DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

JRATUNSELUNA BASIN UPDATED DEVELOPMENT PLAN

PART I

TUNTANG/JRAGUNG RIVERS BASINS
INTEGRATED DEVELOPMENT PLAN

PART II

TUNTANG AND RELATED RIVERS BASINS
DEVELOPMENT PLAN

APPENDIX D

PROJECT PLANNING

MAY 1980

SUBMITTED BY

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

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PREFACE

The Directorate General of Water Resources Development (DGWRD) of the ministry of Public Works, Government of Indonesia (GOI) contracted PRC Engineering Consultants, Inc. (PRC/ECI) to provide consulting engineering services for preparing an integrated development plan for the Tuntang/Jragung Rivers in the Jratunseluna Basin. The study for the preparation of the plan started on May 16, 1979 and was originally scheduled to be completed on November 30, 1979.

An interim report on the study was submitted by PRC/ECI on August 15, 1979 which was reviewed by all the concerned agencies and later discussed on September 24, 1979 in a meeting held by the DGWRD at Jakarta. In that meeting and in subsequent discussions between PRC/ECI and DGWRD, it was the consensus of opinion of all the participants that it would be very beneficial if the study on the Tuntang/Jragung Rivers could be modified by including the entire Jratunseluna Basin in certain aspects of the study. In that modified study the interrelationships of the existing, proposed and the potential development works of the Tuntang/Jragung Subbasins and those of the adjoining subbasins within the Jratunseluna Basin should be examined. Thus, the master plan for the development of the Jratunseluna Basin which was prepared earlier by NEDECO in the year 1973, would be reviewed and updated insofar as it related to the development of water resources for providing irrigation and Municipal and Industrial water supplies to the project areas.

The changes in criteria and constraints which have occurred and the large amount of new data which have become available since preparation of the original master plan would be incorporated in the modified study for formulating a conceptual optimized development plan. The attention of the reader is drawn to the basic assumptions made in this regard in the study and described in Section D.1.2. of Part II of this Appendix. The original contract between GOI and PRC/ECI for the engineering services was, therefore, amended to include the revised scope of work for the modified study.

For the preparation of the integrated development plan for the Tuntang/Jragung Rivers, as contemplated originally, a report was prepared on Project Planning for supporting the proposed plan. That report is being produced as Appendix D - Part I, Project Planning, related to the Tuntang/Jragung Rivers Basins Integrated Development Plan.

The above mentioned modified study to update the Master Plan for the Jratunseluna Basin was started in December 1979 and completed in May 1980. The results of that study pertinent to the planning of the development works done by the consultant to support the proposed plan are reported in this document as Appendix D - Part II, Project Planning, related to the Tuntang and Related Rivers Basins Development Plan.

Semarang, May 1980 PRC Engineering Consultants, Inc.

PART I

TUNTANG/JRAGUNG RIVERS BASINS
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PROJECT PLANNING

D.1. INTRODUCTION

The appendix describes the rationale behind, and the methods used in the planning studies carried out in the Tuntang/Jragung River Basins. As with most modern water resource development activities, development within the subject basin will of necessity require utilization of the basins water for a number of purposes. Present and potential water uses within the basin include irrigation, municipal and industrial water for the city of Semarang and water for the generation of hydroelectric power.

Basin planning requires that each structure or project element proposed be physically and economically viable as an individual project, but even more important, that all planned elements eventually function effectively together to meet the ultimate water and power requirements of the basin. It is possible that a single project or element may be originally designed to serve a particular function during one period of time, and as other planned project elements are implemented, changes in the operation of the initial elements allow it to serve a modified or different function.

This part of the report (Appendix D - Part I) serves as a planning report covering the many physical, social and economic aspects which are of necessity considered. This Appendix will deal more specifically with plan formulation, that is, the procedures used to evaluate all pertinent information and identify an economically and physically feasible array of elements so phased to meet the growing water requirements of the basins' population.

Subjects discussed in detail in other appendices and special reports [3, 4, 5] include, but are not limited to, hydrologic data, examination of the pattern of existing and future demands for irrigation water, demand for municipal and industrial water supply, existing power generation and future power requirements, geologic conditions at various potential storage sites and the economic data for the project area.

The planning study considers single element developments, various combinations of development elements, various irrigation service areas, varying M & I water supply rates and transbasin diversions as well as power generation and power potential associated with development.

