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MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

JRATUNSELUNA BASIN

UPDATED DEVELOPMENT PLAN

MAIN REPORT

MAY 1980

SUBMITTED BY

PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO, U.S.A.   SEMARANG, INDONESIA

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
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In the preparation of the updated development plan for the Jratunseluna Basin, useful comments and suggestions were received from the following officials of the Department of Public Works, Republic of Indonesia, and of the Agency for International Development (U.S. AID) of the United States of America.

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The names of counter[illegible] ho actively participated in the planning work are given below.

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CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

The study to update the Development Plan of 1973, prepared by NEDECO for the Jratunseluna Basin, has been completed. All projects in the constituting subbasins (Figure I-1), studied and reported by previous investigators and those identified during the course of this study were examined individually. Then, different combinations of projects were analyzed to produce a logical and viable scheme for the overall development of the water resources of the entire basin.

The optimization of the development plan was derived with the help of a mathematical model of the basin (Figure I-2). The physical characteristics of the basin, potential irrigation service areas (114,840 ha), projected demands for M & I water in the city of Semarang (4,000 l/s), and existing and potential hydropower generating stations were incorporated in the model. The potential irrigation areas are shown on Figure I-3. The simulation studies of the integrated operation of all the reservoirs, transbasin diversions, diversions for irrigation and M & I water demands, and of the hydropower plants in the model, were done by computer application.

The study was originally started in May 1979 to prepare an integrated development plan for the Tuntang and the Jragung River Subbasins. The scope of the study was subsequently enlarged, in December 1979, to include all subbasins into a conceptual development plan for the entire Jratunseluna Basin. The conclusions drawn from the study and the recommendations made by the Consultant are summarized in the following.

CONCLUSIONS

1. The development of individual subbasins and the integrated development of all subbasins in the Jratunseluna Basin were studied in accordance with the special conditions specified by the Directorate General of Water Resources Development. These special conditions are:

   a. Large projects should not be proposed for implementations in the Jratunseluna Basin during the near-term (10 years) period; however, development of irrigation and municipal water supply within the basin should begin in the near future for which only small-size, low-cost projects should be considered.

b. Hydropower development in the basin has low priority. Generation at existing power plants should not be reduced significantly.

2. In view of the special conditions stated in (1) above, the Consultant identified small-size, low-cost projects which are technically and economically feasible and which can be recommended for early implementation. These small-size development projects have the potential to become a part of the scheme for the overall development of the total basin.

The status of these small-size projects in the overall development plan was also examined for the case that the abovementioned constraints would be removed.

3. The updated development plan is presented in three alternatives. Out of thirteen individual projects identified in the Jratunseluna Basin, ten are compatible with the alternative development plans proposed. The projects are: 1) Raising of Rawa Pening, 2) Gunung Wulan Dam, 3) Tuntang - Jragung Transbasin Diversion, 4) Glapan Barrage , 5) Dolok Dam, 6) Jragung Dam, 7) Kedungombo Dam, 8) Ngemplak Dam, 9) Banjarejo Dam, and 10) Mid Lusi Diversion Structure. A design report for these structures is given in Appendix C.

All of these projects were analyzed individually and are technically feasible with the exceptions stated in paragraph (4). The salient features of the projects are tabulated below.

Project	Live Storage Capacity (10^6 m^3)	Project Cost (US $ 10^6)	Benefits 1/ Irrigation 95% Firmness (ha)	Benefits 1/ M & I Water Supply (l/s)	Benefits 1/ Annual Value (US $)	IRR (%)
1. Raising of Rawa Pening	125 175	31.01 43.96	14,204 18,060	1,500 1,500	12.98 17.98	21.5 21.0
2. Gunung Wulan Dam	190	130.38	23,375	2,000	30.27	14.1
3. Tuntang-Jragung Transbasin Diversion	-	2.40	(In conjunction with Projects 1, 2 and 4)			
4. Glapan Barrage	87	32.77	13,517	1,500	12.15	20.8
5. Dolok Dam	35	15.73	996	500	2.93	11.3
6. Jragung Dam	75	71.39	8,200	1,500	15.63	13.8
7. Kedungombo Dam 2/	655	207.2	44,500	-	39.90	14.1
8. Ngemplak Dam	68	18.79	2,880	-	4.58	14.0
9. Banjarejo Dam	77	48.29	8,356	-	13.28	16.1
10. Mid Lusi Diversion Structure	-	3.3	(In conjunction with Projects 8 and 9)			

1/ At full development. 2/ December 1978 Analysis by SMEC [11].

The planning reports and the economic analyses for the above listed projects are given in Appendices D and E, respectively.

4. The individual small, low-cost projects which are recommended for detailed study and early implementation are listed as follows.

a. <u>Raising of Rawa Pening</u>

This project, for the different storage capacities analyzed, is very attractive economically. However, certain technical and sociological problems need to be investigated and resolved before embarking upon the final design and construction of the works. These problems are identified as follows.

(i) For raising the level and the storage capacity of the lake, dikes are proposed to protect the adjoining agricultural lands and urban and rural areas from flooding. The results of limited exploration and material testing show that the foundations for the dikes are weak and susceptible to large settlements.

(ii) The disposal of drainage by gravity from behind the levees appears to be problematic. Because of lack of adequate maps for the area, a workable drainage system could not be proposed. It is known however, that all areas behind the dikes cannot be drained by gravity, and that pumped drainage might be required.

(iii) If Rawa Pening is raised without dikes, large tracts of valuable agricultural lands and 17 villages around the lake will be flooded. More than fifty thousand people will be directly or indirectly affected by the raising of the lake. The sociological problems associated with large scale relocations may be prohibitive.

The storage at Rawa Pening is very attractive and should be exploited to the extent possible. Therefore, three alternative plans were studied for the following conditions:

- Live Storage Capacity increased by diking to 125 million cubic meters. This is the optimum size of storage at Rawa Pening. (See Appendix D - Part I).
- Live Storage Capacity increased to 175 million cubic meters without dikes. This will flood all agricultural lands and populated area around the lake.
- Live Storage Capacity maintained at 43 million cubic meters, the existing capacity of the lake.

(iv) It is felt that the sucessful implementation of raising Rawa Pening is dependent on resolution of the dispute which arose from damage claims filed after the previous increase of the water level in 1966. Without a settlement of that dispute the project will not receive support from the local population. As Rawa Pening is a key element in development of the western subbasins, whose implementation affects selection and sizing of other projects and their priority in the development program, an early resolution of the conflict of interests is necessary. Based on strictly engineering and economic considerations the raising of Rawa Pening is recommended.

b. Dolok Dam

Constructing a dam and storage reservoir on the Dolok River is an attractive project. This project can supply 500 liters per second of municipal and industrial water to the low-lying eastern part of the city of Semarang and also provide perennial irrigation water to the upper 996 hectares of the present Dolok Service Area. It appears that the balance of the service area could be served from the Jragung Diversion after full development on the west side of the Jratunseluna Basin. However, for interim development, assured water for two crops per year could be supplied to the entire Dolok Service Area, in lieu of the perennial irrigation water supply to the upper 996 hectares, the 500 liters per second M & I water supply to the city of Semarang remains the same. If M & I water supply is increased to 750 liters per second, the corresponding service area for perennial irrigation will decrease to 650 hectares.

The reservoir created by this project will flood forest plantations. The economic implications have not been investigated as yet. The fact that this reservoir area has very few inhabitants, eliminates most of the sociological problems associated with storage reservoirs in almost all other projects in the development plan.

c. Glapan Barrage

The barrage at the originally proposed site for the Glapan Dam should be constructed for a full supply level at El. 30.0 M.S.L. with a live storage capacity of 87 million cubic meters. This capacity out of the initial gross capacity of 125 million cubic meters can only be maintained throughout the 50-year life of the project if all wet season flows with high sediment concentrations are passed through the barrage from October 1 to March 31 every year.

d. Tuntang-Jragung Transbasin Diversion

Withdrawing water from the Muncul Spring for M & I water supply would reduce water available in Rawa Pening for hydropower generation at the existing Upper Tuntang System (Jelok and Timo power plants) and at the potential third power plant at Sambirejo. Diversion of

M & I water at a point below the power plants would not result in power losses. Therefore, diversion of Tuntang water for M & I water demands in the city of Semarang, and augmenting Jragung River flows for irrigation in the western subbasins is proposed at a point below the potential third power plant of the UTS. This diversion is an important component in any scheme in which raising of Rawa Pening is planned. The economic evaluation of this diversion scheme should include a comparison of the energy lost in the UTS with the energy required for pumping and water treatment which would not be needed if the Muncul Spring water was fed directly into the Semarang distribution system.

e. Lusi River Development

Development of perennial irrigation of about 13,800 hectares along both the right bank and the left banks of the Lusi River above its confluence with the Serang River appears attractive and should be pursued. The components of this development are:

(i) A diversion at Mid Lusi can provide wet season irrigation to areas both on the left and the right banks of the river. The areas which can be served, without significantly reducing existing wet season use of Lusi River water at Wilalung, are 4,200 hectares on the left bank and 7,000 hectares on the right bank.

(ii) The construction of Ngemplak Dam, with or without Kedungwaru Dam, may be considered for early implementation as it has insignificant effects on the present downstream use of Lusi waters at the Wilalung Diversion for the Lower Sedadi areas. Ngemplak is especially attractive because of its ability to serve the upper 1,680 hectares of the South Grobogan Service Area which are presently planned for pumped irrigation in the Serang River Project. The Ngemplak Dam Project, without Mid Lusi Diversion, can provide perennial water to 2,880 hectares of potential irrigation service areas.

Mid Lusi Diversion flows in conjunction with the Ngemplak Reservoir could supply perennial irrigation water to 2,520 hectares in the Lusi Left Service Area, in addition to 1,680 hectares in the South Grobogan Area, even if no other storage is provided on the Upper Lusi and its tributaries. However, in that case no water will be available for diversion to the Lusi Right Service Area.

As indicated in the overall development plan, an area of 5,700 hectares on the Lusi Right Bank can eventually be supplied with perennial irrigation water from the Mid Lusi Diversion at full development, i.e. after storage at Banjarejo has been provided.

An alternative scheme for Lusi River development is to combine Banjarejo Dam with Mid Lusi Diversion without Ngemplak Dam. This case is shown as Project No. 9 in the preceding paragraph (3).

The irrigated area on the Lusi Right Bank could be increased by providing additional storage on the Lusi tributaries at the possible damsites, namely Kedungwaru, Tirto and Bandungharjo. In the present study construction of dams, as individual projects, at these site was not found feasible.

The estimated costs and economics of small projects proposed above for early implementation are given in the preceding paragraph (3).

5. The Jragung Dam Project designed to pass sediment during a part of the wet season is technically feasible but economically marginal if used for irrigation only. This project can be justified as an element in the overall development of the Jratunseluna Basin if Rawa Pening cannot be raised due to technical and/or sociological reasons.

6. A storage dam on the Penggaron River was proposed in the original Development Plan of 1973. The present study found that the Penggaron project should be eliminated from the development plan due to the following reasons.

   a. Marginal site geological conditions.

   b. Sediment yield of the watershed is high. If the reservoir is operated for passing sediment through the reservoir during the wet season, it will greatly reduce reservoir effectiveness.

   c. More than half (342 hectares) of the reservoir area is presently used for irrigated rice production.

   d. Reservoir area is highly populated. Villages occupy about 125 hectares of the area. Evacuation and resettlement would be required.

   e. Anticipated costs of the project are very high in comparison to the anticipated benefits.

7. The integrated use of the waters of the western subbasins, namely Tuntang-Jragung-Dolok-Penggaron, and the eastern subbasins, namely Lusi and Serang has been studied. Due to lack of viable storage sites in the western subbasins for meeting projected needs for irrigation and demands for M & I water, the diversion of water from the Tuntang to the Serang-Lusi Rivers is not desirable. It has been found also that periods of high demand and of irrigation shortages coincide in both subbasins, which makes diversion of water from the Serang to cover Tuntang-Jragung shortages ineffective. Therefore, the development on the Lusi-Serang System and the Tuntang-Jragung-Penggaron-Dolok System have been considered independently in this study.

8. In the previous study done by SMEC for the development of the Serang River System, the cropping pattern used for the irrigation service area of the Kedungombo Project was two rice crops and one upland crop every year. In updating the development plan, it has been found that by adopting a cropping pattern of three crops of rice in 75 percent of the irrigated area in the Serang-Lusi System, similar to the cropping pattern in the Tuntang-Jragung System, the irrigation service area will not be decreased, provided that the Kedungombo releases are governed by irrigation demands only.

9. The updated Jratunseluna Basin Development Plan is presented in three alternatives shown in Tables VII-1, VII-2 and VII-3.

Due to reasons stated in the preceding paragraph (4) of this chapter, the development plan for Rawa Pening is not yet finalized. As a key project in the overall basin development, this unknown factor necessitated the development of possible alternative schemes. The alternative schemes for the proposed Development Plan, therefore, are based on the three cases proposed for the Rawa Pening development listed in Paragraph 4.a. (iii).

10. It is possible to transform certain rainfed areas along the Lusi and the Serang River to wet season irrigation by diverting run-of-river regulated water supplies at appropriate locations on those rivers. Those rainfed areas fall in the following two categories.

- The rainfed areas which are included for full development to perennial irrigation in the updated development plan. It is proposed that by constructing diversion structures 1) near Talun on the Peganjing River for the Upper South Grobogan Area (1,680 ha); and a part of Lusi Left Area (1,200 ha); 2) at Mid Lusi for areas on the Lusi Left (3,000 ha) and Lusi Right (7,000 ha); and by installing technical irrigation system in the Juana Valley (6,160 ha), a total of 19,040 hectares of the presently rainfed/non-technical irrigation areas should be provided with technical irrigation, as an interim measure for development.
  A part (1,500 ha) of South Grobogan Area originally proposed for development from the Serang River may also be included in this category for wet season irrigation by diverting run-of-river supplies from the Glugu River.

- The rainfed areas along the Lusi River for which water is available by run-of-river diversion from the main river, under conditions explained in Section VII.4. of the main report may be provided technical irrigation. Since feasible storage sites for these areas have not been found on the Lusi River System, these are not included in the updated development plan for perennial irrigation; however, these areas may be developed to receive only wet season technical irrigation in the future.

11. Municipal and Industrial (M & I) water supply to the city of Semarang can be supplied from the Muncul Spring up to maximum of 2,000 liters per second if storage is provided on the Tuntang River or at Rawa Pening. The amounts of withdrawal for M & I and the corresponding irrigation areas, for different combinations of projects, are given below.

Element	Volume Diverted from Muncul (l/s)	Irrigated Area (ha)
Rawa Pening Storage Capacity 125 x 10^6 m^3 (F.S.L. El. 467.0 M.S.L.)	500	15,500
	1,000	14,700
	1,500	14,204
Glapan Barrage	500	15,200
	1,000	14,500
	1,500	13,800
Gunung Wulan Dam	2,000	23,775

If 500 liters per second of water are diverted from Muncul without providing adequate storage on the Tuntang River, the area presently receiving year-round irrigation at Glapan will be reduced by about 800 hectares.

12. A total of 4,000 liters per second of water for M & I demands in Semarang can be provided from the surface waters of the Jratunseluna Basin if and when the full development plan is implemented. Proposed schedules fitting a 20-year developing period are shown in Tables VII-1, VII-2 and VII-3.

13. The results of a brief study to evaluate flood and drainage problems in the Tuntang-Jragung Service Area, are reported in Special Report III [9]. The report establishes that flood and drainage control measures will be needed with and without storage dams on the Tuntang and the Jragung Rivers. A similar study should be carried out for the Dolok and Penggaron Rivers as well.

On the Lusi-Serang system, SMEC has proposed a scheme of flood control works including drainage improvements in the Juana Valley.

Interim flood control measures may be taken to alleviate flood damages in the affected areas; however a full scale flood control plan must await decisions on whether storage reservoirs will be constructed in the upper reaches of the basins. Upstream storage will have an important bearing on the flooding conditions of the lower plains.

14. The data and information used in the study for updating the Development Plan were obtained from the previous studies done by NEDECO and

SMEC. Hydrological data and data on irrigation and agriculture, as updated in this study, are given in Appendices B and C, respectively.

15. A brief reference is made by NEDECO in the original development plan for the Jratunseluna Basin of prospects for developing water resources of the Rivers Gelis, Mayong, Pucang and Lagung which drain the southern slopes of the Gunung Muria. The possibility of creating storage dams on these rivers at assumed locations is indicated.

The scope of work for the present study is to prepare a conceptual plan for the development of the Tuntang and the related subbasins of the Jratunseluna Basin. Inasmuch as no data are available for the Gunung Muria area and the integration of the water resources of the area with the subbasins of the Tuntang and the related rivers does not appear possible, the potential for developing water resources on the Muria slopes was not studied.

The topography of the area suggests that a collection system could be developed for conveying water to rivers with potential storage sites and that diversion structures and irrigation systems could be developed for improving agriculture practices in the area. It is suggested that a study be initiated to confirm the potential and evaluate the technical feasibility of the development envisioned by NEDECO for the Gunung Muria area.

RECOMMENDATIONS

1. In order to carry out feasibility studies and prepare designs for the small-size projects proposed for implementation in the updated development plan, it is important that accurate and detailed maps of all project-related areas and complete hydrological data are available to the engineers. The non-availability of this vital information and data could lead to inordinate delays, and may adversely affect the quality of the study.

   Unfortunately, neither the topographic maps nor the up-to-date hydrological data are available for any of the sites proposed for the first stage development. It is imperative that preparation of topographic maps and collection of hydrological data be started by the DGWRD forthwith and completed within a period of one year as scheduled in the updated development plan. Further, it is recommended that mapping and collection of data should be done under the guidance and supervision of qualified and experienced engineers.

2. For all projects proposed for early implementation, foundation investigations at the damsites and at locations of the related works, and exploration and testing of construction materials should be initiated by the DGWRD. These include the test embankments for the proposed Rawa Pening dikes. Although full scale investigations and explorations will continue through the feasibility and preliminary design stages, the availability of basic data on foundations and materials will greatly facilitate expediting the feasibility studies and final designs of the proposed works.

   It is recommended that an experienced geologist or geotechnical engineer should carry out field reconnaissance to determine the scope of geological investigations needed at each site and identify potential borrow areas and other sources of materials for the construction of dams and other projects. From these field reconnaissances an investigation and exploration program can be developed.

3. Optimum development of the water resources of the basin would require that large size multiple purpose projects, e.g., Kedungombo Dam and Gunung Wulan Dam should be phased early in the Development Plan to derive maximum benefits in the basin. However, the priorities for implementing the proposed updated development plan were fixed in accordance with the directions of the DGWRD to give preference to low-cost small storage projects over large dams during the next 10 years or so. The priorities thus established are in the following order.

   Rawa Pening

   Dolok Dam

   Mid Lusi Diversion

   Glapan Barrage

It is recommended that implementation of the development plan should be started in accordance with the schedules shown in Tables VII-1, VII-2 and VII-3, and for interim development in accordance with the schedule given in Table VII-4.

4. The small-size works proposed for early implementation in the updated development plan have been tested for economic feasibility at the preliminary level of study. It is recommended that full scale feasibility studies of the projects listed in paragraph (3) should be started in the same order of priority as given therein. This should be followed by carrying out feasibility studies of remaining projects proposed in the development plan. If results obtained from the proposed investigations for foundations and materials support the projects as presented in this report, the feasibility studies should proceed into the preparation of final designs as scheduled in Tables VII-1, VII-2 and VII-3. Therefore, the scope of work for the next stage of the study should include preparation of final designs, after the economic feasibility of any project has been established and accepted by the prospective funding agency.

5. In carrying out the feasibility study of the Rawa Pening Project, it is important that PLN should be closely associated with the study. The diversion of water from Muncul Spring for M & I water supply to Semarang will significantly alter the present schedules of the PLN for hydropower generation in the UTS and will also reduce energy production. A possible alternative is to route Muncul water through Rawa Pening to the power plants of UTS and the Tuntang-Jragung Transbasin Diversion and then divert it for M & I supply at Jragung. From there, water will be pumped to the treatment plant and storage at the city of Semarang. This arrangement, although not ensuring the existing power generation schedules of PLN, may eliminate energy losses in the UTS. However, for pumping water from the Jragung Diversion to Semarang additional power will be needed. It should be noted that by diverting water from Muncul, no pumping and probably no treatment will be required; on the contrary, the gravity flow from Muncul to Semarang may have some power generating potential which should be investigated in the feasibility study.

Inasmuch as the point of diversion of the M & I water is a key factor in the projected operation of Rawa Pening, and will affect existing power generation schedules, any operation scheme adopted in the feasibility study for storage and diversion of water should have the concurrence of the PLN.

6. For some of the structures appurtenant to the proposed projects, the final design should be based on the results of hydraulic model tests. These structures are the Glapan Barrage, Mid Lusi Diversion structure and the spillway for the Dolok Dam. Soon after conceptual designs of these structures have been prepared during the feasibility studies, arrangements should be made to carry out model tests in the laboratory so that hydraulic designs are supported by model performance at the time of preparation of final drawings.

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

I.1. PURPOSE AND AUTHORIZATION

PRC Engineering Consultants, Inc. (PRC/ECI) of Denver, Colorado, U.S.A. was selected by the Directorate General of Water Resources Development (DGWRD) of the Ministry of Public Works, Government of Indonesia (GOI), to prepare an integrated development plan for the Tuntang/Jragung Rivers in the Jratunseluna Basin of Central Java. The study was subsequently extended to all the subbasins of the Jratunseluna Basin for the purpose of evaluating surface water resources for multipurpose utilization with irrigation, and municipal and industrial (M & I) water supply being the main uses. The hydropower generation was to be evaluated as a byproduct of releases for irrigation and M & I supplies.

The surface water resources of the Jratunseluna Basin were originally identified by NEDECO [1] in the Master Plan for basin development prepared in 1973. That Master Plan has been updated in this study by including the present-day data, conditions and constraints. The results of the study are presented in this Updated Development Plan.

The study was authorized under a contract No. B.58/CES/79, dated August 20, 1979 between GOI and PRC/ECI which was later amended by Amendment I No. 248/CES/80 dated April 23, 1980. The completion date of the contract is June 15, 1980.

I.2. BACKGROUND OF STUDY

The Jratunseluna Basin Development Plan [1], formulated by NEDECO in the year 1973, contained recommendation for building dams and other engineering works on the rivers in the basin for the purpose of providing water for irrigation, generating hydropower and effecting flood control in their respective areas. The development on each river system was planned individually and the coordinated use of the combined water resources of the basin was not studied in that plan.

Prior to the presentation of NEDECO's Development Plan a study for developing the waters of the Dolok, Penggaron and Jragung Subbasins was done [2] as a result of which preliminary feasibility reports for building dams on these three rivers were presented. The most notable projects identified in that plan are a dam on the Jragung River at Jragung; a dam on the Serang River at Ngrambat or Kedungombo; a dam on the Tuntang River at Glapan; and a possible dam on the same river at Gunung Wulan. Towards implementation of the Development Plan, feasibility studies of the Jragung [4], Glapan [7] , Ngrambat Dam [6] were carried out followed by preparation of detailed designs for the Jragung and the Kedungombo (Ngrambat) Dam [5, 11].

In addition to the abovementioned Development Plan, the potential for development of Rawa Pening, a natural lake in the head waters of the Tuntang River, was studied at feasibility level by NEDECO in the year 1971/72 [8], as a result of which certain short-term and long-term measures were recommended for the exploitation of the potential storage capacity of the lake for irrigation development and hydropower generation. Also, a Master Plan was prepared by Burns and McDonnells in the year 1976 [10] for supplying municipal and industrial water to the city of Semarang. In that plan, demand for water was placed on certain water resources developments of the Jratunseluna Basin which was not accounted for in the original Development Plan. It was important that the M & I water supply from the water resources of the surrounding basins, including the Jratunseluna Basin on which the city of Semarang depends should also be included in the development plan.

On the Jragung River, a dam was studied at feasibility level and final designs were prepared for construction. In that study it was found that for the development of water resources of rivers draining small subbasins, it is prudent to consider integrated development of the subbasins by making coordinated use of waters of adjoining subbasins by transbasin or interservice-area diversions. Similarly, for the development of the Serang River System [11], it was recognized that the plan of development should also consider the Lusi River System for an integrated development of the water resources of both river systems. Likewise the waters of the Serang and the Tuntang Rivers could be put to optimum use by integrated and coordinated development. A similar prospect exists to the west of the Jragung River, where the Dolok and Penggaron Rivers had existing wet season irrigation in service areas which could be combined into one block, and part of that area could be integrated with the Jragung Service Area.

