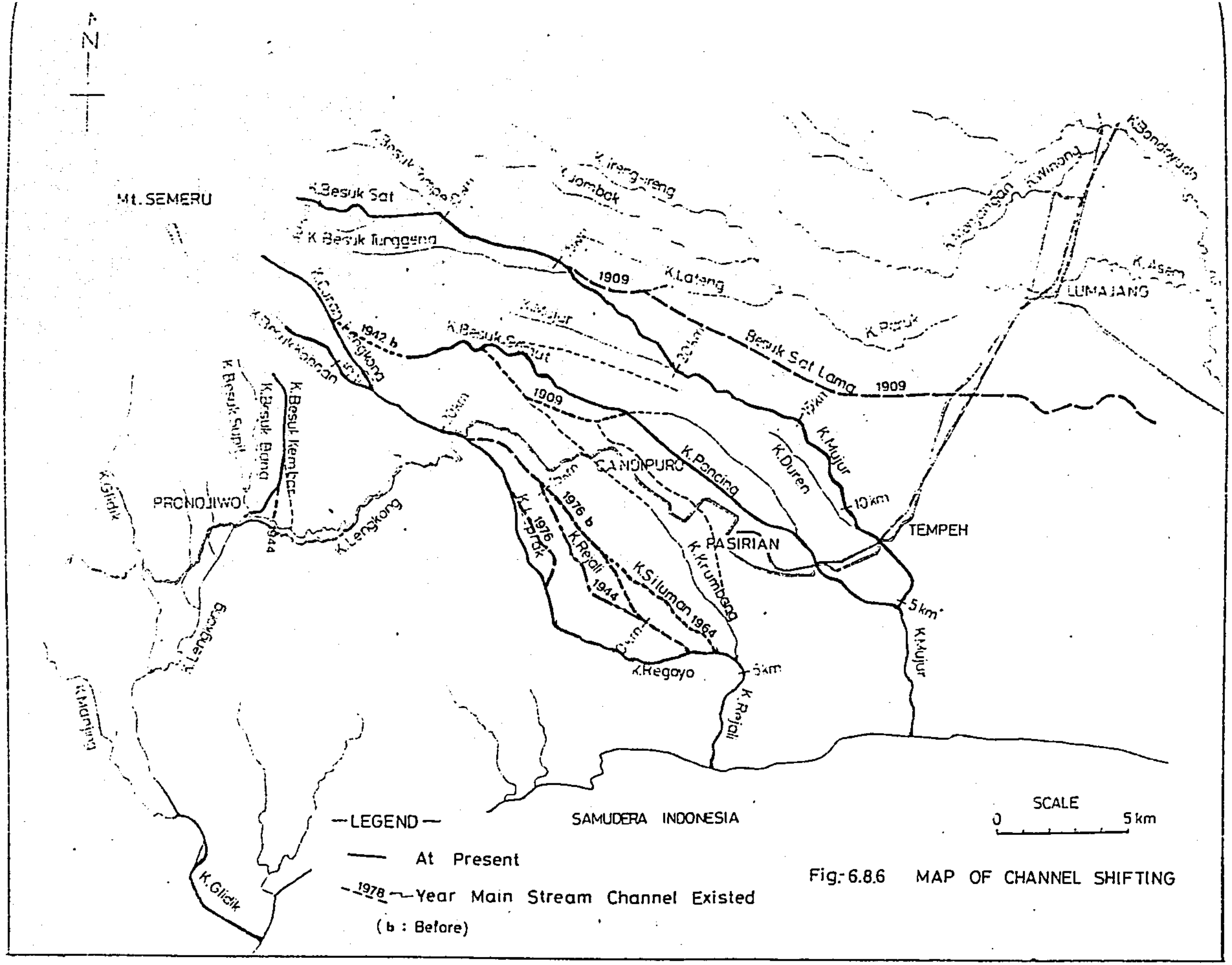


Fig. 6.8.6 MAP OF CHANNEL SHIFTING

Among the tributaries, the upper reach of the K. Lengkong has different characteristics. Other tributaries are major valleys of the Semeru volcanic slope. However, the K. Lengkong flows down the topographical boundary between the volcanic slope and the tertiary mountainous area. The upper reach of the K. Lengkong seems like rivers on the alluvial plain with gentle slope in the river-bed and meander.

Under the nick points, the rivers cut deep valleys. The lower reach of the K. Glidik, also a deep valley exists forming a narrow valley bottom plain.

After 1976, the main crater has faced the B. Bang. At present, the B. Bang, the B. Kembar and the B. Sarat Basin are most disastrous by the direct inflow of eruption products.

(5) History of channel shifting

Fig. - 6.8.6 shows the history of channel shifting.

The distribution of the former river channel and the channel shifting points are interpreted through aero-photo interpretation. We tried to confirm by some data and field survey when the channel shifting occurred. Regarding the B. Semut and the B. Sat, recent channel shifting is rare. On the K. Rejali fan, river channel shifts frequently in a few decades.

The B. Sat was shifted artificially by excavating a diversion channel.

From fig. - 6.8.2 it seems that the channel shifting points are distributed at the top of steep-slope fan and the gentle-slope fan where the river-bed gradient changes sharply.

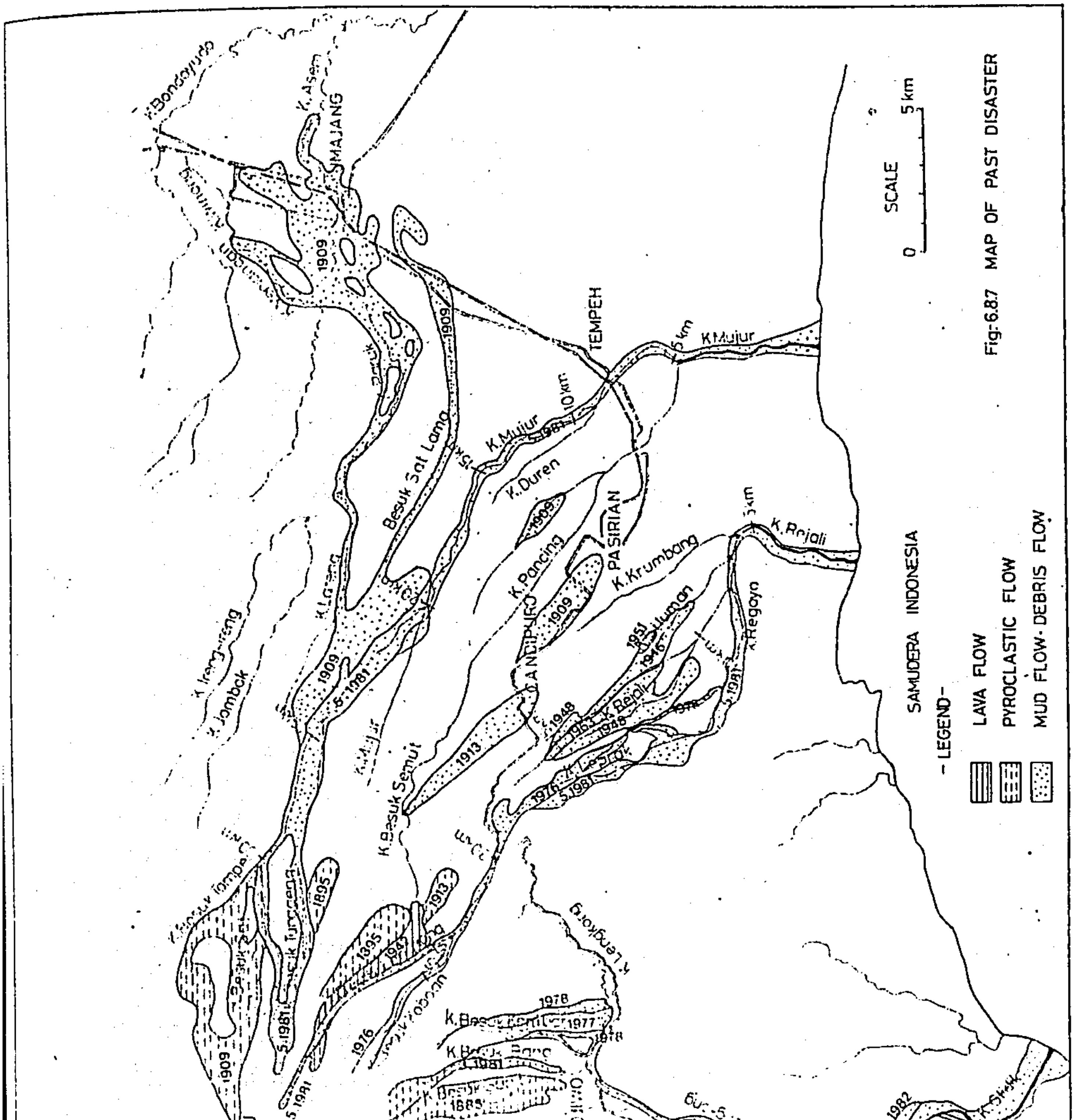


Fig. 6.87 MAP OF PAST DISASTER

6.8.3 DISASTER STUDY

(1) The Results of Field Survey

The field survey for the past disaster was done by using questionnaire and aero-photo interpretation. And the study is now under investigation. However, some actual conditions of disaster have appeared.

As the results, we could add the 2 past disasters along the B. Cukit and the K. Glidik to the existing data.
We could, also reconfirm that the existing data about the past disaster is almost correct, and understand the actual disaster area or actual disaster conditions. The existing data was partly revised by this study. It is shown in Fig. - 6.8.7. From the result of the questionnaire, some fact became apparent as follows;

1) B. Sat Fan

a) The 1909 disaster might originate from eruption because the mudflow was hot on the fan area.

b) The area of the 1909 disaster can be partly interpreted by aero-photographs. The land use in the main part of the deposition still reamins undeveloped, large boulders remain in the rice paddy.

c) It is confirmed that the hazard area drawn in existing map is correct.

d) After 1909 disaster, the B. Sat fan area did not suffer severely until the 1981 disaster happened.

2) B. Semut Fan Area

a) The waste land which extends on the left side of the B. Semut and the K. Pancing is the old disaster area before 1909. We could not confirm the years of lahar occurrences.

b) The 1909 disaster and the 1913 disaster in the B. Semut Fan area was confirmed. Mudflow in 1913 was hot whose deposits was still apparent.

c) Before the 1913 disaster, the B. Semut flowed into the B. Semut lama.

3) K. Rejali Fan Area and B. Kobo'an Basin

a) After 1940's, the frequency of disaster increased and materials transported and deposited became coarser than before.

b) Mostly, mudflows were so called hot lahar whose temperature was high.

c) Channel shifting occurred many times in the fan area.

d) In 1976, lava flow the main crater flowed into the B. Kobo'an and filled up the upper reach of the B. Kobo'an. As the results, the direction of main crater has been directed to the B. Bang.

e) Before 1976, pyroclastic flow often rushed down along the B. Kobo'an until the Curah Kobo'an.

4) K. Glidik Basin

a) Along the B. Bang and the B. Cukit, lahar disasters occurred in 1921 or 1922 and 1937. After 1937, the B. Bang did not suffer severely from the disaster until 1976. The 1937 disaster gave some damage along the K. Glidik. This disaster is still remembered by the people in the Temple Sari.

b) The 1921 or 1922 disaster was caused by hot lahar. The hazard-hit area of the 1921 or 1922 lahar can be interpreted by aero-photographs on the right side of the B. Cukit.

c) The disaster of the K. Lengkong after 1977 were due to hot lahar.

(2) Activities of Semeru Volcano

From the results of field survey, it seems that the volcanic activities and the direction of the main crater are most important for the frequency of lahar disaster. This is because lahar in most cases was hot lahar and frequency of disaster relates to the direction of the crater.

The history of activities of Semeru Volcano is described in the chapter of geological study.

Accordingly, in this chapter, shifting of the main crater's direction is summarized.

a) We can confirm the shifting of direction of main crater in 1895 from B. Semut to B. Kobo'an by the report, printed in 1947, which describes the activities of Semeru Volcano (Fig. - 6.8.8).

b) We can confirm the direction of the main crater in 1945. U.S. ARMY MAP SERVICE revised in 1945 the existing map (scale, 1:50,000) by photo-planimetric methods. It is shown in Fig. - 6.8.9. From this map, it is known that the direction of the main crater was towards the upper reach of the B. Semut in 1945.

c) In 1941-1942, lava flow filled up the B. Semut valley. As the results, the B. Semut lost the upper part of the catchment area and the K. Rejali basin increased catchment area, amalgamating the catchment area of the B. Semut upper reaches.

d) In 1976, the direction of the main crater did not shift. However, the alternation of the catchment area occurred because of lava deposition between the upper B. Kobo'an and the B. Bang basin.

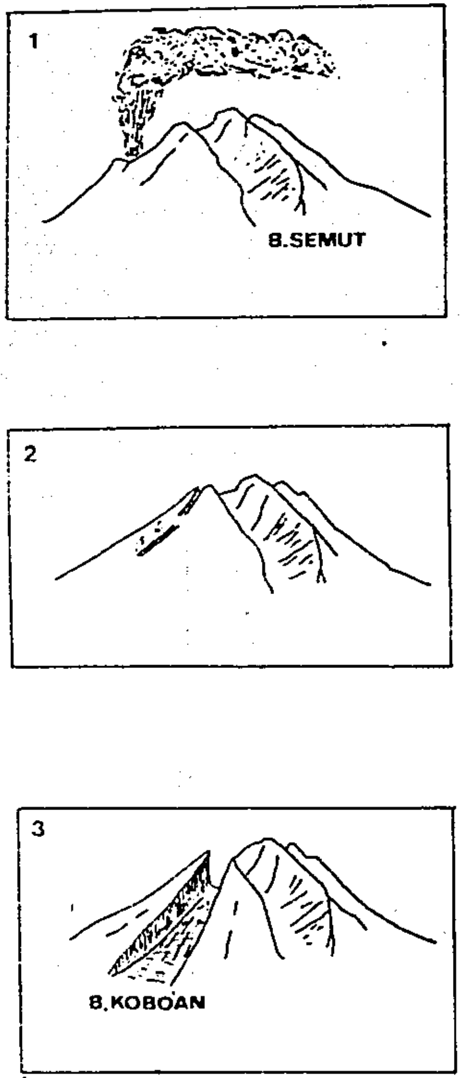


Fig:6.8.8 SHIFTING OF CRATER DIRECTION IN 1895

Quoted by Report on Mt Semeru Activities and Disaster

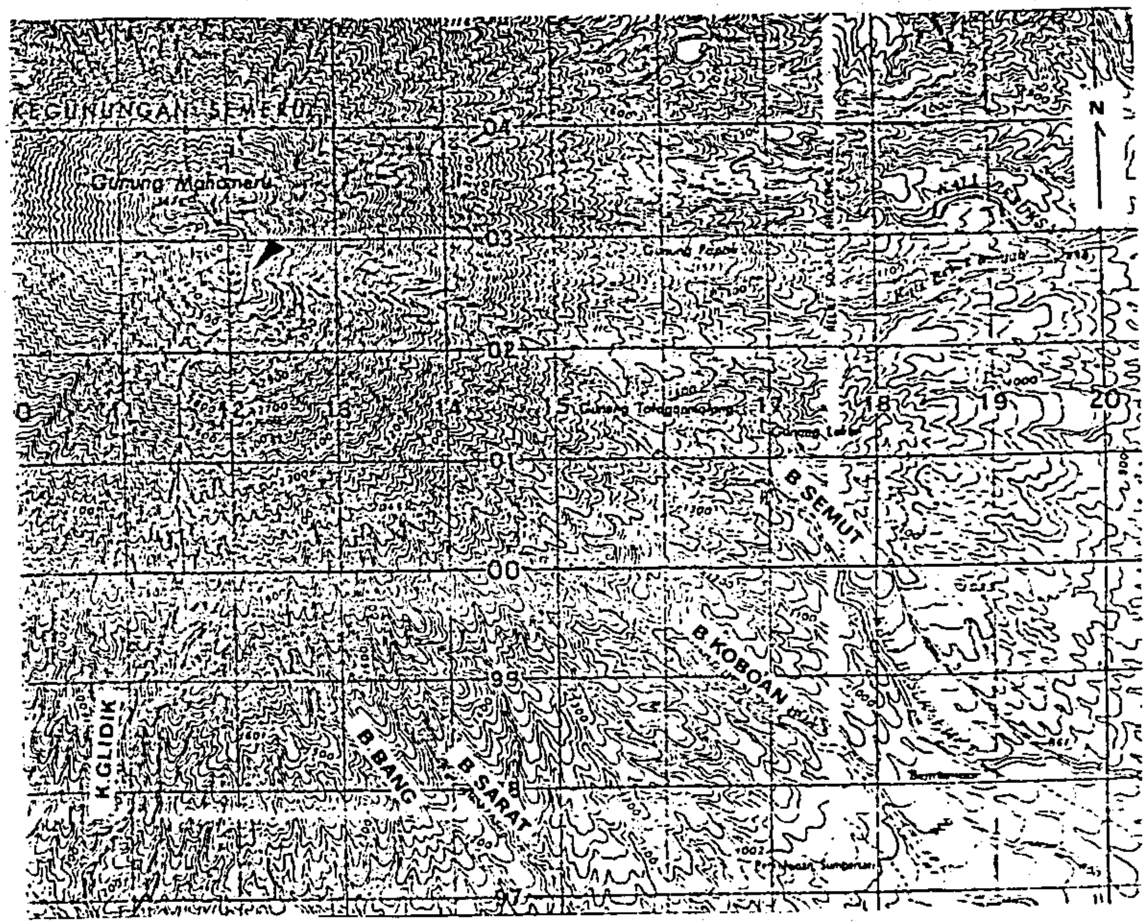


Fig.-6.8.9 DIRECTION OF MAIN CRATER IN 1945

Quoted by Topographic Map (1:50000) Revised in 1945

(3) Activities of lahar disaster

The past disaster area is shown in Fig. - 6.8.7 and the situation of the past disaster is described in Table - 6.8.3. The relation between volcanic activities and lahar occurrences is summarized in Table - 6.8.4.

Accumulated data indicate that the occurrence of lahar disaster is colsely related to volcanic activities.

It seems from the above, that the large-scaled lahar is rarely attributable to the large-scaled landslide having no direct relations with volcanic activities.

However, it seems that frequent occurrence of hot lahar is caused by rainfall, while the frequency of large-scale landslide can be understood to be the same as landslides in the non-volcanic mountainous area.

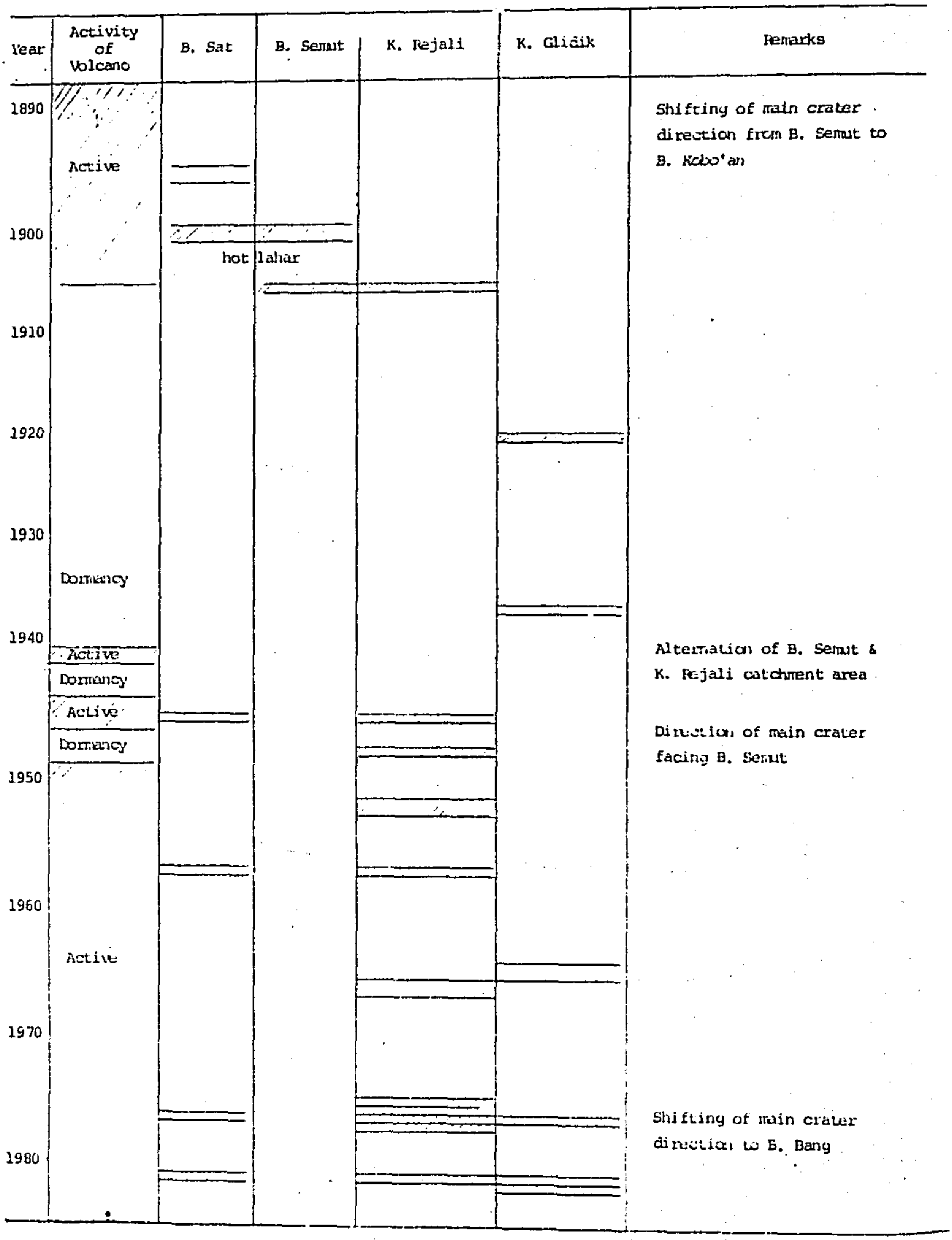
Table - 6.8.3 LAHAR FLOOD OCCURRENCES IN THE STUDY AREA SINCE 1895

No.	Years	Volcanic Activities	Besuk Sat River	Besuk Semut River	Besuk Kobo'an-Rejali River	Glidik River
1.	1895	Active	Flood originated from the Laki and Tengah Rivers causing sand inundated so much in the B. Sat River channel			
2.	1909	Active	The biggest flood ever known devastated 38 villages and killed 208 people. The flood originated from B. Sat and B. Semut rivers devastated 1043 ha of rice fields, 337 ha of uplands, 227 ha housing lands, and washed away 1449 houses and 313 cattles.	Flood devastated 5 villages and 1 person was dead		
3.	1913	Active		Flood from B. Semut River jumped to Kajarkuning River and finally to Kobo'an River. To Eastern direction flood jumped to Pancing river.		
4.	1921	Dormancy				Food from B. Cukit and B. Bang gave some damage along K. Glidik.
5.	1937	Dormancy				Flood from B. Cukit and B. Bang gave some damage along K. Glidik.
6.	1946	Active	Flood jumped from B. Sat to Sumber pakel river at Bendo devastated some parts of Pasrujambe village		Flood from K. Rejali expanded to devastate Sumber Wuluh and finally entered K. Siluman after devastated Sudimoro, Jugosari and West side of Danurejo Villages.	
7.	1948	Active			Lahar hit Sumber Wuluh, east part of Kebondeli, Candipuro, Sudimoro and Danurejo villages. K. Rejali changed to left side at + 250 m elevation.	
8.	1951	Active			Flood from K. Rejali jumped to Uranggantung and entered K. Siluman	
9.	1957	Active	Flood attached Bendo Dike to Sumber Pakel River and destroyed some parts of Lumajang City.			