An earlier study of the Jragung and Tuntang basins was completed in 1973 by NEDECO when they developed the "JRATUNSELUNA BASIN DEVELOPMENT PLAN" [1]. A number of single element developments were considered at that time and a number of these are included herein, but in conjunction with other elements.

Other studies previously conducted in the basin are discussed and described in detail in the Interim Report, Integrated Development of the Tuntang/Jragung River Basins submitted by PRC/ECI in August of 1979 [2].

D.2. BASIN DESCRIPTION

D.2.1. Project Area

The Tuntang and Jragung Rivers Basins extend from the eastern and southern slopes of the volcanoes Ungaran, Telomoyo, and Merbabu to the northern coast of Java. The Tuntang and Jragung Rivers are two of several rivers draining the plain and adjacent highland to the east of Semarang and flowing into the Java Sea. The total area is referred to as the Jratunseluna Basin and has an area of approximately 7,400 km^2. The word Jratunseluna originates from the names of the five major rivers within the basin - JRAgung, TUNtang, SErang, LUsi and JuaNA.

The location of the project area within the basin is shown in Figure D-1.

The climate in the project area is characterized by two distinct seasons; the wet season from November through May and the dry season from June through October. The annual rainfall on the coastal plain averages between 2,000 and 2,500 mm and the average annual precipitation on the upper watershed area is about 2,700 mm.

D.2.2. Water Resources

D.2.2.a. Surface Water

The mean annual discharge of the Jragung River at Borangan bridge is 3.82 m^3/s. This represents an average annual runoff of 1,280 mm over the 94 km^2 catchment and an annual runoff volume of 121 x 10^6 m^3.

The mean annual discharge of the Tuntang River at the proposed Gunung Wulan damsite is estimated at 24.4 m^3/s. This represents an average annual runoff of 1,150 mm over the 659 km^2 catchment and an average annual runoff volume of 770 x 10^6 m^3. An additional 110 x 10^6 m^3 of local inflow reaches the Tuntang between the Gunung Wulan damsite and the Glapan Weir.

Full information on the basins surface water resources is found in Appendix A - Part I, Hydrology.

D.2.2.b. Groundwater

The geology of the Jratunseluna Basin has been analyzed on a number of occasions in attempts to locate or quantify groundwater supplies or potential. Basic conclusions are that the coastal plains are unlikely to provide groundwater in suitable quantity or quality to be of significance. Groundwater potential is relatively more favorable in the volcanic uplands. These sources are yet unproven and no attempt has been made in these planning studies to incorporate groundwater supplies into this basin plan. Further information on basin groundwater conditions may, however, be found in Special Report I, Tuntang/Jragung River Basins, Municipal and Industrial Water Supply [3].

D.2.3. Water Use in Basin

D.2.3.a. Present Use - Irrigation

Water is presently diverted from both the Jragung and Tuntang Rivers at the Jragung and Glapan Weirs, respectively. Full dry season water supplies are available to some 6,000 ha in the Tuntang System but dry season supplies are not adequate for any year-round irrigation in the Jragung System. Current practices and irrigation usage is discussed in Appendix B-Part I, Irrigation and Agriculture.

D.2.3.b. Present Use - Municipal and Industrial Water

The city of Semarang presently uses 805 l/s to meet a part of their requirements, out of which 303 l/s is derived from springs, 17 l/s from wells and 485 l/s from the Kali Garang. Details are given in Special Report No. I, Tuntang/Jragung River Basins, Municipal and Industrial Water Supply [3].

D.2.3.c. Present Use - Hydropower

Two hydro plants are currently operated on the upper reaches of the Tuntang below Rawa Pening. Combined installed capacity of the Jelok and Timo Power Plants is 32.5 MW, however, their maximum generating capacity is limited to about 26.0 MW. Current operation produces approximately 50 Gwh of firm energy and 110 Gwh of secondary energy annually. Details are presented in Appendix C-Part I, Dams and Hydropower.

D.3. NEED FOR WATER RESOURCES DEVELOPMENT

D.3.1. Irrigation

There are 35,000 ha of irrigable land in the basin below the existing Glapan and Jragung Weirs. Accurate estimates of the number of hectares of land receiving a full (year-round) water supply are difficult to derive. Present cropping patterns presented in Appendix B - Part I indicate that some 6,000 to 7,000 ha could be considered to have firm water supplies for two to three rice crops per year. Optimum water resources development in the basin would dictate that the entire 35,000 ha be provided a full water supply if possible.