Inasmuch as the coordinated development of the water resources of the Jratunseluna Basin would yield considerably more benefits, as compared with the case in which the water resources of the constituting subbasins are individually exploited, it was concluded that a fresh evaluation should be made of the development possibilities of all the Jratunseluna Basin. A study originally started for the subbasins of the Tuntang and the Jragung Rivers was consequently extended to include all the subbasins of the Jratunseluna Basin.

I.3. SCOPE OF WORK

The development of water resources of the Jratunseluna Basin has been studied in the past and a number of reports have been issued by various consultants and other agencies containing the data related to, and the results of, those studies. Some of these were carried out to prefeasibility level [2, 8], some to feasibility level [4, 6, 7], and storage dams on the Jragung River and the Serang River have been studied through final design [5, 11]. In light of the reasons stated in the preceding Section I.2., a study was implemented and contracted to PRC/ECI on the preparation of an integrated development plan for the Tuntang and the Jragung Rivers. The study was limited to reviewing all available data and existing reports, to carrying out field reconnaissance to verify critical factors, reconnaissance level geological investigations and geotechnical data evaluation in order to identify alternative scheme for development. PRC/ECI carried out multiple reservoir operation studies for that purpose on a computer model of the subbasins.

In the subsequently amended scope of work, the studies which originally were started on the Tuntang/Jragung Rivers were to be extended to cover the entire Jratunseluna Basin.

In consideration of the limited time and funds available for this contract, it was decided to restrict the study to the preparation of a conceptual basin development plan by upgrading the original Master Plan conceived by NEDECO. The upgraded plan would consist of a combination of small scale projects for near term development and large scale projects for future development. The optimization for the development plan would be done by enlarging the computer model prepared originally by PRC/ECI for the Tuntang/Jragung Rivers Basins to encompass the entire Jratunseluna Basin and to simulate the operation of the proposed storage reservoirs in the system on an integrated and coordinated fashion.

The original scope of work also envisaged preparation of a conceptual layout and configuration of the Glapan Barrage on the Tuntang River and investigation of designs of levees, drainage schemes and raising of the Jelok Wei- for the development of Rawa Pening for water storage to as much detail as would be possible using existing maps and subsurface data. The investigation would also be concerned with the technical, economic and socio-environmental aspects of the proposed raising of Rawa Pening and the planned construction of the Glapan Barrage.

During the course of the study the scope of work was discussed with the DGWRD in the light of data and maps which were available, and it was decided that more emphasis should be placed on evaluating in more detail than was originally contemplated, the small scale works and projects on the Lusi River system and areas related to the Tuntang River Basin. To allow time for this work, it was decided that the scope of work on the Rawa Pening and the Glapan Barrage designs should be reduced to only producing conceptual design sketches for the two works. The DGWRD has planned to carry out detailed feasibility level investigations leading to preparation of final designs and contract documents for the Rawa Pening works and the Glapan Barrage as a follow up work after the completion of the present study.

Furthermore, it was contemplated as part of this study, that a general scheme for soil conservation and erosion control would be prepared for the basin, including design criteria, typical measures to be used for the different types of terrain, soils and geology, and typical drawings for various erosion control measures. Also, a pilot project for demonstration of soil conservation and erosion control measures would be identified and designed in the Jratunseluna Basin.

The scope of work for this study also includes training of the personnel of the Directorate General of Water Resources Development (DGWRD) in obtaining and analyzing river sediment data and assisting in operating the sediment laboratory at Semarang. The purpose of this effort was to enable DGWRD personnel to continue the training program started by NEDECO for measurement of sediment in the main rivers of the Jratunseluna Basin, to analyze data for determining sediment yields in the watershed and to make realistic estimates of sedimentation in the reservoirs proposed in the development plan. This training program was done on a larger scale and in more details by PRC/ECI for the Tuntang and the Jragung Rivers during the years 1977 to 1980. The results of the erosion and sedimentation studies are not presented in this main report; however, the excessive sediment yields from the watersheds of the proposed storage reservoirs have been mentioned where considered relevant. The detailed results of the Erosion and Sedimentation Study are given in Appendix H of this report.

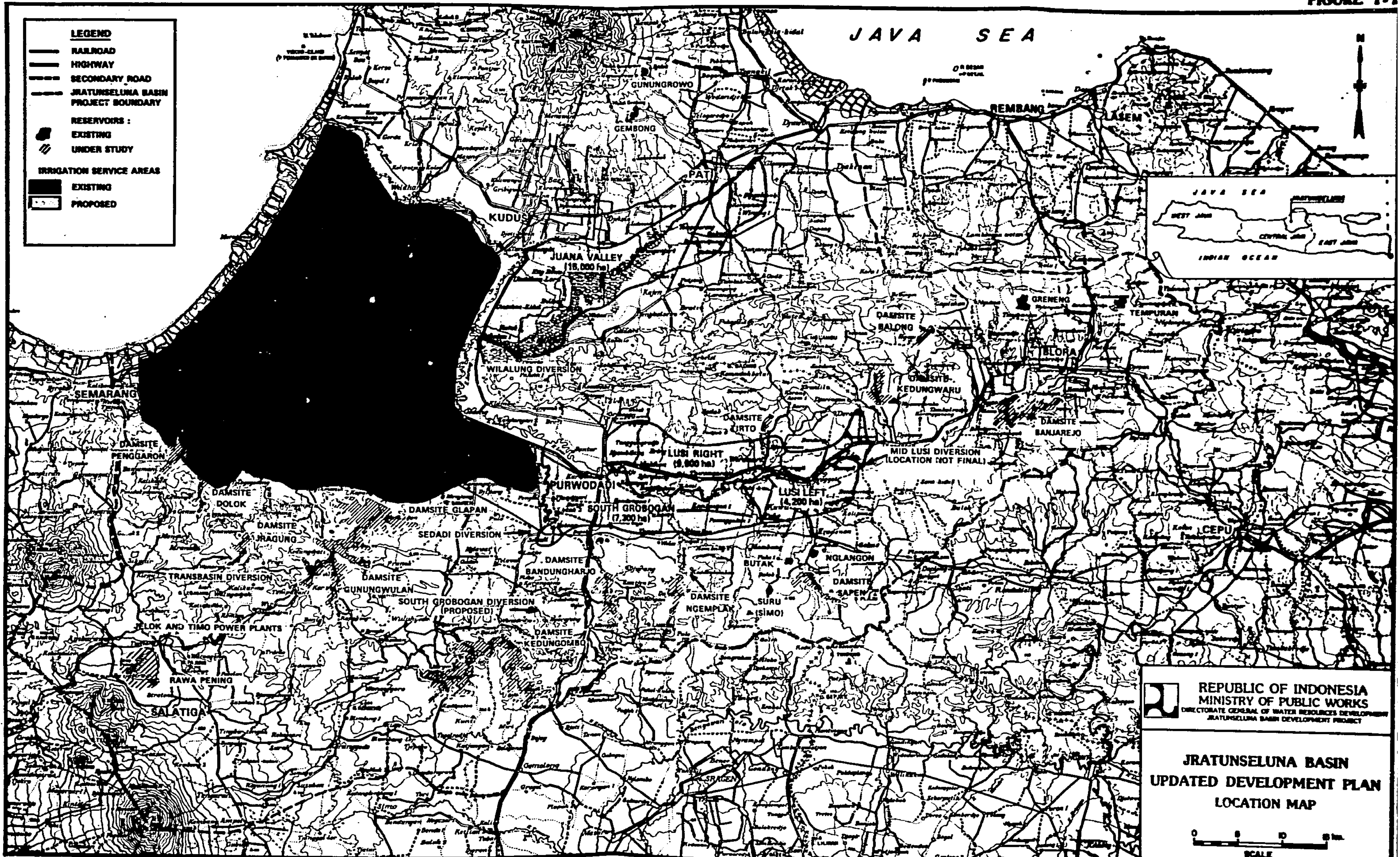
I.4. PROJECT AREA

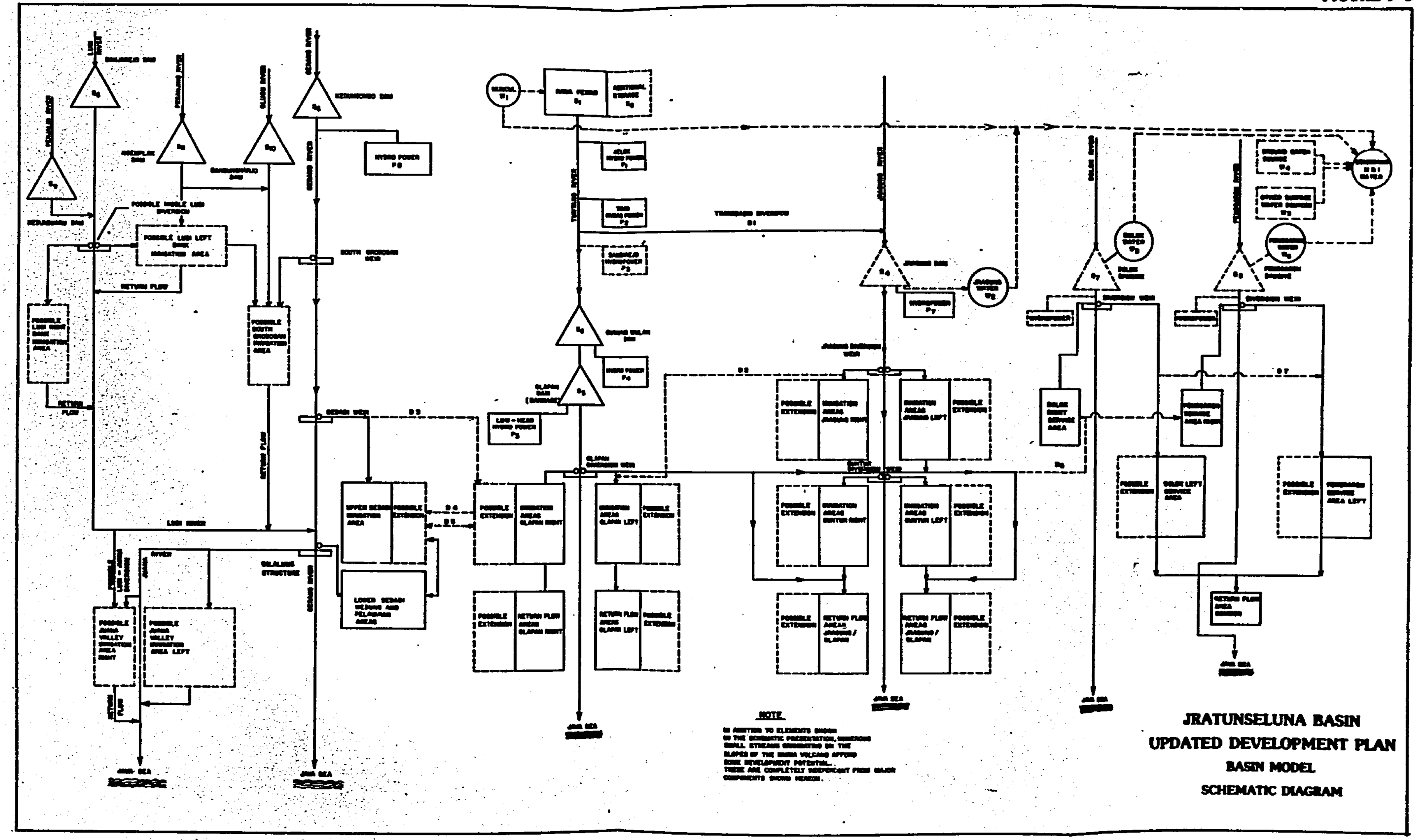
The Jratunseluna Basin is formed by the morphological action of the five main rivers of Central Java, namely, Jragung, Tuntang, Serang, Lusi and Juana. Two other small rivers falling within the basin but draining directly into the Java Sea are the Dolok and the Penggaron Rivers. Besides this system of main rivers, there are a number of tributary streams which are part of the total water resources potential of the basin.

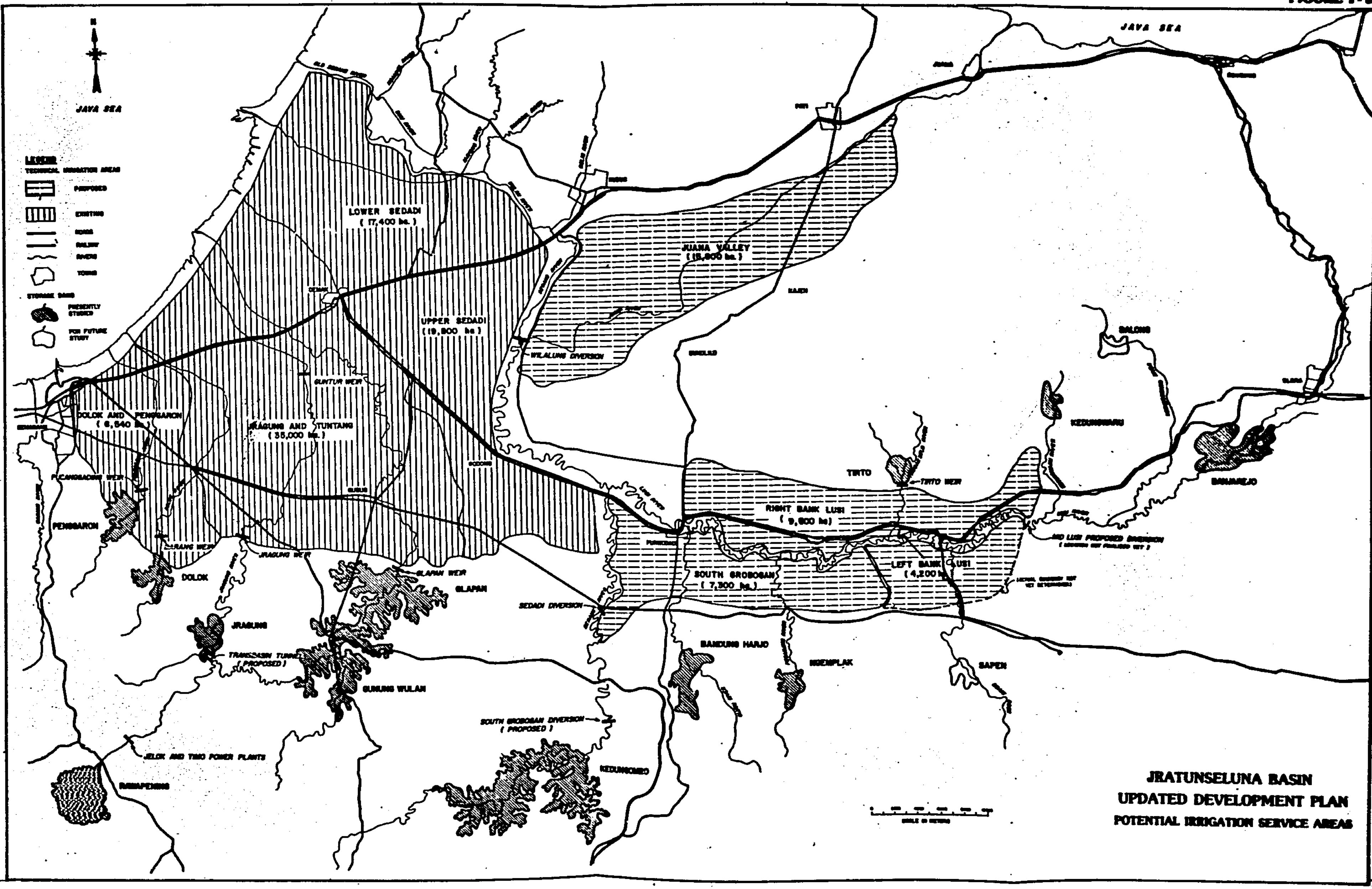
The Jratunseluna Basin covers an area of about 7,700 km^2 including part or all of the following seven Kabupatens (Regencies): Semarang, Blora, Demak, Purwodadi, Pati, Kudus and the Kotamadya (Municipality) of Semarang. The basin is bounded by the slopes of the volcanoes Ungaran, Telomoyo and Merbabu on the south west, by volcano Muria on the north, highlands from where the Lusi River originates on the east and the south, and by the Java Sea on the remaining sides. The watersheds of most of the streams in the basin are located on the slopes of the above named extinct volcanoes.

The location map of the Project Area is presented in Figure I-1 and a schematic diagram of the basin features is given in Figure I-2. The potential irrigation service areas in the Jratunseluna Basin are shown in Figure I-3.

FIGURE 1-1


LEGEND
RAILROAD
HIGHWAY
SECONDARY ROAD
JRATUNSELUNA BASIN PROJECT BOUNDARY
RESERVOIRS :
EXISTING
UNDER STUDY
IRRIGATION SERVICE AREAS
EXISTING
PROPOSED
JAVA SEA
N
GUNUNGROWO
GEMBONG
REMBANG
LASEM
PATI
KUDUS
JUANA VALLEY (15,000 ha)
GRENENG
TEMPURAN
DAMSITE BALONG
BLORA
WILALUNG DIVERSION
DAMSITE KEDUNGWARU
SEMARANG
DAMSITE KIRTO
DAMSITE BANJAREJO
DAMSITE PENGGARON
LUSI RIGHT (9,800 ha)
MID LUSI DIVERSION (LOCATION NOT FINAL)
PURWODADI
LUSI LEFT (4,200 ha)
DAMSITE DOLOK
DAMSITE GLAPAN
SOUTH GROBOGAN (7,300 ha)
DAMSITE JRAGUNG
SEDADI DIVERSION
CEPU
DAMSITE BANDUNGHARJO
BUTAK
NGLANGON
TRANSBASIN DIVERSION
DAMSITE GUNUNGWULAN
DAMSITE SAPEN
DAMSITE NGEMPLAK
SURU (SIMO)
SOUTH GROBOGAN DIVERSION (PROPOSED)
JELOK AND TIMO POWER PLANTS
DAMSITE KEDUNGOMBO
RAWA PENING
SALATIGA
SRAGEN
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
JRATUNSELUNA BASIN DEVELOPMENT PROJECT
JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
LOCATION MAP
0 5 10 15 km.
SCALE
JAVA SEA
INDIAN OCEAN


NOTE
JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
BASIN MODEL
SCHEMATIC DIAGRAM



JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
POTENTIAL IRRIGATION SERVICE AREAS

CHAPTER II

PREVIOUS STUDIES - SYPNOSIS OF REPORTS

CHAPTER II

PREVIOUS STUDIES - SYNOPSIS OF REPORTS

II.1. GENERAL

Investigations to determine the water resources of the Jratunseluna Basin and the constituting subbasins, and their potential for development have been done in the past by many agencies. The earliest study in this regard was made by NEDECO during the years 1970-71 and was titled "Feasibility Study, Water Resources Development, Jragung, Dolok and Penggaron Basins".

A comprehensive study for the development of the Jratunseluna Basin was made by NEDECO, the results of which are given in the report titled "Jratunseluna Basin Development Plan", and in many appendices issued in the year 1973. Subsequently, a feasibility study was carried out by NEDECO and a report titled "Glapan Dam, Irrigation, Flood Control and Hydropower Project" was issued in July 1975.

To study the possibility of developing Rawa Pening and of improving its exploitation, a prefeasibility report was prepared by NEDECO in February 1972. It was followed by a report called "Results of Investigation of Rawa Pening/Muncul Spring water for the Supply of Municipal Water for Semarang City", which was compiled in 1976 by the work team for the investigation of Rawa Pening operations of the Directorate General of Cipta Karya of the Ministry of Public Works.

The investigations to build a dam on the Jragung River have been carried out by many agencies culminating in a "Final Design Report" prepared by ECI and issued in April 1979.

On the power side, most recently, Preese, Cardew and Rider Consulting Engineers carried out a review and analysis of the previous studies done in Central Java, results of which are given in a report titled "Java Power System Development Plan" issued in 1975. The earliest study done on this subject was by Chas. T. Main in 1970 and a report titled "Central Java Long Range Plan for Power System Development" was issued.

Snowy Mountains Engineering Corporation (SMEC) of Australia have completed a design level study on the Serang River Project including a multipurpose storage reservoir at the Kedungombo Site. In addition to providing perennial irrigation water to the Sedadi system off the Serang River, feasibility studies have been carried out by SMEC for irrigating South Grobogan and the Juana Valley areas.

A brief description and the conclusions drawn from the above mentioned studies are given in the following sections of this chapter.

II.2. RAWA PENING

II.2.1. Rawa Pening Prefeasibility Study (NEDECO, 1972)

The main conclusions drawn from the prefeasibility study which was done to ensure the best exploitation of the Rawa Pening for irrigation and hydropower, were the following:

II.2.1.a. Short-term Aspects

1. The exploitation schedule of the Rawa Pening waters in force at that time used an average of 85 percent of the total inflow. A new exploitation schedule was suggested as an interim measure, the application of which would increase power production by an additional 2.9 GWh of energy and would cause an increase in the guaranteed minimum flow by about 1 cubic meter per second.

2. The power production at the Upper Tuntang System (UTS) could considerably be increased if the capacity of the conduit system was enlarged from that existing of 13 to 16 cubic meters per second.

3. The conduit between the Jelok tailrace channel and the daily storage reservoir of the Timo Power Plant has an estimated capacity of 7.5 cubic meters per second, whereas releases at Jelok could be as high as 16 cubic meters per second and the same should be used for generating power at Timo.

4. The efficiencies of turbo generators at both Jelok and Timo could be substantially improved by repairing/replacing the existing installations.

II.2.1.b. Long-term Aspects

1. The conversion of hydropower from base load to peaking at both the Jelok and Timo Power Plants was proposed. Also a power system analysis to evaluate the best mode of power generation at the two power plants was recommended.

2. The study confirmed the possibility of installing a third power station downstream of the Timo Plant, near Sukorejo.

3. To provide additional storage capacity, raising of the maximum water level of Rawa Pening from El. 463.40 to El. 465.90 was considered. For the protection of land from flooding and for avoiding relocation

of population, it was suggested to build dikes for the protection of low-lying areas.

4. The economics for raising the maximum water level of Rawa Pening to El. 465.90 resulted in an internal rate of return (IRR) of about 10 percent. It was, therefore, concluded that under the conditions prevailing at that time, a full scale feasibility study for increasing the capacity of Rawa Pening was justified.

II.2.2. Investigation of Rawa Pening/Muncul Spring Water for Supply to Semarang

The purpose of the study was to examine the possibility of utilizing Rawa Pening water for municipal and industrial use in the city of Semarang without adversely affecting the benefits which were already accruing from water uses for irrigation and hydropower generation. In the ensuing report the programmed use of water from Muncul Spring for the basic water requirement for the city of Semarang and the exploitation of Rawa Pening storage at different lake elevations and its effects on the environments and the generation of hydropower were discussed. The results of the study are summarized below:

1. If water up to 2,000 liters per second was withdrawn from the Muncul Spring for M & I water supply for the city of Semarang, it was estimated that the area presently irrigated in the dry season from the Glapan Diversion Weir would decrease by 2,500 - 3,000 hectares.

2. There would be a substantial reduction in the production of power at UTS. The minimum outflow from the lake would be reduced to about 3 cubic meters per second which could result in shutdown of operation of the Jelok and Timo Power Plants.

3. Several preliminary investigations were made to optimize use of Rawa Pening water by avoiding spills at the Jelok Weir. It was found that by ensuring a maximum flow of 15 cubic meters per second from Rawa Pening to the Jelok hydropower plant only a volume of about 32,000,000 cubic meters per year would be spilled compared to the existing condition in which, on the average, about 73,000,000 cubic meters per year of water are spilled every year.

4. The operation of Rawa Pening at different lake surface levels was investigated and it was concluded that increasing Rawa Pening storage

would benefit hydropower generation and irrigation besides supplying M & I water to the city of Semarang. The possibility of optimizing the resources of Rawa Pening for these uses as well as for fishery and tourism should be investigated.

II.3. JRATUNSELUNA BASIN DEVELOPMENT

II.3.1. General

To examine possibilities of developing water resources for agricultural expansion in the Jratunseluna Basin, the DGWRD undertook an investigation during the period March 1972 through June 1973 [1]. The study was done by NEDECO who established an order of priority for continuing further investigations and for implementation of a Development Plan.