No.	Years	Volcanic Activities	Besuk Sat River	Besuk Semut River	Besuk Kobo'an-Rejali River	Glidik River
10.	.				Flood expanded along K. Rejali to (100-400m) width after jumping at Sumber Wuluh and ending at Sudimoro village.	
11.	1967	Active				Lahar destroyed river bank near bridge at Sumberrowo Village
12.	1968	Active			Flood from K. Rejali devastated uplands, ricefields of Sumber Wungkel village and entered K. Leprak at + 353 m elevation. At that time 5 persons were dead, 36 houses were damaged, 15 ha rice fields and 10 ha cassava were inundated by sand.	
13.	Aug. 7. 1975	Active			A weir was swept away, 3½ ha rice fields were covered by muddy water for ½ hour. 6 houses were damaged. A channel was broken causing 75 ha of secondary crops were un-irrigated. Road connecting Jugosari-Jarit was cut off. Loss estimation was about Rp. 1.5 million.	
14.	Sept 13, 1975	Active			Road connecting Sumber Wuluh-Kebondeli was cut off. 100 ha rice fields devastated, 5 houses swept away and 5 houses damaged, loss estimated, to be Rp. 20 million.	
15.	Oct. 13, 1976	Active	Flood from B. Sat damaged Side Mulyo Village. 1 person dead.		Flood from K. Leprak damaged Kebondeli and Jugosari. 10 persons dead. All houses in these villages destroyed. 450 ha rice fields damaged	In Purorejo 8 persons were dead, and 50 houses were destroyed. Taman ayu along K. Leng-kong was also damaged.
16.	Sept	Active	In Gesang Village, 14 persons lost. 3,300 ha rice fields damaged. 4 intake and and 2,950 m irrigation channel also damaged. At Pasrujambe, 575 ha rice fields damaged.		Flood from K. Leprak hit Kebondeli, Condoruso, Jugosari village. 23 houses destroyed.	

No.	Years	Volcanic Activities	Besuk Sat River	Besuk Semut River	Besuk Kobo-an-Rejali River	Glidik River
17.	May 12	Active	Flood from B. Sat and B. Tunggeng. Along B. Sat, B. Tunggeng and K. Mujur. 242 persons were dead. Extensive fields and facilities damaged. Lecess dike destroyed and flood jumped to B. Sat lama.		Flood from Curah Langkong. Along K. Leprak, 2 persons dead, extensive fields and many houses destroyed.	In Purorejo 63 houses were destroyed.
18.	Jan. 1982					In Purorejo Village, many houses destroyed and all rice fields covered by sand.

Table - 6.8.4 THE RELATIONS BETWEEN VOLCANIC ACTIVITIES AND LAHAR OCCURRENCES



6.8.4 THE POSSIBLE DISASTER AREA MAP PREPARATION

(1) The relationship between landform and disaster seen from topographical aspects.

To sum up the relationship between the landforms and the disaster (flow type) is shown in Table - 6.8.5.

Furthermore, the overflow points of past mudflows concentrated at the top of fans where channel shifting points get together. If the lahar overflow, the flood or debris flow rush down along the former stream channel because the former stream channel make the lowest part around the overflow points. The detail of micromorphology related to the overflow will be described in a river condition study.

(2) The possible disaster Area map preparation

Through disaster study and geomorphological study, the relationship between the landform and the overflow of lahar was recognized in relation with past disaster. As one of the results of this study, it can be stated that the main overflow occurs at the top of the fan where channel shifting point and former river channel exist. If the overflow occur, spread into fan area will incur the hazard.

Under river-bed shifting high consideration, it seems that the fan area is exposed to possible danger of lahar overflow except the section where a main river excavates the fan surface and peripheral surface by the depth of 5 m or more.

It is presumed that in one landform unit has the possibility of danger due to channel shifting does not differ. However, the frequency of disaster differs from river to river and from one landform unit to another.
Also, the degree of damage differs one another according to the flow type. The flow type is classified into 4 by means of mudflow study. As already stated, these 4 flow types almost correspond to landforms on the fan area (see table - 6.8.5).

Table - 6.8.5 Relations Between Landform Units and Sediment Flow

Sediment Flow Types	Landform Units	Main Sections of Disaster	
		K. Rejali	K. Mujur
Pyroclastic Flow (Nuée Ar-dente) *	Main Part of the volcanic Cone, Upper Part of slope Volcanic Fan	Crater → Top of K. Rejali	Crater → Confluence with B. Tompe and B. Sat
Debris Flow (Lahar) *	Upper Part of the steep Slope Vol-canic Fan	Top of K.Rejali → Kebondeli	Confluence with B. Tompe and B. Sat → Confluence with B. Tunggeng
Mud Flow (A) (Lahar) *	Steep Slope Volcanic Fan	Kebondeli → Gn. Jugo	Confluence with B. Tunggeng → Confluence with K. Mujur
Mud Flow (B) (Lahar) *	Gentle Slope Volcanic Fan	Gn. Jugo → Bogoraksan	Confluence K. Mujur → Confluence with K. Pancing
Bed-Load Flow (Banjir) *	Peripheral Area, Alluvial plain	Bogoraksan → River Mouth	Confluence with K. Pancing → River Mouth

* Technical Term, generally used in Republic of Indonesia.

The estimation of possible disaster on an area map is as follows;

(a) Determining overflow section

(b) Determining the end of flooded area

The boundary at the end of flooded area was decided refering to the past disaster area as follows;

1) The boundaries adjoining mountains, hills, another fan units and large scale valley.

2) Regarding the B. Sat fan area, it is difficult to determine the boundary showing the end of flood without assuming flood scale. In this area, the past disaster area was referred for the decision.

3) Classification of flow type in a fan area and peripheral area.

The possible disaster area map is shown in Fig. - 6.8.10. This map was prepared without quantitative analysis. Therefore, it must be revised by conducting the quantitative analysis in the near future.

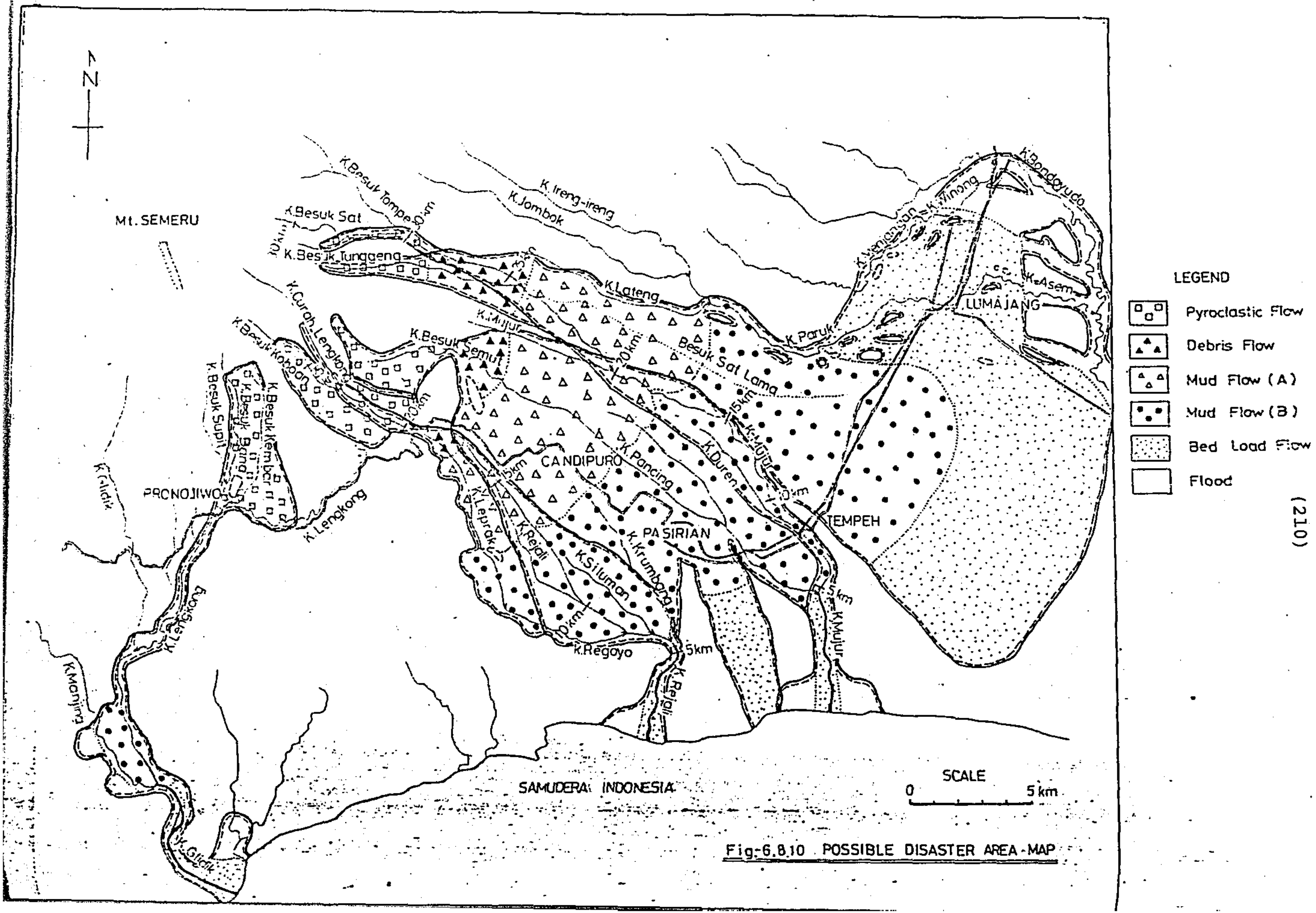


Fig-6.8.10 POSSIBLE DISASTER AREA-MAP

6.9 RIVER CHANNEL INVESTIGATION

Y. SHIMODA

6.9.1 PURPOSE

The purpose of this investigation is to investigate the characteristic of river channel, existing facility and promising sediment control facility location in order to make sediment control plan. The characteristics of river channel to be investigated here are profiles, cross sections, meandering, strength of river bed, grain size distribution of river channel.

6.10.2 METHODOLOGY

The investigation is according to the following methods.

Table - 6.9.1 Method of River Channel Investigation

Item		Method
River channel characteristic	Profiles and cross sections	Existing maps, Field Inv.
	Meandering	" Aerial photographs
	Strength of river bed	Visual observation
	Grain size distribution	Field test, Visual observation
Existing facilities		Existing materials, Field Inv.
Promising sediment control facilities		Field Inv.

River bed gradient, river width and bank height are obtained by profiles and cross sections.

6.9.3 PROGRESS OF INVESTIGATION

At present (August '82), progress of each investigation is as follows;

Table - 6.9.2 Progress of River Channel Investigation

Item		Collection of existing materials	Field investi-gation	Arrange-ment
River channel charac-teristic	Profile and Cross section	already finished	executed now	executed now
	Meandering		executed now	not yet executed
	Strength of river bed		executed now	not yet executed
	Grain size distribution		already finished	executed now
Existing facilities		already finished	already finished	already finished
Promising sediment control facility location			already finished	executed now

already finished

executed now

not yet executed

The results of the investigation which have already been finished are explained in the following chapters.

6.9.4 Existing facility

(1) Classification of facility

The facility existing along the river channels in the study area is classified as follows for the use of planning:

① Disaster prevention works executed by Mt. Semeru Project Office after 1977 in which it was established.

② Disaster prevention work executed before 1977.

③ Intakes for irrigation.

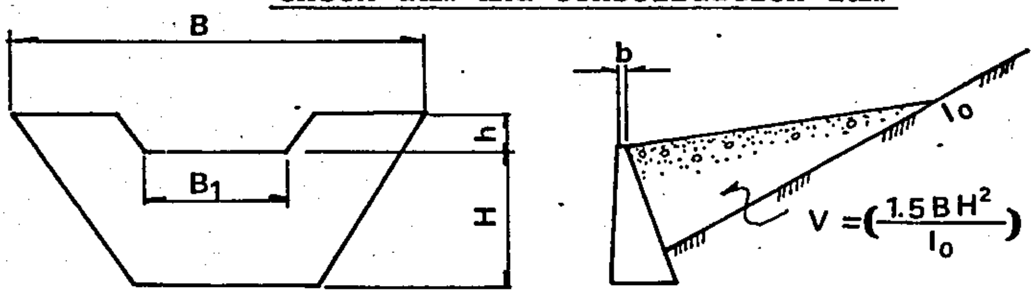
(2) Investigation Method

Existing facilities belonging to group ① is investigated by the Drawings which Mt. Semeru Project office has. Existing facilities belonging to group ③ is investigated by the materials which Irrigation Office (DPU Seksi Pengairan Pekalen-Sampean Lumajang) has. These group ① and group ② are confirmed by field investigation.

Existing facilities belonging to group ② is quoted from the Master Plan of K. Mujur.

Investigation items include locations, name, completed year, construction and element of facilities as shown in Fig. - 6.9.1.

Check dam and consolidation dam



Dyke and spurdyke

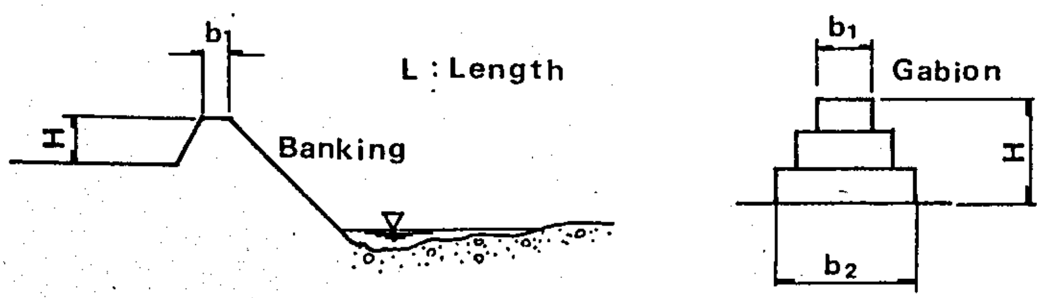


Fig - 6.9.1 Legend of Facility Elements

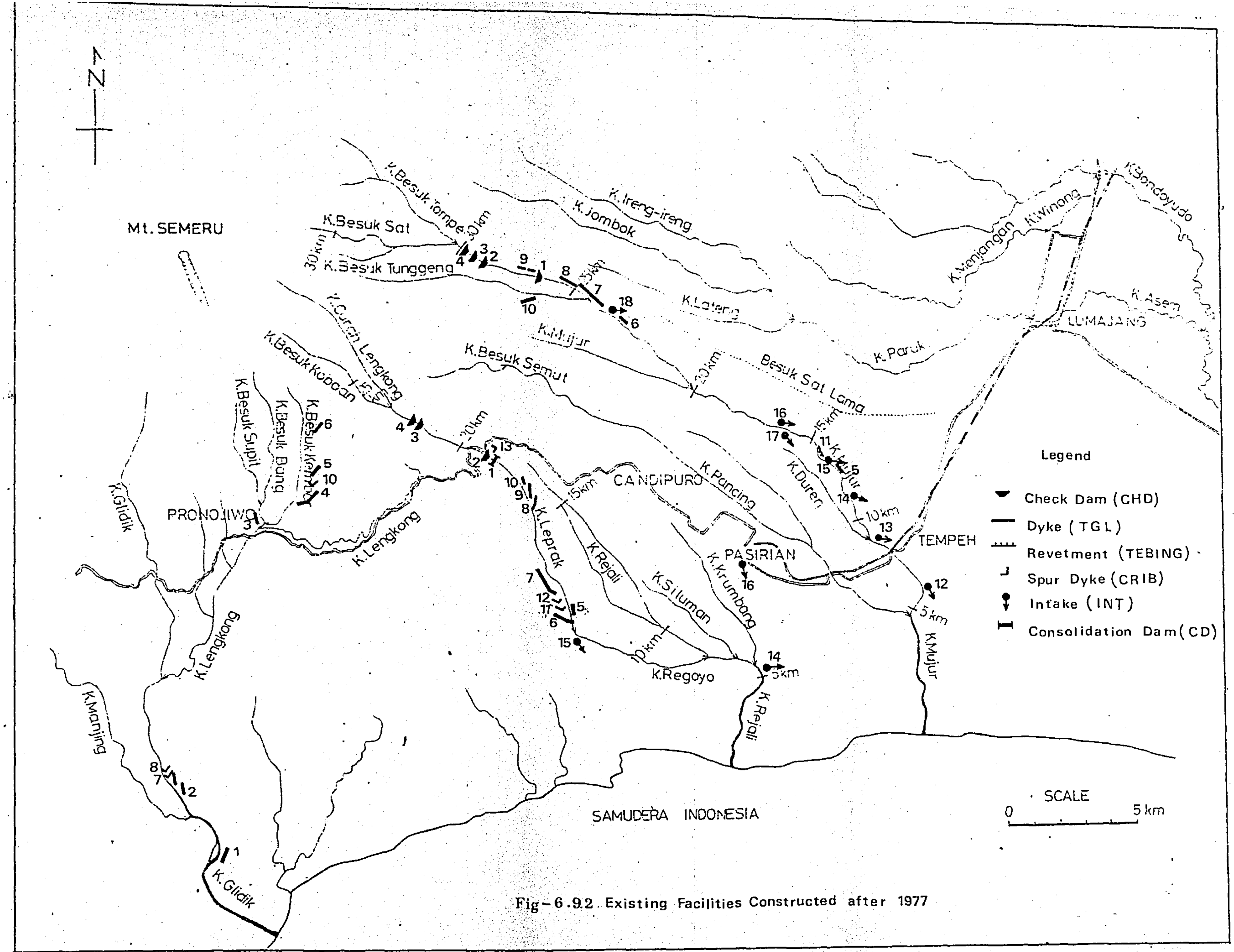


Fig-6.9.2 Existing Facilities Constructed after 1977

K. Mujur

1. CHD Besuk Sat I
2. IV
3. III
4. II
5. TGL Mujur
6. " Tunggeng Bawah
7. " Kertosari I+II
8. " Leces
9. " Besuk Sat
10. " Sumbersari
11. TEBING Mujur
12. INT Pandanwangi
13. " Soponyono
14. " Kedung Caring
15. " Klerek
16. " Lobang 1
17. " Lobang 2

K. Rejali

1. CD Leprak 1
2. CHD Leprak 2
3. CD Curah kobo'an 2
4. CHD Curah kobo'an 1
5. TGL Leprak 10
6. " Leprak 9
7. " Leprak 8
8. " Leprak 2+3+5+6+11
9. " Leprak 1+7
10. " Leprak 4
11. KRIB Swakelola
12. " Swakelola

13. KRIB Leprak
14. INT Banjr Scherm
15. " Rahayu
16. " Talang

K. Glidik

1. TGL Umbul Sari
2. " Wareng
3. " Besuk Bang
4. " Besuk Sarat 2+3
5. " Besuk Sarat 1
6. " Besuk Sarat 4+5
7. KRIB Wareng 1
8. " Wareng 2
9. " Besuk Sarat.

Table - 6.9.3 Existing Facility in K. Mujur

River Name	Tributary Name	Facility	Facility Name	Completed year	Elements	Constructor	Remarks
K. Mujur	K. Besuk Sat	check dam	CHD.BS.SAT 1	'77 '79	H=7.3,Bl=28,B=129 h=4.0	Mt. Semeru Project Office	
			CHD.BS.SAT 4	'80	H=10.5,Bl=62.14, B=203, h=5.6	"	
			CHD.BS.SAT 3	'80	H=9.0,Bl=50,B=200 h=6.0	"	destroyed at May 1981
			CHD.BS.SAT 2	'79	H=11.0,Bl=48 B=197,h=5.25	"	
	K. Mujur	dyke	TGL.MUJUR	'81	L=86,H=2.5,bl=2.5	"	
	K. Tunggeng		TGL.TUNGGENG BAWAH	'81	L=190,H=5,bl=5.5, b2=15.5	"	
	K. Besuk Sat		TGL. LECES	'78	L=160,H=4.0	"	
			TGL. KERTOSARI 1 + 2	'81	L=835,H=5,bl=4, b2=15	"	partially destroyed at May 1981
	K. Tunggeng		TGL. BS.SAT	'80	L=200,H=3,bl=2.5	"	
			TGL.SUMBERSARI	'81	L=275,H=4,bl=5.5 b2=15.5	"	destroyed at May 1981
	K. Mujur	Revetment	Tebing Mujur	'78	L=120,H=4	"	
	K. Mujur	Intake	INT.Pandanwangi		TECH		
			" Soponyono		"		
			" Kedung Caring		"		
			INT.Klerek		"		
			" Lobang 2		"		
			" Lobang 1		"		
	K. Tunggeng		INT.Rowogedang		HALF-TECH		

Table - 6.9.4 Existing Facilities in K. Rejali

River Name	Tributary name	Facility	Facility Name	Completed year	Elements	Constructor	Remarks
K. Rejali	K. Leprak	Check dam	CHD.Leprak 1	'82	H=8,B=30,Bl=18, h=7.5	Mt. Semeru Project	
			CD. Leprak 2	'82		"	under constructing
	K. Kobo'an		CD.Kobo'an 2	'80	H=6.5,B=56,Bl=20, h=6.5	"	
			CD.Kobo'an 1	'80	H=11.5,Bl=30, h=7	"	
	K. Leprak	Dyke	TGL.Leprak 1	'78	L=250,H=3	"	
			TGL.Leprak 7	'80	L=30,H=4.3,bl=4, b2=12.3	"	
			" 2	'78	L=157,h=3.5,bl=3, b2=8	"	
			" 3	'78	L=98.5,H=3.0,bl=4.0 b2=7.0	"	
			" 5	'79	L=125,H=2,bl=3, b2=8	"	
			" 6	'80	L=49,H=2,bl=3, b2=8	"	
			" 11	'82	L=185,H=3	"	
			" 4	'78	L=160,H=45,bl=3 b2=11	"	
			" 8	'80	L=308,H=2.5,bl=3, b2=8	"	
			" 9	'81	L=132,H=3,bl=2.5, b2=6	"	Destroyed at May 1981
			" 10	'82	L=215,H=3,bl=3,b2=10	"	
			TGL.Jugosari 1			"	Destroyed at May 1981
			TGL.Jugosari 2			"	"
		Spur dyke	KRIB.Leprak			"	
			KRIB.Swakelola	'81		"	
	K. Rejali	Intake	INT.Banjir SCHERM		TECH		
			INT.Talang		TECH		
			INT.Rahayu		HALF-TECH		

Table - 6.9.5 Existing Facilities in K. Glidik

River Name	Tributary Name	Facility	Facility Name	Completed Year	Elements	Constructor	Remarks
	K. Besuk Bang	Dyke	TGL. Besuk Bang	'81	L=275 H_1=3.0 b_1=2 b_2=4	Mt. Semeru Project	
	K. Besuk Sarat		TGL. Besuk Sarat 3	'81	L=350 H_1=3.5 b_1=3 b_2=10	"	
			TGL. Besuk Sarat 2	'80	L=58 H_1=2.0 b_1=3 b_2=7	"	
			TGL. Besuk Sarat 1	'79	L=136 H_1=2.0 b_1=3 b_2=7	"	
			TGL. Besuk Sarat	'82	L=121 , H1=6.0	"	
	K. Glidik		TGL. Wareng	'82	H_1=3.0 L=116	"	
			TGL. Umbulsari	'81	H_1=3.0 L=42	"	
		Spur dyke	KRIB Besuk Sarat			"	
			KRIB Wareng 1	'81	H_1=3 L=102	"	
			KRIB Wareng 2	'81	H_1=3 L=41	"	

(4) Existing facilities belonging to group ②

Many disaster prevention works were executed along K. Besuk Sat and K. Besuk Sat lama before 1977. These facilities are quoted from the Master plan of K. Mujur as Table - 6.9.6.