D.3.2. Municipal and Industrial Water

One of the most serious water problems in the basin at present is the short supply of municipal and industrial water for the city of Semarang. Projections developed in Special Report No. I - Tuntang/Jragung River Basins, Municipal and Industrial Water Supply [3] indicate a total need of 6,010 l/s by the year 2000 while the present supply is only 805 l/s. A portion of these municipal and industrial water supplies should be developed within the basin. In the planning process municipal and industrial water is supplied through various project elements in quantities ranging from 2,000 to 4,000 l/s at ultimate development. The maximum amount of M & I water economically available from the Tuntang/Jragung Rivers Basins, without unfairly depriving other potential users is considered to be 4,000 l/s.

D.4. IDENTIFIED POTENTIAL FOR ACCOMPLISHING REQUIRED DEVELOPMENT

Appendix C - Part I outlines in detail all sites with development potential considered in this planning study. The sites for storage, diversions, delivery and power generation are shown schematically in Figure D-2.

D.5. BASIN MODEL DEVELOPMENT

D.5.1. General

A computer model of the Tuntang/Jragung Basin was developed to simulate multi-reservoir operation. The plan, or arrangement, of a water resources project may be considered as a system. The project formulation of the system is sometimes referred to as system design. The development of the water resources of the Tuntang/Jragung Rivers Basins constitutes a relatively complex system which may be created with different combinations of system elements (reservoirs, diversions, power plants, canals etc.), levels of output, and allocation of capacity of the units to various purposes at different times. The objective of system design is to select the combination of these variables that maximize net benefits in accordance with requirements of criteria imposed. The maximization is subject to many constraints. In the case of the Tuntang/Jragung Rivers Basins, constraints are technical, budgetary, social and administrative. The optimal plan or an array of elements is subject not only to technical limitations but economic and sociopolitical limitations as well.

In the case of this basin a large number of combinations can be arranged. By utilizing the basin model, it was possible to consider a large number of different project element combinations simultaneously. A basin model makes it possible to simulate the behavior of relatively complex water resources elements for periods of any desired length; to perform numerous and repetitive computations needed for many combinations of system variables, and finally to evolve an optimal or near optimal design of the system.

The basin model of the Tuntang/Jragung Basin developed by PRC/ECI during this study considers storage at four sites, diversion of water from subbasin to subbasin, power generation at two existing and two proposed hydroelectric plants, municipal and industrial water supply from two points on the system and irrigation demands at the Jragung and Glapan Weirs. All studies utilizing the basin model were performed on the IBM 370 computer system at the DPU Computer Center in Jakarta.

D.5.2. Model Features

The model utilizes monthly inputs of streamflow and irrigation water requirements and in turn computes monthly volumes of reservoir inflows, reservoir evaporation, irrigation releases, spill and shortage. In addition it computes the ending storage and water surface elevation at each storage site and the monthly firm and secondary energy produced at the existing power plants on the upper Tuntang as well as Jragung and Gunung Wulan Reservoirs.

Twenty-one years of record were used in simulating operation of single elements as well as total development packages including a number of elements. The ways in which the model handles storage, transbasin diversion, provision of municipal and industrial water, computes shortages, spills and releases are discussed in the following sections.

D.5.2.a. Storage

As discussed in Appendix C-Part I, four storage sites were identified as being potentially attractive from both a technical and economical viewpoint. The model includes the potential for storage of water at these four points on the system; Rawa Pening, Gunung Wulan and Glapan sites on the Tuntang and the Jragung damsite on the Jragung River. Storage capacity at each site may be adjusted from zero (run-of-river conditions) to the maximum feasible storage at the site. Releases from Rawa Pening can be governed by either power or irrigation demands, while releases from the remaining three sites are governed by irrigation demands only.

Sediment passing, as discussed in Appendix A-Part I and C-Part I can be simulated at any or all of the downstream reservoir sites as desired.

D.5.2.b. Transbasin Diversion

An integral part of basin development is the transfer of water from the Tuntang Subbasin to the Jragung Subbasin. The model incorporates such a diversion to increase water availability as required. Two operational rules govern the diversion of water in the final version of the model.