As a result of the study, which was limited to the coastal plains including the Juana Valley and the Lusi Valley and covering an area of 1,950 square kilometers of the total Jratunseluna area of 7,700 square kilometers, six (6) major projects, four (4) minor projects and a number of complementary projects were identified. The major projects which were identified and investigated at different levels of details, are described in the following paragraphs.

II.3.1.a. Dam on the Jragung River

The possibilities of building dams on the Jragung, Dolok and Penggaron Rivers were investigated at prefeasibility levels during the years 1970 and 1971. Subsequently, a feasibility study of the Jragung Dam Project was completed in November 1973.

The prefeasibility studies of dams at the Dolok and Penggaron Rivers did not show satisfactory economics. However, it was suggested that constructing reservoirs on the Dolok and Penggaron Rivers for dry season irrigation or perhaps for industrial water supply should be investigated in more detail at some time in the future.

II.3.1.b. Dam Construction in the Tuntang River System

For formulation of the NEDECO Development Plan, an earlier report which resulted from the prefeasibility study of increasing the potential of Rawa Pening, prepared in 1971-72 [8], was available. This project, along with the alternative possibilities of constructing dams at Gunung Wulan or at Glapan, comprised the major proposed developments of water resources of the Tuntang River Basin.

It was suggested that, after construction of either one of the two proposed dams, the exploitation of the Rawa Pening Lake which served the dual purposes of irrigation and hydropower generation could be adapted to power production. The ensuing benefits would be credited to the new dam.

The feasibility of constructing a third hydropower plant at Sambirejo, below the existing plants at Jelok and Timo, was not investigated as the study was directed towards agricultural production rather than hydropower.

Increasing the storage capacity of Rawa Pening for irrigation and flood control was not found economically feasible based on the conditions at that time. Similar benefits could be obtained by building either one of the proposed dams on the Tuntang River.

II.3.1.c. Dam Construction in the Serang River System

Two alternative sites, one at Nglanji and the other near Ngrambat were investigated. The increased water supply from storage on the Serang River could either be used in a part of the Tuntang area and in the Pelayaran area of the Glapan Sedadi System, or in the Wedung area. In the former case, the Tuntang discharges could more fully be used in the areas to the west of Glapan. In the second case, the irrigation water supply in the Wedung area could be improved and the function of the Karanganyar pumping station would have to be investigated in more detail during the course of the feasibility study.

Although some reduction of floods in the Serang would be obtained from the construction of the Ngrambat Dam, the flooding problems at the Wilalung Flood Diversion Structure and in the Juana Valley would not be solved.

In addition to the above projects, the following major projects were proposed in the Basin Development Plan.

1. A dam on the Lusi River at Banjarejo;

2. Diversion of Serang floods away from the Juana Valley by either widening the Wulan River, by making a cross connection between the Wulan River and the Tuntang River, or by constructing a Diversion Canal directly to the sea; and

3. The drainage of Juana Valley. It was stated that if the Serang and Lusi waters were not discharged into the Juana River, this water course would become available for the single purpose of draining off excess runoff from its own catchment area.

Other projects which were identified in the Development Plan are listed below:

1. Kedungwaru Dam
2. Bandungharjo Dam
3. Ngemplak Dam
4. Nglanji Dam
5. Balong Dam
6. Sapen Dam

II.3.2. Dolok and Penggaron Dams

In a combined report on the feasibility studies of the water resources development of the Jragung, Dolok and Penggaron Basins prepared by NEDECO in 1971 [2], the following conclusions concerning dams on the Dolok and Penggaron Rivers are recorded:

1. A storage dam on the Penggaron River was found technically and economically feasible. The project would ensure wet and dry season irrigation of about 4,619 hectares and 500 hectares, respectively. Inclusion of hydropower in the project would yield only marginal economic benefits.

2. A storage dam on the Dolok River was found technically feasible but from an economic point of view, flood control benefits were more attractive than benefits from irrigation. The service area allocated to the project is 2,735 hectares. Hydropower development at the damsite was considered unattractive.

II.3.3. Jragung Dam

In 1973, NEDECO prepared a feasibility report [3] for the Jragung Dam as a flood control and irrigation project. The maximum net storage considered for the reservoir would irrigate 2,800 hectares in the dry season and 7,900 hectares in the wet season with 80 percent firmness.

The report recommends further project related investigations of the foundations and construction material sources.

The feasibility report was reviewed by Tudor Engineering Company of U.S.A. in 1974 who endorsed the findings of NEDECO, but recommended that studies of technical significance be undertaken along with further geological and hydrological investigations.

The Jragung Dam Project feasibility study was upgraded by PRC/ECI in 1976 [4] and the gross storage capacity of the reservoir was established at 141,000,000 cubic meters. The estimated cost of the Project was

$ 46.3 million. The benefits which could be derived from the project are listed below.

1. Full irrigation water supply to 7,627 hectares of riceland in both wet and dry seasons.

2. Two thousand liters per second M & I water supply to Semarang.

3. Average generation of 29,700 megawatt hours of electricity per year from a 6 megawatt plant.

4. Flood alleviation on 1,800 hectares.

To supplement water in the Jragung Subbasin for projected uses it was proposed to divert an average annual volume of 81,000,000 cubic meters from the Tuntang River to the Jragung Reservoir.

Since data to evaluate sedimentation in the reservoir were not available, it was recommended that measurements in the Jragung River should be made at the damsite so that an estimate of sediment yield could be made and the required capacity for sediment storage could be provided in the reservoir.

The IRR of the project as designed was 17.9 percent.

The final design of the Jragung Dam Project including all investigations, design criteria, standards and codes were presented in the Final Design Report submitted by PRC/ECI in April 1979 [5]. The major conclusions derived from the design stage investigations and studies are stated in the following.

1. The annual rate of sedimentation in the Jragung Reservoir is estimated to be 1,600,000 cubic meters. Provision for this estimated sedimentation during the life time of the project should be made which requires an estimated gross storage capacity of 177,000,000 cubic meters.

2. The estimated cost of the project in 1978 currencies was US $ 85.67 million. The project would result in an IRR of 13.2 percent if the

projected cropping pattern of "5 rice crops in two years" would be adopted in the service area.

With a less intensive cropping pattern "two rice crops plus an upland crop" every year, the IRR would increase to 14.6 percent.

At the completion of the final design of the Jragung Dam Project, an additional study was carried out to investigate the project economics by building the dam and the project in stages which significantly reduced the projected benefits. Reference is made to the design report [5] for full description of the design and the additional study of staged development of the Jragung Dam Project.

II.3.4. Glapan and Gunung Wulan Dams

A feasibility report [6] for the Glapan Dam Project was prepared by NEDECO in the years 1974/75. The main conclusions drawn in the report are stated in the following.

1. The proposed dam and reservoir on the Tuntang River at Glapan would provide irrigation water to 31,000 hectares for rice agriculture in the wet season and would increase the dry season irrigation from the 6,000 hectares cultivated without the project to 28,000 hectares, or twice that area if soybean replaced rice, with the project implemented.

2. The reservoir having a gross storage capacity of 320,000,000 cubic meters (net storage 305,000,000 cubic meters) would cover an area of 2,750 hectares. A substantial population relocation from the town of Kedungjati and relocation of the railroad and highway would be required, should the project as proposed be built.

3. The project costs were estimated in 1975 currency as follows.

Dam and irrigation facilities	US $ 60.80 million
Upgrading existing irrigation system	US $ 1.78 million
Relocation of railway	US $ 4.02 million
14 MW power station	US $ 8.85 million
or 6 MW power station	US $ 4.80 million

4. The project as proposed would have an IRR of 10 percent.

5. In the Jratunseluna Basin Development Study a second potential damsite on the Tuntang River near Gunung Wulan (Storage capacity 115,000,000 cubic meters) was identified and investigated at prefeasibility level. The construction of the proposed Gunung Wulan Dam would eliminate the necessity of building a separate day storage reservoir below the UTS power plants.

It was, therefore, recommended to continue the investigation of development possibilities of UTS and to examine the technical and economic feasibility of constructing a storage dam at the Gunung Wulan site including a study of an integrated irrigation and power operation of the Rawa Pening and the Gunung Wulan Reservoirs together with the Jragung Reservoir and/or a reservoir on the Serang River.

II.3.5. Serang River System

In the general basin development plan of 1973 [1] prepared by NEDECO for the Jratunseluna Basin, a storage dam at Ngrambat on the Serang River and other works for the development of the Serang River were proposed. Subsequently, a feasibility study for the development of the Serang River was completed by NEDECO in 1975. The Government of Indonesia contracted a team of consultants, namely SMEC et al in 1977 to review the findings of the Serang River study and then to prepare a detailed proposal for a definite development scheme. The main conclusions drawn in the Definite Scheme Report [11] of February 1979 are stated below.

1. A dam on the Serang River called Kedungombo Dam having a gross storage capacity of 749,000,000 cubic meters and a net storage capacity of 655,000,000 cubic meters should be constructed. The project includes a power station of 20 MW rated capacity. The estimated annual firm energy and secondary energy are 17.0 gegawatt hours (GWh) and 57.4 GWh, respectively.

   The estimated cost of the dam and the power station in 1977 currencies was estimated at US $ 138 million.

2. The following downriver works were proposed and designed on the Serang River.

   Flood Control (Cost US $ 31.8 million)

   - Wulan/Lower Serang River Improvements
   - Welahan Bum Drainage Improvements
   - Juana Valley Drainage Improvements

   Drainage

   - Glapan Sedadi Drainage Improvements (US $ 14.7 million)
   - Kedung Semat Drainage Improvements (US $ 2.2 million)

   Irrigation Development

   - Glapan-Sedadi Irrigation Adjustment (US $ 9.3 million)
   - South Grobogan Irrigation System (US $ 13.5 million)
   - Juana Valley Irrigation System (US $ 20.1 million)

3. The irrigated agricultural areas (2 rice crops plus one upland crop) under full project condition would be as follows.

   - Glapan-Sedadi Area 37,200 hectares
   - South Grobogan Area 7,300 hectares
   - Juana Valley Area 10,000 hectares

4. The flood and drainage control works would have sufficient capacities to discharge a 1-in-5 year runoff with negligible damage to the standing crops.

5. The total cost of the complete project, excluding Juana Valley Irrigation and Kedung Semat Drainage, would be US $ 227.3 million; the net present worth of all the benefits at a 12 percent rate of discount would be US $ 37.3 million; the IRR would be 15.3 percent.

II.4. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

A study was conducted by Burns and McDonnell [10] for a Water Supply Master Plan for the city of Semarang in 1976. In this plan, a heavy dependence was placed on the surface water resources of the Jratunseluna Basin to meet the municipal and industrial (M & I) water demand of Semarang. The available water supply in 1976 from all the sources was 774 liters per second, whereas the estimated average demand in 1980 would be 1,240 liters per second. The corresponding demands in 1985, 1990, 1995 and 2000 were estimated at 1,800, 2,650, 4,100 and 6,590 liters per second.

To meet those demands, it was proposed to draw water to the extent from the following sources.

Muncul Spring (Rawa Pening)	- Year 1982	1,000 1/s
Muncul Spring	- Year 1987	1,000 1/s
Jragung Reservoir	- Year 1989	2,000 1/s
Penggaron Reservoir	- Year 1994	3,200 1/s

Subsequent to the issuance of the master plan, a short study was conducted by Eddy and Metcalf to explore the availability of groundwater in the adjoining areas to supplement M & I water supply for Semarang. No definite result could be obtained from that study due to lack of the field data. However, they reported the availability of groundwater in certain areas (1,000 to 1,500 liters per second from the basins of the following Rivers: Babon, Garang, Mangkang and Blorong) and recommended detailed investigations to determine the quality and the quantity of water available from these sources.

A detailed study of groundwater potential in the upper watershed of the Garang River and the adjacent rivers, namely, Kreyo River and Kripik River has been started by Nihon Suido Consultants working with Cipta Karya. The initial results of the study are that groundwater may occur in four areas within the study area: 1) lava flows of the Ungaran Volcano, 2) volcanic sand and gravel in Ungaran Volcanic rock area, 3) weakly cemented volcanic breccia in the upper and middle hilly area, and 4) selected alluvial basins along reaches of the Garang River and adjacent rivers. The proposed method to acquire more information on these sources of groundwater is by geoelectric prospecting which is being done at present. The results of this study will be known sometime in the latter part of 1980.

As part of PRC/ECI's study for the preparation of an integrated development plan for the Tuntang/Jragung Rivers Basins, a review was conducted of all investigations for determining the potential of the Jratunseluna Basin to supply M & I water to the city of Semarang. A special report [9] was issued on this subject in November 1979. The conclusions drawn in that report are summarized below.

1. Due to increase in population and heavy anticipated industrial growth, the city of Semarang will have a large demand for additional water supplies in the years to come. These water demands are calculated to be 1,215, 1,720, 2,660, 3,870 and 5,650 liters per second by the years 1980, 1985, 1990, 1995 and 2000, respectively.

2. The most feasible source for a large first-phase water supply will be from the waters of the Tuntang and Jragung Rivers Basins, taken either at Muncul Springs or at Jragung Dam. The economics favor Muncul Springs, but the existing uses of this water are a problem which must be addressed. Storage on the Tuntang River will alleviate the damage to downstream irrigation users from taking water at Muncul Springs, but will not prevent a possible loss of power generation at existing and future hydroelectric power plants. A total of 2,000 liters per second can be allocated to Semarang from either one of these two sources.

3. Extensive groundwater investigations, such as the one currently in progress, will be necessary before a determination of the role of groundwater in supplying future water requirements can be made. However, even the most optimistic projection of groundwater potential does not envision this source to be able of supplying the remaining 2,850 liters per second following development of the recommended first-phase water supply of 2,000 liters per second. This will force the development of an additional surface water supply. The Penggaron

damsite *) appears to be the most feasible source for this supply. The major advantages of the Penggaron damsite are the close proximity to the city of Semarang and a large potential yield. A feasibility study of this damsite, which should emphasize its municipal and industrial water supply capability, should be initiated.

4. The future water requirements of other towns and rural areas which would potentially be served from waters of the Tuntang and Jragung River Basins were studied briefly. The total demand was not found to be large, and can likely be met from groundwater sources. The fact that the points of demands are spread out over a large area, and that the demand at each point is small, makes the use of groundwater possible and practical.

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*) Later studies show Dolok Dam to be more feasible than the Penggaron which has been dropped from the updated development plan package.

II.5. FLOOD CONTROL

In addition to the flood control measures for the Jratunseluna Basin recommended in the Master Plan of 1973 [1], three main studies have been made by SMEC [11], NEDECO [14] and PRC/ECI [9] to propose flood and drainage control in the Tuntang/Jragung/Serang service areas and in the Juana Valley. The flood control situation in these reports was considered with and without the proposed storage reservoirs constructed in the upper reaches of the respective rivers.

As stated in Section II.3.5., in the Serang River development plan prepared by SMEC [11], recommendations have been made to improve drainage and effect flood control in the Lower Serang River System, Glapan-Sedadi system and in the Juana Valley. The measures recommended in the proposed scheme are enlargement of existing flood/drainage canals, building new canals, construction of levees and providing a system of temporary flood storages to reduce the flood peaks.

In the NEDECO study [14] for the Sedeku area, proposals have been made for improving the drainage system in the service area to meet the possible situation that a dam may not be built on the Jragung River. One of the benefits to be derived from the multipurpose Jragung Dam Project [5] is flood control in the service area.

The report by PRC/ECI [9] takes into consideration the entire irrigation service area both on the Tuntang and the Jragung Rivers. Seven alternative proposals which dealt with drainage and flood control in the affected areas were presented. The alternatives recommend floodways and drainage canal enlargement, construction of levees and other flood control structures to protect the areas with and without the Jragung Dam on the Jragung River and with and without a major dam (Gunung Wulan) on the Tuntang River. A design flood with a frequency of occurence of 1 in 50 years was assumed for sizing the flood control works.

CHAPTER III

INVESTIGATIONS

CHAPTER III

INVESTIGATIONS

A search for data required for this study was made from the previous reports prepared by others for the Jratunseluna Basin [1], Rawa Pening [8], Serang River System [11] and the Jragung Dam [4, 5].

Many reports and documents became available from the PLN and their consultants which provided useful information on existing hydropower systems in the subbasins.

To update the original master plan and development plans for the subbasins as prepared by NEDECO, certain investigations were carried out in the fields of hydrology, to a limited extent of materials and geology, of sediment yields from the watersheds, and of the socio-environmental impacts of two of the proposed projects on the general area. These investigations are described in the following sections.

III.1. HYDROLOGY

The study for updating the development plan was essentially at a prefeasibility level for the individual elements considered. The primary objective was to establish the sizes and locations of the storage reservoirs and the diversion works. As explained later in this report, the optimization of the basin development plan was done on a computer by simulation on a basin model.

To provide input information to the computer basin model, it was necessary to determine water yields at the points of interest of the various subbasins within the entire Jratunseluna Basin. For that purpose, all hydrological investigations carried out earlier by PRC/ECI and other consultants were reviewed and updated. Also, necessary data which were not available were generated from the information that could be collected from the relevant sources. The investigations done related to determining basin rainfall and runoffs, flood frequencies and the probable maximum floods. These are described in detail in Appendix A to this report.

The summaries of the hydrologic data thus produced are presented in Tables III-1, III-2 and III-3.

For estimating flood frequencies in the Tuntang and the Jragung River basins, regional flood frequency curves were used. During the course of the study, in January/February 1980, a high intensity rainfall occurred in the basin which caused exceptionally large floods in all the streams of the western part of the Jratunseluna Basin. Unprecedented rainfall and runoff was recorded as an important hydrological event. After reviewing information on all new flood peaks including the above mentioned super flood, the flood frequency curves were revised and are included in Appendix A.

Based on the revised flood frequency curve, the flood peaks on the Jragung River are affected in the manner given below.

1. The peak of the probable maximum flood (PMF) for the catchment upstream from the proposed Jragung Dam would remain unchanged at 3,000 cubic meters per second. However, the volume of runoff in the PMF would be increased.

2. The flood peak for a given return period would be larger than that reported before. The percentage increase would depend upon the size of the drainage area for the point of interest.

3. The latest flood which occurred on 22 January 1980 with a peak discharge of 752 cubic meters per second would have a return period of approximately 20 years. Previously, a flood of the 25-year return period had a peak discharge of 560 cubic meters per second.

TABLE III-1

SUMMARY OF HYDROLOGIC DATA*)

TUNTANG AND JRAGUNG CATCHMENTS

	Unit	Tuntang River at Glapan Weir	Tuntang River at Gunung Wulan Damsite	Tuntang River at Jelok Weir	Jragung River at Jragung Damsite
Area					
Catchment Area	km^2	796	669	282	94
Rainfall					
Mean annual rainfall	mm	2,630	2,700	2,720	2,640
Maximum monthly rainfall	mm	600	608	612	950
Minimum monthly rainfall	mm	0	0	0	0
Maximum daily station rainfall	mm	400	400	400	306
Probable maximum 24-hour catchment rainfall	mm	577	598	612	680
Runoff					
Mean annual runoff	mm	1,120	1,150	1,420	1,280
Mean annual volume of runoff	10^6 m^3	892	770	400	121
Mean annual discharge	m^3/s	28.3	24.4	12.6	3.82
Floods					
Mean annual flood peak	m^3/s	540	450	360	280
25-year flood peak	m^3/s	940	800	640	560
Flood volume for the 25-year flood peak	10^6 m^3	37	25	15	5.6
Probable maximum flood peak	m^3/s	-	6,700	5,600	3,000

*) Without the data of the flood recorded in January 1980.

TABLE III-2

SUMMARY OF HYDROLOGIC DATA
PENGGARON AND DOLOK RIVERS BASINS

	Unit	Penggaron River	Dolok River
Area:			
Catchment area at weir	km^2	77.7	41.5
Catchment area at damsite	km^2	75.6	34.0
Rainfall over Catchment:			
Mean annual rainfall	mm	2,721	2,415
Maximum annual rainfall	mm	3,455	3,098
Minimum annual rainfall	mm	2,212	1,635
Maximum daily station rainfall (Sta. No. 79, No. 686)	mm	501	273
Rainfall over Service Area:			
Mean annual rainfall	mm	2,175	2,241
Maximum annual rainfall	mm	2,864	2,780
Minimum annual rainfall	mm	1,583	1,625
Maximum daily station rainfall (Sta. No. 79)	mm	501	501
Runoff: (At weir)			
Mean annual runoff	mm	1,325	1,116
Average annual discharge	m^3/s	3.3	1.50
Annual yield	10^6 m^3	103.0	46.31
Floods:			
Mean annual flood peak	m^3/s	240	130
Diversion design flood peak	m^3/s	400	230
Diversion design flood volume	10^6 m^3	3.2	0.9
Probable maximum flood peak	m^3/s	2,700	1,800
Probable maximum flood volume	10^6 m^3	21.6	7.3

TABLE III-3

SUMMARY OF HYDROLOGIC DATA LUSI RIVER AND TRIBUTARIES

Area:

Lusi Catchment at Banjarejo damsite	:	506 km^2
Lusi Catchment at Purwodadi Weir	:	1,981 km^2
Lusi Catchment at Confluence	:	2,101 km^2
Serang River at Kedungombo	:	614 km^2
Kedungwaru Catchment at damsite	:	88 km^2
Glugu Catchment at Bandungharjo damsite	:	41 km^2

Rainfall over Catchment: (mm)	Upper Lusi	Lower Lusi	Purwodadi	Kedungwaru	Bandungharjo
Mean annual rainfall	1,750	1,936	1,873	1,931	2,086
Maximum annual rainfall	2,206	2,480	2,368	3,369	2,769
Minimum annual rainfall	1,241	1,528	1,534	1,545	1,466
Maximum daily station rainfall	370	350	370	256	238

Rainfall on Service Area: (mm)	South Grobogan	Juana Valley	Wedung	Pelayaran
Mean annual rainfall	2,164	2,375	2,418	2,342
Maximum annual rainfall	2,606	3,313	3,283	3,025
Minimum annual rainfall	1,439	1,845	1,643	1,787

Runoff:

Lusi River:	Banjar-ejo	Purwodadi	Confluence with Serang	Kedungwaru	Bandung-harjo
Annual Runoff (mm)	-	883	-	89.5	971
Average annual discharge (m^3/s)	13.1	55.4	58.8	2.5	1.3
Annual Yield (10^6 m^3)	411.5	1,737.9	1,807.8	78.8	39.7

Serang River:	Kedungombo	Sedadi	Wilalung
Annual Runoff (mm)	-	1,179	-
Average annual discharge (m^3/s)	22.2	30.6	95.5
Annual Yield (10^6 m^3)	690.5	951.8	2,971.9

Floods:	Banjarejo	Kedungwaru	Bandungharjo
Mean annual flood peak, m^3/s	540	270	150
Diversion design flood peak, m^3/s	920	505	305
Diversion design flood volume, 10^6 m^3	36	4.5	1.4
Probable maximum flood peak m^3/s	7,100	2,850	1,900
Probable maximum flood volume 10^6 m^3	277	25.6	8.9

III.2. EROSION AND SEDIMENTATION

A detailed study and analysis of erosion and sedimentation in the Jragung watershed have been carried out by PRC/ECI based on the sediment measurement made at the Borangan Bridge since 1977. The results obtained from that study, stated in detail in Appendix H of this report, are summarized in this section. Similar measurements and analyses of data have been initiated on the Tuntang River for which necessary equipment has been purchased. This work initiated by PRC/ECI on two major rivers of the Jratunseluna Basin should provide procedures and guidelines for DGWRD to collect data and analyse erosion rates in other areas and sedimentation in the other rivers of the Basin.

III.2.1. Jragung Watershed

The results of the sedimentation studies carried out during the years 1977 to 1978 are the following.

1. Using the measurement data of suspended load of only the first year, the long-term average sediment yield from the Jragung Watershed is 20,000 tons per square kilometer per year. This amounts to a sediment transport of about 1,920,000 tons or 1,750,000 cubic meters (assuming a density of 1.1 tons per cubic meter) past the proposed damsite on the Jragung River.

2. Using the measurement data of suspended load of two years, the corresponding average sediment yield and the sediment transport figures are 16,000 tons per square kilometer per year, 1,530,000 tons and 1,400,000 cubic meters, respectively.