Table - 6.9.6 Existing Facilities Constructed before 1977

Facility name	Constructed year	Facility name	Constructed year
Jabon dam	1951	penutup baru dyke	1913
Lobang dam		Kertosari "	1910
Leces excavation	1912	Kertosari baru "	1912
Genting "	1909	Tesirejo "	1912
Kletek "	1910	Glodog "	
Sumber Duren dyke	1913	Kletek tengah "	1910
Bendo dyke	1922	Kletek wetan "	1910
Pasru dyke	1914	Tumpeng "	1912
Leces dyke	1913	Gladak "	
Genting dyke	1910	Sumber suko "	before 1910

The facilities mentioned above contain those as already destroyed and indistinguishable from the natural surface of land at present. The useful facilities along K. Besuk Sat which is the main river at the upstream of K. Mujur are as follows:

Leces excavation
Sumber Duren dyke, Bendo dyke, Pasru dyke, Leces dyke.

6.10 SEDIMENT FLOW AND VOLUME INVESTIGATION

6.10.1 INTRODUCTION

S. HAMANA

(1) Outline of Disaster

The study area often suffers from the severe disaster due to the volucanic debris flow and the pyroclastic flow. This volcanic debris flow is generally called as "lahar" or "banjir" and the pyroclastic flow,as"nuée ardente" in Indonesia. However there is no distinct difinition between lahar and banjir. While it is reported that the nuée ardente consists of several sediment flow types

The latest lahar occured in May 14,1981 and gave much disaster on the study area. The flood marks and sediment deposits are now remained clearly. According to the recording rainfall data of Busuk Sat station, the flood rainfall which caused this lahar began at around 14:00 and came to an end at 19:00 . The maximum rainfall intensity was 75mm/hr.(17:00 - 18:00) and the total rainfall mounted to 164mm. The lahar occured at 18:30 in the K.Mujur basin and damaged the area along the rivers of K.B.Sat,K.B.Tungeng and K.Mujur. At the same time the lahar occured in K.Rejali basin and damaged the area along the rivers of K.Leprak,K.Legoyo and K.Rejali.

(2) Object of the Investigation

The object of the investigation is to obtain the information on the sediment flow occured in May 14,1981. The investigation consists of the following two works.

① to investigate the characteristics of the deposits structure.

② to estimate the amount of the sediment volume.

The information gained in this investigation will be usefull for the planning of debris control works and the study of disaster.

6.10.2 METHODOLOGY

(1) Selection of the Disaster to be Investigated

As the disaster to be investigated, the lahar in May 14, 1981 was selected because of the following reasons.

① The flood marks and sediment deposits are now remained clearly as they were.
② The disaster occured in each river system (K.Mujur and K.Rejali) of the study area and classified as relatively large one among the past disaster.
③ The aerophotographs of the whloe study area, taken just after it,are available.

(2) Investigation Method of the Deposit Structure

The deposit structure is usualy clarified by means of the observation and measuring of deposit distribution, deposit section, sedimentary fabrics and deposit grain size distribution.

In this study, the deposit structure investigation was carried out concerning the above mentioned items and the deposit structure is classified , as the following manners.

① Aerophoto-interpretation
Using the aerophotographs, the distribution of deposit was grasped and the investigation points were selected.
② Field Investigation
The following items were observed by tape-measurement and eye-measurement.
- outcrops on rill wall ,trench wall and scarps of terraces.
- sedimentary structure
- deposit sections

③ Classification of Deposit Structure
The deposit structure of lahar was classified on the basis of the field investigation results.

(3) Investigation Method of the Deposit Volume

The deposit volume is obtained by the difference between the topography before disaster and after disaster. The difference of topography is usually gained by two sets of (or before and after disaster) aerophotographs or surveyed river sections.

In this study , the difference of topography was investigated in the field by the observation of the outcrops , buried structures and by the hearing the inhabitant's verbal evidence.

(a) Distribution of Deposit

To estimate the deposit distribution area , the aerophoto-interpretation on the lahar flooding area in 1981 , were carried out. After that , the results of the aerophoto-interpretation were transcribed of the topographic maps which was available on the investigated area. These aerophotographs were taken by EXSA in July 1981 , just after the lahar disaster in 1981. The scale of the photos is 1:10,000.

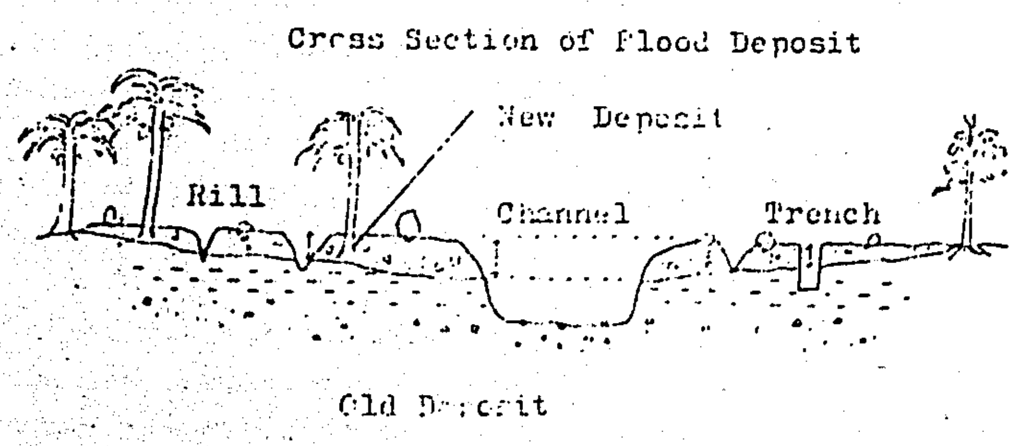
(b) Deposit Thickness

The deposit thickness of the lahar disaster was investigated as the following ways.

1 At the points where the deposits (older one and the 1981 lahar disaster) were clearly distinguishable , the thickness of the deposit was investigated by tape-measurement and eye-measurement.
2 The structures buried by the 1981 lahar were investigated to estimate the deposit thickness.
3 In the area where no outcrops and no buried structures were noticed ., the inhabitant s verbal evidence on the river bed change or the deposit thickness were investigated.

Fig-6.10.1

Conception of deposit



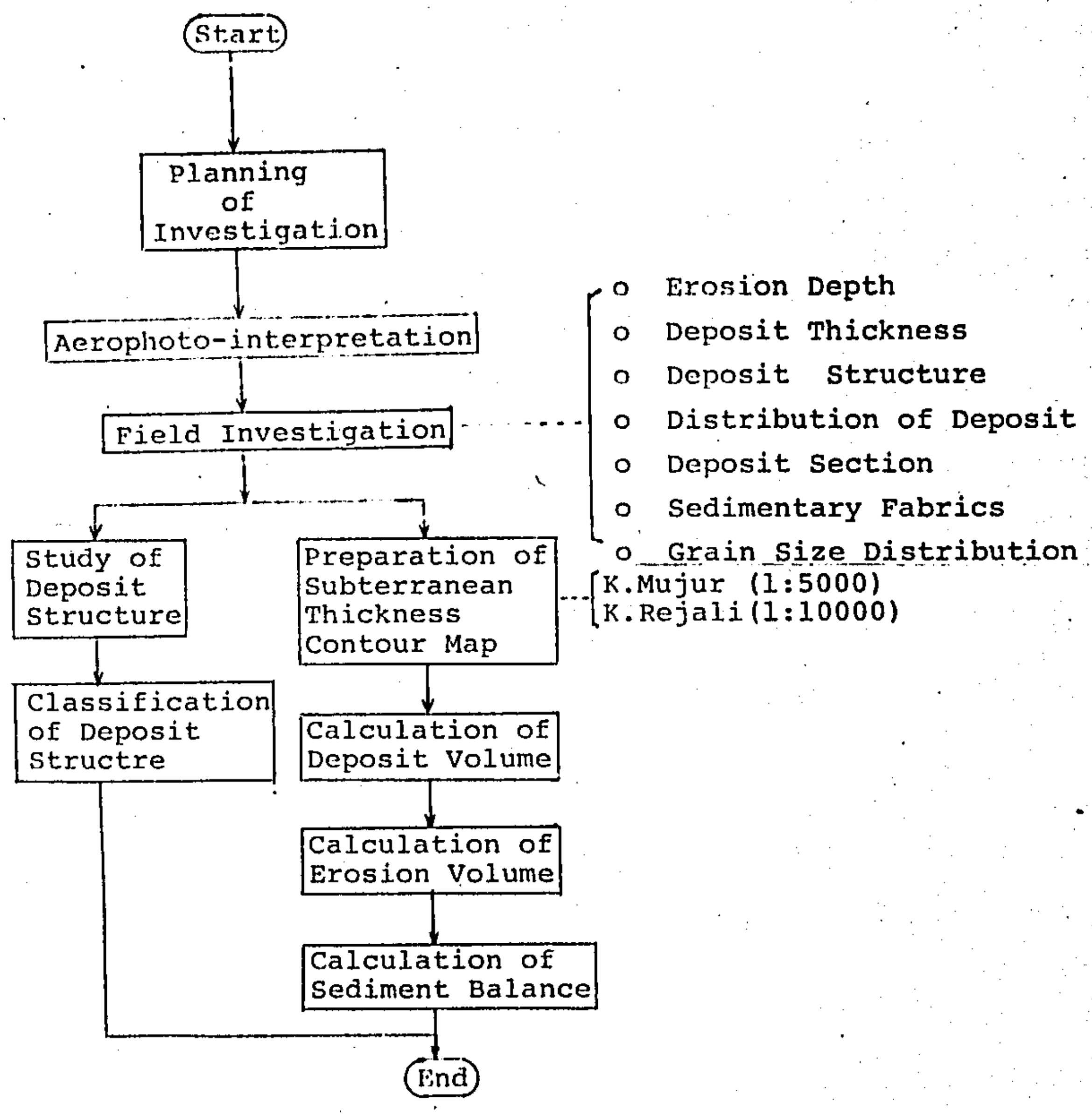
(c) Preparation of the Subterrnean Thickness Contour Map

The Maps of the subterrnean thickness contour concerning the 1981 lahar disaster, were prepared on the basis of the results of the above mentioned investigations (a),(b).

(d) Calculation of the Deposit Volume

The calculation of the deposit volume of the 1981 lahar disaster was carried out using the maps mentioned above item (c). The details of the calculation are described in the following article 6.10.3.

Refer to the investigation flowchart shown below.



6.10.3 INVESTIGATION RESULTS AND CONSIDERATION

(1) Investigation Results

(a) K.Rejali Basin

1) K.Curah Lengkong

a) Zone of Sediment Source

Forms of new landslide are observed in the Curah Lengkong's valley head (elevation : 2,000 - 2,800m). Staffers at Mt. Semeru Project Office said that these landslides had been observed just after May 14,1981. Judging from this, the above mentioned landslides seems to be one of the starting point of the 1981 May lahar. The aerophoto-interpretation disclosed several forms of landslide at the upper reach of K.Curah Lengkong.

The area extending between the elevation of 900 - 2,000m on the K.Curah Lengkong volcanic slope is covered with forests with deeply denudated valleys. The 1941-42 lava settled in this area. This area is presumed to be in an erosion processrestoring the state before 1940. The aerophoto-interpretation tells that the 1981 lahar did not flow out the Curah Lengkong valley. The errosion seems to be dominant in htis area becouse of the above mentioned reasons.

b) Zone of Sediment Transportation

Between the elevation of 800 - 900m the terraces formed by the 1981 lahar,exists on the both or either side of the valley. Each terrace height is from 1.5 - 3m. These terraces deposit are mainly composed of silt,fine sand and pebles. Sometimes, stratous structure due to different perticle sizes is observed. The terrce surface is more or less smooth and boulders of 2 m indiameter are found on the surface of or in the deposits.

In the vicinity of the K. Curah Lengkong's conflunce point where the the elevation is from 720 - 800m , the valley bed consists of lava and the river channel forms the gorge.

The valley wall height is about 4 -8m. Terraces rarely exist along this river channel, and no marks of overflow is seen on the outside of the river channel. In this area lahar seems to have flowed away in to the K. Besuk Koboan without causing any deposition or erosion.

2) K. Besuk Kobo'an

On the volcanic slope (elavation : 1,700m or more) where the upper reach of Besuk Kobo'an is located, a lot of gullies are developed. Through aerophoto-interpretation, It seems that no form of landslide which is considered to be related to the 1981 lahar is observed. The field survey at the elevation of 1,500m revealed that: the max. erosion depth is 2.5m ; the average erosion depth is about 1 m ; the valley width is about 30 m ; the length of erosion is 2.5 km.

The lahar deposit forms terraces with heights of 1 - 2.5m in the valley between the elevation of 750 - 1,100 m. The deposit mainly consists of silt and sand although a lot of boulders with diameters ranging from 2 - 3 m are included. The structure of deposit partly shows stratous layer , and the surface is more or less smooth.

3) Vicinity of Kobo'an Dam

In the deposit area of Kobo'an Dam (elevation: 680 - 720m) , the terrace deposits exist distinctly. For example, the terrace height reaches 4 - 5m on a bit upstream of the dam. The matrix of the deposit chiefly consists of silt and fine sand. Boulders measuring 2 m in diameter also also contained in large number. Stratous structure is observed on the out-crops of the terrace scarps. It seems that the deposit materials mainly came from K.Curah Kobo'an.

Deposits of the same structure as the deposits on the upper reaches side of the dam exist in one area extending 1 km downstream from Kobo'an Dam. This seems to be due to the gorge located at the elevation of about 600m functioning as a natural dam.

4) K. Leprak Fan

In the K. Leprak fan , there are 4 units of flooding morphology, among which 2 are located on the upperstream side of Mt. Jugo and the other 2 units are located on the downstream side.

On the upstream side of Mt. Jugo, 2 units of flooding morphology settle thick in a narrow space compared with the downstream side. The deposits mainly consist of silt and sand mixed with boulders with diameters measuring 2 - 4 m. Stratous structure is partly seen in the deposits. The max. deposit thickness is 3 m and the average thickness is about 1 m. The deposit surface is relatively smooth.

The 2 units of flooding morphology on the downstream side of Mt. Jugo settle less thicker in wider area compared with the upstream side, the deposits thickness is 0.5 - 1 m. Although the composit materials are the same as the those of the upperstream side deposits, the proportion of cobbles in the deposits is a little smaller.

Downstream side from K. Leprak and K. Rejali's conflunce point, the relative quantities of pebbles and cobbles decrease.

(b) K. Mujur Basin

1) K. Besuk Tungeng

a) Zone of Sediment Source

The form of a landslide at the valley head of K.Besuk Tungeng and K. Besuk Sat located between the elevation of 1,900 - 2,000 m is the starting point of the 1981 lahar. The said landslide seems to have developped eroding the suface soils of the volcanic slope, valley walls, and valley bed at the elevation between 1,500 - 1,900m and have flowed downhill. The lahar branched off near the point with elevation of 1,500 m and flowed down along K. Besuk Tungeng and K.Besuk Sat.

b) Zone of Transportation

The lahar flooded over the valley because K.Besuk Tungeng channel is too narrow. The max. overflood width was 1.3 km and the average one was 0.7 km. The deposit mainly consists of fine particle materiales such as sand and silt. Howevere, a large number boulders with diameters ranging from 1 - 2 m are included along the river cource located lower than the elevation of 800 m.

The lahar flowed down through the area between the elevation of 900 - 1,500 m under a condition where erosion and deposition are well balanced. At the elevation lower than 900 m, the deposition exceeds the erosion,and consequently the flood partly went into K. Besuk Sat on the left side.

2) K. Besuk Sat

The lahar originating itself from the valley head of the Besuk Tunggeng flowed down leaving terrace deposits on both or either side of the valley between the elevation of 750 - 1,500 m . The deposit mainly consists of silt and sand, boulders with diameters ranging from 1 - 2 m are also included in large number. Although stratous structure is not recognized , the deposit surface is close to flat.

Apart from the lahar originating from the Besuk Tunggeng's valley head , a small-scale landslide can be recognized at the gully head of the Besuk Sat above the forest line , nearly 2500 m , on the aero photograph. The trace of small lahar is located from the said landslide to the confluence of Besuk Tengah at the elevation 950 m . The above mentioned terrace depositions by lahar were formed between the confluence of the Besuk Tengah and the one of the Besuk Tompe.

Besuk Sat fan area is located at the elevation of about 600 - 650 m. The lahar's deposition tendency is strengthened from this area, and it flooded over a 4 - m high valley wall and rushed into the right-bank side at the elevation of 600 m.

3) K. Besuk Tunggeng // K. Besuk Sat - K. Mujur

The area between the confluence point of Besuk Tunggeng and Besuk Sat and the confluence point of Besuk Tunggeng and K. Mujur composes the upper part of the volcanic fan formed by these rivers.
In this area large-scale deposits , morphology and traces of the flood due to the 1981 "lahar" are recognized.

The max. deposit thickness reaches 2 m. Deposits of cobbles (0.5 - 1 m) and boulders (2 m) are concentrated in this area. However , the surface of the deposits are flat.

On the downstream side of Gesang (Elevation: 170 m), deposit concentration or overflow is not observed although there are boulder deposits.
This implies that the "lahar" flow was relatively gentle.

On the downstream from K. Pancing's joint , no cobbles and no boulders are observed.

(2) Classification of Sediment Deposit

(a) Deposits structure

1) Deposit structure classification

The deposits structure in the 1981 lahar were classified into 3 types in this area. On the basis of the investigation on deposit ;

- Distribution of deposit
- Sectional shapes
- Sedimentary structure
- Grain size distribution of materials

Fig-6.10.2
Sketch map of sedimentary movement on the catchment area of Kali Rejali

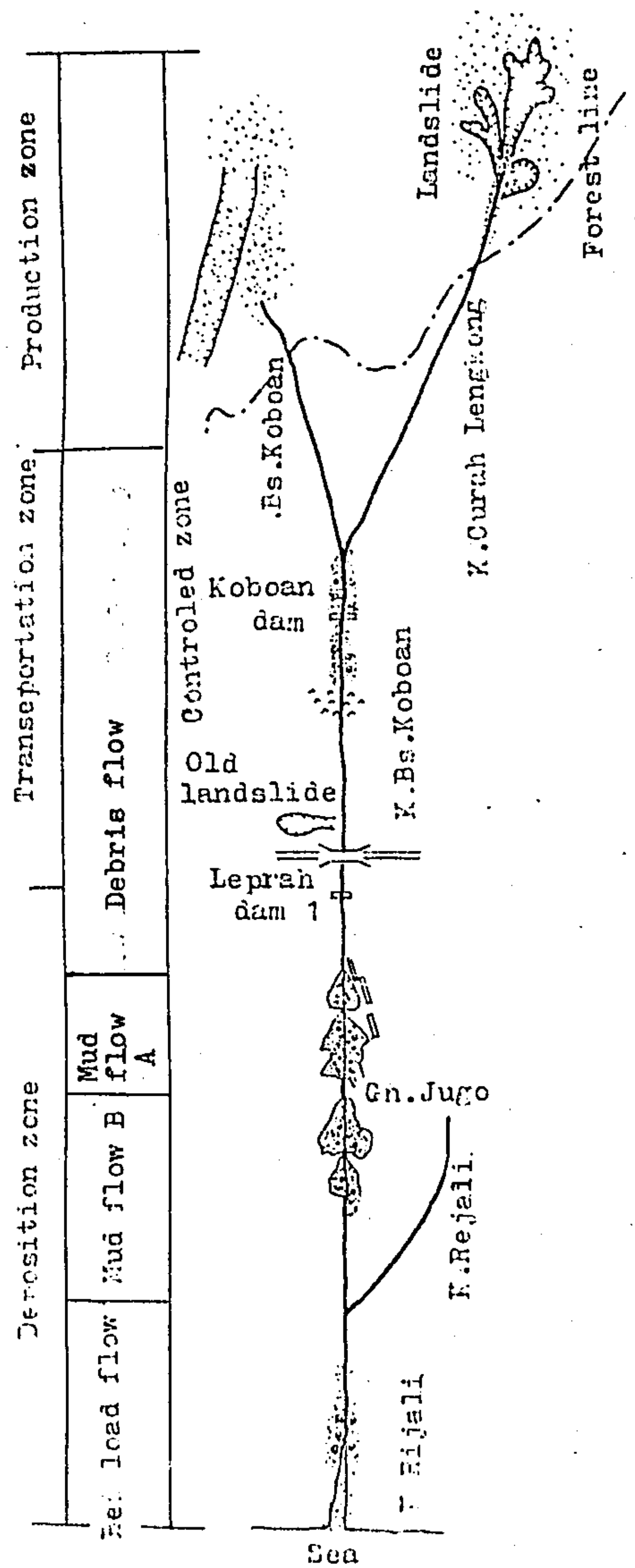


Table-6.10.1
Volume of sediment product and deposit on the catchment area of Kali rejali

Alti. (m)	Dis. (km)	Sediment Volume (x 1000 m) Deposit	Eroded
		316.9*	950.5*
2400–2000	0.8	--	—
2000–900	0.7	--	--
900–800	1.2	--	--
800–720	1.5	0	0
720–700	0.5	131.7*	--
700–650	0.5	87.0*	--
650–490	1.5	—	--
490–400	1.7	--	--
400–330	1.9	234.3	78.5
330–250	1.9	332.0	135.7
250–190	2.0	437.1	183.0
190–140	2.8	232.2	128.2
140–100	3.3	106.9	11.0
100–60	1.8	59.8	9.3
60–	2.8	502.4	125.5

Fig-6.10.3
Sketch map of sedimentary movement on the catchment area of Kali Rejali