With the exception of the months of March, April and May, water is diverted to Jragung only if irrigation shortages exist at the Jragung service area. If storage is provided at Jragung, sediment would be bypassed during the months of December, January and February and diversion to the storage in March, April and May is governed by the storage capacity remaining. In cases where the flow available at the diversion is of a magnitude less than the total irrigation demands at Jragung and Tuntang the available flow is proportioned in direct proportion to the two demands.

D.5.2.c. Municipal and Industrial Water

Provision is made in the model to allow delivery of any amount of municipal and industrial water from four points in the system. Municipal and industrial water may be diverted from Muncul Springs, above Rawa Pening, from Rawa Pening itself, from Jragung at the reservoir or from river diversion, as well as from Gunung Wulan on the Tuntang.

In addition to the municipal and industrial water for Semarang the model incorporates river maintenance flows to assure that residents presently using the river water would have continued use of that water in the event of constructed storage on either river.

D.5.2.d. Reservoir Releases

As stated, releases from Rawa Pening were governed by power in some early runs. The review by the Directorate General of Water Resources Development of PRC/ECI's Interim Report [2] and the subsequent review meeting revealed that if secondary power generation could be maintained to between 80 and 90 percent of present production, Rawa Pening releases could be governed by irrigation. As a result, all model runs herein reported control Rawa Pening releases based on downstream irrigation demands.

Irrigation shortages, as considered by the model, occur when that month's irrigation demand cannot be met from the combination of inflow and storage at a given site. These monthly shortages in 10^6 m^3 are totaled for each year, the annual totals computed and the total annual shortages subsequently accumulated allowing determination of the average annual shortage for the twenty-one year simulation period. If the shortage volume in any given month is greater than 5 percent of the irrigation demand volume for that month a month of shortage is counted. To compute irrigation firmness the total number of months during which shortages are counted is divided by 252 (number of months in the simulation period), the quotient representing the percent of time during which shortages occur. Firmness is then 100 percent less the percent of time which the shortages occur.

In the case of all four reservoir sites, monthly evaporation is estimated based on the water surface area and average free water surface evaporation as described in Appendix A-Part I and is subtracted from reservoir storage and inflow to relate true available water supply.

At Gunung Wulan and Glapan the only reservoir demand recognized is the irrigation demand. If reservoir storage plus monthly inflow volume meet or exceed that demand then the controlled release is equal to that demand. If reservoir storage plus monthly inflow volume is not equal to the irrigation demand all water is released from the reservoir and a shortage exists.

In those alternatives where storage at Jragung is provided the primary demand is the irrigation demand. In addition to the irrigation demand the reservoir is also called upon to supply municipal and industrial water at the rate of up to 2,000 l/s in some alternatives. Actual outflows are handled by the model as for the other reservoirs. Using the stage storage relationships which are included in the model the ending elevation of the reservoirs water surface for each month is computed.

D.5.2.e. Hydropower Features

The model includes generation of hydroelectric power at four points. The existing Jelok and Timo plants on the upper Tuntang are model elements. As stated previously, the releases from Rawa Pening are governed by downstream irrigation demands in the model. The turbine release to Jelok and Timo is limited to the irrigation release plus spill up to the present peaking capacity of 26 MW. The remaining excess water which cannot be released through the power plant is discharged to the Tuntang at the weir.

In alternatives where Gunung Wulan and Jragung Dams are considered, power plant installations of 10 MW and 6 MW respectively are introduced into the model. At each site the model uses the controlled releases and excess flows up to the capacity of the plant to compute hydropower generation. The energy in Gwh which can be generated each month is determined. The model computes both firm energy and secondary energy with firm energy defined as that which can be generated on a continuous basis for 100 percent of the time. Because of the empty reservoir at Jragung during sediment by-pass in December, January and February and because of irrigation release patterns at Gunung Wulan no firm power is generated at these plants.

D.5.3. Model Inputs

D.5.3.a. Inflows

In computing total monthly inflow at the diversion site, the model considers the local watershed yield from the catchment area between Rawa Pening and the diversion point and adds this volume to that months' release from Rawa Pening.

For sites further downstream similar procedures are used. Local inflow is added to the release from the upstream structure.

At Jragung the inflow from the Jragung River is added to the monthly diversion volume to establish the total monthly reservoir inflow.