3. To illustrate the severe erosion in the Jragung watershed, the amount of sediment which passed during the latest flood of record which occurred on January 21/22, 1980 are given. The flood peak had a discharge of 752 cubic meters per second and the volume of water which passed through the measurement station was 17,600,000 cubic meters. The total suspended sediment discharged between 2030 hours on 21 January and 0800 hours on 23 January 1980 was 805,000 tons. The average sediment concentration for the flood was 45,700 milligram per liter.

4. The measurement of sediment is continuing on the Jragung River and the methods of collection of data and analysis have been explained to the DGWRD personnel and laid down in Appendix H of this report. With the collection of additional data on a continuing basis, a better estimation of the erosion in the Jragung Watershed and sedimentation in the river would be possible.

III.2.2. Other Watersheds

A sediment measurement program similar to the one previously established on the Jragung Watershed has been initiated in the Tuntang River at the Kedungjati railroad bridge. Sufficient measurement data have not yet been collected.

In the absence of necessary sediment measurement data, it is not possible to make any realistic estimate of sediment yield of the Tuntang and other rivers considered for development in the present study. However, to make this vital input to the computer model for simulating the proposed multi-reservoir operation in the system, very approximate estimates of sediment yields were made for the subbasins of the Jratunseluna Basin. These estimates of sediment yield, ranging from 5,000 tons per square kilometer per year to 20,000 tons per square kilometer per year, were based on comparison of the unmeasured watersheds with the measured watershed (Jragung) under consideration of the geological and topographical conditions, vegetal cover, land use and land management practices. Accordingly, in sizing the reservoirs to obtain firm annual yield of water, allowance has been made for the storage of sediment, based on the above mentioned estimates of sediment yield from the watersheds.

For the Serang watershed, the estimate of sedimentation at Kedungombo previously made by SMEC [11] has been maintained in the present study. That estimate amounts to about 2,500 tons per square kilometer per year.

III.3. GEOLOGY

The geology as part of this study was limited to the review of geological data and their interpretation for the previously proposed project sites in the Jratunseluna Basin as given in the respective reports by NEDECO [1, 6, 7, 8], PRC/ECI [5] and SMEC [11], to preliminary investigations for newly proposed developments in this study; and to presentation of the site geological data for the proposed projects on the Tuntang and the Jragung Rivers. The results are presented in Special Report II by PRC/ECI [9] submitted in November 1979.

Reference is made to the abovementioned reports for geological data of all the sites considered for development in this plan. However, a brief description of the regional geology as applicable to the Jratunseluna Basin is given in the following.

III.3.1. Regional Geology

The geological history of the Jratunseluna Basin is closely related to the concept of global plate tectonics. The island of Java is situated on the leading edge of the South Pacific Plate which is moving southward and is over-riding the Australian Plate. The Australian Plate is pushed downward into a subduction zone that expresses itself as a submarine deep called the Java Trench. The Trench is the locus of numerous large earthquakes, but since it is about 100 kilometers off the south Java coast and nearly 200 kilometers from the project area, these seismic events will have little effect on the projects in the basin.

The Java landmass has been broken by the plate collision into a complex of fault blocks. Many of the fault intersections provide conduits for volcanic eruptions. Differential movement of fault blocks, complex folding within fault blocks, deflation of shallow magma chambers, erosion and sea level changes have shaped the surface of Java.

The Jratunseluna Basin shows the effects of these natural processes. Deep-seated regional faults define the boundaries of the basin. The Kendeng Anticlinorium was formed during the Plio-Pleistocene Javanese uplift. It was formed by N-S oriented stresses. Soft, late Tertiary marine sediments were raised, folded and faulted. Concurrent and subsequent erosion of the uplifted sediments yielded fine-grained sediments which were quickly redeposited along shores. Accretional littoral development is presently continuing at a rapid pace.

III.3.1.a. Lithology

Tertiary sedimentation consisted of marine claystone deposited in shallow sea environment, tuffaceous siltstone and sandstone and debris flow-type sandstone with gravel derived form volcanic rocks. These rocks are cyclically interlayered; the layers ranging in thickness from 100 millimeters to about 15 meters. Some claystone surfaces exhibit ripple-marks reflecting a very shallow depositional environment. Siltstone layers exhibit polygonal desiccation cracks which represent exposure above water level.

The claystone layers are more wide-spread and uniform in thickness. Some sandstone units, which appear more prominent because of resistance to erosion, tend to pinch out over short distances.

The estimated maximum thickness of the marine layers probably does not exceed 3,000 meters. Since uplift occurred in Recent geological time prior to any significant overburden cover, the sediments are only slightly over-consolidated. Some of the tuffaceous sandstone and siltstone display compaction features. Most of the siltstone and sandstone units are friable. The claystone tends to slake readily on cyclic drying and wetting. Fissuring in the rock is partially open thus allowing for variable permeability.

Rock formations around Rawa Pening are volcanic. Alluvial sediments capping the lower slopes and filling the lake basin are of volcanic origin. The upland slopes are composed of basalt and andesite derived from the Telomoyo, Merbabu and Ungaran volcanoes. Basalt flows extend to the headrace pond above the Timo power station. Agglomeratic sediments cap the marine sediments to about Sambirejo and to about 3 km upstream of the Jragung II Damsite. The agglomerate is composed of subangular to subrounded basalt and scoria fragments within a sandy matrix. Residual agglomeratic soils can be found on the top of several lower ridges further downstream.

The foothill and floodplain border is located at about El. 20.0 above MSL, the level at which erosion of the marine sediments ceases and deposition of the floodplain and slope wash sediment starts. Fine sand, silt and clay make up most of the flood plain sediments with silt restricted to the drainage channels and natural levees, and clay to the lower coastal reaches. There is no lithological uniqueness about the area. Recent sediments range in thickness from 50 to 90 meters.

Below these depths, bedding appears to be folded and identification of correlatable units is difficult. Deposits are either continental or shallow marine but most contain a high saline level showing a strong marine depositional influence.

Weathering of the rock mass has produced lateritic soil rich in iron and alumina ions and deficient in silica. Outcrops exhibit iron oxide case-hardening which protects the softer core material. The volcanic uplands are covered by reddish, iron-rich soils while the lowlands and floodplains contain grey to black soils probably richer in alumina and with chemically reduced iron. Lateritic soils may be sensitive to environmental changes and could exhibit appreciable strength variation.

III.3.1.b. Structure

Geological structure was formed by development of the volcanic uplands which formed the Kendeng Anticlinorium. The layered marine sediments were pushed northward, folded and faulted into high amplitude anticlines and slightly lower amplitude synclines. Faulting occurred when deformation exceeded the shear strength of the rock mass. As the principal plane of weakness on the rock mass is parallel to the bedding, most of the faults in those weak rocks are along bedding planes. Only when folding became tight did the shear faults cross the slightly higher strength sandstones.

The regional geologic map of the area is given in Figure III-1.

III.4. MATERIALS

No material testing for any of the projects was done during this study except for some foundation material testing at Rawa Pening. The information required for preparing conceptual designs of the works proposed in this plan was obtained by reviewing the data available from earlier reports on projects in the Jratunseluna Basin [1, 5, 6, 7, 8, 11]. These data are given in the design reports of the individual works proposed for development in Appendix C of this report.

Should the maximum water surface level of the lake be raised to provide additional storage of water at Rawa Pening on the Tuntang River System, it will be necessary to build levees around the lake to protect villages and agricultural land from being flooded. A limited material investigation, therefore, was done to determine the technical feasibility of building the proposed dikes.

Inasmuch as the raising of Rawa Pening to provide additional storage of water in the Jratunseluna Basin is an element of considerable consequence in the development plan, it is important that the results of the above mentioned preliminary investigation be summarized in this report as follows.

1. The material at the sites, where dikes are proposed, is generally an about 2.0 meters thick layer underlain by highly compressible organic matter (peat) with occasional thin layers of less permeable material such as clay and silt. The laboratory testing of some of the representative samples obtained from the area yielded low values for the undrained shear strength and high values for the compression index. From a qualitative point of view, the tests indicated that the initial stages of consolidation of the foundation material, if subjected to the levee loads, could occur rapidly and the resulting settlement could be large.

2. Consolidation of foundation material at Rawa Pening will occur in two stages. The first stage, referred to as primary consolidation, is a result of the volumetric deformation that occurs under load as water is expelled from the soil pores, and the stress increase is transferred to the soil skeleton. The volumetric deformation that

occurs during secondary consolidation is a result of an intergranular viscosity phenomenon. While for a great many cases secondary consolidation has a minor effect, it has been recognized that for organic soils, this phenomenon may contribute a major component of the overall settlement. The quantitative determination of secondary consolidation of materials at Rawa Pening will require much detailed investigation.

3. It is estimated that in areas beneath the levees where conditions are favorable to drainage, the majority of the primary consolidation could take place in 2 to 5 years. The analysis indicates that the settlement due to primary consolidation could be in excess of 50 percent of the total levee height. As stated above, the extent of settlement due to secondary consolidation cannot be estimated at this stage.

4. From the interpretation of the limited investigation done during this study, it is felt that the construction of the levees is technically feasible, but the problems relating to settlement and consolidation of the levee foundation and potential problems associated with the construction of drainage ditches behind the levees, to dispose off local drainage by gravity, might be insurmountable.

5. A significant amount of additional work should, therefore, be performed to better evaluate foundation conditions for the dikes to make the decision whether or not raising of Rawa Pening could stay as an element in the development plan.

Due to the complicated nature of the problem, best approach would be the construction of one or more fully instrumented test sections in the field to observe the actual behaviour of the foundation. A thorough laboratory testing program should be performed simultaneously to determine the shear strength properties of the foundation and correlate laboratory behaviour of the materials to actual observed field behaviour in terms of total settlement and consolidation. Testing of the materials proposed for the construction of the levees is also of importance because of the large deformations to be expected in the levee foundations. Additional information should also be obtained on groundwater conditions at the site in view of the springs that feed the Rawa Pening to determine what effect thay might have on the behaviour of the foundation under load and the effect of the raised water surface of the Rawa Pening on the performance of the springs. Major consideration should be given to the depth of overlying clay layers, in terms of stability and settlement, when selecting the alignment for the levee. Additional work will have to be done to predict the behaviour of the organic soil layers upon excavation for drainage ditches with the levee load imposed.

These comments should serve as a guideline for initiating full scale feasibility level investigations leading to the final design and implementation of the Rawa Pening Scheme. The results of material testing from selected bore holes drilled in the Rawa Pening area are given in Table III-4.

TABLE III-4

TABULATED SUMMARY OF SOIL PARAMETERS

FOR THE FOUNDATION MATERIALS OF THE RAWA PENING

Hole No	Depth (m)	LL (%)	PL (%)	Classification	G_s	w_o (%)	γt (t/m^3)	e_o	S_u (t/m^2)	C_c (1)	(2)	(3)	(4)	c_v cm^2/s	k cm/s
2	3.0- 3.4	56	28	CH	2.51	49	1.7	1.1	1.3	-	0.4	0.2	0.5	-	-
2	6.0- 6.4	218	125	OH	2.51	193	1.2	5.1	2.2	-	1.9	1.4	2.5	-	-
2	6.4- 6.8	-	-	PT	-	152	1.2	4.3	0.3	-	-	1.2	1.9	-	-
6	5.0- 5.4	110	52	OH	2.51	108	1.4	2.8	-	0.9	0.9	0.8	1.3	$10^{-3}-10^{-4}$	-
7	3.0- 3.4	59	31	CH	-	60	1.6	1.4	0.9	-	0.4	0.3	0.7	-	-
8	15.4-15.8	-	-	PT	-	265	1.2	6.8	0.3	-	-	2.0	3.5	-	-
8	15.4-15.8	-	-	PT	2.44	439	1.01	11.9	-	3.8	-	3.5	6.0	$10^{-4}-10^{-5}$	-
8	12.4-12.8	-	-	PT	-	274	1.2	6.8	-	-	-	2.0	3.7	-	5.10^{-4}
8	15.0-15.4	-	-	OH	-	237	1.2	7.4	-	-	-	2.1	3.1	-	1.10^{-3}

Liquid Limit (LL)
Plastic Limit (PL)
Compression Index (C_c)
Moisture Content (w_o)
Void Ratio (e_o)
Compression Index (C_c)

Specific Gravity (G_s)
Total Unit Weight (γ_t)
Undrained Shear Strength (S_u)
Coefficient of Permeability (k)
Coefficient of Consolidation (C_v)

(1) Based on Lab test
(2) Based on empirical expression after Terzaghi & Peck
(3) Based on empirical expression after Hough
(4) Based on empirical expression after Nishida

III.5. SOCIOLOGY

The major project in this study for the development plan for which it was necessary to evaluate the social impact is the proposed raising of the Rawa Pening Lake. If implemented, this project will involve resettlement of a large number of mostly urban population. A special study was, therefore, undertaken in coordination with the Social Sciences Faculty of the Satya Wacana University at Salatiga to evaluate the sociologic impact of raising Rawa Pening. The study was later extended to include the other two projects, namely, the Gunung Wulan Dam and the Glapan Barrage proposed on the Tuntang River. A summary of the conclusionc drawn from that study and reported in detail in Appendix G of this report, is presented in the following.

III.5.1. Rawa Pening

1. There are 17 desas surrounding Rawa Pening which would be affected in one way or the other by the raising of Rawa Pening for the purpose of providing additional storage capacity in the lake. The population that will be affected is about 50,000 people.

2. The building of the dikes will protect practically all population from flooding, but will otherwise have adverse effects on the areas, e.g. disruption of the natural drainage and loss of existing sources of livelihood for a major part of the population.

3. An area of 465 hectares of land which presently is cultivated to one or more crops during part of every year will be permanently submerged and lost even if dikes are built around to contain the lake within the established boundaries.

4. The implementation of projects affecting Rawa Pening has been done in the past but the experience of the local population with those projects was not pleasant. Nearly three decades of maintenance and management by four different administrations (Dutch, Japanese, Civilian and Military) have resulted in confusing and contradictory response patterns. In an opinion survey, not one of the respondents agreed without reservations to the raising of Rawa Pening. Only 20 percent agreed with conditions, 26.7 percent did not agree at all and 53.3 percent abstained from expressing any opinion. This abstention figure is the crucial one indicating not apathy, but feelings of hopelessness and frustration from their previous experience of changes made in the status of Rawa Pening.

5. An important factor which continues to be unresolved is the contested property damage arising out of the 1966 raising of the lake. It is felt that unless some sort of resolution of this problem can be reached, the successful implementation of any project proposed in Rawa Pening will not be possible.

6. The general response to transmigration, if necessary, or relocation was favorable. However, the village of Candirejo represents one of the few cases where the response towards relocation was definitely negative. Regardless of what the consequences of the project might be, the people of Candirejo do not wish to be moved.

7. It will be unrealistic to assume that fertile land around Rawa Pening Lake that has been farmed continuously for over 150 years will be easily given up; nor is it reasonable to assume that in an area such as Rawa Pening, physically beautiful and fertile, the people would embrace the concept of disruption and/or dislocation whole heartedly. Nevertheless, the proposed project, as a whole, was received favorably but with constraints, which are discussed in Appendix G.

III.5.2. Glapan-Tuntang

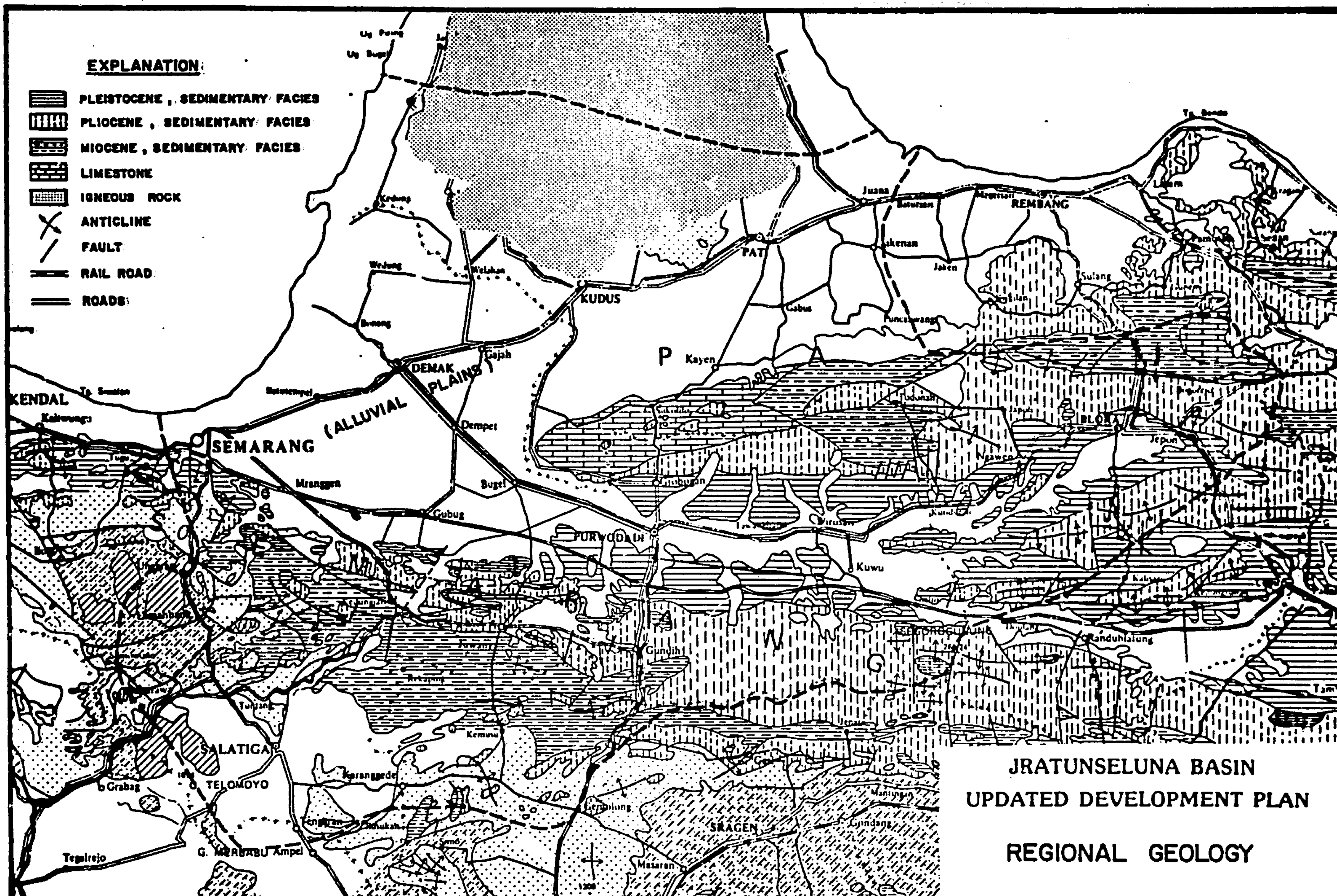
The projects on the Tuntang River for which the social impacts were studied are the Gunung Wulan Dam and the Glapan Barrage. The Glapan Barrage has been recommended as a low-cost project of high priority in the updated development plan proposed in Chapter VII of this report. The major social factors involved in the implementation of the project are listed in the following.

1. A total area of approximately 1,741 hectares will be inundated by the proposed reservoir at Glapan. Six desas and 25 dukuhs containing a current population of approximately 15,100 people in 3,348 families are located within the reservoir.

2. The properties that will be affected are 3,900 buildings (mosques, houses, schools, etc.), 325 hectares of desa's rice fields and 553 hectares of homeyards.

3. A preliminary evaluation of the population's reactions and beliefs concerning transmigration showed satisfactory response. Overall, the population expressed willingness to obey the government if requested to transmigrate. However, they would favor moving to unsettled/untilled lands or to be absorbed by other villages in the area which would not be flooded, rather than to transmigrate. It is,

therefore, suggested that alternatives to transmigration be explored such as the possibility of obtaining land in the surrounding area for resettling the population (Kabupaten or Kecamatan). Anyway, the population can be relocated from the proposed reservoir area provided arrangements satisfactory to the inhabitants are made of their resettlement and the grave yards falling within the reservoir, and definitely the graves of the founders of the villages and of saints are moved to locations outside the reservoir.



JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN

REGIONAL GEOLOGY

CHAPTER IV

DEVELOPMENT POTENTIAL

CHAPTER IV

DEVELOPMENT POTENTIAL

IV.1. GENERAL

Reviews of previous reports [1, 2, 5, 11] for the individual projects within the Jratunseluna Basin, and reconnaissance carried out during this study identified the potential irrigation areas which could be served and the M & I water demand which could be met by developing the surface water resources of the basin. Due to reasons explained in the following chapter of this report, hydropower potential was evalauted only as a by-product of the irrigation and M & I water releases from the proposed storage sites.

These development potentials and the evaluation of benefits that would accrue with the implementation of a development plan, are described in the following sections.

IV.2. IRRIGATED AGRICULTURE

The total area considered in this study for development in the whole of the Jratunseluna Basin is 114,840 hectares. This comprises 41,540 hectares in the western subbasins, namely, Tuntang, Jragung, Dolok and Penggaron and 73,300 hectares in the eastern subbasins of the Lusi and the Serang Rivers. These areas are shown in Figure I-3.

The present cropping pattern in the Glapan-Sedadi area indicates that some 6,000 to 7,000 hectares of land may already be receiving firm water supplies throughout the year for perennial irrigation. There is no evidence of any other area in the Jratunseluna Basin in which dry season irrigation is being practiced.

The recommended cropping pattern and the cropping calendar for the post development irrigated agriculture are shown in Figure IV-1. These are based on an appraisal of the existing practices and a reasonable projection of the future conditions considering the current trend of development and the apparent priorities in agriculture being followed by the government and the farmers. The reasons supporting the recommended cropping pattern and the calendar are stated in Appendix B of this report.

The potential service areas are as follows.

IV.2.1. Dolok-Penggaron

A total of 6,540 hectares is presently available for irrigation. None of this areas is presently receiving complete technical irrigation. The breakdown of the area is given below.

Service Area	Area (ha)
Dolok	1,950
Penggaron	4,590
Total	6,540

IV.2.2. Tuntang-Jragung

A total area of 36,781 hectares in the Tuntang and the Jragung agricultural area may presently be available for irrigation with all but about 3,940 hectares already being under irrigation. The rehabilitation plans being considered in the Jratunseluna Basin would upgrade the present system to include tertiary development on about 35,000 hectares including the Grogol West area.

The potential service areas for the Tuntang-Jragung Subbasins are given hereunder.

Jragung Area	Area (ha)
Jragung Right	1,101
Jragung Left	3,011
Pamongan	1,502
Guntur Left	1,554
Guntur Right	383
	7,551
Prauwvaart Area	**Area (ha)**
West	3,150
East	992
	4,142
Subtotal	11,693
Tuntang Area	**Area (ha)**
Glapan East	9,177
Glapan West	9,800
Glapan Setu + Ketitang	2,171
Grogol West	3,940
Subtotal	25,088
Total area	36,781 ha

Due to doubtful development of certain low-lying coastal areas, the potential irrigation service area being considered is 35,000 hectares.

IV.2.3. Juana Valley

The potential irrigation service areas in the Juana Valley are:

Service Area	Area (ha)
Undaan	4,500
Prawoto	4,000
Sukolilo	2,500
Sono	2,500
Dermoyo	500
Additional Lift Areas	1,000
Total	15,000

IV.2.4. Lusi Valley

A total area of 13,800 hectares is presently considered available for irrigation with none of this now receiving technical irrigation. A few local small areas have run-of-river wet season supplemental irrigation only. With proposed storage facilities and an adequate distribution system, the Lusi River could provide water to irrigate a major portion of the total area. The potential service areas in the Lusi Valley are as follows.

Potential Service Areas	Area (ha)
Lusi Left Bank	4,200
Lusi Right Bank	9,600
Total	13,800

There are additional rainfed areas scattered along the upper reach of the Lusi River. Those areas have not been included in the potential service areas for perennial irrigation in the Lusi Subbasin, because the storage capacities of feasible storage projects in the Lusi River System are hardly sufficient to supply dry season irrigation to the areas shown above in the middle reach of the Lusi River and the Lower

Sedadi and Juana Valley areas in the Lower Serang System.

The wet season irrigation of those rainfed areas may be considered by diverting run-of-river water supplies at appropriate locations from the Upper Lusi River and its tributaries.