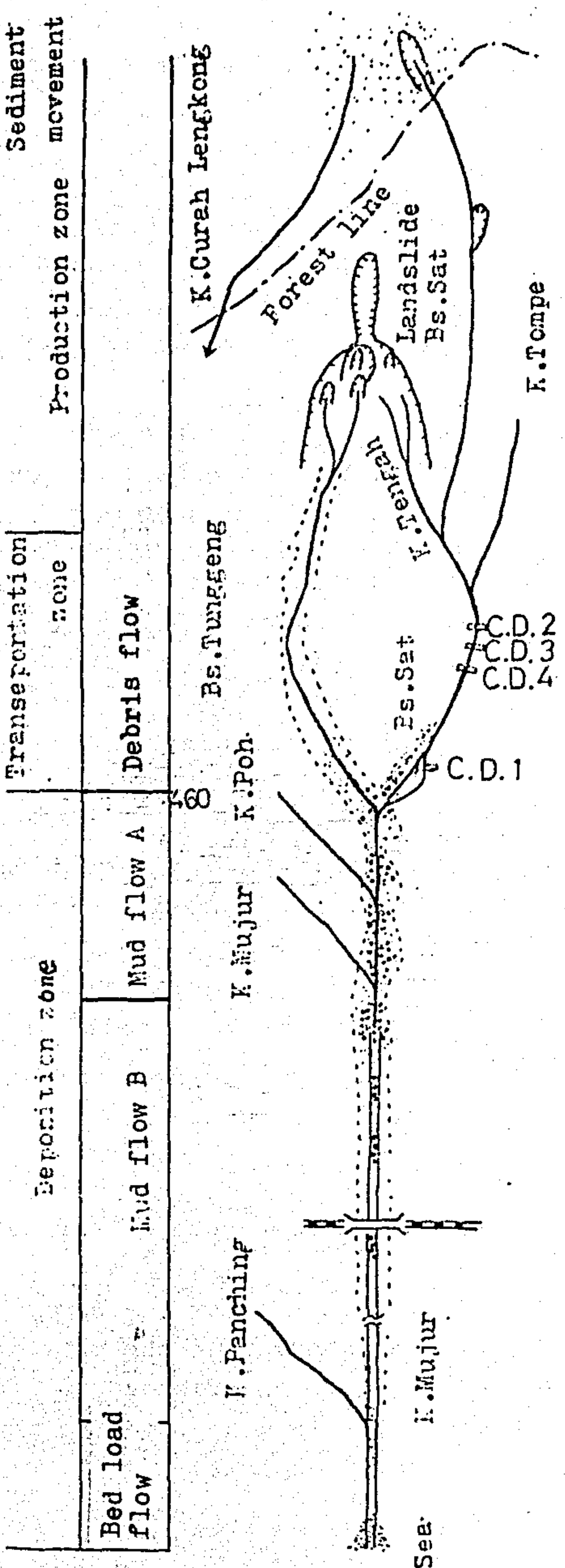


Table-6.10.2

Volume of sediment product and deposit on the catchment area of Kali Mujur

\+ Deposit
\- Eroded

Alti.(m) Dist.(km)	Sediment Volume (x1000 m³)		
2000			
	- 95.1 *		
1900			
1.5	- 383.5 * + 155.5 *		
1500	Tunggeng	Sat	
3.5	+153.7 *	-	
1000			95.0
4.5	+444.5 *	+102.3 *	
			75.0
		+ 96.0	
750			67.0
4.5	+496.7	+415.7	
			52.0
		+204.7	
460			
5.0	+ 781.8		
295			
5.0	+ 365.3		
150			
5,5	+ 198.7		
70			
3.4	+ 130.2 *		
30			
5.0	+ 194.6 *		

In this report , we gave each deposit type the following tentative name , from the upper reach to the lower reach of river channel respectively.

1 Debris flow deposit
2 Mad flow deposit
3 Bed load flow deposit

The characteristics of these 3 types of deposit structure were described as follows;

a) Debris flow deposits

- The max. thickness of deposits is 3 m or more.
- The matrix of deposits consists of mainly silt and sand , a large number of boulders distributed in the deposits or on the surface of it.
- The gathering of boulders at the front of deposits is seen , however , the boulders are distributed dispersedly.
- The deposits surface is rather flat.
- The longitudinal cross section shows the max. thickness of deposits at the front of deposit and the thickness to the upper reach in the many cases.
- The deposits consists of several layers in some case. The thickness of it is ordinary 1 m or more ,in a layer , the clear sedimentary fabric is not seen.

b) Mud flow deposits

- The matrix of the deposits become coaser than Debris flow.
- The max. thickness of deposit is from 1 - 3 m.
- The stratous structure is observed in the many cases.
- A large number of boulders are distributed in and on the deposits dipersedly. But in some case the boulders are gathered at the front of deposit.

- As the thickness of deposit is rather thin , so the front morphology is not so clear in many cases.
- In the deposits , the stra'tus structure is developed in many cases. In some layer , the sedimentary fabrics are seen like as lamina and imbrication.

From the observation results , this type seems to be a transition type between debris flow deposit and bed load flow deposit . The area where this type is distributed , the debris flow deposit and bed load flow deposits exist to be mixed.

The mud-flow deposit is classified into 2 types according to the frequency of distribution of bed load flow deposit and debris flow deposit and max. thickness of deposit. 2 types of deposit was named in this study tentatively as follows;

① Mud-flow A :
The deposit in which characteristics of debris flow deposit surface. Max thickness of deposit is 1.5 m or more.

② Mud-flow B :
The deposit in which characteristics of bed load flow deposits surface. Max. thickness of deposit is 1.5 m or less.

c) Bed load flow deposit

- The stra'tus structure is developed clearly.
- In a layer , the grain size is well sorted.
- In a many cases , laminas are developed.
- The surface of deposit is flat and have gentle slope.
- The thickness of deposit is max. 1 m.
- The distribution of boulders decrease.

Taking landform classification into consideration, the sections which correspond to the each deposit types are shown in fig.-6.8.2 and 6.8.3.

3) Volume Calculation

On the basis of the field investigation and aero photo interpretation . The deposit volume of 1981 lahar was calculated the map of subterranean conteur thickness as follows .

① Deposit volume on the volcanic fan area (Vd m^3)

$$Vd = Ad \times \frac{ha + hb}{2}$$

where : Ad Area between contour ha and hb (m^2)

ha,hb Thickness of deposit (m)

② Deposit volume in river channel (Vc m^3)

$$Vc = Dc \times Wc \times L$$

where : Dc Mean deposit thickness (m)

: Wc Mean width of channel (m)

: L Length of channel (m)

③ Total deposit volume (m^3)

$$Vt = Vc + Vd$$

The results is shown in Table 6 . 10 . 1 and 6 . 10 .2

As the field data about erosion volume such as river bed changes and aero-photo interpretation , we tried to calculate the erosion volume , and the balance of sediment products and deposit as follows ;

Erosion volume on the general earth surface where lahar deposit covered.

$$Ve = A_{50} \times 0.5_m$$

where ; A_{50}: Area which deposit thickness exceeded over 50 cm.

0.5_m:Mean deposit thickness

Erosion volume of landslide (V_E)

$$V_E = A_a \times H_a$$

where ; A_a : Projected area of form of landslide
H_a : Mean depth of landslide

The results of this calculation about K. Rejali fan area are shown in Table-6.10.1 and 6.10.2.

Deposit volume investigated in K. Leprak fan and in K. Mujur fan shows as follows;

K. Rejali fan (check dam No.1 - river mouth) ; 1.95×10^6 m^3

K. Mujur fan (confluence between K. Besuk Sat and K.Besuk Tunggeng - river mouth) ; 1.67×10^6 m^3

6.11 SEDIMENT CONTROL FACILITY

K. HIRAO
Y. SHIMODA
T. ISHIZAKA

— SUMMARY —

(1) PURPOSE

The purpose of this study is to plan the sediment control facilities and to design them in order for the selection of priority projects and project evaluation.

(2) METHODOLOGY

This study is based on the existing Master Plans, the existing materials and the interim results of the field investigation, because the field investigation and analysis have not yet been finished. The facilities proposed here may be revised after the field investigation and analysis are finished.

The design of facilities is rough one and based on the Technical Standard of River and Sabo Engineering, Ministry of Contruction Japan.

(3) MAIN RESULTS

The sediment control facilities as planned aiming to prevent the disasters in Rejali fan area are shown in Table - 6.11.1.

The facilities in K. Mujur have not yet been finished.

Table - 6.11.1 Sediment Control Facility Plan

River System	Facility	Contents	Location and Remarks
K. Reja-li	Diversion channel	Channel length = 1.9 km	from 1.1 km upstream in K. Curah Kobo'an to K. Lengkong
	Check dam	dam height H = 15 m 2 units	belongings of diversion channel
	Sand Pocket	1 unit	
	Leprak sand pocket	dike height H = 6.5 m 2 units	at Leprak fan
K. Leng-kong	Pronojiwo check dam	dam height H = 30 m dam length L = 450 m	at 300 m upstream of Pronojiwo Bridge
	Nanas dam	dam height H = 10 m	at 1300 m upstream of Pronojiwo dam
K. Mu-jur	not yet planed		

6.11.1 DIVERSION PLAN FOR THE K. CURAH KOBOAN

(1) Outline

Regarding the diversion from the K. Curah Koboan to the K. Lengkong, the following diversion channel and related facilities are planned:

- Starting Point of Diversion Channel	:	1.1 km upstream from Curah Koboan Checkdam I
- Ending Point of Diversion Channel	:	28.18 km upstream from the K. Lengkong's river mouth (Supit Urang)
- Total Length of Diversion Channel	:	L = 1.9 km
- Approx. Excavation Quantity	:	Ve = 920,000 m3
- Check dam	:	1 Unit
- Sand Pocket	:	1 Unit
- Related Work	:	- Length of shifted road L = 2.6 km - Checkdam = 1 unit

(2) Selection of Proposed Diversion Channel Routes for Comparison.

Possible routes through which transported sediments and water at the time of flooding can divert from the K. Curah Koboan to the K. Lengkong are selected.

(a) Conditions for Selecting Proposed Diversion Routes

The requirement that a diversion route should satisfy and the favourable factors as a diversion route are indicated below:

① Requirements to be satisfied

- Being able to secure a riverbed gradient which enables sediment transportation

- The river channel trait connecting the K. Curah Koboan and the diversion channel being free from disturbing curves or angles (Easy inflow of transported sediments)

- Possible to construct an excavated channel.

② Favorable Factors

- Small quantity of excavation

- Possible to secure sufficient space to deposit sediments on the downstream side of the diversion channel's outlet

- Diversion channel being as straight as possible

- Giving minimum influence on villages and main roads.

(b) Selecting Proposed Routes for Comparison

Fig. - 6.11.1, Fig. - 6.11.2, and Table 6.11.2 shows 5 routes which satisfy the above-mentioned conditions as proposed diversion routes. To obtain the riverbed gradient indicated in Table 6.11.2, the existing riverbed is assumed to be raised by 13 m by means of a checkdam.

Table 6.11.2 Diversion Channel Route

Route	Intake			Outlet		Different of elevation of intake and outlet	Length of Channel	Gradient of design riverbed
	Location (distance from checkdam I)	Elevation of present riverbed	Elevation of design riverbed	Location (Distance from K. Glidik river mouth	Elevation of present riverbed			
1				28.183 km	EL 730 m	23	190 m	1/85
2	2.500 m	EL 740 m	EL 753 m	27.623 km	EL 720 m	33	2300 m	1/68
3				26.673 km	EL 715 m	38	3000 m	1/78
4	1.100 m	EL 823 m	EL 836 m	27.623 km	EL 720 m	116	3500 m	1/30
5				26.673 km	EL 715 m	121	6200 m	1/35

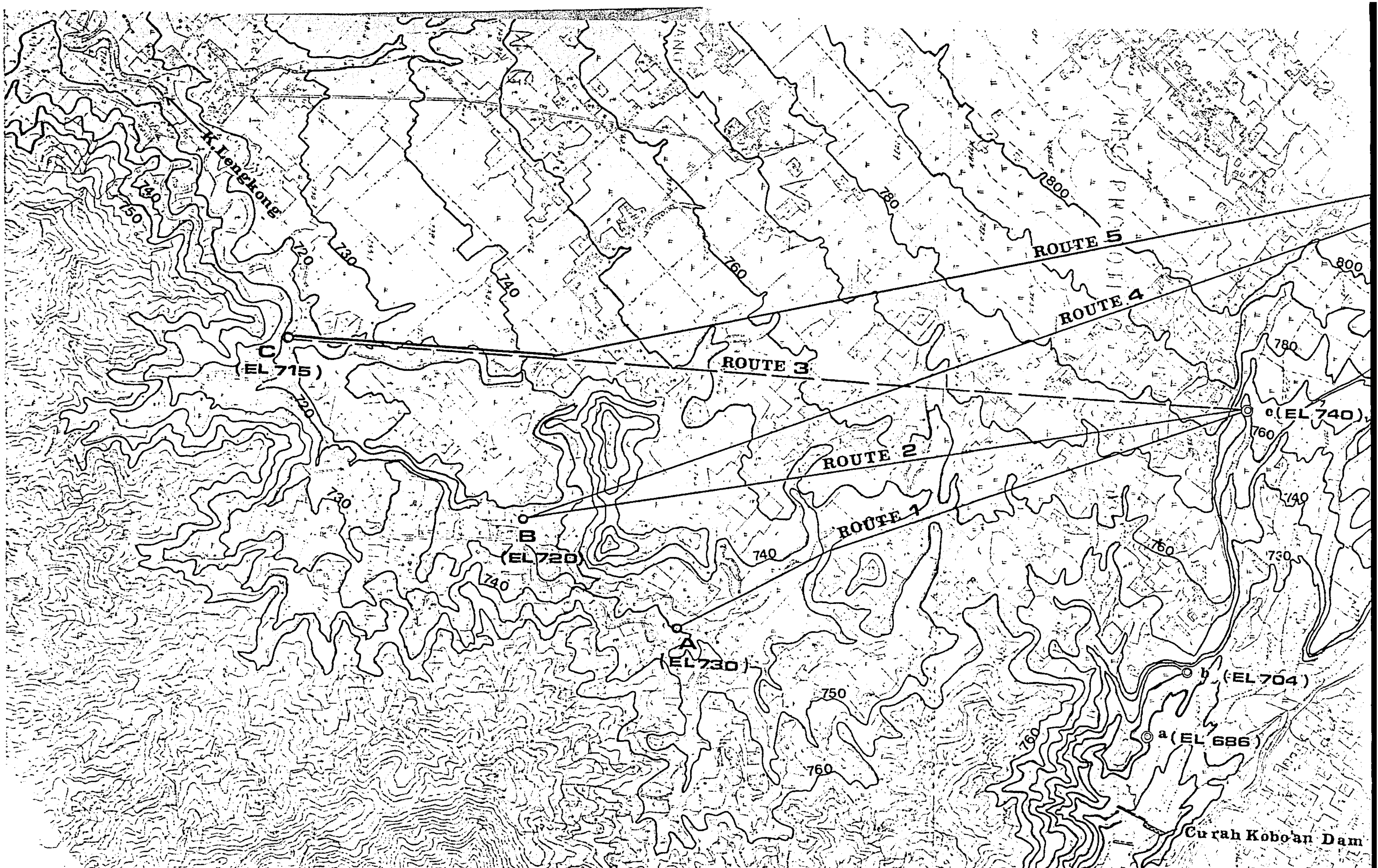
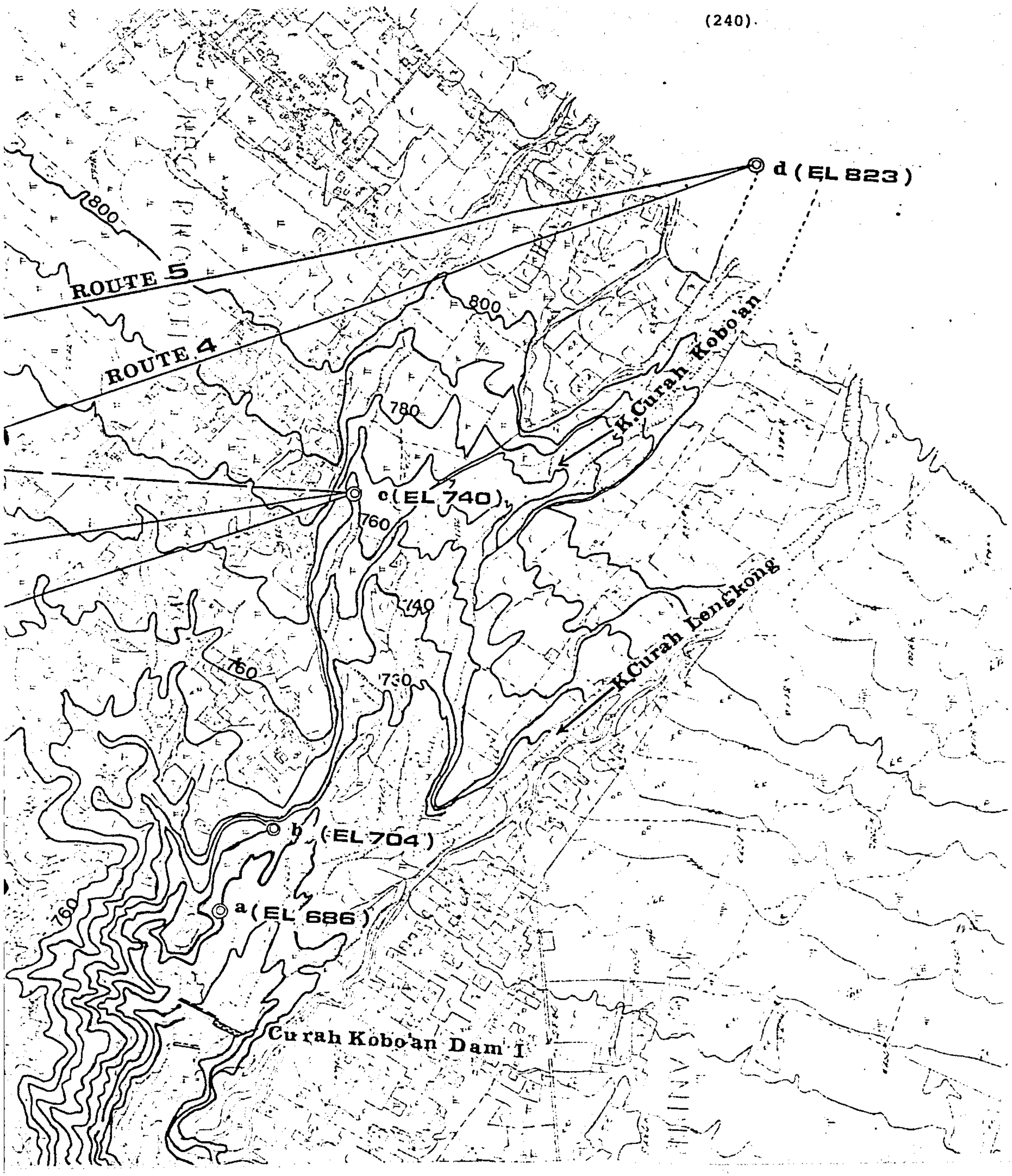


Fig-6.11.1 Diversion Channel Route
Scale 1 : 10 000


d (EL 823)
ROUTE 5
ROUTE 4
800
800
780
c (EL 740)
760
740
760
730
K.Curah Kobo'an
K.Curah Lengkong
b (EL 704)
a (EL 686)
760
Curah Kobo'an Dam I

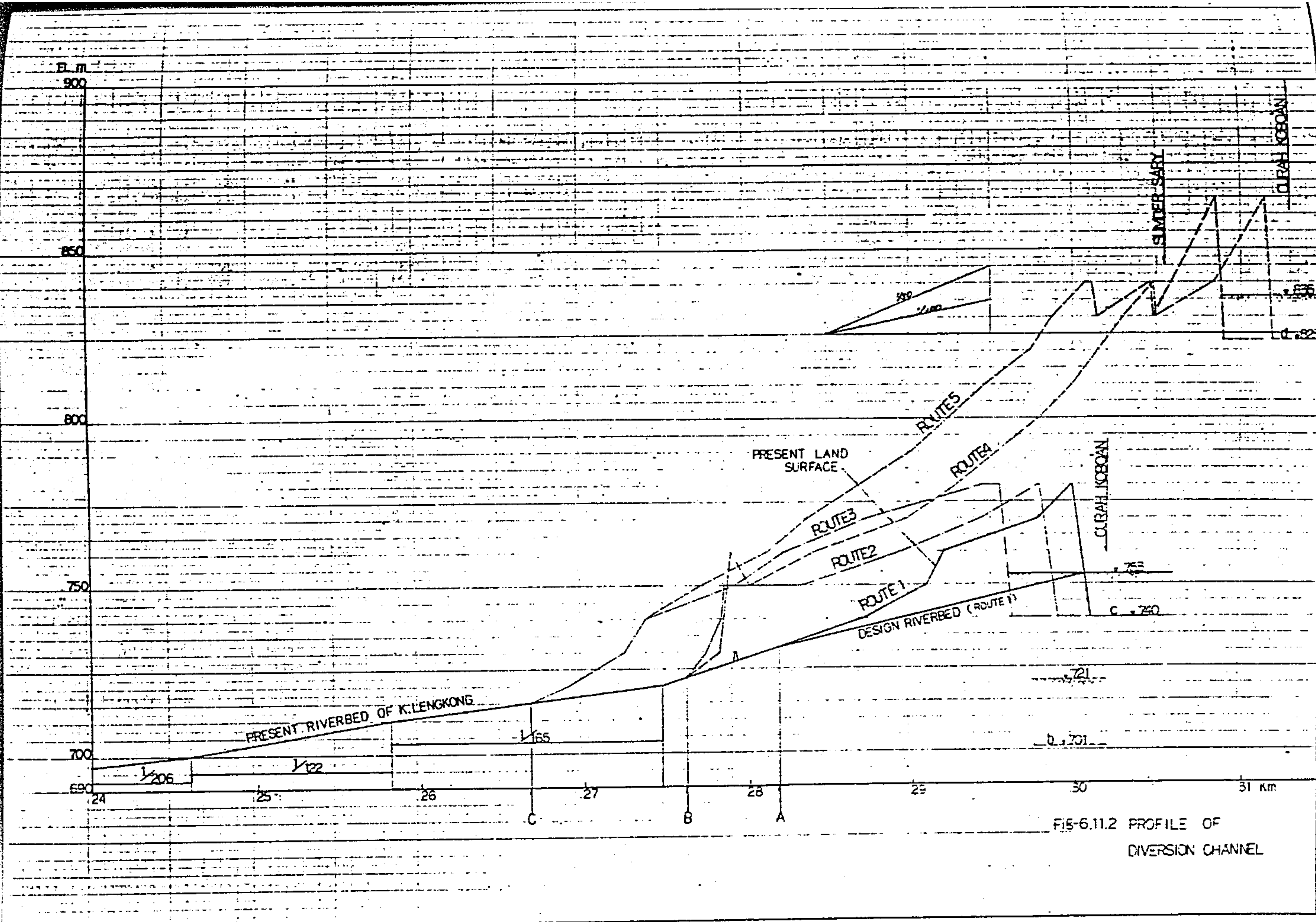


Fig-6.11.2 PROFILE OF DIVERSION CHANNEL

(3) Determining Diversion Route

The selected diversion routes are compared centered around the following 4 factors which are important requirements of the diversion route:

i) Sediment tractive force,
ii) Easiness in sediment's incoming,
iii) Possibility constructing excavated channel,
iv) Quantity of excavation work.