Streamflow records for Rawa Pening and Glapan are available for the period from water year 1953 through water year 1973. The Rawa Pening data are presented in Table D-1.

Inflow records at the transbasin diversion site were generated by reducing the inflows at Glapan using drainage basin ratio to derive inflows at the site, and subtracting Rawa Pening releases. Thus, the inflows generated represent only the natural runoff from the catchment between Rawa Pening and the diversion site. These records were generated for the period 1953 through 1973 and appear in Table D-2. In model operation, these flows are added to Rawa Pening release to obtain the available flow at the diversion site.

Inflow records at the Gunung Wulan Dam were also generated for the same period of time by reducing flows at Glapan by drainage area proportion and subtracting Rawa Pening releases. These data appear in Table D-3. Using the above procedure resulted in some negative flow values, which are negligible. These negative values were retained as they represent a use between Jelok Weir and the damsite. Total site inflow volume for a given month is the natural runoff from the intermediate catchment plus Rawa Pening release less the amount diverted from the Tuntang to the Jragung.

The drainage area between the Gunung Wulan damsite and the Glapan Weir is 127 km^2. The local inflow between Gunung Wulan and Glapan was generated for the period 1953 to 1973 by subtracting the Gunung Wulan inflows without release from Rawa Pening from the Glapan inflows without release from Rawa Pening. These data are presented in Table D-4. This procedure also resulted in negative flow values at the Glapan Weir. These too were retained as they represent an existing use between the Gunung Wulan site and the Glapan Weir.

Jragung reservoir inflows can come from two sources, the Jragung River and the Tuntang diversion. Jragung flows for the period of record were derived by the runoff-rainfall model for the watershed developed by PRC/ECI in 1976 when updating the Jragung Feasibility Report [6]. These data are presented in Table D-5. Total site inflow is represented in the model by the natural runoff plus the flow diverted from the Tuntang.

D.5.3.b. Irrigation Requirements

In developing the basin plan, one major objective was to attempt to serve the total irrigable land in the basin. The total area to be served is 35,000 ha; 11,625 ha on the Jragung and 23,375 ha on the Tuntang. The service areas are shown in Figure D-3. The model has the flexibility to allow shifting of lands from one service area to the other so the above breakdown is simply the models norm.

The cropping patterns projected for the project area in the future are developed in Appendix B. The water requirements for the recommended cropping pattern are entered into the model as total monthly volume demands on each system with the normal areal distribution of lands.

Irrigation demands expressed as monthly volumes were computed using an additional program which used as input the computed average monthly evapotranspiration and service area monthly rainfall for the period 1953 to 1973. The service area monthly rainfall data were generated in accordance with procedures described in Appendix A. These data are summarized in Table D-6.

Crop water requirements were reduced by effective rainfall (RE) which was estimated from the monthly rainfall (RF) data using the relationship:

$$RE = 1.8\ (RF)^{0.8}$$

An average overall irrigation efficiency of 50 percent is assumed on the systems. Fifty percent of the excess water diverted, that is 25 percent of the total diverted can be applied to additional area as return flow at a total efficiency of 60 percent. Fifteen percent of the total area can thus be served by return flow. Water releases from reservoir sites for irrigation would then be necessary only for 10,095 ha on the Jragung and 20,340 ha on the Tuntang. The balance of 4,565 ha would be irrigated as return flow areas.

Using the recommended cropping pattern, irrigation demands on the Jragung and Tuntang (full development) are summarized in Tables D-7 and D-8 respectively. For comparison, similar demands were generated for a cropping pattern of two rice crops plus one upland crop per year. Under this pattern, demands on the Jragung and Tuntang are summarized in Tables D-9 and D-10 respectively.

During the development and refinement of the basin model and in the final phase of the study over 1,000 computer runs were made. A summary of pertinent runs is presented in Table D-42.