IV.2.5. South Grobogan

The area which can be provided by gravity flow with irrigation water from diversion on the Serang River is 5,620 hectares. The possibility of providing irrigation water from the Lusi River to the remaining about 1,680 hectares which can not be commanded from the Serang River without lifting, has been investigated. It is concluded that the area in question can be served from the proposed Ngemplak Reservoir on the Peganjing River, a tributary of the Lusi River.

IV.2.6. Sedadi

This area falls on the left of the Serang River and borders the designated Tuntang Service area on the west. The total irrigable areas in the designated Upper Sedadi and Lower Sedadi are 19,800 hectares and 17,400 hectares, respectively.

IV.3. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

The use of surface water from the rivers in the west of the basin for the much needed municipal and industrial (M & I) water supply of the city of Semarang was considered as one of the major benefits to be derived in the proposed development plan. The possible sources are the Penggaron, Dolok and Jragung watersheds and Rawa Pening and the Gunung Wulan reservoir on the Tuntang River.

The estimated need of M & I water for Semarang in the year 1980 is 1,215 liters per second whereas the supply available is only 774 liters per second. The projected need by the year 2000, in view of the development taking place in this part of Java, is 5,650 liters per second. Water demands for the intermediate years are tabulated below.

Year	1980	1985	1990	1995	2000
Total M & I Water Demand (l/s)	1,215	1,620	2,660	3,870	5,650

In planning the water resources development of the Jratunseluna Basin, M & I water supply is being considered at the rates ranging from 2,000 liters per second at the completion of the first phase of development, involving only small-size projects, to 4,000 liters per second at ultimate development.

In addition, the capacity of each of the development components is being studied to determine the maximum potential to supply M & I water from the individual projects. With the availability of this information, interim development for water supply pending implementation of the overall development plan, can be planned.

IV.4. HYDROPOWER

The existing Central Java Power System consists of the Tuntang System, the Ketenger System and a number of isolated diesel generating units referred to as the Local System. The area served measures about 305 kilometers in the east-west direction and about 130 kilometers in the north-south direction, resulting in a total area of about 36,000 square kilometers.

The Tuntang System serves the cities of Semarang, Solo, Yogyakarta and Magelang and supplies about 85 percent of the total Central Java Power System load. The Ketenger System serves the eastern portion of Central Java and accounts for about 8 percent of the total load in the system area. Approximately 6 percent of the load is provided by isolated diesel generators installed in numerous small towns. The following tabulation presents the existing capacity of the Central Java System.

	Central Java System	
	Total Installed Capacity (Nameplate Rating)	Estimated Reliable Capacity
Tuntang System		
Thermal	178.0 MW	135.0 MW
Hydro	32.5 MW	25.5 MW
Ketenger System		
Thermal	10.6 MW	5.0 MW
Hydro	6.5 MW	6.5 MW
Local System		
Thermal	17.1 MW	13.0 MW
Total	244.7 MW	185.0 MW

The total Installed Capacity presented above is the nameplate rating of all electric generating units within the Central Java Power System which have not been retired from service. An estimate has been prepared of the units which presently cannot generate at rated capacity and which units are old and prone to excessive maintenance, to arrive at the presently existing "Estimated Reliable Capacity".

The daily peak demand at present is about 90 megawatts. This is somewhat deceiving as it represents a supressed demand figure due to lack of supply. PLN has in excess of 190 megawatts of installed distribution transformer capacity on the new Central Java 120 kilovolts distribution system and is presently installing customer service drops. Once full scale conversion work is completed, demand will increase dramatically

The projected load forecast is as follows.

Year	Estimated Demand
1980	140 MW
1985	225 MW
1990	333 MW

As can be seen by comparing the projected load forecast with the estimated reliable installed capacity, PLN will be short on capacity by 1983.

A proposed development plan to meet projected needs has been prepared by PLN. The major near term components of that plan are:

Project	Planned Timing
PLTU III Semarang, 200 MW Thermal	1982-83
Garung, 28 MW Hydro	1980-81
Wonogiri, 10 MW Hydro	1981-82
Mrica 1, 60 MW Hydro	1985-86
Mrica 1 & 3, 120 MW Hydro	1986-87
Mong 1 & 2, 170 MW Hydro	not indicated

It should be noted that the Jragung, Kedungombo and Glapan plants all within the Jratunseluna Basin were previously included in the PLN development plan. Because both the Jragung and Kedungombo projects have been indefinitely postponed, and the Glapan project has not reached design stage and probably never will in its originally proposed form, these power plants have been dropped by PLN from their near-term development plan. The hydropower generation potential at these locations and at other locations identified in the Jratunseluna Basin is as follows.

Location of Power Plant	River	Generating Capacity
Jragung Dam	Jragung	6 MW
Kedungombo Dam	Serang	20 MW
Gunung Wulan Dam	Tuntang	10 MW
Sambirejo	Tuntang	10 MW

Due to projected small releases from the other dams considered in the development plan, hydropower generating potential at those sites is insignificant and has not been evaluated.

It is important to note that in the updated development plan, releases from the proposed reservoirs have been made primarily for irrigation and M & I water supply; therefore, the power generated is secondary power although predictable as to the time of availability. The loss of firm power at the existing power plants resulting from the operation dictated by the irrigation and M & I releases has been duly accounted for in the economic analysis of schemes causing that loss.

IV.5. FLOOD CONTROL

A viable and effective flood control and drainage plan in the Jratunseluna Basin can only be formulated after decisions have been made on the location and size of the storage reservoirs on the rivers in the basin and on the mode of operation for providing irrigation and M & I water and possibly, generating hydropower. Without that information, sizing of flood control works cannot be optimized from an economic point of view.

It must be recognized that a serious flood problem exists on the flood plains of all the rivers, namely Penggaron, Dolok, Jragung, Tuntang and the Serang. From an engineering standpoint it is feasible to develop a flood control plan that will provide a high degree of flood protection to the project area. However, for economic reasons it is important that any flood control plan must be linked with the development plan to be implemented in the upper reaches of the rivers.

In order to illustrate the magnitude of the flood problem, the areas affected, and the damages caused by floods in the coastal plains of the Jratunseluna Basin as reported by the present operation organization, are given below.

Year	Number of Villages Affected	Flooded Area (ha)	Casualties Livestock	Casualties People
1976	76	12,316	94	-
1980	146	83,383	2,850	3

In the course of conducting the present study, a special report on flood control and drainage was prepared and issued [9]. The report contained recommendations for flood control in the Tuntang/Jragung service areas, with and without storage dams on the Tuntang and the Jragung Rivers. A similar study should be carried out for the Dolok and Penggaron Rivers as well.

On the Lusi-Serang system, SMEC [11] has proposed a scheme of flood control works including the Juana Valley drainage improvement. The decision whether Kedungombo Dam should be built or not will have an important bearing on the proposed scheme. Interim flood control measures may be taken to alleviate flood damages in the affected areas; however, a full scale flood control plan must await the outcome of on-going development efforts in the upper reaches of the rivers.

In the economic analyses for testing the viability of the individual storage dams of the proposed development plan and of the plan as a whole, flood control benefits expected to accrue from those projects have been duly considered.

IV.6. EVALUATION OF BENEFITS

The evaluation of benefits is based on with and without-project conditions. The net gains attributable to the project are evaluated and are used in determining the economic viability of the project. The data applied and generated in the economic analyses for the development plan are given in detail in Appendix E - Economics, of this report. However, a summary of the unit cost evaluation of the benefits is presented in the following.

IV.6.1. Irrigation Benefits

The analysis is essentially based on rice economy. The wet rice yields suggested in Appendix B - Agriculture and Irrigation, of this report were adjusted to dry rice yields. The estimated yields in the future in the western subbasins are listed below.

Year	1987	2000	2020
Without the Project	3.2 t/ha	3.6 t/ha	3.9 t/ha
With the Project	3.2	4.9	5.4

In the eastern subbasins, average yields with and without the projects are based on PRC/ECI studies of agricultural conditions and on SMEC studies. Tables E-1 to E-6 in Appendix E - Economics show the appropriate yields in each area, according to variety of rice and availability of water.

Irrigation benefits were evaluated at 1985 IBRD projections of rice price at 1978 constant dollars adjusted to 1979 dollars. Since the projects have been analyzed for an expected life of the project of 30-50 years, yields for the year 2000 were chosen for the economic analyses. Crop budgets for both rice and palawija crops represented by soybean and corn, were prepared and are given in Appendix E of this report. The net comparable farm income based on the existing cropping pattern in the future without the project, and on the recommended cropping pattern in the future with the project were evaluated and the net income under post project conditions was estimated. These estimates are given below.

Area	Net Income ($/ha)
Western Subbasins (Presently growing 2 rice crops)	1,157
Western Subbasins (General)	1,406
Juana	1,163
Lower Sedadi	1,103
Upper Sedadi	670
New Areas	1,589

A period of 5 years was assumed for the full irrigation development to be required after a project is put into operation.

IV.6.2. Municipal and Industrial (M & I) Water Supply Benefits

The evaluation of M & I benefits has been done using the principle of the benefits equaling the costs most likely to be incurred in producing comparable quantity and quality of water. The construction of a single-purpose dam at Jragung to supply the daily requirements of M & I water is estimated at a cost of $ 33,000,000. This facility is assumed to produce alternative water supply of equal quality and quantity as any project planned in the western subbasins. The alternative cost of $ 33,000,000 amorized at 15 percent over a 50-year period would require annual payments of $ 4,962,000. This amount is accepted to be the annual M & I benefit accruable from the Project at the rate of $ 78.67 per thousand cubic meter of raw water.

IV.6.3. Hydropower Benefits

The power generation is of secondary priority to releases for M & I and irrigation purposes. The M & I water releases will be constant and will thereby produce firm energy. The releases for irrigation, and those surplus to normal requirements, will be used to produce secondary power. The economic justification for the hydroelectric power plants in the system has been tested by the conventional procedure of comparison with the project cost of the most likely alternative source of producing a comparable type and quantity of power. For this comparison, an oil-fired steam plant was considered.

The investment in an oil-fired steam plant is estimated to be $ 750 per installed kilowatt. The price of crude oil being charged by the OPEC members in early 1980 was $ 30 per barrel. This cost was applied in determining the unit cost of power. To the extent that a thermal plant is capable of producing form power a monetary value for the available capacity is indicated and is assumed to be $ 120 per kilowatt and $ 0.0498 per kilowatt hour of energy. All secondary energy is valued at $ 0.0415 per kilowatt hour. The evaluation of benefits is given in Appendix E of this report.

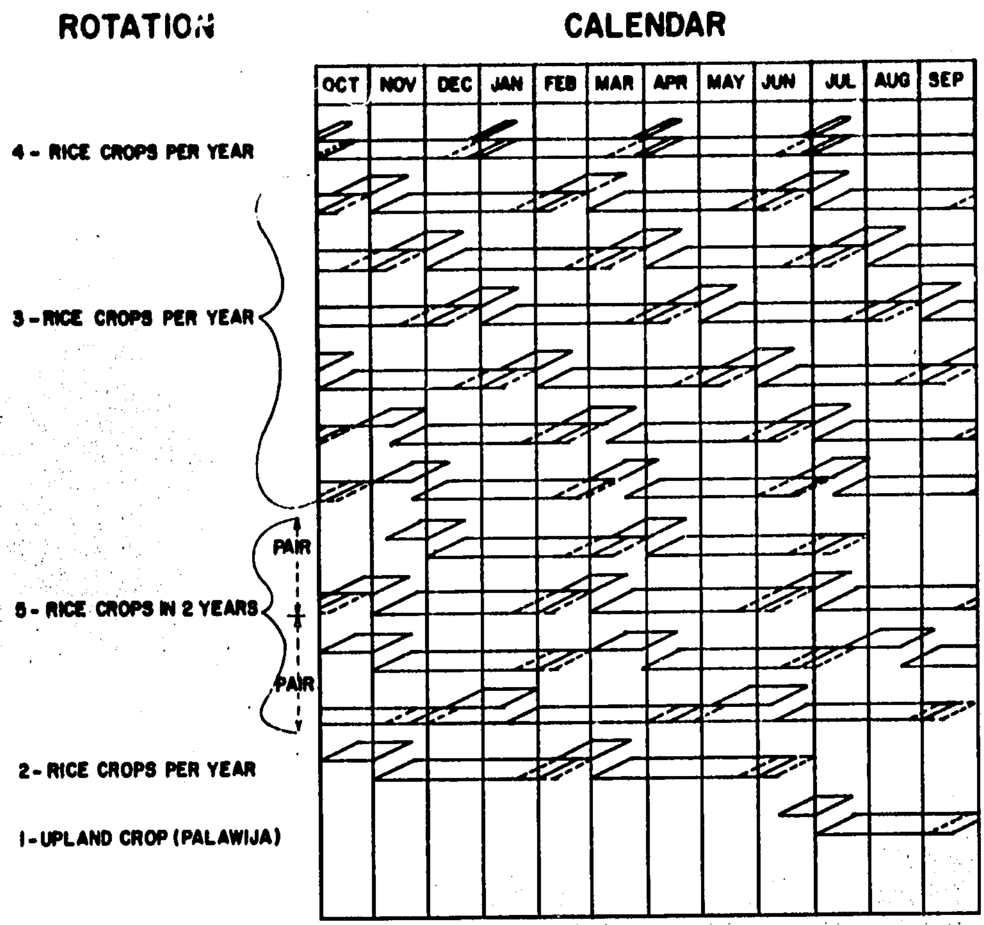
In the case that a project causes a loss of firm power, corresponding negative benefits evaluated from the above capacity value and power costs were applied to determine the economic costs of the projects.

IV.6.4. Flood Control Benefits

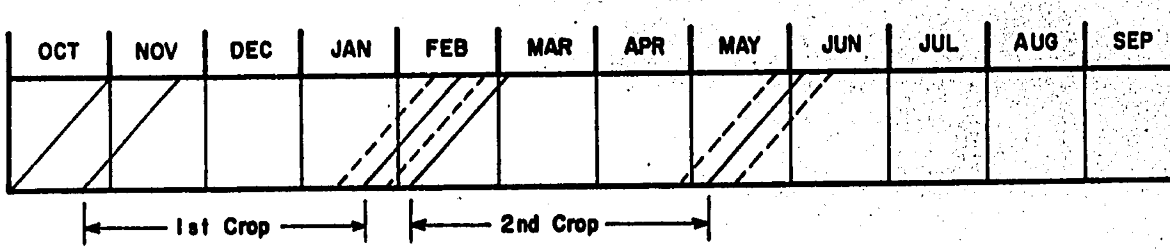
The flood control benefits which would accrue from the project were estimated by evaluating the amount of relief that would be provided to the irrigation service area for damages by flooding to crops and to other types of damageable property, including houses, roads, and bridges, and irrigation structures.

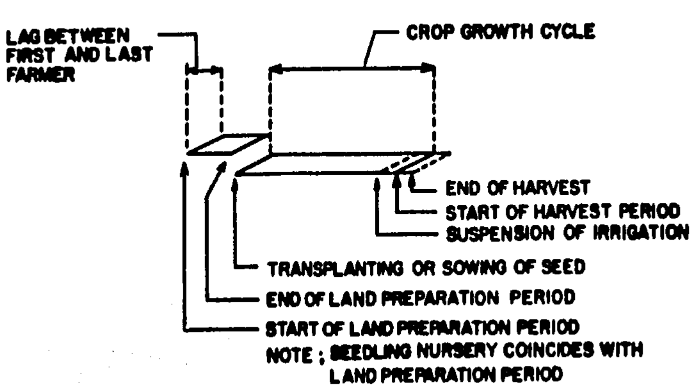
Relief for damages to crops is estimated from the assumption that the crop yields will be reduced by 12.5 percent in areas inundated less than three days and 32.5 percent in areas flooded for more than three days.

The relief to other types of damageable property was based on damage surveys by the Jratunseluna Project office showing that crop damage amounts to 65 percent of all damage, and the remaining 35 percent is damage to other property. The unit benefits calculated on the above basis in Appendix E are $ 211 per hectare per year applied to the area protected from flooding.



TWO RICE CROPS GROWN IN WET SEASON
RUN-OF-RIVER IRRIGATION





NOTES

1. RECOMMENDED CROPPING PATTERN IS AS FOLLOWS :

3 RICE CROPS PER YEAR	– 75 PERCENT OF SERVICE AREA
5 RICE CROPS IN TWO YEARS	– 10 PERCENT OF SERVICE AREA
2 RICE CROPS AND 1 UPLAND CROP PER YEAR	– 15 PERCENT OF SERVICE AREA

2. CROPPING CALENDAR OF 4 RICE CROPS PER YEAR IS PRESENTED AS A POSSIBILITY FOR LIMITED AREAS IN THE FUTURE AND IS FOR INFORMATIONAL PURPOSES ONLY

JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN

RECOMMENDED CROPPING PATTERN AND CROPPING CALENDAR

CHAPTER V

SELECTION OF PROJECT ELEMENTS

CHAPTER V

SELECTION OF PROJECT ELEMENTS

V.1. GENERAL

The prospective elements by which the water resources of the Jratunseluna Basin could be exploited for beneficial use were identified by studying the previous development reports and from field reconnaissance where no other information was available. Preliminary office and field studies of the previously available and the newly generated data were done for the purpose of screening. Elements which were found not to be promising for development were discarded. The remaining projects thus obtained were used to determine the total potential for storage of water and diversion for various uses in the Jratunseluna Basin.

It should be noted that the development of irrigated agriculture in the potential service areas was studied for perennial irrigation to the possible extent.

The costs for implementation of the projects were estimated at current currency values, and tha projected benefits were evaluated. A preliminary economic analysis of each of the projects, retained after the screening process, was carried out. Those elements which showed attractive rate of return were selected for further consideration in the development plan and are described in the following sections.

V.2. STORAGE SITES

The sites for storage of water identified as potential elements of a development plan are as follows.

Storage Site	River
Gunung Wulan	Tuntang
Glapan	Tuntang
Jragung II	Jragung
Penggaron	Penggaron
Dolok	Dolok
Bandungharjo	Glugu (Lusi)
Ngemplak	Peganjing (Lusi)
Banjarejo	Lusi
Kedungwaru	Kedungwaru (Lusi)
Tirto	Tambakselo (Lusi)

The screening of the storage sites was based primarily on the following factors: geologic conditions, availability of construction materials, ratio of reservoir volume to embankment volume, and the numbe of inhabitants within the proposed reservoir area.

The storage sites which were considered but eliminated in the screening process are the following.

Storage Site	River
Sambirejo	Tuntang
Tempuran	Tuntang
Jragung I	Jragung
Jragung III	Jragung
Sapen	Soco (Lusi)
Balong	Kedungbendo (Lusi)

The reasons for eliminating the above storage sites from the development plan are: their limited storage potential, insufficient benefits because of need for seasonal-operation as run-of-river project, poor geology and foundation conditions, and availability of better alternative sites. All the storage sites are shown in Figure I-1.

Previously, dam projects on the Jragung River, Jragung II Damsite [5], Tuntang and Serang Rivers [6, 7, 11] and a transbasin diversion from the Tuntang River to the Jragung River [5] have been studied to feasibility and design levels. The design and updated cost data from the previous reports of these projects were used in the optimization study for the development plan. Full description of the preliminary design of the remaining damsites selected for the basin development model is given in Appendix C of this report.

The maximum storage capacities of the reservoirs retained for formulation of the development plan and estimated construction costs are presented in Table VI-1.

V.3. DIVERSION SITES

Diversion works exist at present on all the major rivers to supply run-of-river waters to the designated irrigation service areas in the Jratunseluna Basin. These are listed hereunder.

Diversion Structure	River
1. Pucanggading	Penggaron
2. Barang	Dolok
3. Gablok	Jragung
4. Guntur	Jragung
5. Glapan	Tuntang
6. Sedadi	Serang
7. Wilalung	Serang

The above structures, in existing or rehabilitated conditions, are capable of diverting irrigation supplies to the potential development areas in the Jratunseluna Basin except to the proposed irrigation areas along the middle of the Lusi River. A diversion-cum-storage dam called the Mid Lusi Diversion is proposed. Due to nonavailability of adequate maps of the area, the final location of the proposed diversion structure has not been decided. The function of this sturucture will be to divert and regulate Lusi waters to the designated Lusi Left (4,200 hectares) and Lusi Right (9,600 hectares) irrigation service areas. A conceptual design of the structure is described in Appendix C of this report.

V.4. HYDROPOWER PLANTS

A potential to generate hydropower from irrigation and M & I releases exists at all sites where storage for water has been proposed in the development plan. In addition, the potential is available for installation of a power plant at Sambirejo on the Tuntang River as part of the UTS. Eliminating small storage sites where hydropower generation would be insignificant leaves the following major sites which have considerable potential for power generation.

Site	Power Potential (MW)
Upper Tuntang System including the proposed plant at Sambirejo	37.5
Jragung	6.0
Gunung Wulan	10.0
Kedungombo Dam	20.0

V.5. TRANS-SUBBASIN DIVERSIONS

The only direct diversion from one river to another found technically feasible in the Jratunseluna Basin is the one called Tuntang/Jragung Transbasin Diversion, which was previously designed as part of the Jragung Dam Project [5]. The estimated cost of this structure is US $ 2.4 million.

A search was made to possible diversions from the Serang River to the Tuntang River and from the Jragung River to the Dolok River, but no technically feasible scheme could be found. The diversion of waters from one to another service area was found possible, however.

All such points where surplus water from one service area can be transferred to another service area are listed hereunder.

Service Area	Source of Irrigation	Source of Diversion
Dolok	Dolok River	Jragung
Penggaron	Penggaron River	Dolok/Jragung
Jragung	Jragung	Tuntang
South Grobogan	Serang	Lusi

After elements of the development plan and their sizes and capacities are finalized, the limits of the above listed designated service areas should be adjusted accordingly. The existing irrigation supply and distribution systems will need to be adapted to the changed source of diversion.

CHAPTER VI

DEVELOPMENT PLAN FORMULATION

CHAPTER VI

DEVELOPMENT PLAN FORMULATION

VI.1. GENERAL

The development of water resources of a complex system, such as the Jratunseluna Basin, comprising several major streams, potential storage sites, transbasin diversion, diversions for irrigation and M & I water supply, and hydropower plants can be accomplished by testing individual projects and different combinations of projects for optimization. The most attractive combination of projects which are technically and economically feasible individually, would then become the development plan.

A basin operation model as shown in Figure I-2 was formulated to simulate all the project elements including storage sites, diversion works and points of diversions, irrigation service areas and hydropower facilities. This model was then translated into computer language to facilitate studying a large number of different project elements individually and in any desired combination. The demands on the water resources of the basin, under the simulated conditions and the imposed constraints were defined and an operation study to meet those demands was carried out.

Multi-reservoir operation, inter-and trans-subbasin transfers of water and optimization of water use were investigated by applying simulation techniques. The methodology used is explained in the following sections.

VI.2. CONSTRAINTS

Simultaneously with the review of previous reports and data related to the water resources of the Jratunseluna Basin, an effort was made to identify factors such as, physical, economic and social conditions, and governmental policies which could have direct or indirect influence on the implementation, operation and future performance of individual elements or grouped projects of the proposed plan. The present study was aimed at the formulation of an optimum development plan for integrated use of the water resources of the Tuntang and Jragung Rivers for irrigated agriculture, municipal and industrial (M & I) water supply and hydropower generation. It is referred to in this document and all its appendices as Part I of the study. Later on, the scope of the study was extended to the entire Jratunseluna Basin to update the development plan prepared earlier by NEDECO [1]. The extended part of work is referred to as Part II of the study. In Chapter I of this report, the reasons which led to broadening the scope of this study were stated in detail.

An interim report [15] on Part I of the study was prepared for developing the water resources of the Tuntang-Jragung Rivers for irrigated agriculture, M & I water supply for the city of Semarang, and hydropower generation. The report was reviewed by DGWRD and all other governmental agencies concerned with the development plan. As a result of the review, the following constraints were defined by DGWRD for guidance of the Consultant for completion of the study.

1. Large projects would not be considered for the development of the Tuntang or the Jragung Basins during the near term (about 10 years); however, development of irrigation and municipal and industrial water supply within the basins should begin in the near future.

2. PLN (National Electricity Board) has no plans to upgrade the existing Upper Tuntang Hydropower System, or to add to that system.