Comparison based on the above-mentioned factors is indicated in Table - 6.11.4. Evaluation basis for each comparison factors are as follows:

i) Sediment tractive force,

Regarding the Curah Koboan River, the diversion channel, and the Kali Lengkong River, U_*^2 was calculated tentatively. The result is indicated in Fig. 6.11.3. With regard to the diversion channels tractional capacity proposed Routes 1, 2 and 3 are less capable than the K. Curah Koboan. However, if we apply the principle generally used for designing erosion control channel works, i.e. "The fluctuation of U_*^2 must not exceed the double amount of the original value", the sediment transportation capacities of Routes 1, 2 and 3 are considered to be sufficient. Furthermore, sediment transportation capacity can be increased by increasing the height of the checkdam at the intake.

For the above-mentioned reasons, the sediment transportation capacities of all the proposed diversion routes are considered to be sufficient. Nevertheless, Routes 4 and 5 are evaluated to have larger sediment transportation capacities.

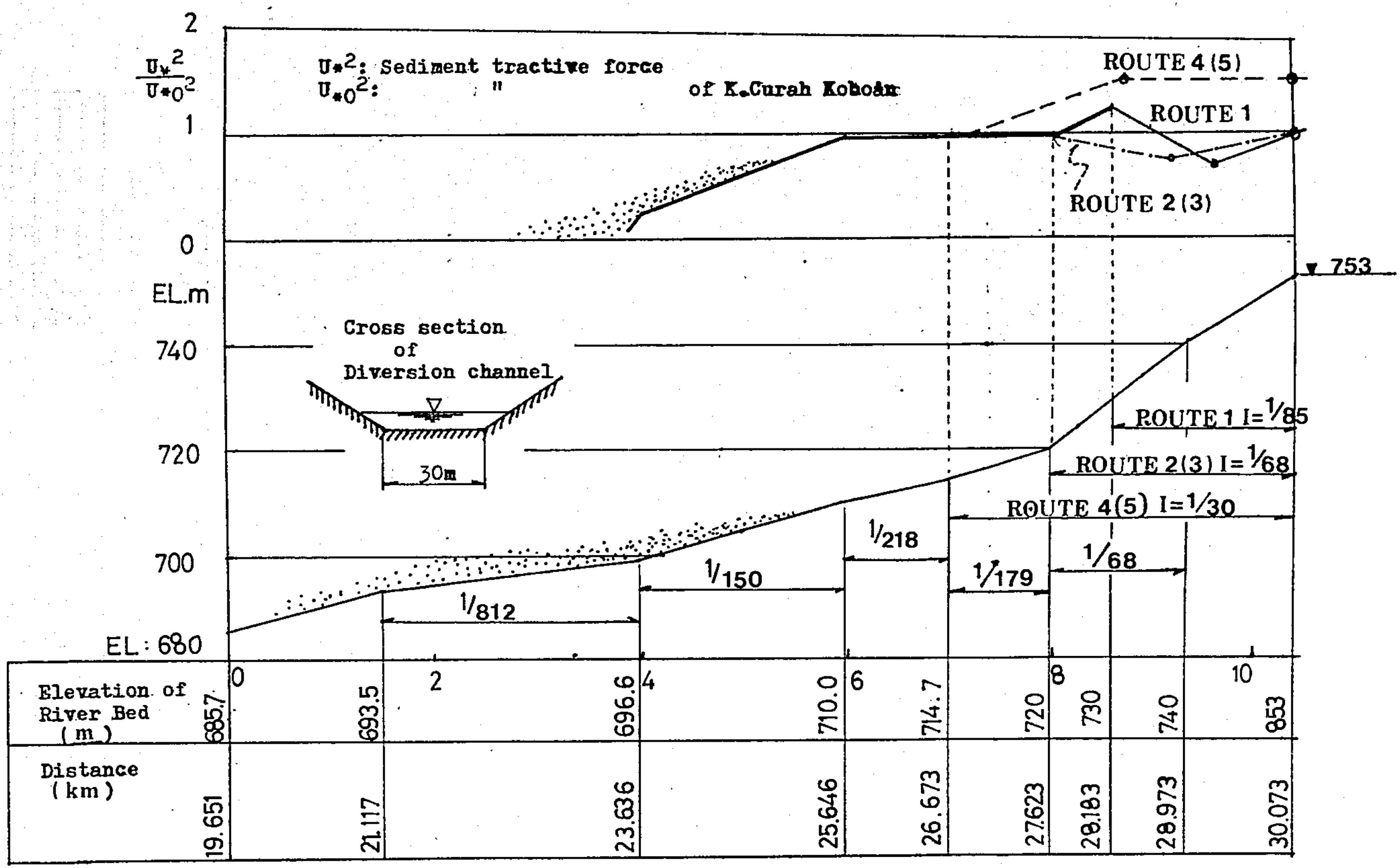


Fig-6.11.3 Sediment Tractive Force of Diversion Channel

ii) Easiness in sediment's incoming

For Routes 1, 2 and 3, a curve of the K. Curah Koboan located 1.1 km upstream of Curah Koboan Dam is utilized. Therefore, transported sediments from the Curah Koboan River can easily flow into the proposed diversion channels.

On the other hand, Routes 4 and 5 are to be constructed along the straight part of the Curah Koboan River. The river and each diversion channel's trait form an angle of 65 degrees. Therefore, transported sediments' flowing into these diversion channels are less easy compared with Routes 1, 2 and 3.

iii) Possibility of constructing excavated channel

As it is possible to make a 10 to 20 m deep excavated channel for each route, all the routes are evaluated to be on the same level in this respect.

iv) Quantity of excavation work

Rough estimation of excavation work quantity in each proposed diversion route is indicated in Table 6.11.3. Routes 2 and 5 require the largest quantities. Route 1's excavation work quantity, which is about 1/3 of those of Routes 2 and 5, is the smallest. Therefore, Route 1 is the most economical route estimated on the basis of excavation work quantity.

Table 6.11.3 Excavation volume of Diversion Channel

Diversion Route	Excavation Volume (10^6 m3)
1	0.9
2	2.1
3	2.5
4	2.3
5	2.8

Table 6.11.4 Comparison of Diversion Channels

Factors for Comparison \ Routes		1	2	3	4	5
Specs.	Channel length (km)	1.87	2.25	2.95	3.45	4.2
	Riverbed Gradient	1/85	1/68	1/78	1/30	1/35
	Max. Excavation Depth (m)	27	27	27	30	30
Sediment Tractive Force		1	1	1	2	2
Easiness in Sediment Incoming		2	2	2	1	1
Possibility of Constructing Excavated Channel		2	2	2	2	2
Excavation Work Quantity		2	0	1	1	0
Total Evaluation		7	5	6	6	5

Note: The larger the evaluation on figure is the higher the degree of satisfying the requirement.

Assuming that the same importance is given to each comparison factor indicated in Table 6.11.4, Route 1 is evaluated as the optimum route. Moreover, regarding the favorable factors as the diversion channel, Route 1 is most satisfactory compared with the other proposed routes. Therefore, Route 1 is selected as the diversion route.

(4) Diversion Channel Plan

The following facilities are required to divert sediments from the K. Curah Koboan to the K. Lengkong:

① Checkdam at Intake: A checkdam is needed at the intake for the following purposes:

a) To increase the riverbed gradient of the diversion channel as much as possible,
b) To minimize the quantity of channel excavation,
c) To make the form of flow from the K. Curah Koboan a sediment flow.

② Diversion Channel:

③ Sand Pocket at Outlet of Diversion Channel : A sand pocket is required at the confluence point of the natural river and the diversion channel where sediment tractive force changes largely causing deposition.

④ Related Work : - Shifted road
- Checkdam on upstream side of intake.

The specifications for the planned facilities mentioned above are as follows:

① Diversion Channel

ⓐ Diversion Channel Length	:	L = 1.87 km
ⓑ Planned Riverbed Gradient of Diversion Channel	:	I = 1/85
ⓒ Riverbed Width of Diversion Channel	:	B = 30 m
ⓓ Roughly Estimated Excavation Quantity	:	Ve = 920,000 m3

② Checkdam

ⓐ Dam height : H = 15 m
ⓑ Dam Length : L = 380 m
ⓒ Concrete Volume : Vc = 58,000 m3

③ Sand Pocket

ⓐ Embankment : L = 200 m
ⓑ Concrete Volume : Vc= 5,000 m3

④ Related Work

* Shifted Road

ⓐ Length : L = 2.6 km

* Checkdam

ⓐ Dam height : H = 15 m
ⓑ Dam Length : L = 155 m
ⓒ Concrete Volume : Vc= 31,000 m3

6.11.2 PLAN TO INCREASE HEIGHT OF CURAH KOBOAN CHECKDAM I (IN RELATION WITH DIVERSION OF THE CURAH KOBOAN RIVER)

(1) Purpose of Increasing Dam Height

Along the Kali Rejali River, erosion process is vigorous causing frequent flooding of mudflow on the alluvial fan in the lower reaches because of the following reasons:

ⓐ The Kali Rejali River and the upper reaches of the Besuk Semut River were connected in 1942 as described in Section 6.8;

ⓑ This river incurs direct influence of volcanic activities.

To stabilize the Kali Rejali River in the alluvial fan area, large amount of materials transported by the river from the upper reaches need to be controlled.

As one of the measures for controlling the transported sediment in the Kali Rejali River, diversion from the Curah Koboan River to the Kali Lengkong River is planned. Curah Koboan Checkdam I is located 1.1 km downstream from the planned diversion point. If raising the Curah Koboan River's riverbed by means of increasing the dam height can be utilized for the diversion purpose, the said plan is economical. Therefore, increasing the height of Curah Koboan Checkdam I is planned for the following goals in relation with the Curah Koboan River diversion plan:

i) Raising the riverbed at the diversion point

ii) Storing and controlling sediments transported by the river

(2) Flow Chart of Plan

The flow chart of the plan to increase Curah Koboan Checkdam I's height is indicated in Fig. 6.11.4.

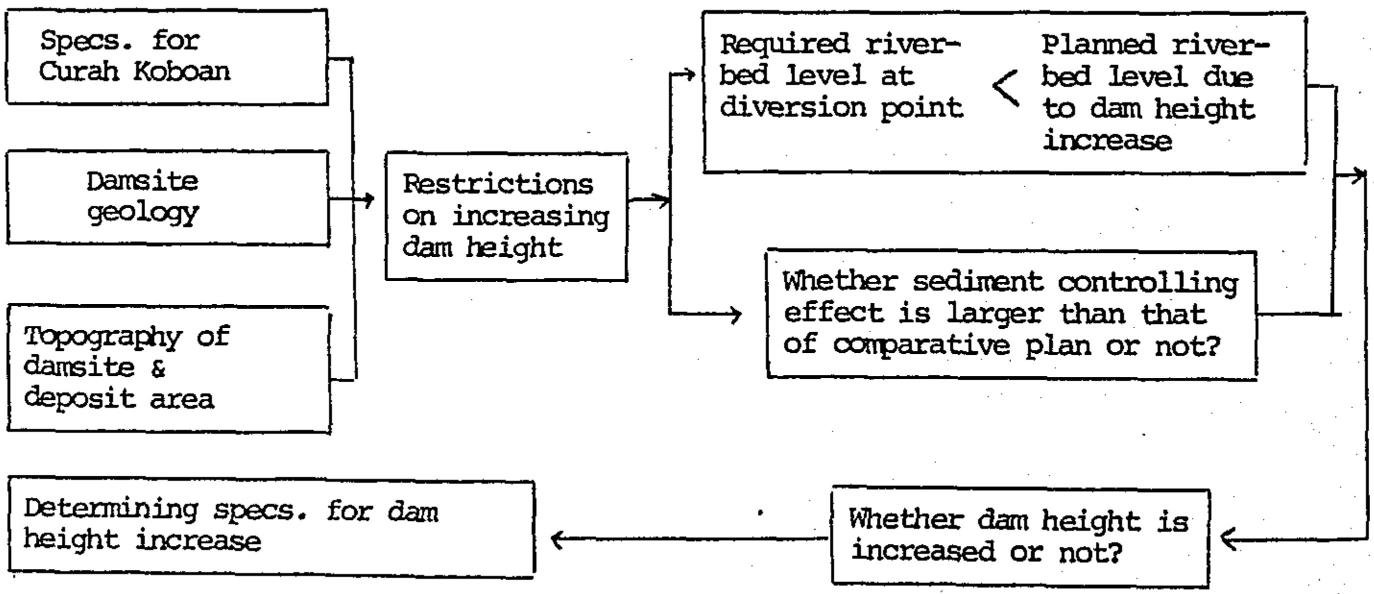


Fig. 6.11.4. Flow Chart of Raising Curah Koboan Dam I

(3) Specification for Curah Koboan Checkdam I

The specifications for Curah Koboan Checkdam I are shown in Fig. 6.11.5. The May 1981 disaster destroyed the dam's spillway and part of the left-bank-side wing. Repairement and improvement of this dam is planned in the following ways as the Urgent Improvement Project:

- Top of the spillway to be restored to the original state,

- Increasing wing height by 3 m.

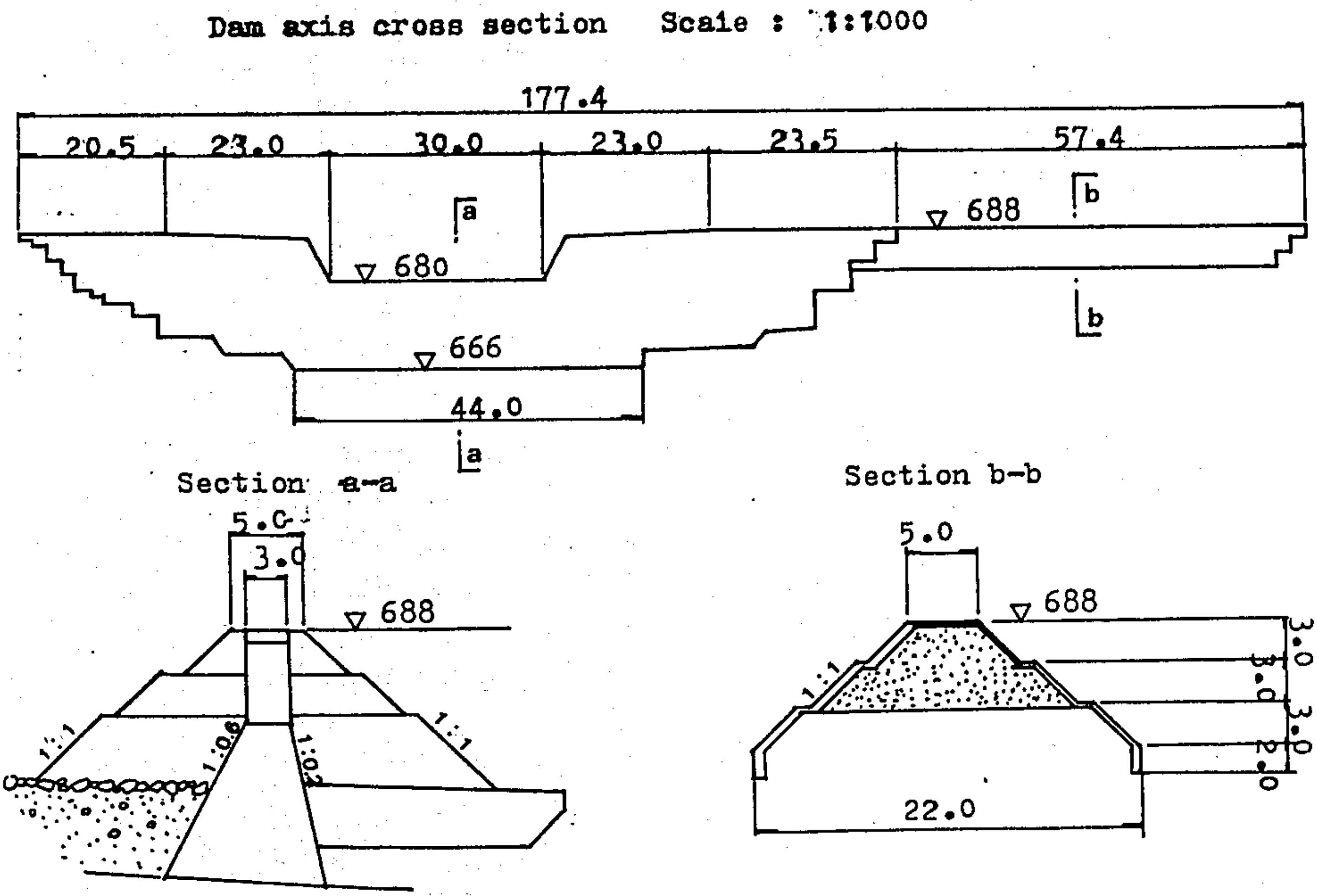


Fig-6.11.5 Existing Curah Koboan Dam I

(4) Restrictions on Dam Height Increase

(a) Topographical Restrictions on Dam Axis

The cross-sections parallel with dam axis were provided on the basis of a 1/2,000 topographical map. Then, 4 cases concerning the dam shape were assumed and indicated on Fig. 6.11.6. From Fig. 6.11.6 the following topographical restrictions on increasing dam height are obtained:

i) The part of the right-bank side of the existing dam higher than the elevation of 710 m consists of a thin mountain ridge with gentle slope. If the dam axis is angled and protection on the thin mountain ridge is provided, the difference in height between the design riverbed and the banks needs to be about 10 m. Therefore, topograhically, the dam height cannot exceed 20 m.

ii) Without mountain ridge protection and angled dam axis, the dam height cannot exceed 15 m.

(b) Topographical Conditions in Deposit Area

When determining the dam height, safety must be secured considering overflow from the both river banks due to the risen surface of dam deposit. The design riverbed and the topography of the both river banks are shown in the profiles of Fig. 6.11.7. On the other hand, the required difference in height between the design riverbed and the river banks is 10 m or more, because the Curah Koboan River's deposit surface fluctuation is 5 m and the mudflow height is considered to be 5 m. Therefore, the design riverbed height at the 2 points whose respective distance from the dam axis is 400 m and 1,400 m. Namely, the max. dam height ΔH = 38 m.

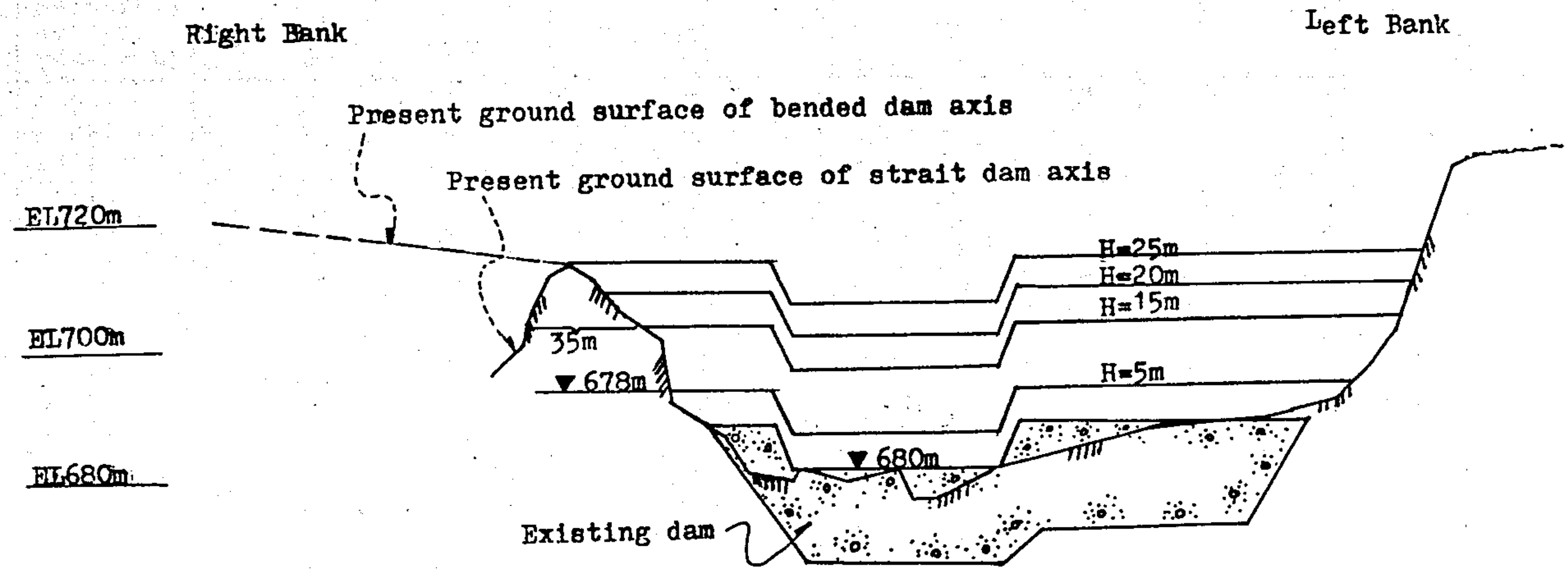
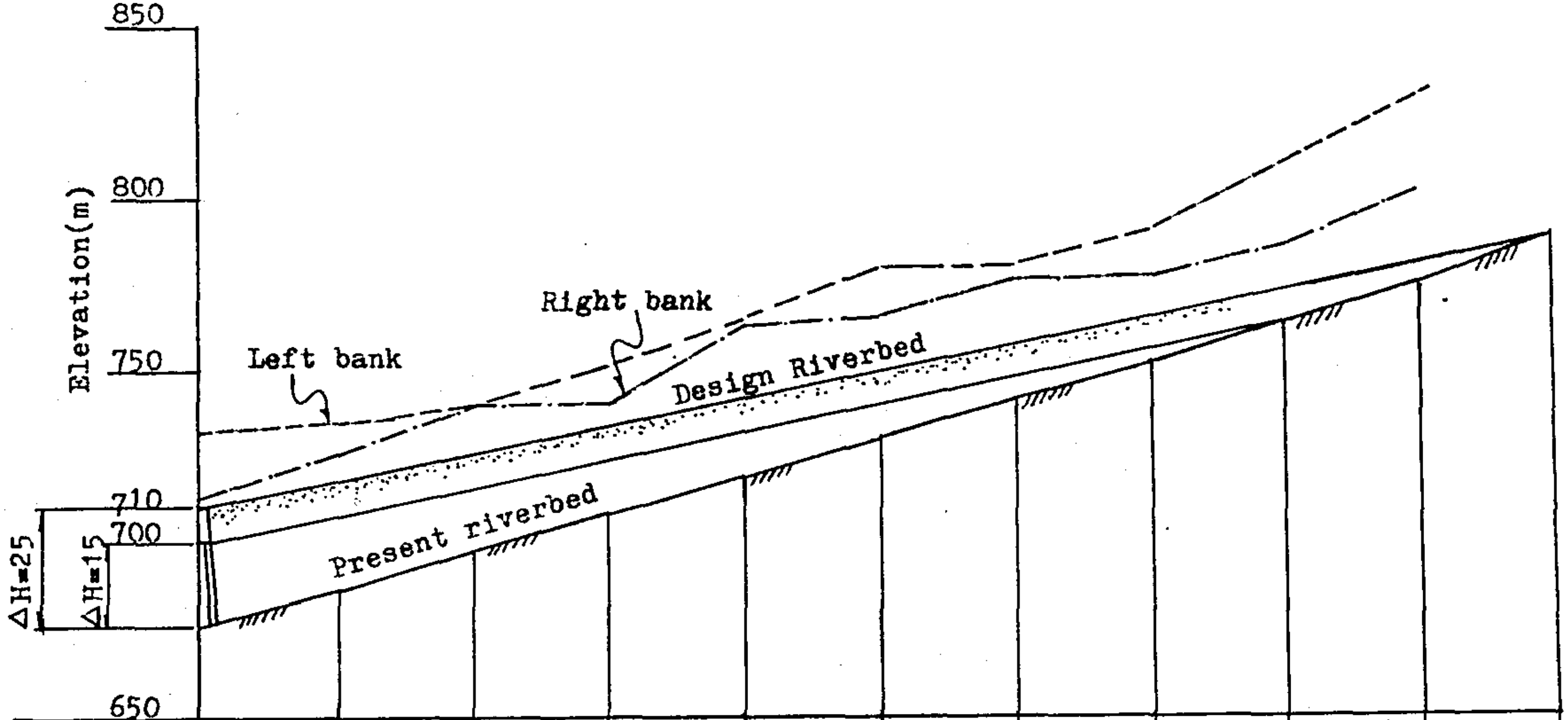