TABLE D-1

MODEL INPUT DATA

MONTHLY INFLOWS INTO RAWA PENING IN 10^6 m^3

Month / Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	20.09	45.62	40.98	40.99	38.95	61.60	69.98	68.57	31.88	25.98	16.87	13.74
1953-54	9.91	19.96	28.39	41.78	39.19	45.00	40.44	39.91	26.96	22.77	30.27	18.66
1954-55	17.95	45.88	43.66	42.32	32.66	52.50	52.76	50.35	30.07	51.69	33.75	25.66
1955-56	23.84	30.07	32.41	67.23	30.86	40.18	27.99	24.91	44.58	22.77	27.86	18.14
1956-57	16.87	21.00	39.64	46.87	27.58	74.19	46.66	37.77	17.63	42.85	18.48	16.85
1957-58	13.39	15.81	45.80	45.80	71.85	65.35	76.20	58.12	31.62	45.53	35.35	22.81
1958-59	28.66	23.07	59.73	50.35	62.42	57.05	53.14	67.50	42.51	49.55	21.43	16.07
1959-60	21.70	19.96	41.25	41.25	57.13	43.93	53.65	55.44	27.73	31.61	17.14	14.77
1960-61	18.75	34.21	30.80	49.55	30.48	39.10	27.96	46.60	23.33	23.03	16.61	11.40
1961-62	11.78	15.81	19.82	38.03	33.87	41.78	58.58	33.48	25.66	21.43	24.11	11.92
1962-63	18.75	23.07	31.31	38.30	33.38	54.10	40.69	28.39	17.28	14.73	11.78	14.77
1963-64	12.86	15.03	20.09	23.84	31.57	32.68	35.77	31.87	23.07	16.87	15.53	15.55
1964-65	30.53	35.51	27.59	42.85	36.77	36.96	32.66	19.28	14.26	14.73	13.12	9.85
1965-66	10.45	14.77	25.18	36.43	43.30	57.32	37.34	26.52	22.03	15.00	7.50	11.66
1966-67	20.89	19.15	42.32	43.12	48.15	36.96	66.17	31.34	16.85	13.93	12.05	11.92
1967-68	10.98	12.96	27.86	40.44	46.35	47.94	46.69	54.10	43.03	44.19	48.21	21.00
1968-69	22.50	31.88	45.80	53.03	59.03	39.46	72.52	39.37	32.92	22.77	15.53	12.70
1969-70	13.39	27.22	43.39	31.34	35.56	54.64	47.95	46.34	27.73	31.87	15.27	15.03
1970-71	13.93	26.18	31.07	31.87	38.47	40.44	43.03	44.73	36.55	23.57	13.66	13.74
1971-72	24.11	43.03	51.37	39.91	41.59	57.32	42.25	46.60	22.03	19.28	15.20	13.20
1972-73	10.45	14.00	24.37	42.05	41.61	39.77	44.06	63.48	39.92	31.07	21.16	35.51

TABLE D-2

MODEL INPUT DATA

MONTHLY FLOWS IN 10^6 m^3 AT TUNTANG DIVERSION SITE WITHOUT RAWA PENING RELEASE

Month / Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	1.46	11.59	9.89	13.68	11.01	10.03	18.92	16.64	2.12	1.12	0.00	.20
1953-54	.27	3.94	7.05	11.00	12.04	11.11	9.20	6.48	3.50	1.81	2.09	1.08
1954-55	2.82	10.55	8.50	10.93	8.15	8.27	7.58	4.98	2.26	6.03	2.09	.54
1955-56	1.32	8.69	6.51	17.55	11.98	5.33	1.15	1.50	5.36	.31	1.81	.64
1956-57	.69	3.27	10.10	7.49	4.40	17.55	8.66	2.23	.57	2.96	-.42	-.80
1957-58	-.28	1.15	10.62	8.25	20.89	20.58	16.34	12.64	3.74	6.62	8.08	1.75
1958-59	2.22	2.76	20.89	18.13	10.72	7.91	15.43	13.54	4.95	8.84	1.67	.24
1959-60	1.39	3.17	16.40	9.67	12.79	9.82	8.83	6.48	.91	1.60	-.14	-.54
1960-61	.41	6.33	4.84	12.99	6.32	11.45	6.03	8.36	.71	0.00	-.35	-.81
1961-62	.68	.61	1.15	69.6	7.74	12.99	15.43	3.65	.37	.63	1.22	-.47
1962-63	.38	6.44	10.31	15.49	6.64	15.25	7.28	1.43	0.00	-.03	-.14	-.24
1963-64	-.52	.44	5.47	3.76	7.05	7.55	8.02	7.47	1.95	-.14	-.11	-.03
1964-65	3.71	6.50	3.03	10.48	9.37	11.77	7.01	.10	.27	.25	-.07	-.30
1965-66	-.35	3.04	2.82	6.27	5.98	16.50	5.02	1.53	1.52	.66	-.59	-.17
1966-67	1.57	1.85	11.56	9.12	11.57	6.75	7.99	.87	1.01	1.29	-1.71	-1.35
1967-68	-.21	.13	4.32	11.63	7.61	10.31	8.93	13.51	8.63	5.64	2.54	-.06
1968-69	2.68	8.35	6.93	7.66	15.19	15.39	20.05	2.54	1.45	.84	-.56	-.54
1969-70	.11	1.78	5.05	3.52	2.74	13.40	5.42	4.21	1.35	.84	0.00	.88
1970-71	.59	2.86	5.36	6.23	8.73	9.37	9.16	6.41	3.81	.45	-.42	-.71
1971-72	1.50	4.78	11.00	14.48	4.15	8.50	11.96	5.22	-.10	.69	-.17	-.78
1972-73	-.76	4.65	9.30	9.26	6.10	10.41	14.46	18.28	3.30	3.24	.42	2.26