3. Operation of the Rawa Pening can be revised; however, the average annual energy production (160 GWh) of the existing Upper Tuntang System should not be reduced significantly.

Furthermore, the Consultant was advised by DGWRD that the waters of the Tuntang and the Jragung Rivers should be considered for the irrigation of service areas lying west of the existing boundary between the Serang and the Tuntang Service Areas. The waters of the Serang System would be used for developing the areas in the Jratunseluna Basin on the eastern side of that boundary line, namely, Glapan, Sedadi, South Grobogan, Juana Valley etc.

In the preparation of the development plan under Part I of the study, the above listed constraints became the major factors which dictated the sizes, locations and types of various elements of the plan. When the scope of the study was extended to cover the entire Jratunseluna Basin, the same factors controlled the formulation of the updated development plan. However, investigations for the total basin plan did include possible transbasin diversions between the Tuntang and the Serang Systems.

VI.3. APPROACH TO STUDY

In view of the constraints listed in Section VI.2., it was agreed that the development plan should schedule implementation of small projects in the near future while implementation of large projects should be postponed. It was further agreed that the near-term small projects should be an integral part of the optimum development plan for the basin; or would continue to serve a useful purpose in conjunction with the large projects, if and when they are built in the future. To meet those objectives, the study was carried out as follows.

VI.3.1. Basic Assumptions

1. The development of irrigation within the subbasins and M & I water supply for the project area and the city of Semarang should begin in the near future. Irrigation and M & I water should be considered the primary benefits to be derived from any proposed project.

2. Due to PLN's reported plans neither to upgrade the Upper Tuntang System (UTS) of hydropower generation nor to add to that system, hydropower development in the subbasins should be given low priority. However, the present energy generation in the UTS should not be reduced significantly. Also, hydropower potentials at all the proposed damsites should be investigated for reservoir releases as dictated by the irrigation and M & I water demands.

3. No basic changes will be made to the Serang River Plan as formulated by SMEC [11]. The size of the storage reservoir at Kedungombo which is about the optimum for the water yield of the Upper Serang River will not be changed. Irrigation in the Juana Valley will be maximized with waters in the system found surplus to the requirements of the existing irrigated areas.

VI.3.2. Model Features

For simulating the operation of single elements in the basin development plan and of the total scheme of development, 21 years of recorded hydrological data were used. The input data to the model are monthly streamflows, irrigation water requirements, M & I water demands at the points of interest, storage and diversion capacities, irrigation service areas and the generating capacities of the power plants. The output from the model indicates irrigation efficiencies, spill and shortage volumes, monthly volumes of diversions for irrigation, M & I, and transbasin transfer, reservoir water surface elevations and the firm and the secondary energy for each site.

VI.3.2.a. Storage

The eleven sites within the Jratunseluna Basin where storage is considered are as follows.

No.	Site	Maximum Live Storage 10^6 m^3
1.	Banjarejo	77
2.	Kedungwatu	19
3.	Bandungharjo	22
4.	Kedungombo	655
5.	Penggaron	57
6.	Dolok	43
7.	Rawa Pening	250
8.	Jragung	110
9.	Gunung Wulan	260
10.	Glapan	87
11.	Ngemplak	68

VI.3.2.b. M & I Water Supply

Provision is made in the model to allow delivery of municipal and industrial water to the city of Semarang in specific amounts from the following points.

1. Muncul Springs
2. Rawa Pening Lake
3. Jragung Dam
4. Gunung Wulan Dam
5. Dolok Dam
6. Penggaron Dam

Provision is also made to release some minimum river maintenance flows from the proposed reservoirs even if irrigation and M & I releases are nil, so that the population along the rivers currently using river water is not deprived of its needed water supply.

VI.3.2.c. Irrigation Service Areas and the Sources of Water

The irrigation service areas reported in Chapter IV were adjusted for the Tuntang and Jragung areas as indicated therein by eliminating certain difficult coastal areas, and for the Juana Valley by adding 1,000 hectares of pump irrigation area. The maximum sizes of the irrigation service areas and the sources of water used in the operation study are as follows.

Service Area	Area (ha)	River	Diversion Point
1. Tuntang	23,375	Tuntang	Rawa Pening, Gunung Wulan and Glapan
2. Jragung	11,625	Tuntang/Jragung	Jragung & Rawa Pening
3. Dolok	1,950	Dolok	Dolok
4. Penggaron	4,590	Penggaron	Penggaron
5. Lusi Left Bank	4,200	Lusi	Banjarejo, Kedungwaru, Mid Lusi Diversion
6. Lusi Right Bank	9,600	Lusi	Banjarejo, Kedungwaru, Mid Lusi Diversion
7. South Grobogan	7,300	Lusi/Serang	Kedungombo, South Grobogan Weir, Bandungharjo and Ngemplak
8. Upper Sedadi	19,800	Serang	Sedadi Weir
9. Lower Sedadi	17,400	Serang	Wilalung Structure
10. Juana Valley	15,000	Serang	Wilalung Structure
Total	114,840		

VI.3.2.d. Trans-Subbasin Diversions

Provision was made in the model to make diversion of surplus water from one subbasin to the other as follows.

Serang	-	Tuntang		
Tuntang	-	Jragung		
Jragung	-	Dolok	-	Penggaron

The detailed operation of the basin model and optimization studies carried out on the model by computer application are described in Appendix D of this report.

VI.3.2.e. Hydropower

Irrigation and M & I releases from the proposed reservoirs have been used to generate hydropower at the following points.

Power Plant		Generating Capacity (MW)
Upper Tuntang System		
Existing		26
Potential		37.5
Jragung	(Potential)	6
Gunung Wulan	(Potential)	10
Kedungombo	(Potential)	20

VI.4. OPTIMIZATION STUDY - INDIVIDUAL ELEMENTS

As a part of the overall planning process, the operation of the individual elements which were found technically feasible was done separately. Each project was evaluated on its own merit. Later, compatibility of this project with other planned projects was studied, groupings were made and operations were coordinated to evolve an overall viable development plan. The results of that study are presented in Table VI-1.

In interpreting the results given in Table VI-1, the following factors should be noted.

1. The irrigation areas shown in the table are served at 95 percent firmness and will be irrigated perennially.

2. The M & I water supply is assured at 100 percent firmness.

3. The project costs include the cost of construction of all works, land acquisition, irrigation system rehabilitation and development costs.

4. The benefits applied in the economic analysis and shown as net annual benefits account for negative benefits from loss of firm hydropower where applicable.

5. The period of development of full irrigation benefits after the implementation of the project is assumed to be 5 years. During these years the irrigation benefits are progressively incremented.

The assumed duration of construction of the projects is shown in Table VI-1.

TABLE VI-1

JRATUNSELUNA BASIN UPDATED DEVELOPMENT PLAN

OPTIMIZATION STUDY - INDIVIDUAL ELEMENTS

Plan Element	Live Storage Capacity (10^6 m^3)	Irrigated Area 95% Firmness (ha)	M & I Water Supply (1/s)	Annual Energy Generated		Project Cost ($x10^6)	Annual Benefits ($ x 10^6) at Full Development					IRR (%)	Period of Construction	General Remarks
				UTS (GWh)	Local (GWh)		Irrigation	M & I	Power	Flood Control	Total			
1. Rawa Pening 1/	100	11,640	1,500	143.0	-	23.69	7.93	3.72	-2.10	0		21.29	4	
	125	14,204	1,500	138.7	-	31.01	10.53	3.72	-2.265	0		21.47	4	
	175	18,060	1,500	127.5	-	43.96	16.00	3.72	-2.70	0		21.01	4	Note: Sociological Implications.
	200	19,640	1,500	119.5	-	-						-	-	23% reduction of power at UTS. Cost and benefits not evaluated
2. Glapan Barrage 1/	87	13,517	1,500	142.0	-	32.77	10.57	3.72	-2.14	0		20.80	4	
3. Gunung Wulan Dam 1/	190	23,375	2,000	134.0	61	130.38	24.43	4.96	- .07	.95		14.10	5	
	260	30,900	2,000	135.0	65	145.85	35.01	4.96	+ .12	.95		16.12	5	
4. Jragung Dam	75	8,200	1,500	161.0		71.39	11.53	3.72	-	.38		13.84	5	
5. Dolok Dam	35	1,950	-	-	-	16.00	2.74	-	-	.29		9.53	4	
	35	996	500	-	-	15.73	1.40	1.24	-	.29		11.28	4	
	35	650	750	-	-	15.57	0.91	1.86	-	.29		14.64	4	
6. Penggaron Dam	57	1,584	-	-	-	25.32	2.23	-	-	.67		6.53	4	
	57	1,056	500	-	-	25.15	1.48	1.24	-	.67		6.74	4	Sediment bypassed
7. Bandungharjo Dam	22	1,333	-	-	-	12.84	2.12	-	-	0		11.18	4	——— = ———
8. Ngemplak Dam	68	2,880	-	-	-	18.79	4.58	-	-	0		13.95	4	
9. Banjarejo Dam with Mid Lusi Diversion	77	8,336	-	-	-	48.29	13.28	-	-	0		16.08	4	
10. Kedungwaru Dam	19	1,333	-	-	-	17.95	2.12	-	-	0		8.02	4	
11. Kedungombo Dam 2/	655	44,500	-	-	-	207.2				0		14.10	5	

1/ Actual Area Benefited is 6,000 ha less than shown.
2/ December 1978 Analysis by SMEC [11].

VI.5. GROUPING OF ELEMENTS FOR BASIN DEVELOPMENT PLAN

VI.5.1. Tuntang-Jragung Rivers Integrated Development

Initially, grouping of elements for the integrated development of water resources of the two subbasins of the Jratunseluna Basin, namely, the Tuntang and the Jragung Rivers, was done to optimize their resources for dry season irrigation in the designated service areas and for M & I water supply to the city of Semarang. Each grouping was treated as a possible partial or a total development plan and was subjected to an optimization study. Applying the imposed constraints and considering the basic assumptions mentioned in Sections VI.2. and VI.3.1., the optimization study gave the following results.

1. The maximum capacity to which Rawa Pening could be raised without appreciably reducing hydropower generation in the UTS is 125 million cubic meters. This storage is the optimum and will ensure perennial irrigation to 14,204 hectares including about 6,000 hectares which are being perennially irrigated at present; and will allow diversion of 1,500 liters per second of M & I water from Muncul to Semarang.

2. A small reservoir at Glapan to provide a live storage capacity of 87 million cubic meters in addition to raising of Rawa Pening as in (1) above, will increase the perennially irrigated area on the Tuntang to 20,907 hectares and the M & I water supply to Semarang to 2,000 liters per second.

3. By building a dam at Gunung Wulan to provide a live storage of 190 million cubic meters, in addition to storages at Rawa Pening and Glapan proposed in (1) and (2) above, a total area of 23,375 hectares on the Tuntang River and 11,625 hectares on the Jragung River can be supplied with perennial irrigation water. The total M & I water diversion from Muncul to Semarang will be a maximum of 2,000 liters per second.

The benefits that would accrue and the results of the economic analyses are presented in Table VI-2, Case I.

Optimization studies were carried out to investigate the results of development of storage at only one location on the Tuntang River in addition to raising Rawa Pening to its optimum capacity of 125 million cubic meters. It was found that the same benefits from the total development in Case I could be achieved by building Gunung Wulan with a live storage capacity of 260 million cubic meters and eliminating storage at Glapan. The results of that study are presented in Table VI-3 Case II.

It should be noted that the development proposed in Case I affords two small-size projects, which could be implemented early, namely raising of Rawa Pening and the Glapan Barrage. In Case II, there is only one small-size project, suitable for early construction, namely the raising of Rawa Pening, thereby postponing improvement of living standard to a number of farming families for many years. In view of the preference of the GOI to implement small-size development projects rather than building major storage dams at this time, Case I is more attractive.

VI.5.2. Integrated Development of Tuntang-Jragung-Serang Rivers

The size of the reservoir proposed at Kedungombo by SMEC [11] as part of the Serang River Project has a live storage capacity of 655 million cubic meters. Inasmuch as it was found to be about the optimum considering water yield at the damsite and projected benefits, it was kept the same in this operation study.

In the early stage of study, multiple reservoir operation indicated a possible need to divert surplus water from the Serang River System to the Western Subbasins, the diversion of water from the Western Subbasins to the Serang River System did not appear advantageous. However, the volume of water diverted from the Serang River to the Western Subbasins, was found to be insignificant on an annual basis. The resulting increase in the irrigation service area on the Tuntang-Jragung Rivers was about 1,616 hectares or about 7 percent of the area under the Phase

I and II development of Case I in Table VI-2. Consequently, consideration was given to large tracts of irrigable lands in the Lusi and the Serang River System which are presently rainfed, and have a good potential for development. It was concluded that there would be distinct benefits from the Serang-Lusi System development, as compared to a Serang-Tuntang diversion, for the optimum use of water resources of the overall basin.

VI.5.3. Maximizing Development on the Lusi River

In proposing development of the Serang River System, SMEC [11] had proposed an area of 7,300 hectares to be supplied with perennial irrigation water in South Grobogan. Out of this, an area of about 1,680 hectares would require pump irrigation. In the present study it was found that this high-elevation area could be supplied by gravity-flow from the tributaries of the Lusi River.

An additional area of 13,800 hectares (9,600 hectares on the right bank and 4,200 hectares on the left bank) along the Lusi River was identified as potential irrigation service area. For the Lusi River development, therefore, the potential service areas to be supplied with water for perennial irrigation are: (1) 1,680 hectares of South Grobogan (2) 9,600 hectares on Lusi Right and (3) 4,200 hectares on the Lusi Left Bank.

The groupings of the project elements of the Serang-Lusi Rivers System which were considered in the reservoir operation and the optimization study, are as follows.

VI.5.3.a. Ngemplak, Bandungharjo and Mid Lusi Diversion

The individual-element studies had established that the Bandungharjo Reservoir alone would not meet the irrigation demands of the upper 1,680 hectares of South Grobogan Area. It was also found that the Ngemplak

Reservoir alone could serve the 1,680 hectares of South Grobogan Area in addition to 1,200 hectares area of the Lusi Left Bank without any diversion from the main Lusi River. Furthermore, it was established that the Ngemplak Reservoir supplemented by the Mid Lusi Diversion could serve 4,200 hectares on the Lusi Left Bank plus the 1,680 hectares area of the South Grobogan. The operation study done by grouping the above elements gave the following results.

1. The Bandungharjo and the Ngemplak Reservoirs operating in parallel but without Mid Lusi Diversion could serve the 1,680 hectares of South Grobogan Area plus 2,954 hectares of the Lusi Left Service Area with perennial irrigation water.

2. The Bandungharjo and the Ngemplak Reservoirs in conjunction with the Mid Lusi Diversion could serve the 1,680 hectares area of South Grobogan in addition to 4,200 hectares potential area identified on the Lusi Left Bank.

3. The internal rate of return for the above two combinations of elements are 14.0 percent and 16.3 percent and the average annual benefits are \$ 7,200,000 and \$ 10,930,000, respectively.

The proposed Bandungharjo site is marginal from both the technical and the economic feasibility point of view. This consideration and the fact that this project has to function in conjunction with other elements to be feasible, eliminated the Bandungharjo Dam as part of any development plan package from further consideration.

VI.5.3.b. <u>Ngemplak, Banjarejo Dams and Mid Lusi Diversion</u>

The operation studies showed that the combination of the Ngemplak and Banjarejo Dams in conjunction with the Mid Lusi Diversion would supply perennial irrigation supplies to 1,680 hectares of the South Grobogan Area, 4,200 hectares of the Lusi Left Bank Area and 5,700 hectares on the Lusi Right Bank Area. The total area served is 11,580 hectares; average annual net benefits will be \$ 18,400,000; and the IRR is 15.9 percent.

VI.5.3.c. Ngemplak, Banjarejo and Kedungwaru Reservoirs and Mid Lusi Diversion

This combination would severe a total area of 12,880 hectares comprising of 1,680 hectares in the South Grobogan Area, 4,200 hectares on the Lusi Left Bank and 7,000 hectares on the Lusi Right Bank. The average annual net benefits of this scheme are estimated at $ 20,470,000; and the IRR will be 14.8 percent. However, due to poor economics of Kedungwaru Dam as an individual project (See Table VI-1), storage at Kedungwaru is not included in the proposed updated development plan.

VI.5.4. Integration of Mid Lusi Development and Serang River Project

No basic changes to the Serang River Plan as formulated by SMEC [11] were made. The plan, as proposed, provides 655 million cubic meters of live storage at Kedungombo and would serve perennial irrigation water to 7,300 hectares in the South Grobogan (including 1,680 hectares pump irrigation area), 19,800 hectares in the Upper Sedadi, 17,400 hectares in the Lower Sedadi and between 10,000 and 15,000 hectares, including 5,000 hectares of pump irrigation, in the Juana Valley. The plan calls for maximum beneficial use of run-of-river flows of the Lusi River and the Lower Serang River at Wilalung for both the Juana Valley and the Lower Sedadi Areas.

The Lusi development scheme evaluated in Section VI.5.3. wherein the waters of the main Lusi River and its tributaries would be diverted for irrigation would reduce flow at the Lusi-Serang confluence, thus increasing the demands on storage at Kedungombo to meet the projected requirements at Wilalung. On the other hand, demand on the Kedungombo storage for South Grobogan will be reduced with the introduction of Ngemplak, which would serve approximately 23 percent of the South Grobogan Area.

To evaluate the inter-relationship of the Tuntang and the Serang Rivers, reservoir operation studies were conducted by imposing the maximum

Lusi development and the Serang River Plan mentioned above, on the Lusi-Serang Subbasins. The results of that study, presented in Tables VI-4 and VI-5 show that with the integrated use of the waters of the Serang and the Lusi Rivers, all the designated areas in the Serang and the Lusi Subbasins could be served with perennial irrigation; the only exception being the Juana Valley, where the irrigated area would be 12,000 hectares against a maximum of 15,000 hectares in the Serang River Plan.

It should be noted that this integrated development of the Serang and the Lusi Rivers would ensure a net increase of irrigation of 9,900 hectares of potential service area in the two subbasins over the area served in the Serang River Plan; it will also eliminate the need to provide pump irrigation in the South Grobogan Area.

VI.5.5. Maximum Development - Western Subbasins

The subbasins of the Tuntang, the Jragung, the Dolok and the Penggaron Rivers are designated the Western Subbasins.

In Section VI.5.2., it is stated that there is a distinct advantage in associating the development of the Serang River with the Lusi River rather than to make any excess Serang water available to the Tuntang River System. Therefore, the integrated development of the Western Subbasins may for all practical purposes be considered separately from the Lusi and Serang Rivers development.

In Section VI.5.1. of this report, the integrated development of the Tuntang and the Jragung Rivers was analyzed as Cases I and II presented in Tables VI-2 and VI-3. On the schemes of works included in these two cases were imposed the potential elements of the remaining two of the Western Subbasins, namely, the Dolok and the Penggaron, and operation studies carried out.

The Penggaron Dam was dropped from the list of the proposed projects due to the following reasons.

1. Most likely there will be social implications from flooding heavily populated villages in the proposed reservoir area;
2. Very high sediment yield from the watershed is expected which would necessitate sediment-passing during the wet season;
3. The internal rate of return of the project as an individual element is not satisfactory (See Table VI-1); and
4. The damsite is marginal from a technical point of view.

The optimization study, therefore, concentrated on the following projects in the Western Subbasins.

1. Rawa Pening
2. Gunung Wulan Dam
3. Glapan Barrage
4. Jragung Dam
5. Dolok Dam

VI.5.5.a. Raising of Rawa Pening

Serious sociological implications are expected to arise if the plans for raising Rawa Pening with or without dikes are implemented (See Section III.5). Before the technical feasibility for constructing the proposed dikes around the lake can be assured, detailed foundation investigations and laboratory testing must be carried out. The problem of draining the land behind the dikes has not been fully addressed in this study because of lack of adequate topographical maps. A technical and economical sound solution to this problem has yet to be found.

In view of the above mentioned factors concerning the proposed raising of Rawa Pening it was considered prudent to analyze the development of the Western Subbasins with and without the raised Rawa Pening. In the event the problems related to raising of Rawa Pening become insurmountable, an alternative development plan would then be available. Without increased storage at Rawa Pening, a reservoir on the Jragung River will have to be provided if all the projected benefits are to be achieved.

VI.5.5.b. Development Case I

The proposed plan in Case I includes small size projects recommended for immediate implementation and large size projects phased for implementation at a later stage. This criterion is in line with the present policy of GOI to give preference in the near future to the development of low-cost projects.

This case is further analyzed for three different storage capacities at proposed Rawa Pening Project as follows.

(i) Rawa Pening Capacity - 125,000,000 cubic meters

The operation study has shown that the optimum size of Rawa Pening, is 125 million cubic meters of live storage for the case that dikes are constructed for the protection of populated areas from flooding. The maximum lake elevation will be El. 467 M.S.L.; the dikes (average height 2.5 meters) will be needed in a length of over 20 kilometers; and the project is estimated to cost $ 24.0 million.

(ii) Rawa Pening Capacity - 175,000,000 cubic meters

If construction of dikes is not possible because of poor foundation condition and problematic drainage from behind the dikes, consideration may be given to raising Rawa Pening without dikes and to flooding the surrounding populated areas. The maximum size to which the lake should be raised in this case is 175 million cubic meters. Existing hydropower generation at the Upper Tuntang System (UTS) would be reduced by not more than 20 percent.

The population to be adversely affected by total flooding of the area is estimated to be about 50,000 people.

(iii) Rawa Pening Capacity - 43,000,000 cubic meters

The present live storage capacity of Rawa Pening is 43 million cubic meters. If the sociological and technical problems associated with the raising of Rawa Pening dictate that these plans be abandoned the proposed development plan should include an alternative scheme for obtaining the projected benefits from the water resources of the basin. In that alternative scheme the live storage capacity of Rawa Pening has been kept at its present level of 43 million cubic meters.

All the above conditions have been analyzed for optimization. The results are presented in Table VI-6.

VI.5.5.c. Development Case II

In this case, consideration is not given to the requirement of programming only small size projects in the early phase of implementation; instead, the works are so planned as to provide optimum capacities for yielding maximum benefits. Case II is also studied for three different storage capacities at Rawa Pening.

The results of the optimization study of Case II, are presented in Table VI-7.

VI.5.6. M & I Water Supply from Muncul

It has been established in the reservoir operation and optimization studies that diverting water from Muncul springs to the city of Semarang for M & I use without adequately increasing the storage capacity of Rawa

Pening will adversely affect the two existing uses of Tuntang water, namely irrigation from the Glapan Diversion structure, and hydropower generation in the UTS. If M & I water is supplied from Muncul Springs, the irrigation shortage in the Tuntang can be made up by providing adequate storage in the proposed reservoirs at Glapan and Gunung Wulan. The losses of the firm power in the UTS can only be avoided by providing additional storage at Rawa Pening.

The effect on existing irrigation of diverting 500 liters per second of water from Muncul Springs without increasing the storage capacity of Rawa Pening is estimated to be a loss of irrigation in about 800 hectares presently being irrigated perennially. In addition about 10 gegawatt hours of energy will be lost annually.