Fig-6.11.6 Dam Axis Cross Section of Curah Koboan I

Scale V=1:1000 H=1:2000



Distance (m)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Right bank height (m)	713.3	725.0	740.0	740.0	763.0	765.0	775.0	767.0	785.0	802.0	
Left bank height (m)	732.0	735.0	740.0	750.2	765.0	779.0	780.3	789.0	809.0	830.0	
Lowest river bed height(m)	676.0	686.5	697.5	707.0	719.0	730.0	741.0	751.0	762.0	774.0	786.0

Fig-6.11.7 Profile of Curah Koboan Dam I Deposit Area

Based on the following considerations, the deposit slope gradient after the height of Curah Koboan Checkdam I are increased is decided to be i = 1/25 which is about 1/1.8 of the original riverbed gradient, = 1/14:

i) The lowest riverbed profile cannot be regarded to represent the deposit gradient because the riverbed has become lower due to the partial destruction of the existing dam. Therefore, the profile was drawn based on the highest deposit surface to figure out the deposit shape on the assumption that the dam had not been damaged.

ii) The point where the riverbed gradient in the profile mentioned above changes distinctly are chosen. Furthermore, changes in sediment grain sizes and the development of gullies on the deposit surface due to the damaged dam are studied through field reconnaissance. Based on such information, the deposit area has been decided to cover the area extending from the dam axis to 500 m upstream from the dam axis.

iii) The average deposit surface gradient obtained in the item i) above in the area mentioned in Item ii) was taken as the deposit gradient (see Fig.6.11.8)

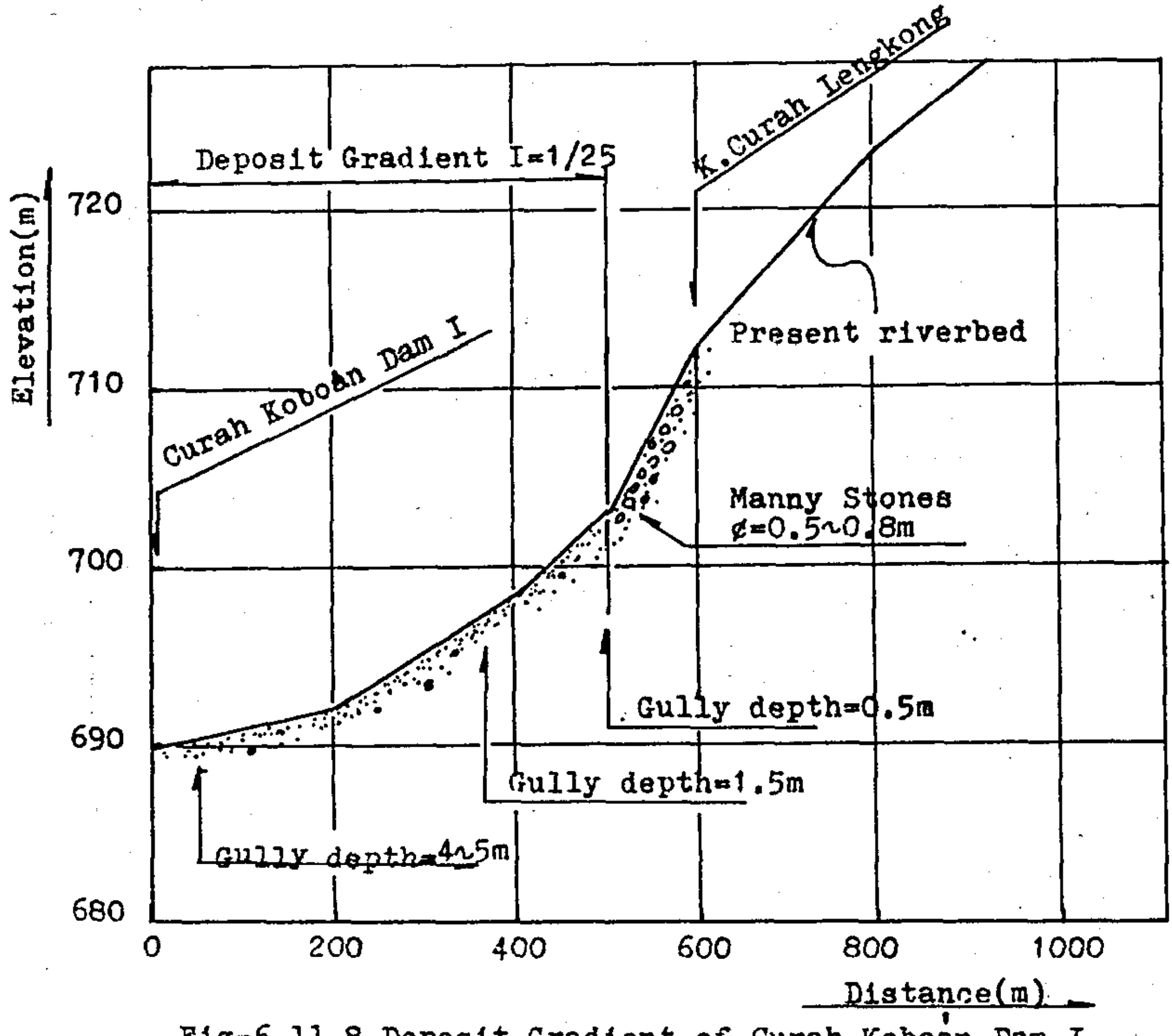


Fig-6.11.8 Deposit Gradient of Curah Koboan Dam I

(c) Restrictions Due to Existing Dam's Structure

It is not appropriate to make the total dam height more than 15 m because the existing dam's left wing is the earth type. Therefore, in order to increase the dam height, the concrete type or the rock fill type must be applied to construct the left wing. If the rock fill type is to be applied, there will be no structural restriction.

(d) Geological Restrictions in the Damsite

Geological problems in the damsite are mentioned below:

i) Strength of the alternating andesite lave, tuff, tuff breccia, and mudstone which serve as the spillway foundation,

ii) Strength of the "lahar" deposit as the left wing's foundation,

iii) Landslide on the left bank constructed with loose "lahar" deposits.

The dam height is determined based on Item ii) among the above-mentioned conditions. Namely, the dam height is restricted in the following ways on the basis of the bearing capacity of the "lahar" which composes the dam foundation subgrade:

- In the case of constructing concrete type left wing :
  - Total dam height $H \leqq 20$ m
  - Increase in dam height $\Delta h \leqq 10$ m

- In the case of constructing rock-fill-type left wing :
  - Total dam height $H \leqq 30$ m
  - Increase in dam height $\Delta h \leqq 20$ m

(e) Limited Increase in Dam Height

The restrictions on increase in the dam height explained in (a) - (d) above can be summarized as the following Table 6.11.5:

Table 6.11.5. Restrictions on Raising Dam Height

Items	Max. Increase in Dam height H (m)	Descriptions
Topography of dam axis	$\Delta H < 15$	No protection for right-bank side thin mountain ridge; No angle in dam axis
	$\Delta H < 20$	Thin mountain ridge used as dam foundation by angulating right-bank-side dam axis
Topography of deposit area	$\Delta H < 38$	Planned deposit gradient : $i = 1/25$ Securing about 10 m as bank height from lowest riverbed
Structure of existing checkdam	-	Constructing rock-fill-type left wing
Geology of damsite	$\Delta H < 20$	Do

From Table 6.11.5, the possible max. increase in the height of Curah Koboan Checkdam I is determined as follows:

- Thin mountain ridge on the right side bank protected; dam axis angulated : $\Delta H \leqq 20$ m

- No protection for thin mountain ridge on the right-side bank provided; Dam axis not angulated : $\Delta H \leqq 15$ m

(5) Riverbed Elevation at Diversion Point Corresponding Increased Dam Height

The diversion channel from the K. Curah Koboan to the K. Lengkong is planned as follows:

i) Intake : about 1.1 km upstream from dam

ii) Outlet : K. Lengkong which is about 1,900 m away from intake (Elevation: 730 m)

iii) Design Riverbed Gradient : I = 1/85

As Curah Koboan Checkdam I's possible max. increase in dam height is H = 20 m, the design riverbed height of the intake of diversion is 744 m from the sea. When the elevation of the intake is 744 m, the design riverbed gradient of diversion channel is I = 1/136. Therefore, it is difficult to divert the channel by increasing the height of Curah Koboan Checkdam I.

(6) Sediment Control Effect

As the index for evaluating a sabo dam's sediment control effect deposit area "A" is used. As the index for evaluating the sediment storing effect, deposition quantity "V" is generally used.

The relation between the increase in height of Curah Koboan Checkdam I (H) and the above-mentioned "A" and "V" is indicated in Fig. 6.11.9.

(7) Conclusion & Recommendation

As the result of the study of this time conducted in the above-mentioned framework, the height of Curah Koboan Checkdam I will not be increased for the following reasons:

i) It is difficult to utilize dam height increase for raising the riverbed at the intake of the diversion channel from the K. Curah Koboan to the K. Lengkong.

ii) The dam structure of the left wing needs to be changed for the purpose of dam height increase of more than a few meters.

iii) The "lahar" deposit constituting the left bank of the upper part of the existing dam is liable to cause a landslide.

If the increase in height of Curah Koboan Check-dam I will be planned to regulate and store sediments transported by the river, the following points needs to be considered:

i) Protection of the thin mountain ridge on the right bank,

ii) Measures against landslide due to loose "lahar" deposits,

iii) Dam structure of the left wing which currently is the earth type.

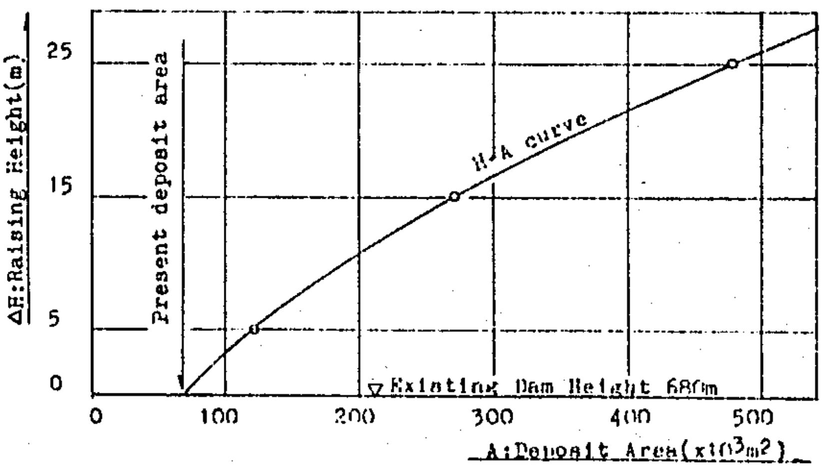


Fig-6.11.9 Effect of Dam Raising (H-A curve)

6.11.3 SEDIMENT CONTROL PLAN IN K. LENGKONG

(1) Object of Plan

The diversion channel is planned to connect K. Curah Koboan and K. Lengkong, which is a main tributary of K. Glidik, in order to prevent the disaster occurred in the Rejali Fan area. After construction of this channel, large amounts of additional sediment volume will flow into K. Lengkong from K. Curah Koboan. Therefore, the sediment control facilities are needed to control it. In this Chapter, the sediment control facility plan concerning the diversion plan is explained.

(2) Methodology

The sediment control plan in K. Lengkong is studied according to the procedures as shown in Fig. 6.11.10.

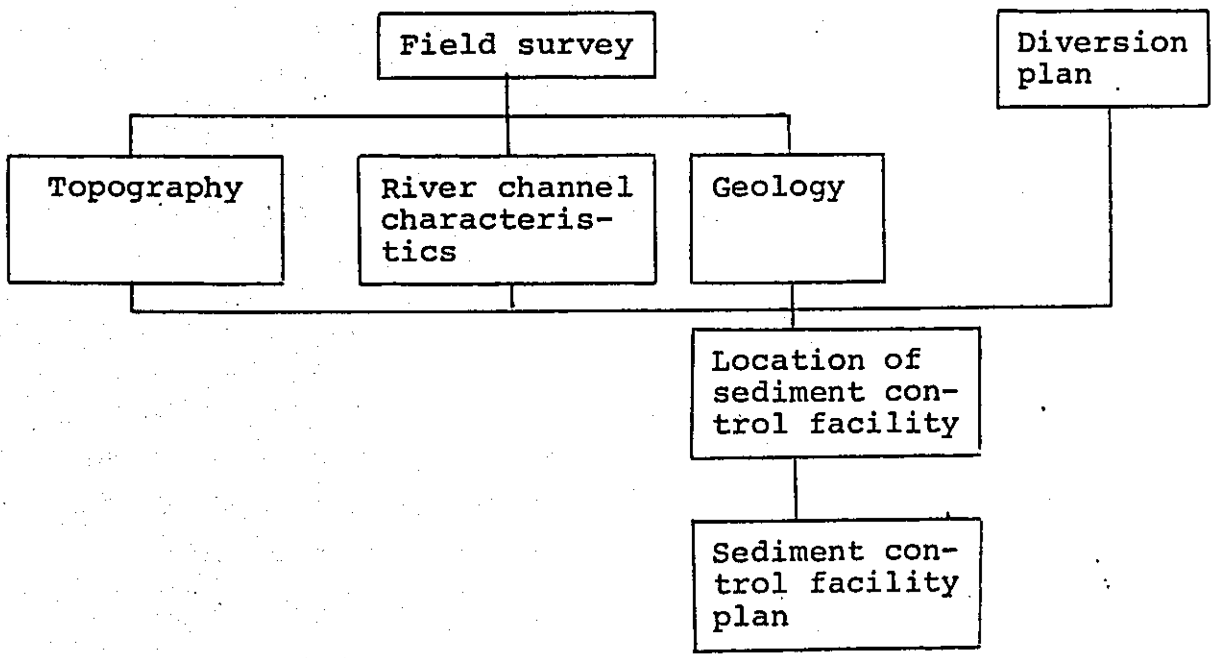


Fig. 6.11.10 Study Flow Chart of Sediment Control Plan in K. Lengkong

(3) Topography

K. Lengkong basin consists of the south slope of Mt. Semeru and the tertiary range which lies in the closer south of Mt. Semeru. K. Lengkong flows toward the West along the boundary of the south slope of Mt. Semeru and the tertiary range as shown in Fig.6.11.11. Since the boundary of the south slope of Mt. Semeru and the tertiary range is shifted toward south at Pronojiwo Bridge, K. Lengkong turns its flow direction toward the southwest. K. Lengkong, before it turns flow direction, is jointed by K. Besuk Bang and K. Besuk Kumbar arising from the summit of Mt. Semeru. At the north side of K. Lengkong, the allurial fan is formed by the K. Besuk Bang and K. Besuk Kumber. K. Lengkong has a deep valley in its downstream at the confluence with K. Besuk Bang.

(4) Geology

In the river basin of K. Lengkong, an andesite lava appears at the confluence with K. Besuk Bang, and this andesite lava continues up to the confluence with K. Glidik. This andesite lava has eroded and formed a very deep valley in the downstream of K. Lengkong. Since the river bed is covered by the very deep deposits in K. Lengkong, a bed-rock does not appear in the upstream of the confluence.

(5) River Characteristics

The profiles of K. Glidik and its tributaries are shown in Fig. 6.11.12. The river bed gradients of these rivers (average gradient of the confluence with K. Glidik or K. Lengkong and the upstream 1 km. far from the confluence) are shown in Table - 6.11.6.

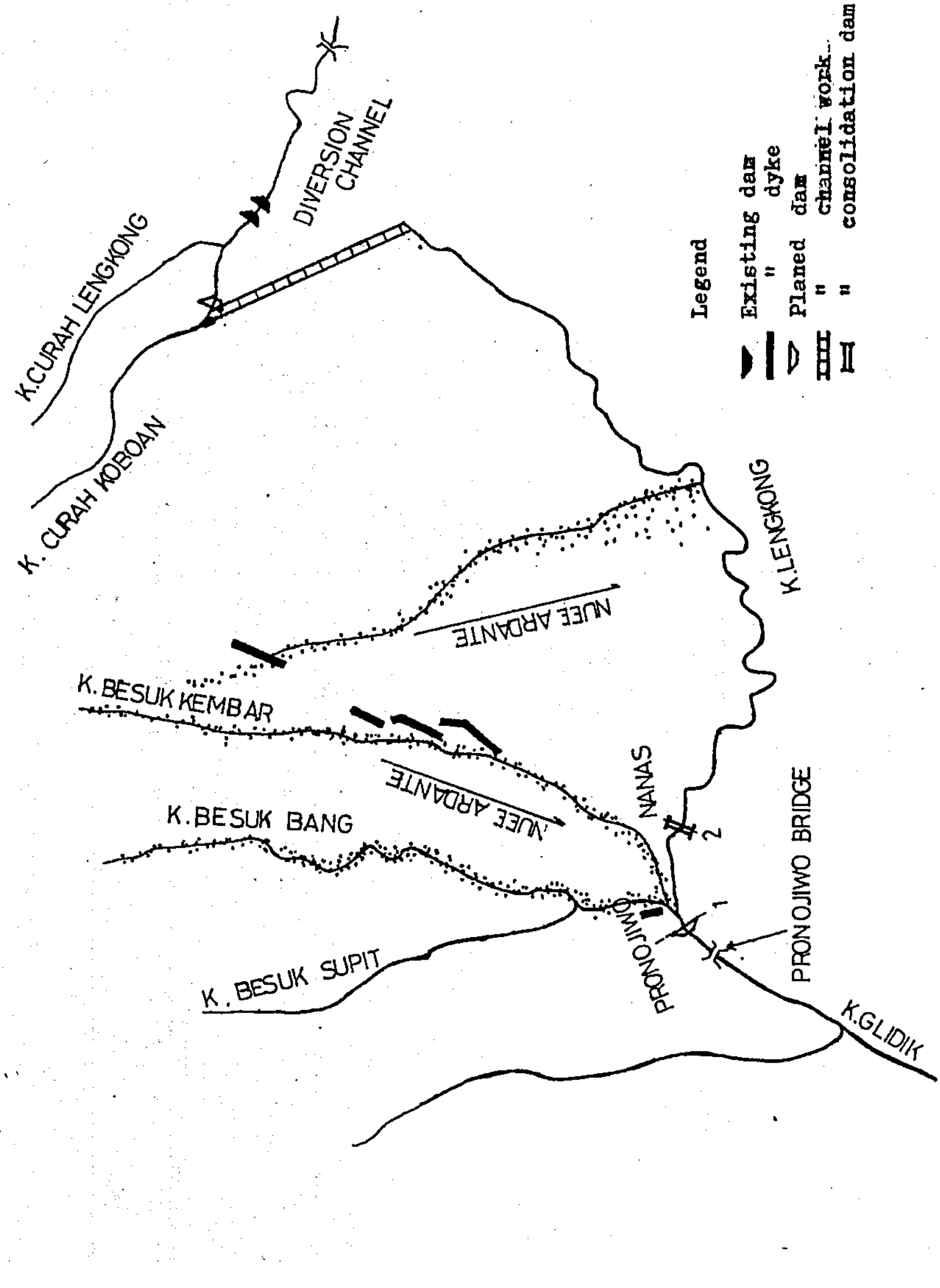


Fig-6.11.11 River System of K.Lengkong

Table 6.11.6 SLOPE OF RIVERBED

TRIBUTARIES	REVERBED SLOPE OF TRIBUTARIES
K.GLIDIK	1/10.4
K.BESUK BANG	1/21.0
K BESUK KEMBAR	1/16.9
K. LENGKONG	1/37

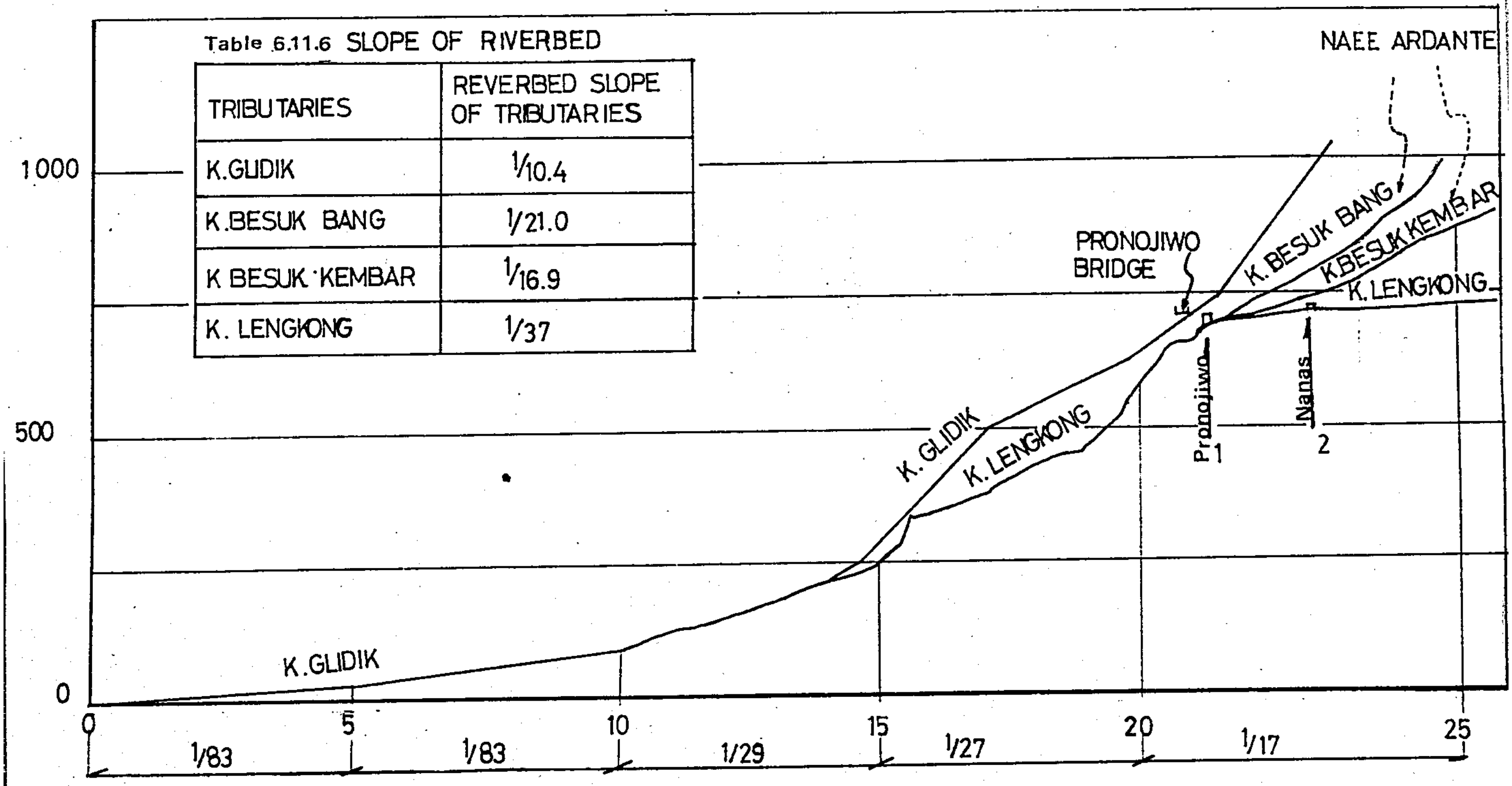


Fig-6.11.12 Profile of K.Glidik

(a) K. Lengkong

K. Lengkong has a very gentle river bed gradient and very low bank at north side at its upstream of the confluence with K. Besuk Bang. Especially, at the upstream of Tompak Nanas, it has a level river bed gradient and forms a pond. Besides, K. Lengkong has a steep river bed gradient and a deep V-shaped valley at the downstream of the confluence. K. Lengkong yields little sediment itself but K. Besuk Bang and K. Besuk Kembar flow a large amount of sediment down into K. Lengkong.