TABLE D-3

MODEL INPUT DATA

MONTHLY INFLOWS TO GUNUNG WULAN WITHOUT RELEASES FROM RAWA PENING 10^6 m^3

Year \ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	8.47	67.14	57.27	79.26	63.76	58.08	109.59	96.40	12.30	6.46	0.00	1.17
1953-54	1.66	22.82	40.81	63.74	69.77	64.34	53.29	37.51	20.30	10.49	12.12	6.25
1954-55	16.34	61.09	49.21	63.33	47.18	47.80	43.91	28.84	13.08	34.90	12.10	3.12
1955-56	7.67	50.36	37.71	101.65	69.40	30.86	6.64	8.67	31.03	1.82	10.49	3.71
1956-57	4.03	18.93	58.48	43.36	25.50	101.65	50.16	12.91	3.32	17.14	-2.42	-4.68
1957-58	-1.61	6.64	61.51	47.80	121.02	119.20	94.66	73.21	21.66	38.32	46.79	10.15
1958-59	12.91	16.00	121.01	104.99	62.12	45.79	89.39	78.45	28.69	51.23	9.68	1.37
1959-60	8.07	18.35	95.00	50.22	74.07	56.87	51.14	37.51	5.27	9.28	-.81	-3.12
1960-61	2.42	36.69	28.03	75.23	36.61	66.35	34.94	48.40	4.10	0.00	-2.01	-4.68
1961-62	-3.95	3.51	6.65	40.34	44.81	75.23	89.39	21.17	2.15	3.63	7.06	-2.73
1962-63	2.22	37.32	59.69	89.75	38.44	88.34	42.16	8.27	0.00	-.21	-.81	-1.37
1963-64	-3.03	2.54	31.66	21.78	40.81	43.76	46.45	43.26	11.32	.81	-.61	-0.20
1964-65	21.50	37.67	17.55	60.70	50.28	68.19	40.60	.61	1.56	1.42	-.40	-1.76
1965-66	-2.02	-1.76	16.34	36.30	34.61	95.59	29.08	8.88	8.78	3.84	-3.43	-0.98
1966-67	9.07	10.73	66.96	52.84	67.04	39.12	46.26	5.04	5.86	7.46	-9.89	-7.81
1967-68	-1.21	.78	25.00	67.36	44.08	59.70	51.72	78.25	49.97	32.67	14.72	-0.39
1968-69	15.53	48.40	40.13	44.37	87.99	89.14	116.13	14.70	8.39	4.84	-3.22	-3.12
1969-70	.61	10.34	29.24	20.37	15.85	77.64	31.42	24.41	7.81	4.84	-0.00	5.07
1970-71	3.43	16.59	31.06	36.10	50.59	54.25	53.04	37.11	22.06	2.62	-2.42	-4.10
1971-72	8.67	27.72	63.74	83.90	24.04	49.21	69.29	30.26	-0.59	4.03	-1.01	-4.49
1972-73	-4.43	26.93	53.85	53.65	35.34	60.30	83.73	105.88	19.13	18.76	2.42	13.08