TABLE VI-2

TUNTANG-JRAGUNG INTEGRATED DEVELOPMENT - CASE I

OPTIMIZED PLAN

Phase	Storage Provided			Area Irrigated		Irrigation Firmness		Average Annual Energy		M & I Water	Project Cost	Average Annual Net Benefits	IRR
	Rawa Pening ($10^6 m^3$)	Gunung Wulan ($10^6 m^3$)	Glapan ($10^6 m^3$)	Tuntang (ha)	Jragung (ha)	Tuntang (%)	Jragung (%)	UTS (GWh)	Gunung Wulan (GWh)	(1/s)	($\$ \times 10^6$)	($\$ \times 10^6$)	(%)
1	125	-	-	14,204	-	95.0	-	139	-	1,500	31.01	12.98	21.47
1 + 2	125	-	87	20,907	-	95.0	-	136	-	2,000	63.51	23.54	20.29
Total Development	125	190	87	23,375	11,625	94.8	94.8	136	49	2,000	179.61	46.21	17.28

TABLE VI-3

TUNTANG-JRAGUNG INTEGRATED DEVELOPMENT - CASE II

OPTIMIZED PLAN

Phase	Storage Provided			Area Irrigated		Irrigation Firmness		Average Annual Energy		M & I	Project	Average Annual	IRR
	Rawa Pening ($10^6 m^3$)	Gunung Wulan ($10^6 m^3$)	Glapan ($10^6 m^3$)	Tuntang (ha)	Jragung (ha)	Tuntang (ha)	Jragung (ha)	UTS (GWh)	Gunung Wulan (GWh)	Water (l/s)	Cost ($ x 10^6)	Net Benefits ($ x 10^6)	(%)
1	125	-	-	14,204	-	94.8	94.8	139	-	1,500	31.01	12.98	21.47
Total Development	125	260	-	23,375	11,625	95.0	95.0	133	49	2,000	162.51	46.49	17.64

TABLE VI-4

INTEGRATED DEVELOPMENT OF SERANG AND LUSI SUBBASINS

OPTIMIZED PLAN

Storage				Irrigated Area						Irrigation Firmness						Power
Kedung-ombo ($10^6 m^3$)	Ngem-plak ($10^6 m^3$)	Banjar-rejo ($10^6 m^3$)	Kedung-waru ($10^6 m^3$)	South Grobogan (ha)	Lusi Left (ha)	Lusi Right (ha)	Upper Sedadi (ha)	Lower Sedadi (ha)	Juana Valley (ha)	South Grobogan (%)	Lusi Left (%)	Lusi Right (%)	Upper Sedadi (%)	Lower Sedadi (%)	Juana Valley (%)	Kedung-ombo (GWh)
655	0	0	0	7,300	0	0	19,800	17,400	15,000	96.0	-	-	93.3	95.2	95.2	52.1
655	68	77	19	7,300	4,200	7,000	19,800	17,400	12,000	97.2	94.8	94.8	94.4	95.6	95.6	51.8
655	68	77	-	7,300	4,200	5,700	19,800	17,400	12,000	97.2	94.8	94.8	94.4	95.6	95.6	51.8

TABLE VI-5

JRATUNSELUNA BASIN UPDATED DEVELOPMENT PLAN

EASTERN (LUSI-SERANG) SUBBASINS OPTIMIZATION STUDY

Phase	Storage Provided (10^6 m^3)				Total Project Cost ($ x 10^6)	Perennial Area Irrigated 95% Firmness (ha)						Annual Benefits at Full Development ($ x 10^6)	IRR (%)
	Kedung-ombo	Ngemplak	Banjar-rejo	Kedung-waru		Lusi Left	Lusi Right	South Grobogan	Upper Sedadi	Lower Sedadi	Juana		
1. Reservoir at Kedungwaru Included													
I	-	68	77	19	86.41	4,200	7,000	1,680	-	-	-	20.47	14.8
II	655	68	77	19	294.41	4,200	7,000	7,300	19,800	17,400	12,000	76.42	14.7
2. Reservoir at Kedungwaru Not Included													
I	-	68	77	-	68.50	4,200	5,700	1,680	-	-	-	18.40	15.9
II	655	68	77	-	276.50	4,200	5,700	7,300	19,800	17,400	12,000	74.35	15.0

TABLE VI-6

JRATUNSELUNA BASIN UPDATED DEVELOPMENT PLAN

WESTERN SUBBASINS OPTIMIZATION STUDY - CASE I

Phase	Storage Provided (10^6 m³)					Total Project Cost ($\$ \times 10^6$)	Perennial Area Irrigated 95% Firmness (ha)			M & I Water (l/s)			Average Annual Energy (GWh)		Annual Benefits ($\$ \times 10^6$) at Full Development					IRR
	Rawa Pening	Jragung	Gunung Wulan	Glapan	Dolok		Tuntang	Jragung	Dolok	Muncul	Jragung	Dolok	UTS	Gunung Wulan	Irrigation	Power	M & I	Flood Control	Total	(%)
I	125	-	-	87	35	79.20	20,907	-	996	2,000	-	500	139	-	22.36	-2.26	6.20	.29	26.59	18.34
II	125	-	190	87	35	208.04	23,375	10,225	996	2,000	1,500	500	141	60.5	40.16	.18	9.92	1.25	51.51	15.72
I	175	-	-	87	35	92.26	20,907	4,200	996	2,000	-	500	124	-	28.26	-2.84	6.20	.29	31.91	18.59
II	175	-	175	87	35	220.49	23,375	11,625	1,950	2,000	1,500	500	124	60.5	43.52	-.48	9.92	1.25	54.21	16.38
I	43	-	-	87	35	48.46	13,517	-	996	1,500	-	500	142	-	11.99	-2.14	4.96	.29	15.31	16.90
II	43	75	-	87	35	120.07	13,517	8,200	996	1,500	1,500	500	137	16.0	24.48	-1.71	8.68	1.25	32.70	16.40
III	43	75	190	87	35	247.98	23,375	8,900	996	2,000	1,500	500	137	76.5	38.34	+ .65	9.92	1.62	50.53	14.87

Note: Actual area benefited by project is 6,000 ha less than irrigated area shown for Tuntang and Jragung because presently, the reported (and confirmed by computer operation) area receiving perennial irrigation is about 6,000 ha.

TABLE VI-7

JRATUNSELUNA BASIN UPDATED DEVELOPMENT PLAN

WESTERN SUBBASINS OPTIMIZATION STUDY - CASE II

Phase	Storage Provided (10^6 m^3)					Total Project Cost ($\$x10^6$)	Perennial Area Irrigated 95% Firmness (ha)			M & I Water (l/s)			Annual Energy (GWh)		Annual Benefits ($\$ \times 10^6$) at Full Development					IRR
	Rawa Pening	Jragung	Gunung Wulan	Glapan	Dolok		Tuntang	Jragung	Dolok	Muncul	Jragung	Dolok	UTS	Gunung Wulan	Irrigation	Power	M & I	Flood Control	Total	(%)
I	125	-	-	-	35	46.70	14,204	-	996	1,500	-	500	139	-	12.14	-1.87	4.96	.25	15.48	17.57
II	125	-	260	-	35	190.82	23,375	10,462	996	2,000	1,500	500	141	80.2	38.06	.95	9.92	1.00	49.93	15.69
I	175	-	-	-	35	59.64	18,060	-	996	1,500	-	500	128	-	17.23	-2.69	4.96	.25	19.75	18.53
II	175	-	260	-	35	203.19	23,375	11,625	1,950	2,000	1,500	500	124	80.2	40.85	.28	9.92	1.00	52.05	15.95
I	43	-	-	-	35	15.66	8,100	-	996	-	-	500	161	-	1.31	-	1.24	.25	2.80	10.80
II	43	75	-	-	35	87.27	8,100	6,700	996	-	1,500	500	161	16.0	12.93	4.96	4.96	.75	18.64	13.98
III	43	75	260	-	35	230.68	23,375	8,900	996	2,000	1,500	500	137	96.2	36.0	.64	9.92	1.25	47.81	13.54

Note: Actual area benefited by project is 6,000 ha less than irrigated area shown for Tuntang and Jragung because presently, the reported (and confirmed by computer operation) area receiving perennial irrigation is about 6,000 ha.

CHAPTER VII

UPDATED JRATUNSELUNA BASIN DEVELOPMENT PLAN

CHAPTER VII

UPDATED JRATUNSELUNA BASIN DEVELOPMENT PLAN

Based on the discussion in Chapter VI, the optimum development of perennial irrigation and M & I supply can be achieved by integrating and coordinating the use of the water resources of all constituting subbasins of the Jratunseluna Basin. In this chapter, the grouping of the various works proposed in the subbasins are analyzed for the following conditions.

1. Rawa Pening Live Storage Capacity = 125 million cubic meters.
2. Rawa Pening Live Storage Capacity = 175 million cubic meters.
3. Rawa Pening Live Storage Capacity (As Existing) = 43 million cubic meters.

The results of analysis are presented in Tables VII-1, VII-2 and VII-3.

VII.1. PHASING

The phasing of elements in any grouping proposed in the Updated Development Plan has been spread over a period of 20 years for full implementation. In line with the current policy of GOI to give preference to the implementation of low-cost small storage projects over large dam projects, the works proposed for implementation during the first five years of the plan are small-size projects, which on completion and full development would bring 23,556 hectares under perennial irrigation and supply 2,000 liters per second of M & I water to the city of Semarang.

The development of the Western Subbasins has generally been given preference over the Serang-Lusi development because the Dolok Dam and Rawa Pening supply the much needed M & I water for Semarang, in addition to providing dry season irrigation to areas where the irrigation systems have already been rehabilitated and enlarged. However, the Mid Lusi Diversion and the Banjarejo Dam have been proposed for construction during the first 5-year period to develop part of the Lusi areas from the presently rainfed agriculture to technical irrigation.

In case the Dolok Dam Project falls through, the Glapan Barrage should be phased in the first 5-year period of the plan. Similarly, if the Banjarejo Dam Project cannot be implemented, the construction of the Ngemplak Dam should be considered instead.

During the second 5-year period of the plan, one project each in the western and the eastern subbasins have been proposed for implementation. The additional area which will be brought under perennial irrigation during that period will be 9,583 hectares.

The two major projects involving large dams on the Tuntang and the Serang Rivers are proposed for implementation during the third and the fourth 5-year periods of the plan. These projects in addition to providing perennial irrigation water to about 65,000 hectares, will augment M & I water supply to Semarang by 2,000 liters per second and add about 135 gegawatt hours of energy to the national power grid. These projects will also yield substantial flood control benefits.

VII.2. ECONOMICS

The results of economic studies for the individual elements of the development plan are presented in Table VI-1. The evaluation of yearly costs of the various groupings of elements which form the total development plan have been done for the full planning period of 20 years. The average annual benefits have been computed progressively after each element of the plan is implemented and added to the scheme of works.

These costs and benefits are shown in Tables VII-1, VII-2 and VII-3 for the three different Rawa Pening storage capacities investigated. The economics of the groupings of elements for the Eastern and the Western Subbasins are presented in Tables VI-5 and VI-6, respectively.

VII.3. STORAGE ON TUNTANG

The results of reservoir operation for the system of the Western Subbasins given for Cases I and II presented in Chapter VI of this report showed that a live storage of 260 million cubic meters at Gunung Wulan on the Tuntang River would yield the same irrigation and M & I benefits as a reservoir with live storage of 190 million cubic meters at the same location and combined with a live storage of 87 million cubic meters provided at Glapan. A comparison of costs for building one large Gunung Wulan Dam (US $ 116,500,000) with construction of two dams: 1) a smaller Gunung Wulan Dam (US $ 103,500,000) and 2) an additional storage dam at Glapan (US $ 23,900,000), favors adoption of a development plan with one large dam at Gunung Wulan for the same irrigation and M & I benefits. However, under consideration of the following factors, the scheme of building two reservoirs has sufficient merits for inclusion in the development plan.

1. The scheme of two reservoirs affords a small size,low-cost project, namely the Glapan Barrage, which can be considered for early implementation.

2. The reservoir at Glapan would act as a re-regulation facility for hydropower releases from Gunung Wulan, should GOI decide to build a power plant at this location.

3. A barrage at Glapan will provide better sediment control and irrigation water regulation for the offtaking canals as compared to the existing structure.

VII.4. WET SEASON IRRIGATION DEVELOPMENT

The updated development plan for the Jratunseluna Basin presented in the preceding sections of this Chapter is a combination of economically feasible projects which, when implemented, will ensure optimum use of water resources of the Tuntang, Jragung, Serang, Lusi, Dolok and the Penggaron Subbasins. Full development of agricultural irrigation on a perennial basis has been projected, with assured water supplies available during both the dry and the wet seasons at 95 percent firmness.

In the Eastern Subbasins, especially along the Lusi River, there are several rainfed areas and eight local run-of-river wet season irrigation systems, with limited structures and other technical irrigation facilities, which serve approximately 2,000 hectares. All the run-of-river irrigation systems are located on the tributaries of the Lusi River; none of them is on the main river. In the updated development plan, some of the rainfed areas and some that now have run-of-river wet season irrigation are included in the areas to be supplied with water for perennial irrigation from storage at Banjarejo, Ngemplak and Kedungwaru.

The net irrigable area which has been identified in the plan on the Lusi River System is 15,480 hectares, of which 12,880 hectares can have perennial irrigation if Kedungwaru Dam is built and 11,580 hectares if it is not built. The remaining area of 2,600 hectares or 3,900 hectares, depending upon whether or not Kedungwaru Dam is built, cannot be served with water for perennial irrigation from the feasible storage reservoirs identified in the Lusi River System.

In addition to the above mentioned areas, there are isolated rainfed areas along the uppermost reach of the Lusi River which were not included in the potential irrigation areas identified in the development plan. For these areas, there is neither storage capacity on the Lusi system to serve perennial irrigation nor are adequate topographical maps available to determine possibility of their command from the Lusi River System.

In all rainfed areas, the present cropping pattern is dependent on the yearly rainfall pattern. In November or December of every year, depending upon when the rains start, farmers try to grow a crop of rice followed by an upland crop. Obviously, the pattern, intensity, and amount of rainfall determine the success of the crops and the yields obtained, from rainfed agriculture. There are frequent shortages of water in the rainfed areas to meet crop requirements. Only that amount of water is available to the crop that can be stored in the paddies during rainfall. Such shortages cause partial or sometimes total failure of crops. Yields are substantially below normal, or there may be no harvest at all. However, these water shortages could be overcome if it is possible to provide regulated irrigation supplies from run-of-river diversion.

In the economic analysis for the updated development plan, presented in Tables VII-1, VII-2 and VII-3, a development period of five years has been assumed for the accrual of full projected benefits after implementation of the project. So, even after full implementation of the storage reservoirs, when water for perennial irrigation will be available, the full projected irrigation benefits will not accrue until 5 years after implementation. This period for full development can be substantially reduced if technical irrigation is introduced in the service areas in advance of the implementation of the storage reservoirs. The partial development of the rainfed areas to wet season technical irrigation, thus achieved, will produce some interim benefits.

It will, therefore, be prudent to develop such rainfed areas included in the development plan to technical irrigation for which water is available for run-of-river diversion during the wet season. This can be achieved by constructing at an early stage the diversion works and irrigation supply and distribution systems which normally would be needed at a later stage to divert perennial irrigation supplies after the storage reservoirs are built. The benefits of constructing the diversion structures and installing technical irrigation systems at an early stage will be twofold. First, the presently rainfed agriculture will be transformed into wet season irrigated agriculture receiving assured irrigation supplies, and secondly, it will eliminate the need of the development period for the full projected benefits to accrue, after the storage reservoirs are built to provide perennial irrigation.

In the Lusi River System, water is available during the rainy season which may be diverted for run-of-river supplies to serve presently rainfed areas, provided those areas are commanded from the source of water considered for diversion. The possibility of converting those rainfed areas along the Lusi River to technical irrigation for wet season agriculture should, therefore, be examined.

The updated development plan and the proposal for developing wet season irrigation are only conceptual. The wet season irrigation potential has simply been identified in this study; it should be evaluated fully after mapping the areas and carrying out the required hydrological analyses, detailed land classification and selection of appropriate sites for run-of-river diversions.

If more water from run-of-river diversions is available than is required to provide interim wet season irrigation to rainfed areas of the development plan, then consideration should be given to provide technical wet season irrigation on a permanent basis to rainfed areas not included in the development plan. In that case wet season irrigation can be developed in the Jratunseluna Basin in two categories of the presently rainfed areas: 1) the areas which eventually will receive perennial irrigation after the development plan is implemented and 2) the areas where perennial irrigation supplies from storage reservoirs is not feasible, but where development of wet season irrigation could be beneficial. Development of this potential will also meet the objective of the current policy of the Government of Indonesia to implement small-size, low-cost projects which provide benefits in the near future rather than awaiting implementation of major dam projects which provide benefits at a much later date.

The areas which should be considered for wet season irrigation are indicated in Table VII-4.

VII.5. IMPLEMENTATION

The optimum development of water resources of the Jratunseluna Basin would require that large size multiple purpose projects, e.g. Kedungombo Dam and Gunung Wulan Dam, should be phased early in the development plan to derive maximum benefits. However, the priorities for implementing the proposed updated development plan were fixed in accordance with the directions of the DGWRD to give preference to low-cost small storage projects over large dams during the next 10 years or so. The priorities for implementing the plan have, therefore, been established by phasing the low-cost projects earlier in the proposed implementation schedule. These are described in the following paragraphs.

VII.5.1. Interim Development

The interim development is proposed of providing wet season irrigation to rainfed areas along the Lusi and the Serang Rivers, which will eventually receive perennial irrigation after implementation of the full development plan, and those areas which will be transformed to only technical irrigation in the wet season.

A proposed implementation schedule for installing technical irrigation in the rainfed areas along the Lusi and the Serang Rivers, including those which should be developed for wet season irrigation only, is presented in Table VII-4.

VII.5.2. Full Development Plan

During the first two years, the results of investigations to establish the technical feasibility of the Rawa Pening diking scheme would become available. If the feasibility of dikes can be established, and problems of drainage behind the dikes can be satisfactorily resolved, the implementation of the plan should proceed further in the chronological order given in Table VII-1.

The development plan for Rawa Pening has not been finalized as yet. As a key project in the overall basin development, this unknown factor required that possible alternative development schemes be investigated. The proposed Development Plan, therefore, comprises three alternatives.

1. The optimum development as shown on Table VII-1 is achieved by increasing the Rawa Pening live storage to 125 million cubic meters. The implementation of this plan is recommended.

2. In the event that raising of Rawa Pening with dikes is not feasible and solutions to the sociological problems associated with the flooding of the total area can be found, the implementation of the plan should follow the scheme proposed in Table VII-2. For this development plan, Rawa Pening will have a total storage capacity of 175 million cubic meters.

3. If investigations proposed within the first two years of the plan prove that, neither the construction of dikes around the lake is feasible, nor the sociological problems resulting from flooding of the area around Rawa Pening can be solved, then the scheme of development presented in Table VII-3 indicates the proposed program. Raising of Rawa Pening is not included in this scheme; instead construction of the Jragung Dam for meeting projected irrigation demands in the area and supplying needed M & I water for the city of Semarang has been programmed as shown in Table VII-3.

TABLE VII-1

JRATUNSELUNA BASIN

UPDATED DEVELOPMENT PLAN

RAWA PENING RAISED TO LIVE STORAGE CAPACITY 125 x 10^6 m^3

Elements of Plan		Live Storage Capacity (10^6 m^3)	PROPOSED PERIOD OF IMPLEMENTATION (YEARS)																					Estimated Cost (US$ 10^6)	IRR (%)
			1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
WESTERN SUBBASINS																									
Dolok Dam		35																						15.73	11.3
Jragung Dam		-																						-	-
Rawa Pening		125																						31.01	22.0
Tuntang-Jragung Trans-basin Diversion		-																						2.4	-
Gunung Wulan Dam		190																						130.38	14.1
Glapan Barrage		87																						32.77	20.1
EASTERN SUBBASINS																									
Kedungombo Dam		655																						208.00	14.1
Banjarejo Dam		77																						48.29	16.1
Mid Lusi Diversion		-																						3.3	-
Ngemplak Dam		68																						18.79	14.0
Yearly Cost		US$ 10^6	-	-	15.35	29.61	30.81	24.96	7.74	15.47	15.47	12.88	20.8	41.6	41.6	41.6	41.6	33.84	32.60	32.60	32.60	19.55	-		
Perennially Irrigated Area		ha	6,000						23,556				33,139						87,959				100,649		
M & I Water Supply		1/s	0						2,000				2,500										4,000		
Annual Benefits	Irrigation	US$ 10^6							5.23	10.47	15.70	20.93	28.97	32.28	35.31	38.34	41.37	41.37	51.95	63.14	74.33	85.52	116.01		
	M & I Water Supply	US$ 10^6							2.1	2.7	3.3	3.9	4.5	5.10	5.70	6.20	6.20	6.20	6.20	6.20	6.20	6.20	9.92		
	Flood Control	US$ 10^6							.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	1.25		
	Hydropower	US$ 10^6							-2.27	-2.27	-2.27	-2.27	-2.26	-2.26	-2.26	-2.26	-2.26	-2.26	-0.1	-0.1	-0.1	-0.1	2.34		
	Total	US$ 10^6							5.35	11.19	17.02	22.85	31.50	35.41	39.04	42.57	45.60	45.60	58.34	69.53	80.72	91.91	129.52		

LEGEND

Mapping

Investigation

Design/Construction

TABLE VII-2

JRATUNSELUNA BASIN

UPDATED DEVELOPMENT PLAN

RAWA PENING RAISED TO LIVE STORAGE CAPACITY 175 x 10^6 m^3

Elements of Plan	Live Storage Capacity (10^6 m^3)	PROPOSED PERIOD OF IMPLEMENTATION (YEARS) 1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Estimated Cost (US$ 10^6)	IRR (%)
WESTERN SUBBASINS																								
Dolok Dam	35	═══	- - -	───	───	───	───																15.73	11.3
Jragung Dam	-																						-	-
Rawa Pening	175	═══	- - -	───	───	───	───																43.96	21.0
Tuntang-Jragung Trans-basin Diversion	-				- - -	───	───																2.4	-
Gunung Wulan Dam	175	═══	- - -												- - -	- - -	───	───	───	───	───		130.33	14.1
Glapan Barrage	87	═══	- - -				- - -	───	───	───	───												32.77	20.8
EASTERN SUBBASINS																								
Kedungombo Dam	655										- - -	───	───	───	───	───	───						208.00	14.1
Banjarejo Dam	77	═══	- - -	- - -	───	───	───	───															48.29	16.1
Mid Lusi Diversion	-	═══	- - -	───	───	───																	3.3	-
Ngemplak Dam	68	═══				- - -	- - -	───	───	───	───												18.79	14.0
Yearly Cost	US$ 10^6	-	-	10.05	26.25	34.70	30.61	19.81	15.47	15.47	12.88	20.8	41.6	41.6	41.6	41.6	33.84	32.60	32.60	32.60	19.55	-		
Perennially Irrigated Area	ha	← 6,000 →						19,400	← 27,756 →			← 37,339 →						← 92,159 →				103,006		
M & I Water Supply	l/s	← 0 →						← 2,000 →				← 2,500 →										4,000		
Annual Benefits: Irrigation	US$ 10^6	←→						3.67	10.00	16.33	22.96	32.00	37.70	40.73	43.76	46.66	46.66	57.85	69.04	80.23	91.42	120.41		
Annual Benefits: M & I Water Supply	US$ 10^6	←→						2.1	2.7	3.3	3.9	4.5	5.1	5.7	6.2	6.2	6.2	6.2	6.2	6.2	6.2	9.92		
Annual Benefits: Flood Control	US$ 10^6	←→						.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	1.24		
Annual Benefits: Hydropower	US$ 10^6	←→						-2.69	-2.69	-2.69	-2.69	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-.68	-.68	-.68	-.68	1.68		
Annual Benefits: Total	US$ 10^6	←→						3.37	10.30	17.23	24.46	33.95	40.25	43.88	47.41	50.31	50.31	63.66	74.85	86.04	97.23	133.25		

LEGEND

═══ Mapping

- - - Investigation

─── Design/Construction

TABLE VII-3

JRATUNSELUNA BASIN

UPDATED DEVELOPMENT PLAN

RAWA PENING NOT RAISED-EXISTING LIVE STORAGE CAPACITY 43 x 10^6 m^3

Elements of Plan	Live Storage Capacity (10^6 m^3)	PROPOSED PERIOD OF IMPLEMENTATION (YEARS) 1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Estimated Cost (10^6 m^3)	IRR (%)
WESTERN SUBBASINS																								
Dolok Dam	35																						15.73	11.3
Jragung Dam	75																						71.39	13.8
Rawa Pening	43																							
Tuntang-Jragung Transbasin Diversion	-																						2.4	-
Gunung Wulan Dam	190																						130.38	14.1
Glapan Barrage	87																						32.77	20.8
EASTERN SUBBASINS																								
Kedungombo Dam	655																						208.0	14.1
Banjarejo Dam	77																						48.29	16.1
Mid Lusi Diversion	-																						3.3	-
Ngemplak Dam	68																						18.79	14.0
Yearly Cost	US$ 10^6	-	-	8.38	22.89	30.14	26.61	22.03	23.49	23.49	23.74	11.9	20.8	41.6	41.6	41.6	41.6	40.36	39.11	39.11	32.60	-		
Perennially Irrigated Area	ha	6,000						14,513	22,869			25,749	33,949						88,769			99,327		
M & I Water Supply	l/s	0						2,000					3,500									4,000		
Annual Benefit: Irrigation	US$ 10^6							2.4	7.46	12.52	17.58	23.54	29.40	32.81	35.83	39.61	40.88	40.88	52.07	63.26	76.45	112.7		
Annual Benefit: M & I Water Supply	US$ 10^6							2.10	2.70	3.30	3.90	4.5	5.1	5.7	6.2	6.95	7.7	8.45	8.68	8.68	8.68	9.92		
Annual Benefit: Flood Control	US$ 10^6							.29	.29	.29	.29	.29	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.62		
Annual Benefit: Hydropower	US$ 10^6							-2.14	-2.14	-2.14	-2.14	-2.14	-1.71	-1.71	-1.71	-1.71	-1.71	-1.71	.45	.45	.45	1.10		
Annual Benefit: Total	US$ 10^6							2.65	8.31	13.97	19.63	26.19	34.04	38.05	41.57	46.10	48.12	48.87	62.45	73.64	86.83	125.3		

LEGEND

- Mapping
- Investigation
- Design/Construction

TABLE VII-4

JRATUNSELUNA BASIN DEVELOPMENT

INTERIM MEASURES - IMPLEMENTATION SCHEDULE

PROPOSED WORKS	PERIOD OF IMPLEMENTATION (YEARS) 1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Wet Season Irrigation Area (ha)	Estimated Cost ($ 10^6)	REMARKS
1. SOUTH GROBOGAN IRRIGATION SYSTEM													
a. From Glugu River Diversion											1,500	2.5	Preliminary economic analyses of all these projects gave internal rates of return of more than 15 percent. These should be checked in the feasibility studies recommended of these projects.
Mapping - Investigation	—	—											
River Diversion Works													
Design		—											
Construction		—	—	—									
Irrigation System													
Design		—	—										
Construction			—	—	—								
b. From Paganjing River Diversion											2,880	4.5	
Mapping - Investigation	—												
River Diversion Works													
Design		—											
Construction		—	—										
Irrigation System													
Design		—											
Construction		—	—	—									
2. MID LUSI IRRIGATION SYSTEM											10,000	15.0	
Mapping - Investigation	—	—											
River Diversion Works													
Design		—											
Construction			—	—									
Irrigation System													
Design			—										
Construction			—	—	—	—							
3. JUANA IRRIGATION SYSTEM											6,160	9.0	
Mapping - Investigation	—	—											
River Diversion Works													
Design						—							
Construction						—	—						
Irrigation System													
Design							—						
Construction							—	—	—	—			
4. UPPER LUSI IRRIGATION SYSTEM												Not yet Determined	
Mapping - Investigation	—	—											
Design					—								
Construction						—	—	—					

CHAPTER VIII

SOIL AND WATER CONSERVATION

CHAPTER VIII

SOIL AND WATER CONSERVATION

VIII.1. INTRODUCTION

The erosion control and soil conservation studies performed as part of updating the Jratunseluna Basin were divided between two principle activities. The first part consisted of a study of the problems and needs for soil and water conservation and erosion control in the Jratunseluna Basin. This study resulted in the development of a conceptual plan for developing a soil and water conservation program in the basin. More accurately it is an instruction manual on how to go about developing a successful soil and water conservation program. The second part of this study was concentrated on developing detailed designs for a Pilot Watershed Demonstration Project for a 5-year period.