(b) K. Besuk Bang

K. Besuk Bang has a steep river bed gradient which is about 1/20 near the confluence with K. Lengkong and U-shaped valley with the depth of 40 m. K. Besuk Bang flows down a large amount of sediment by lahar and Nuee Ardante. Nuee Ardante has flowed down upto the near of the confluence in May 1981 according to Chapter 12.8.

(c) K. Besuk Kembar

K. Besuk Kembar has the same characteristics as K. Besuk Bang.

(6) The Diversion Plan

The diversion channel which is turned from K. Curah Koboan (upstream of K. Rejali) joints K. Lengkong at the upmost-stream of K. Lengkong. The diversion channel will flow a large amount of sediment into K. Lengkong at the time of floods.

(7) Location of Sediment Control Facilities

The main aim of this plan is to control the sediment in flow from the diversion channel. Besides, K. Lengkong has the tributaries (K. Besuk Bang and K. Besuk Kembar) which flow a large amount of sediment down into K. Lengkong; therefore, these tributaries must be taken into consideration when the location of the sediment control facilities are decided to be K. Lengkong. Check dams are suitable as sediment control facilities because K. Lengkong is always threatened by Nuee Ardante flow and lahar flow. The location of a check dam is decided at a bit downstream of confluence of K. Lengkong and K. Besuk Bang because of the following reasons:

1) Topographically, this location is a narrow part with high banks and is changing the point of the river bed gradient.

2) Taking the river characteristics into consideration, this location has very gentle river bed gradient and very wide deposit area in its upstream.

3) Geologically, this location is suitable to construct the check dam because a bed-rock appears in the river bed.

4) At this location, Lahar, which flows down from K. Besuk Bang and K. Besuk Kembar, can be controlled.

This dam is named "Pronojiwo Dam". There is another changing point of river bed gradient at 1.3 km upstream from "Pronojiwo Dam". Therefore, another sediment control facility is proposed at this location. At this location, very low dam or sand pocket is suitable because the foundation is lahar deposit and the right bank is very low (4-5 m. height) with gentle slope. This facility is named "Nanas Dam" tentatively. The location of "Pronojiwo Dam" and "Nanas Dam" is shown in Fig. 6.11.11 and Fig. 6.11.12.

(8) Sediment Control Facility Plan

The height of the dams are decided taking account of sediment control effects, topography, geology and so on. The sediment control effects of Sabo Dam and sand pocket is evaluated by their deposit areas.

(a) The Height of "Pronojiwo Dam"

The height of "Pronojiwo Dam" is decided taking the following conditions into consideration:

- Sediment control effects in relation with "Nanas Dam"
- Safety of K. Besuk Bang
- Dam Structure

Since the latter two conditions are explained in full detail in Chapter hereinafter, at this time the first condition is mainly explained. The height of "Pronojiwo Dam" is decided in relation with "Nanas Dam". Since the sediment control effect of "Nanas Dam" is larger than that of "Pronojiwo Dam" as shown in Fig. 6.11.13. Therefore, the height of "Pronojiwo Dam" must be decided in the manner that the deposit area of "Pronojiwo Dam" does not reach to "Nanas Dam", for the reasons that the higher sediment control effects may be gained by these two dams. Namely, the height of "Pronojiwo Dam" is limited as follows:

$H < 35$ (dam base of Pronojiwo Dam = 630 m)

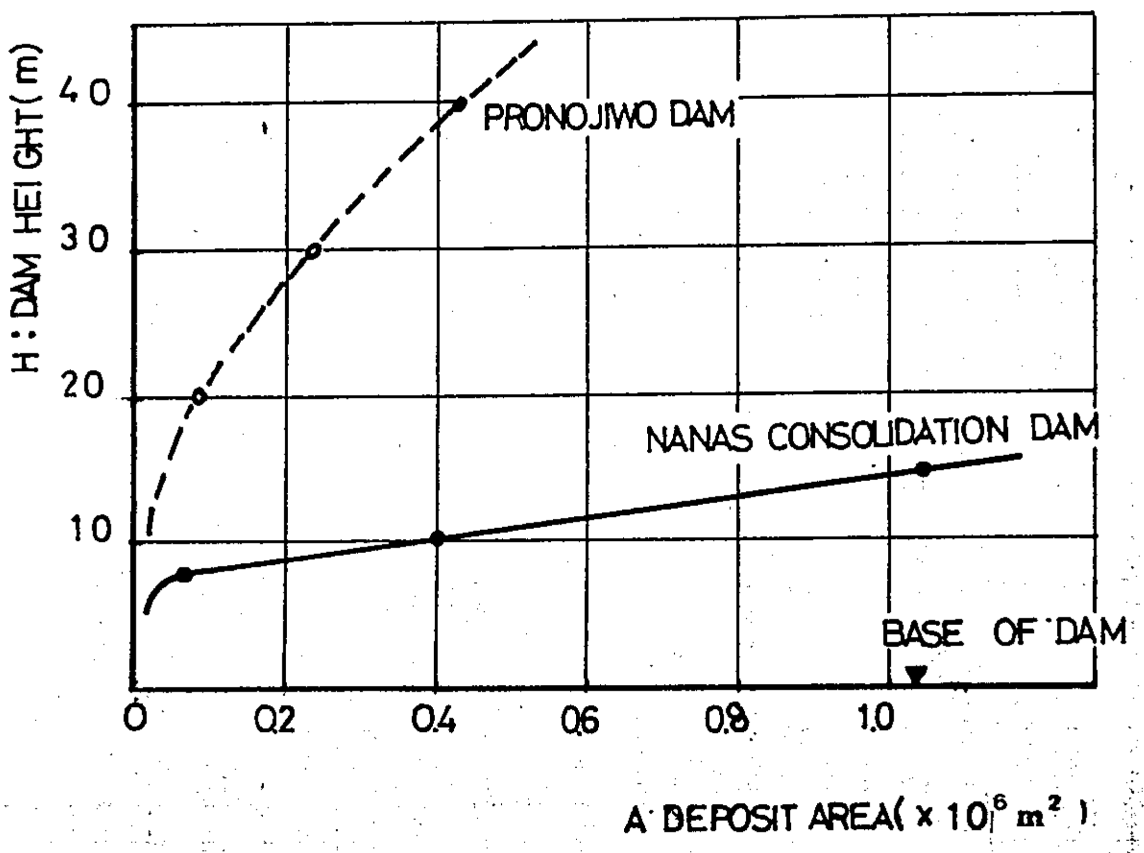


Fig-6.11.13 H-A Curve

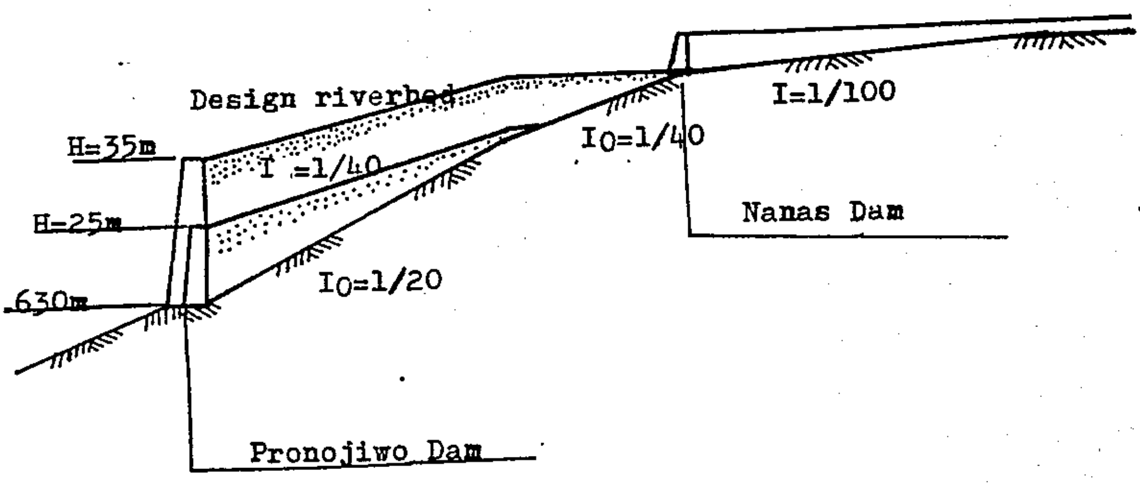


Fig.6.11.14 Profile of K.Lengkong

K. Besuk Bang, which flows into K. Lengkong at a bit upstream of "Pronojiwo Dam", is afraid to be in danger of overflow at the right bank if a very high dam is constructed at Pronojiwo. If the design river bed is allowed to rise as the same height as the right bank, the limit of "Pronojiwo Dam" is

$H < 30$ m. (dam base = EL. 630 m)

But in this case, the dike of about 10 m. height is needed at the right bank.

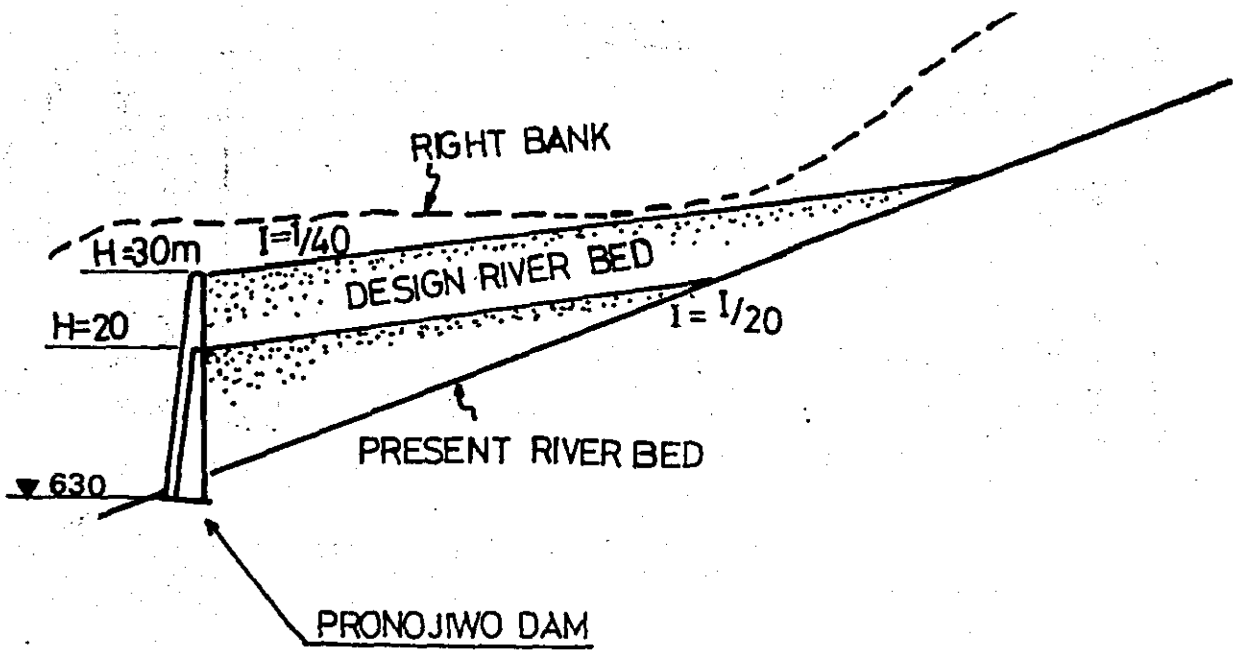


Fig-6.11.15 Profile of K.Besuk Bang

The height of "Pronojiwo Dam" is also limited by the conditions of foundation and abutment. Without special treatment of foundation and abutment, the Dam height is limited as follows:

by abutment $H < 30$ m. (dam base = EL. 630 m)

by foundation $H < 40$ m. (dam base = EL. 630 m)

The above three conditions for the Dam height is arranged in Table - 6.11.7. Therefore, the Dam height of "Pronojiwo Dam" is decided to be 30 m.

Table - 6.11.7. Restriction of Dam Height

Conditions		Maximum Height
Sediment Control Effect		35 m
Safety of K. Besuk Bang		30 m
Dam Structure	Foundation (without special treatment)	40 m
	Abutment (")	30 m

(dam base = EL. 630m)

(d) The height of "Nanas Dam"

The elevation of the dam crest of "Nanas Dam" is decided as the same elevation of the water surface of the pond at 1.7 km upstream of "Nanas Dam", because of the following reasons:

- Dwellings and cultivating fields situated at nearly the same elevation as the water surface.
- National road runs at nearly the same elevation as the water surface.

Therefore, the elevation of the dam crest is decided at EL. 695 m.

6.11.4 PRONOJIWO DAM PLAN

(1) Introduction to the Pronojiwo Dam Project

Principal features of the project conceived for the construction of the Pronojiwo Dam are as follows:

- Dam

Type	Gravity concrete type
Dam height	30.0 m
Crest length	450.0 m
Dam crest elevation	670.0 m
Spillway crest elevation	660.0 m
Dam foundation elevation	630.0 m
Concrete volume	190,000 m3 (inclusive of sub dam, apron and side walls)

- Dike on the right bank

Type	Fill type
Dike height	Max. 10.0 m
Dike length	445.0 m
Embankment volume	130,000 m3

- River Improvement (K. Besuk Bang)

Excavation volume	160,000 m3

(2) Plans for the Pronojiwo Dam

(a) Selection of Dam Type

The Pronojiwo Dam shall be of the gravity concrete type for the following reasons:

① Sabo Dam whose dikes consist of sand are basically of the gravity concrete type, which assures safety against overtopping occurring at time of unforeseen floods; and provision of dams of the filter type should be avoided as much as possible.

② The site possesses foundations sufficient for construction of gravity concrete dam type.

(b) Establishment of Dam Size

The size of the Pronojiwo Dam has been decided upon based on examination of the following three items, and height of the dam was established as 30 m.

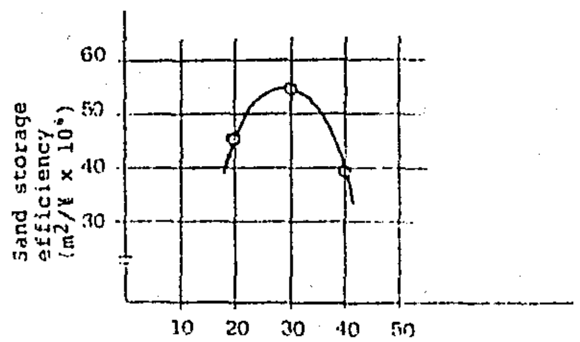
1 Sand storage efficiency

2 Geological conditions of the dam site.

3 Topographical conditions of the right bank arete.

1) Sand Storage Efficiency

The sand storage efficiency where dam heights of 20, 30 and 40 m are assumed is shown in Fig.6.11.16 As indicated in Fig. 6.11.16, a peak is seen when the dam height is 30 m, indicating that such a height is most efficient and gives favorable results.



① Sand storage efficiency = $\dfrac{\text{Planned sediment area}}{\text{Project cost (¥ x } 10^6)}$

② The integrating unit price of the project cost is assumed as follows:

Concrete : ¥ 35,000/m3

Fill : ¥ 6,000/m^3

Fig. 6.11.16 Dam Height and Sand Storage Efficiency

2) Geological Conditions of the Dam Site

Most of the dam founation consists of andesite lava outcropping over the river bed and is sufficient to support dams of the 50 m class in terms of strength; however, the andesite lava lacks sufficient thickness and occurs alternatively with layers of volcanic breccia. The layers are of uniform thickness and continuous.

The volcanic breccia is inferior in terms of strength, and sections bordering layers of andesite lava further deteriorates and its shearing strength (τo) is assume to be approx. 30 to 50 t/m2. These boundaries are principal factors in the determination of the dam size and sliding phenomena can be expected. Shown Fig. 6.11.17.

Shearing strength necessary in respect of dam foundations is approximately twice that of the dam height; and when calculation with regard to the simplified formula indicated below is performed, the dam height is subject to limitation, i.e., 30 to 40 m.

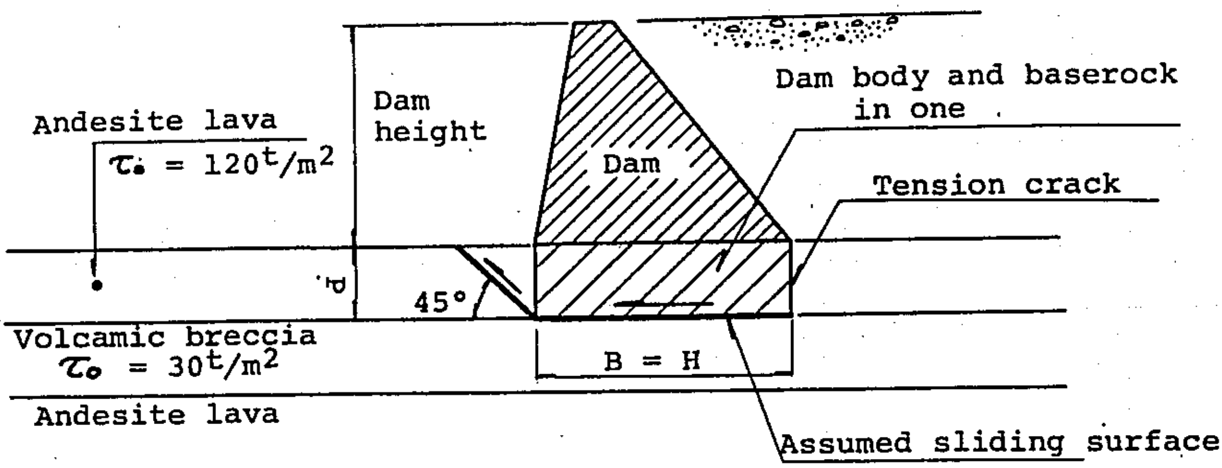


Fig. 6.11.17 Stability Calculation Model for Assumed Sliding Surface

Formula for stability

Necessary shearing strength: $N=2H \times H = 2H^2$

Necessary drag for assumed sliding surface : $R=30H + 120\sqrt{2}\cdot d$

$=30H + 170d$

Stability condition $R > N$

$$30H + 170d > 2H^2 \quad \text{----------} \quad (1)$$

When the layer thickness of andesite d=6 to 10 m is substituted for Formula (1),

$$H < 31m - 38m$$

Further, there is a distribution of lahar deposits on the right and left banks where linking will be made. The depth of the deposits are relatively limited on the left bank side; and therefore, the dam can be easily settled. On the other hand, lahar deposits on the right bank side are distributed in thick layers as indicated in Fig. 6.11.18. Where these lahar deposits are intended as the foundation of a concrete dam, the dam height at such points has to be limited to 10 to 15 m. This results in a dam height of 30 to 35 m at the spillway position.

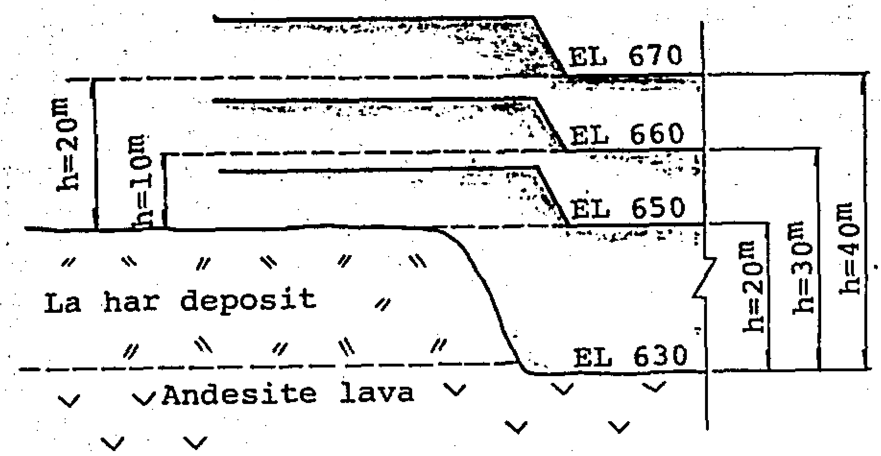


Fig. 6.11.18 Geological Conditions of Right Bank Linking Section.

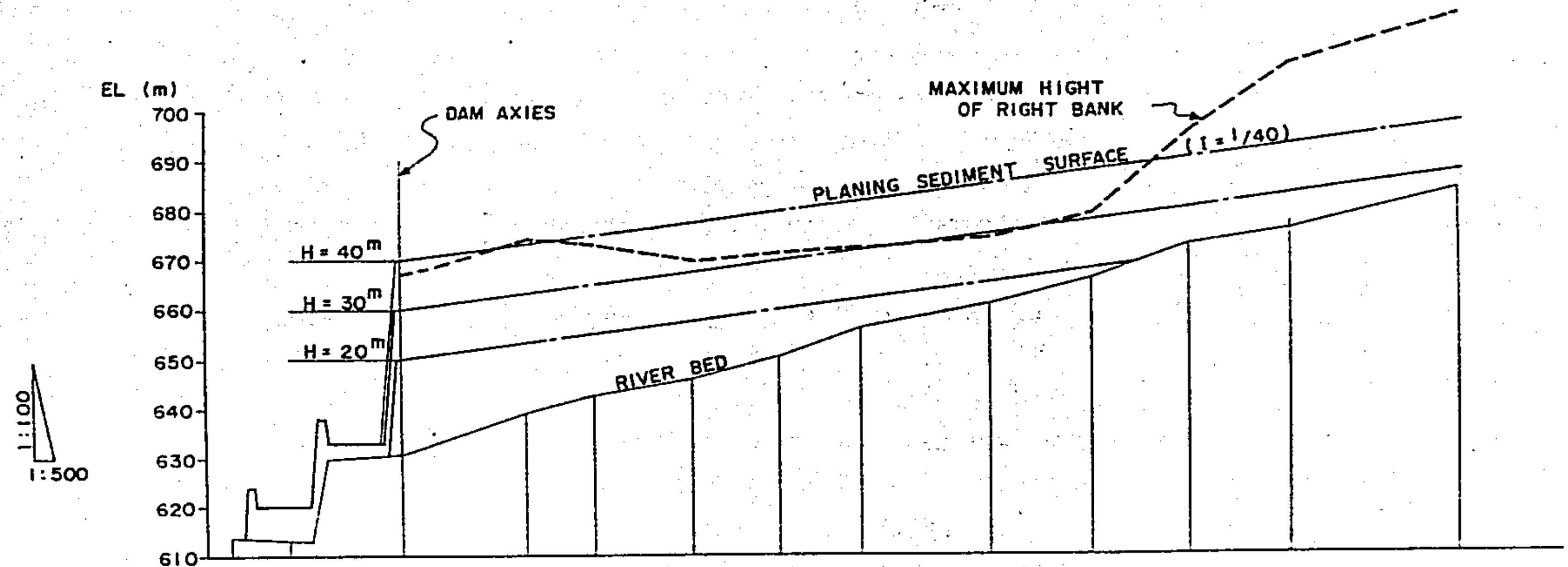
3) Topographical Conditions of Right Bank Arete

The right bank side of the K. Besuk Bang forms a series of arete and is a factor of considerable significance in determining the size of the dam. The planned sediment surface at dam heights of 20, 30 and 40m and a cross section of the right bank arete portion are shown in Fig—6.11.19.

When the margin in respect of the planned sediment surface with reference to effects expected from the movement of the river bed and ladu is established as 10 m, specific measures considered for provision are as shown in Table - 6.11.8.

Table - 6.11.8 Measures to be taken for Right Bank Aretes

Dam Height	Measures
H = 20 m	The planned sediment surface is 10 m below the natural ground and does not require special measures.
H = 30 m	The elevation of the planned sediment surface and that of the natural ground are identical and provision of a dike whose margin is 10 m in height is necessary.
H = 40 m	The planned sediment surface is 10 m higher than the natural ground and a dam structure with a height of 20 m, inclusive of the margin height, is necessary.



POINT NO.	DISTA-NCE	RIVER BED	MAXIMUN OF RIGHT BANK	PLANING SEDIMENT SURFACE H=80m	PLANING SEDIMENT SURFACE H=30m	PLANING SEDIMENT SURFACE H=40m
CP 17 P 9.	-175	614.2				
P 10	-115	613.1				
CP 18	0	630.9	666.9	650.0	660.0	670.0
P 1A	132	639.4	674.5	653.3	663.3	673.3
P 2A	202	643.0	673.0	665.1	665.1	675.1
P 3A	302	646.2	670.0	657.6	667.6	677.6
P 4A	392	650.8	671.5	659.8	669.8	679.8
P 5A	475	656.3	672.5	661.9	671.9	681.9
P 6A	607	661.1	674.5	665.6	675.2	685.2
P 7A	715	666.0	679.2	667.9	677.9	687.9
P 8A	815	672.9	695.5	670.4	680.4	690.4
P 9A	919	676.3	708.8	613.0	683.0	693.0
P10A	1095	684.5	718.6	677.4	687.4	697.4

Fgi.- 6.11.19 Profile of K. Besk Bang

When the topographical and geological conditions of the right bank arete are considered, it is best, basically, to avoid provision of a planned sediment surface higher than the natural ground.
It is, therefore, considered that unfavorable conditions expected at the right bank arete can best be met through provision of a dike with a margin height of 10 m, which is not subject to continuous load, and through limitation on the dam height at approx. 30 m.

(c) River Improvement of the K. Besuk Bang

The relation between the K. Besuk Bang and the Pronojiwo dam is shown in Fig. 6.11.20 in terms of their location. The flow of the river will be diverted by excavating portions of the left bank of the K. Besuk Bang with sufficient care so that the effects of the mud flow and ladu will not bear direct significance to the dam and the dike on the right bank arete.

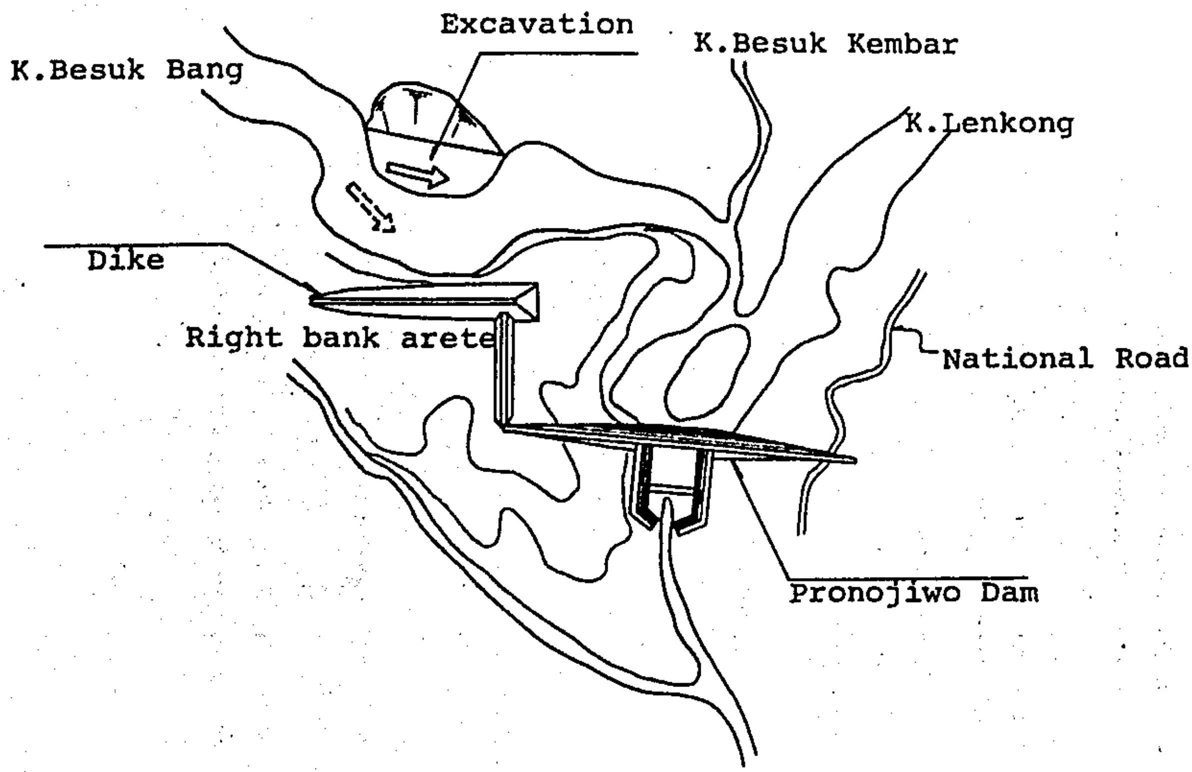


Fig. 6.11.20 Right Bank Arete and River Improvement.

6.11.5 LEPRAK SAND POCKET

(1) Advantage of Constructing Sand Pocket

Sediment transportation in the K. Leprak is extremely large in quantity because it took the catchment basin of the Besuk Semut in 1942 (Section 10.8. Sediment Volume Investigation; The flood in May, 1981 transported 73,000 m3/km2 at once). In the downstream part of the valley, a process of constructing a fan is proceeding. At present, the water flows down near the mountain in the south. According to Section 10.7 Geomorphological Investigation, the alluvial fan along this river consists of 4 units . The watercourse running through the alluvial fan is shallow (3-5 m). For this reason, according to the existing data, the river have often flooded and changed its direction at points where the riverbed gradient changes. On the other hand, there are few appropriate topography for sediment control in the upper reaches, and immediate decrease in sediment transportation is difficult. Therefore, it is proper to construct a large-capacity sand pocket in the upper reaches with the following purposes to stabilize the lower reaches immediately:

- Changing the form of flow
- Regulating the watercourse
- Controlling transported sediments.

(2) Sand Pocket Location

The K. Leprak Fan can be divided into 4 units as indicated in Fig. 6.11.21, and all of them are in the process of development at present. The top of each fan is appropriate as the planned location of erosion control facilities to regulate transported

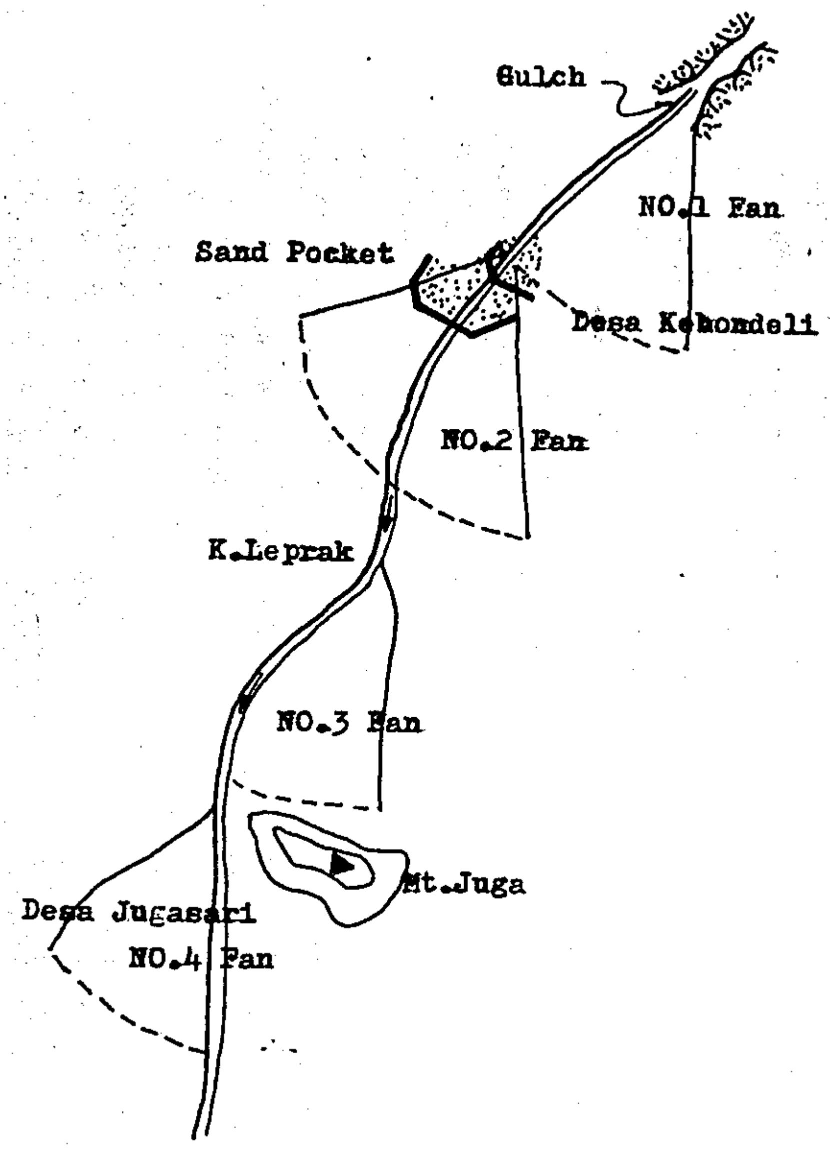


Fig.- 6.11.21 Plane of Leprak Fan Area

sediments as well as to stabilize the lower reach watercourse.

Because the area between the first alluvial fan and the second alluvial fan forms a bank with its height of 10 - 15 m at present. Therefore, the May 1981 flood occurred in the area lower than the second alluvial fan. Therefore, a sand pocket is planned to be constructed on the second alluvial fan.

The sand pocket to be planned for the K. Leprak has the purpose of spreading the sediments at the point where the sediments begin to deposit to decrease the flow rate and the deposit's thickness. In this way, the sediments transported by a flood can be controlled and the lower reach watercourse can be stabilized with relatively low and simple cross-dike and the dike. For this reason, it is appropriate to plan the sand pocket in the location which is a little lower than the top of the fan.

The plan for the K. Leprak sand pockets is provided using the existing dike at the top of the second alluvial fan. Two units of sand pocket with the following functions as the main purposes are planned:

- The first sand pocket : Stabilizing the lower-stream watercourse
- The second sand pocket : Controlling and storing flood-time sediments

(3) Layout of Sand Pocket

At present, the K. Leprak runs through the highest point located at the center of the second alluvial fan. Therefore, if the river floods at this point, the influence is very extensive. Flood-inundated area can be decreased by shifted the watercourse to either the right of left-bank side. If the watercoure is shifted to the left-bank side, the lower reaches incur the influence of a flood while, on the other hand, there will be little influence on the lower reaches if the watercourse is shifted to the right-bank side because the topography of the right bank side is mountainous. Therefore, the sand pocket should be planned to be constructed near the right bank and the sand pocket's deposit area should also be located nearer to the right bank than the alluvial fan's center.

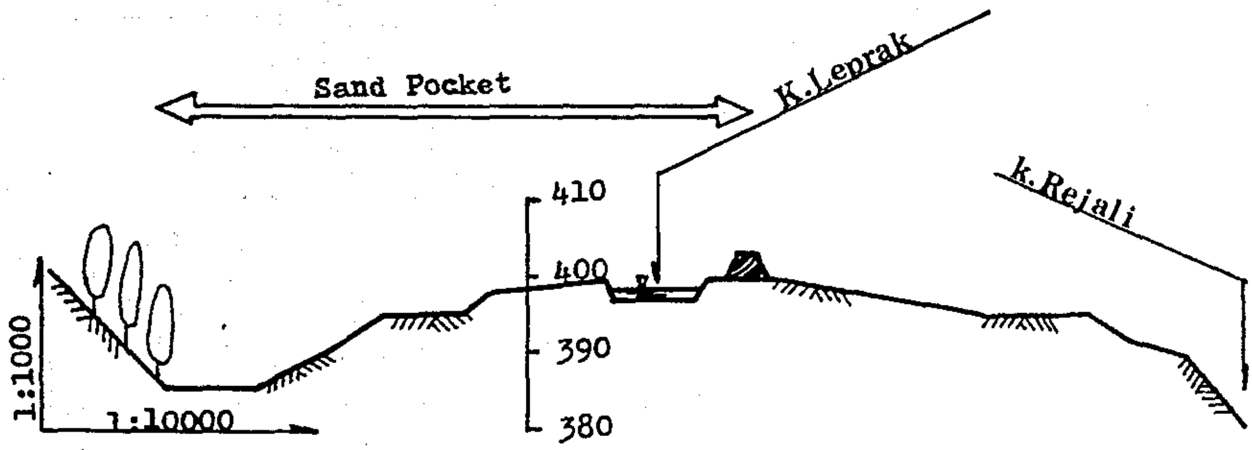


Fig.- 6.11.22. Cross Section of Leprak Fan No. 2

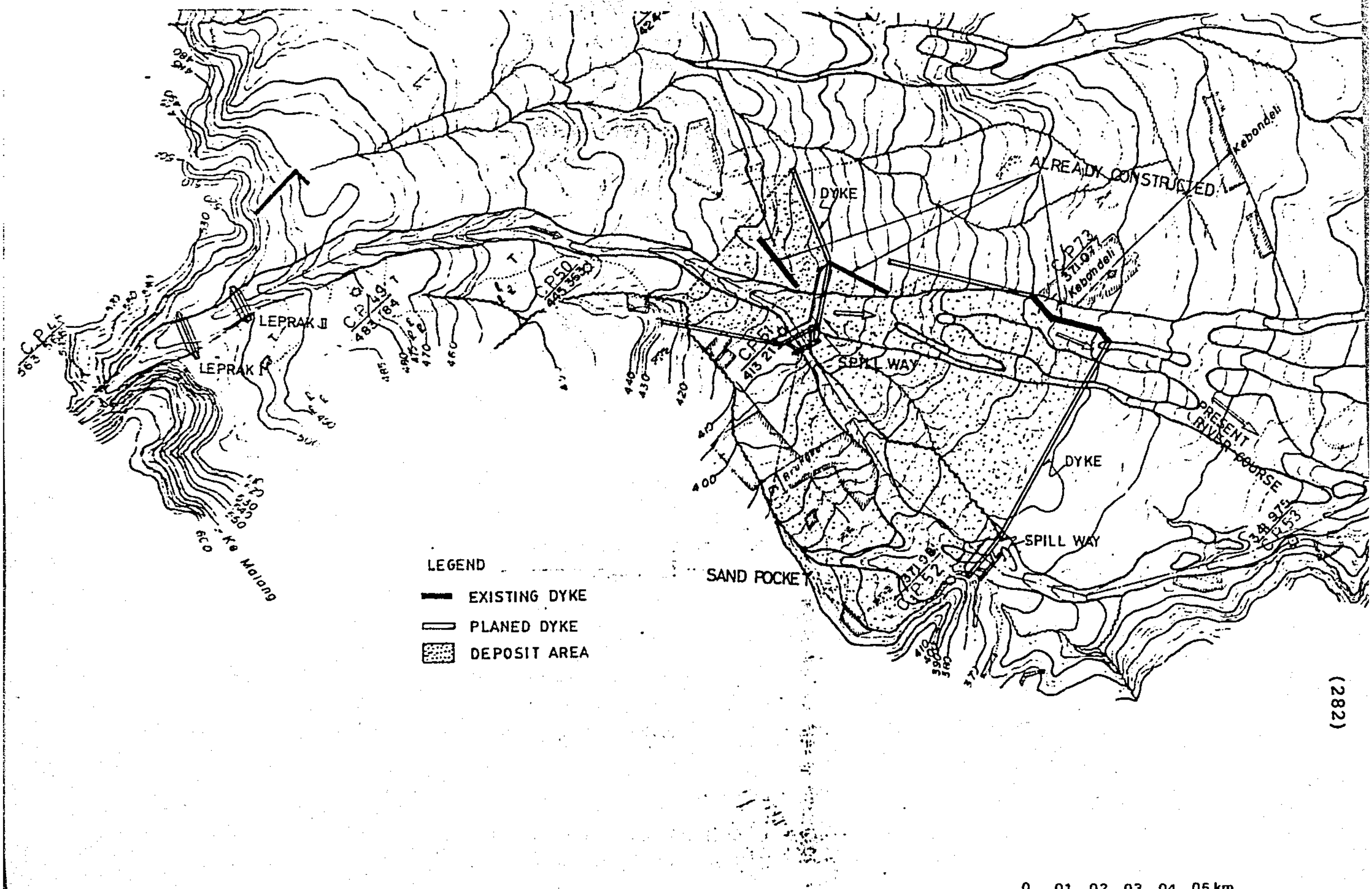


Fig-6.11.23 Plane of Leprak Sand Pocket - Scale 1:10 000

According to the above-mentioned line, the sand pocket can be laid out as shown in Fig - 6.11.23. The specifications of the sand pocket are as follows:

- Sand Pocket 1 : *Deposit area A = 12500 m^2
  *Dike & spillway length L = 980 m

- Sand Pocket 2 : *Deposit area A = 672000 m^2
  *Dike & spillway length L = 1,230 m

(4) Principle Dimensions of Sand Pockets

i) Height

The deposit thickness at the time of May, 1981 disaster, according to Section 12.8 Sediment Volume Investigation, is about 2 m in the location of the second fan. Therefore, if the height of the sand pocket is less than 2 m, it cannot store the transported sediments. For this reason, the sand pocket height needs to be more than 2 m above the existing subgrade. The height and the storage area of the sand pocket are determined based on the required storage volume. If the sediments of the same amount as that of the May, 1981 "lahar" -- whose deposit quantity known from the study described in Section 12.8 is 1,900,000 m3 -- is to be stored, the following figures are obtained:

- Deposit area : A = 797,000 m2
- Average deposit thickness : $t = \frac{1,900,000}{A} = 2.4$ m

Although the average deposit thickness is t = 2.4 m as indicated above, difference in the deposit thickness between the upper and the lower reaches naturally is caused. The proportion of the thickness in the upper and the lower reaches is said to be 1 : 2, the deposit thickness at the downstream eand of the deposit area is estimated to be 3.2 m.

Based on the above-mentioned consideration, the spillway height of the sand pocket from the existing subgrade is set to be 3.5 m. The heights of the dikes extending from the both wings is the sum of spillway height added with overflow height and allowance height. Considering the case where "lahar" comes after the sand pocket is full, the dikes needs to be higher than 2 m. Assuming that the overflow height plus allowance height equals 3 m, the dike height becomes 6. 5m.

- Spillway height : 3.5 m from the existing subgrade
- Dike height : 6.5 m from the existing subgrade

ii) Structure

The spillway will have a concrete-made structure and have the front apron.

The dike is planned to be constructed with the riverbed material with its surface protected with gabions due to the reasons that the sand pocket may be directly hit by a mudflow.

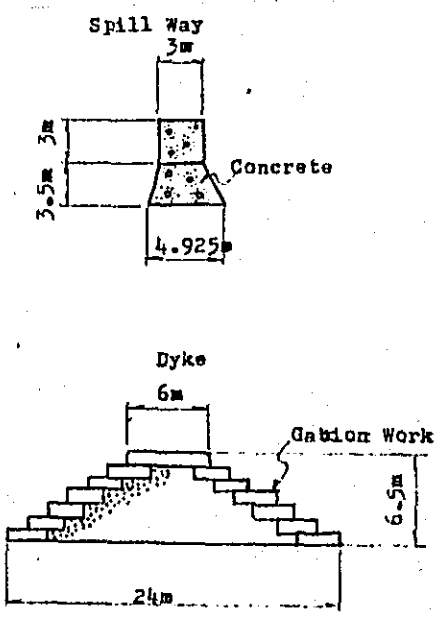


Fig-6.11.24 Cross Section of Sand Pocket