Both the Conceptual Plan and the designs for the Pilot Watershed Demonstration Project are gi en in Appendix F of this Main Report. The location of the demonstration area is shown on Figure VIII-1. A brief description of the Conceptual Plan and recommendations for a soil and water conservation program in the Jratunseluna Basin are presented in the following sections.

VIII.2. CONCEPTUAL PLAN FOR THE JRATUNSELUNA BASIN

The soil erosion problems of the upper watershed area are quite evident to the trained observer, as is the very high sediment load of all the main river systems. The natural ecosystem of the upper watershed has been disrupted by deforestation, uncontrolled agricultural development, severe depletion of the soil resources and many other unwise practices. This has resulted in rapidly increasing sediment loads in the streams, increased downstream flooding and sediment deposition damages, eroded and abandoned upland areas, and a very low standard of living for upland farmers.

There has been a growing awareness of the problems created by soil erosion, but to date there has been no integrated approach to defining and solving the upper watershed problems of the Jratunseluna Basin. One of the principle difficulties is that few of the organizations, trying to solve the erosion problem recognize that it is really a "people problem" that puts economic, technical and physical limitations on its solution. There has also been a general misconception that one can solve erosion problems by structural measures. It has to be understood that the only effective control of erosion is to increase the vegetative cover of the watershed areas.

Therefore, it is necessary to shift the focus of a soil and water conservation project away from the application of structural measures to one that recognizes the importance of the farmer as an individual in the solution of the erosion problems. There is a chance for an erosion control only when the farmer understands the erosion problem on his farm; and he is taught the principles of conservation farming, and assisted in acquiring the resources to apply improved conservation methods. The individual upland farmer must be brought into the planning process because he is the one who will have to put it into operation. He also has to see how he and his family can gain from the application of the conservation farming methods. Finally, there has to be a recognition at governmental policy levels that the fundamental people problem of the upper watershed areas of the Jratunseluna Basin is: too many people for the available resources. Therefore, any improvement in watershed conditions is only temporary unless a number of these people can be provided with economic opportunity elsewhere, and effective population management systems are instituted for the entire Jratunseluna Basin.

VIII.2.1. Existing Soil and Water Conservation Programs

The soil conservation activities for private land to date have been conducted under the Greening Program (P3RP-DAS) which involves the planning, advisory and supervising functions for the conservation works applied by the farmer. The statistics furnished by the Greening and Reforestation Planning Office in Salatiga show that there was an estimated 180,323 hectares of critical land outside of the forests (mostly private lands) at the start of Pelita II (1974-75). During Pelita II there was a reported decrease of 74,954 hectares in the critical area as a result of the Greening Program treatments. Somewhat strangely, there was no additional critical area reported during the period, which probably means it was not estimated. In any case, the remaining 105,369 hectares of critical land outside the forest are scheduled for treatment during Pelita III, which started in 1979-1980.

For lands inside the forest there was a total of 14,211 hectares of critical lands at the start of Pelita II, and all of them were reportedly successfully treated during Pelita II. There were no critical lands in the forests at the beginning of Pelita III.

To the trained observer, the claimed successful treatment is a matter of definition. The given figures are also not borne out by the rapidly increasing sediment loads in the major streams. This emphasizes the need for an interagency study of the entire basin to closely analyze and map the erosion areas, and to set up a system of review whereby the areas treated would be monitored to determine the true success or failure of the erosion control programs.

VIII.2.2. Problem Identification

Investigations conducted for developing the Jratunseluna Basin show a lack of information as to the location of critical erosion areas; land ownership and land use, population densities, and other factors are needed to define the problem. Information will have to be developed as to the acceptable level of erosion for specific soil types and slope conditions. Information must also be developed regarding erosion rates from various land uses and cover conditions that will permit logical decisions as to treatment programs and the urgency of treating a particular area. Use of the Universal Soil Loss Equation needs to be refined to enable assessment of specific effects expected from individual treatment programs.

The seriousness of the upper watershed problems is emphasized by the analyses of sediment production of major upstream watersheds of the Jratunseluna Basin. For the 4,678 square kilometers upper watershed area on which there is some data available the weighted mean annual precipitation is 2,242 millimeters, the estimated evapotranspiration is 1,237 millimeters, and the mean water yield is 1,055 millimeters. The estimated annual sediment yield with this runoff is 24 million tons annually for an average sediment delivery by the streams of 5,140 tons per square kilometer per year from the upper watersheds. This would be an average loss of 3.4 to 5.1 millimeters of soil per year depending upon the unit weight of soil being eroded. This rate is at least 3 to 5 times the acceptable rate of erosion. It also should be emphasized that the upper watershed area includes about 24 percent in ricelands and 21 percent in forests and plantations that are not really susceptible to erosion. Thus, the remaining 55 percent of the upland areas is losing a large percent of its fertile soil cover every year.

VIII.3. JRATUNSELUNA BASIN CONCEPTUAL PLAN - CONCLUSIONS

The investigations leading to the development of the conceptual plan for soil and water conservation in the Jratunseluna Basin were limited in scope but enabled the consultant to reach the following conclusions:

1. The erosion rates in some of the upper watershed areas, such as the Jragung River, are so severe that portions of the watershed have eroded beyond the point where it is possible to return the land to economic production. Much of the upper watershed area is approaching this critical point and it is imperative that a corrective program be initiated in the near future.

2. The real problems of the watershed are "people problems" related to the high population density. These people problems are placing severe technical, economic and physical constraints on a solution of the erosion problem because of the very limited land and economic resources available to the upland farmer.

3. One of the major problems is that the present size and productivity of the upland farms is so small that neither the physical nor the economic conditions for a conventional conservation program exist. The farmer's low productivity, lack of economic resources, lack of technical knowledge, and limited access to seeds, fertilizers and insecticides prevent him from participating in the "green revolution". These problems must be at least partially solved before the upland farmer can become a conservation farmer.

4. There is general lack of understanding that the first and only line of defense against erosion is a good vegetative ground cover. Structures by themselves do not act to reduce erosion and, in fact, may act to increase erosion many times if they fail, because structures tend to concentrate the water in one place.

5. Data information and knowledge are not available to precisely define the problems of the Jratunseluna Basin, and to arrive at a feasible solution. Therefore, the consultant cautions against the rapid implementation of a "crash" program to solve the erosion problems of the watershed. Specific recommendations are included in the following section of the report.

VIII.4. RECOMMENDATIONS FOR A SOIL AND WATER CONSERVATION PROGRAM

The recommendations have been divided into three broad categories: First: program objectives; these are the action levels the programs should be striving for. Second: organizational improvements: changes which are important to develop an effective soil and water conservation program within the existing governmental system. Third: infrastructural and institutional improvements; these improvements are suggested to provide inputs to the organizations responsible for conducting the programs through increased funding and technical assistance.

VIII.4.1. Program Objectives

1. Development of an integrated multidisciplinary plan for solving the "people problems" of the Jratunseluna Basin should be the primary objective. This effort should be focused on solving the real problems of the upland farmers rather than attempting to solve the physical manifestations of the problem. This is to say that erosion is not the real problem; the problem is: too many upland farmers trying to feed their families in the upper watershed areas, and their lack of necessary knowledge and resources for implementing the needed conservation farming methods. Solving this problem will require the cooperation and coordination of all agencies and political subdivisions in all departments from the ministerial level to the village level.

2. Individual farmers and government officials must be given an appreciation of the real nature and condition of the problems they face, and programs must be developed to solve these problems. It is very important that this process involves the local people in the decision making level and thereby teaches them to improve their individual decision making ability. This approach emphasizes the "better farming for better living" concept and attempts to show the farmer that soil and water conservation and improved cultural practices can enable him to make maximum use of his resources with the result of improving the standard of living of his family.

3. All people involved must learn to recognize that the first line of defense against erosion is always the improvement of vegetative cover on the land. Soil conserving structures may be more impressive and satisfying, but if not maintained they can fail and cause more damage than would have occurred if they had not been built. Vegetation is more permanent and even in failure, or removal, there is additional soil and fertility remaining.

4. The integrated watershed management program should capitalize on all soil conservation works previously installed. Traditional terraces can be slowly improved, and by installing grassed waterway system for surplus water disposal they can materially reduce erosion rates. The staff should encourage the best of traditional cropping methods and show the farmer ways of improving agronomic practices. The program should emphasize methods of upgrading existing soil and water conservation systems, and the use of simple structures that can be built with local materials and labor.

5. Fruit, livestock, fish, or bee production are examples of supportive activity for increasing the family income or improving diets. Livestock production provides a use for grass grown on the terrace risers and agroforestry areas. It should be encouraged, aided with loans, and improved through better breeding and management programs, but care must be taken to prevent overgrazing that can create serious erosion problems.

6. The adoption of improved soil and water conservation methods and improved agronomic cultural practices should be encouraged by system of demonstration farms. Since the farmers often cannot read, and will not travel far, the demonstration farms must ultimately be scattered throughout the upper watershed areas. However, this program should not be expanded beyond the availability of funds and trained technicians to train and assist the farmer, and to supervise the program at all levels. The fundamental principle with demonstration farms is that success convinces people to follow the example, but failure breeds contempt and the word is spread fast and far. Building a cadre of professional workers for improving upland agriculture requires a combination of university training, short technical training session, and a major program of on-the-job training for all staff members. This program should also emphasize the promotion potential for exceptionally capable field workers. Farmer advisory groups should be a definite part of the government structure so that their perspectives can affect management decisions. The central government's pronouncements on "the right way to solve problems" never work, but the direct participation by the farmer in the field has been proven to work in most cases, here in Indonesia and other countries. The important feature of these successes was that the project was labled a local rather than a government project.

VIII.4.2. Organizational Improvements

Based on the consultant's review and analysis of prior soil conservation efforts in Indonesia, it is believed that future efforts could generally benefit from a few, but important, organization improvements. Governmental organizations directly concerned with solving the land and water resources degeneration problems often lack understanding of sociologic conditions and therefore tend not to focus on solving the people problems of the upper watershed. Instead they have worked attempting to solve the symptoms, such as denudation and visible erosion. Further, these programs are developed from the national level downward and have little or no relevance to the upland farmers' problems. Organizations created to deal with the downstream irrigation and riceland farming problems neither understand the problems facing upland farmers nor are they involved in real assistance to those farmers. In addition, the past soil conservation efforts have suffered greatly from the lack of continuity and linkages among the individual program elements. The consultants believe that this can only be achieved by an improvement program that is developed from the farmers' level upward. Specific recommendations include:

1. Rather than creating a new organization to accomplish the watershed management objectives, the consultants strongly suggest that the existing central governmental authorities be given the staff and funds necessary to solve the problems at the local level, with the farmers' cooperation. This approach has the advantage of not creating a new bureaucracy with the attendant overhead costs. The Indonesian national government and the Jratunseluna River Basin Project should provide the management goals: staff training assistance; consultant and other technical guidance; and funds for additional staff, equipment, farmer incentives, and materials. Actual management of the watershed development program should rest with the affected kabupaten or kecamatan, with guidance from farmer advisory boards and supervision from the provincial offices.

2. At the national level, a ministerial level council is needed to develop specific soil, water, and renewable natural resources policies for Indonesia. This group would meet infrequently to consider reports or programs, review and make policy decisions, and evaluate progress.

The coordinating body would provide the necessary linkages between programs of the separate government agencies that affect the soil conservation problems. The council should also have a day-to-day coordinator to carry out the directives of the council and to follow up on decisions.

3. A more effective direction and coordination of soil and water development and management programs in the watershed should be provided. A much greater and more deliberate effort should be made at all administrative levels to provide continuity of participation in the soil and water development programs for improving watershed conditions. New programs and staff training should be developed in the light of past experience (including mistakes) to ensure that future programs do not repeat mistakes made in other parts of the watershed or country.

4. A major effort should be initiated to improve the soil and water research and basic data collection systems, and to expand the upland crop and seed improvement program. Research and basic data collection should be placed high on the priority list because it is the only way to evaluate the effectiveness of projects and programs. This program should include a synthesis of existing information from the various area-based rural development or watershed programs in Indonesia. Information from neighboring countries should be analyzed for applicability to Indonesian watershed management projects and recommendation made for its use. Similarly, all new plant varieties that have shown promise in comparable situations should be investigated for introduction to Indonesia's upland farm and watershed areas.

VIII.4.3. Infrastructural and Institutional Improvements

Local differences in resources, infrastructural development, political organizations, and people's attitudes towards development are too diverse to permit a common program approach to infrastructure and institutional changes in the upper watershed areas. The need for too many different improvements prohibits the use of a single approach for the total upper watershed area. The general recommendations are discussed below, but specific project assessments will need to be developed after project selection.

1. Development of additional nonagricultural employment opportunities is a critical need in the upper watershed area. Specific infrastructural development programs should concentrate on the promotion of labor-

BIBLIOGRAPHY

No.	Title
1	NEDECO. Jratunseluna Basin Development Plan, Main Report, Conclusions & Recommendations. November 1973.
2	NEDECO. Jratunseluna Basin Development Project, Feasibility Study, Water Resources Development, Jragung, Dolok and Penggaron Basin, Vol. 1 : Report. December 1971.
3	NEDECO. Jragung Dam Flood Control and Irrigation Project, Feasibility Study. August 1973.
4	PRC/ECI. Jragung Dam Multipurpose Irrigation Flood Control and Industrial Water Supply Project, Upgraded Feasibility Report. December 1976.
5	PRC/ECI. Jragung Dam Final Design Report. April 1979.
6	NEDECO. Jratunseluna Basin Development Plan Central Java, Glapan Dam, Irrigation, Flood Control and Hydropower Project. July 1975.
7	NEDECO. Jratunseluna Basin Development Plan, Central Java, Ngrambat Dam. June 1975.
8	NEDECO. Jratunseluna Basin Development Project, Prefeasibility Study, Rawa Pening. 1972.
9	PRC/ECI. Tuntang/Jragung Rivers Basins Integrated Development Plan. Executive Summary, Appendices and Special Reports I, II and III.
10	BURNS AND MCDONNELLS/TRANS-ASIA. Water Supply Master Plan for the city of Semarang. November 1976.
11	SMEC. The Improvement and Development of the Serang River and Irrigation Project, Central Java, Definite Scheme Report. February 1979.
12	SMEC. The Improvement and Development of the Serang River and Irrigation Project, Central Java, South Grobogan Irrigation Project, Feasibility Study, Technical report. June 1978.
13	SMEC. The Improvement and Development of the Serang River and Irrigation Project, Central Java, Juana Valley Irrigation Project, Feasibility Study, Technical Report. February 1980.
14	NEDECO. Consequences of the Postponement of the Jragung Dam. July 1979.
15	PRC/ECI. Tuntang/Jragung Rivers Basins Integrated Development Plan, Interim Report. August 1979.

intensive activities, using local resources in their production.

2. Improvement of the transportation network is essential to the development of a market economy in the watershed. Villages with the most pressing economic, social, and land deterioration problems often are the most difficult to reach. The farmers from these villages must face uncertain market prospects in the village or must hand carry their produce from the upland farms to market centers in lowlands for sale or trade.

   Because the need for road and trail improvement is so severe the immediate program should concentrate on erosion proofing and surfacing of existing roads and trails as a primary means of reducing erosion. This program will reduce costs for transportation, vehicle maintenance and future road maintenance and will alleviate downstream flood and sediment damages.

3. For long-term success of the upper watershed improvement program it will be necessary to develop a practicable farm credit program which enables upland farmers to purchase the technology that will permit them to participate in the green revolution's methodology for increased crop production.

4. Assistance programs for upland farmers should be redefined and expanded to assist in solving the real problems or, initially, what the farmers perceive to be their problems, because in this way they will learn to rely on the project staff. This will require the addition or many agricultural technicians with broad backgrounds in solving local problems and needs; through knowledge of community economic development methods, extension education programs, and conservation farming techniques. Planning and coordination programs between existing government agencies should be improved to reduce delays to infrastructural developments created by the lack of fertilizers, improved seeds or planting materials, and tools and equipment.

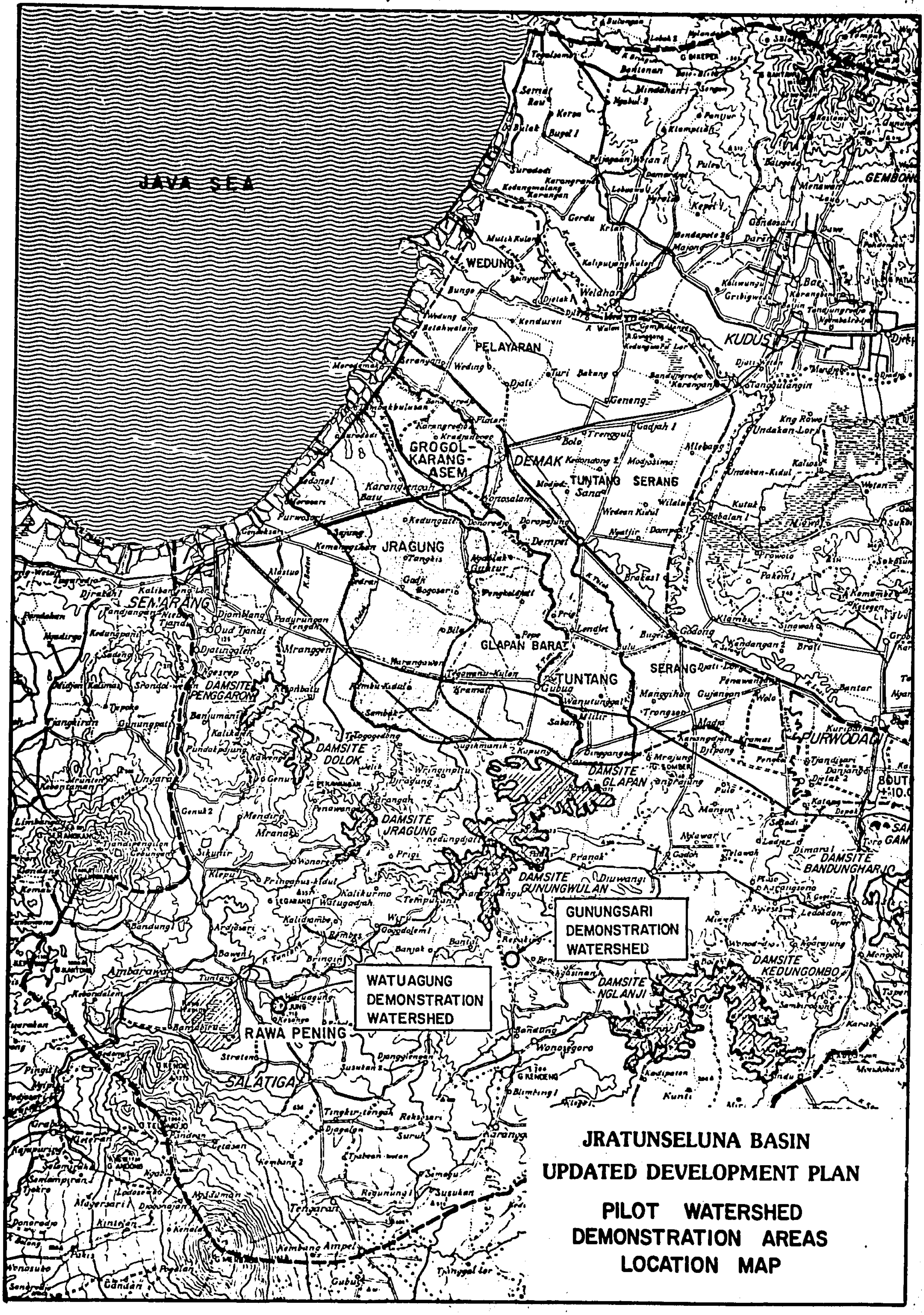
5. The training of all project staff members should concentrate on the team approach to solving the upper watershed problems, as well as developing a respect for the opinions and abilities of the upland farmer and his family. It is only when the farmer believes that the staff members are trying to solve his problems that there is any real chance for a long-term reduction in the erosion rates of the Basin.

6. Conservation education programs should be developed to reach both sexes, all age levels, and economic groups. The programs should also stress economic and social development programs to improve the economic position of the upland watershed residents.

   People selected and trained as Desa Conservation Technicians should, where possible, come from the project area because they must understand the local culture and the institutional strengths and weaknesses in order to be more effective in motivating the local people to action. A program should be initiated to locate, recruit, train, and continuously upgrade the training of the needed conservation technicians for optimum project development. This training program should emphasize cooperative planning methods, as well as the necessary conservation farming techniques.

7. The upland farmers' leadership ability and their sense of cooperation and mutual assistance must be strengthened if they are to adopt the watershed management program and to commit themselves to long-term conservation farming methods and maintenance of project measures after the government assistance is stopped.

8. Implementation activities of the upper watershed management program should concentrate on upland farmers' organizations (Kelompok Conservation Action Units) that are based on small hydrologic units. These organizations should function as the primary mechanism for farmer conservation education; planning of conservation activities; utimately, for community development and for providing guidance to the project staff for watershed management.



JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN

PILOT WATERSHED DEMONSTRATION AREAS LOCATION MAP

BIBLIOGRAPHY