TABLE D-4

MODEL INPUT DATA

MONTHLY FLOWS IN 10^6 m^3 AT GLAPAN BARRAGE GENERATED ON THE CATCHMENT BETWEEN GUNUNG WULAN AND GLAPAN

Month / Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	2.41	22.02	16.34	22.60	27.48	16.57	36.08	27.50	4.03	1.83	0.00	.39
1953-54	1.27	7.51	11.55	18.17	29.50	18.34	17.47	10.70	6.66	2.99	2.65	2.04
1954-55	4.65	20.03	14.03	18.06	19.95	13.63	10.52	8.22	10.67	9.94	3.45	1.03
1955-56	2.18	16.51	10.76	28.79	29.35	8.80	2.17	2.47	10.18	.51	2.99	1.21
1956-57	1.15	6.21	16.69	12.37	10.80	28.99	16.45	3.68	1.09	4.89	-.69	-1.54
1957-58	-.46	2.17	17.48	13.58	50.96	33.87	30.96	20.81	7.09	10.87	13.30	3.32
1958-59	3.67	5.24	34.36	29.95	26.20	13.00	29.23	22.30	9.38	14.56	2.75	.44
1959-60	2.29	5.99	27.00	14.27	24.61	16.17	16.72	10.67	1.72	2.63	-.23	-1.02
1960-61	.69	12.00	7.97	21.37	15.45	18.86	11.42	13.76	1.34	0.00	-.58	-1.54
1961-62	.97	1.15	1.90	11.50	18.90	21.38	29.23	60.25	.70	1.03	2.00	-.89
1962-63	.63	0.00	16.97	25.05	16.21	25.10	13.78	2.35	0.00	0.00	0.00	-.44
1963-64	-.85	.83	9.00	6.19	17.20	9.85	15.19	12.42	3.70	.23	-.43	-.35
1964-65	6.21	12.31	4.98	17.26	22.90	19.35	13.27	1.67	.51	.39	-1.18	-.57
1965-66	-.57	-.57	4.64	10.32	14.60	27.18	9.55	2.52	2.87	1.08	-.77	-.32
1966-67	2.58	3.52	19.03	15.02	28.27	11.11	15.12	1.44	1.91	2.12	-2.80	-2.55
1967-68	.34	.26	7.12	19.14	18.60	16.96	16.92	22.24	16.33	9.29	4.19	-1.28
1968-69	4.41	15.83	11.41	12.61	37.10	25.34	37.97	4.21	2.75	1.38	-.92	-1.02
1969-70	.17	3.39	8.31	5.79	6.68	28.76	10.28	6.93	2.55	1.38	0.00	1.66
1970-71	.97	5.42	8.83	10.26	21.41	15.42	30.61	10.54	7.21	.75	-.69	-1.34
1971-72	2.47	9.06	18.10	23.84	10.14	13.99	22.65	8.59	-.18	1.15	-.28	-1.47
1972-73	1.27	8.81	15.04	15.24	14.91	17.14	27.38	30.09	6.25	5.32	.69	4.27

TABLE D-5

MODEL INPUT DATA

MONTHLY FLOWS IN 10^6 m^3 AT JRAGUNG DAMSITE

Month / Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	3.40	6.20	10.10	11.70	9.30	17.80	13.30	12.70	.10	1.20	0.00	0.00
1953-54	0.00	9.40	7.90	12.50	23.00	13.70	7.60	11.60	1.50	1.00	2.00	5.20
1954-55	4.40	28.10	10.10	12.40	32.50	12.50	16.00	14.70	3.30	6.60	3.20	2.20
1955-56	6.60	13.00	14.60	70.90	21.80	15.80	4.10	11.00	6.10	.90	4.10	0.00
1956-57	1.20	3.80	17.80	16.10	14.30	20.20	7.10	4.70	3.80	5.20	1.40	0.00
1957-58	2.30	7.50	32.90	15.50	34.10	19.90	17.60	10.60	5.10	12.30	9.40	.30
1958-59	3.70	5.00	16.60	23.60	12.20	10.20	16.30	14.80	2.30	4.80	0.00	1.60
1959-60	1.70	2.70	18.20	20.00	25.90	7.40	10.00	9.90	1.20	.70	0.00	0.00
1960-61	.50	20.80	8.50	77.30	9.20	22.50	4.40	13.80	0.00	0.00	0.00	0.00
1961-62	0.00	5.20	11.40	40.40	32.00	36.10	26.70	3.40	2.60	4.10	2.70	0.00
1962-63	6.10	5.80	13.20	63.70	13.50	24.20	11.00	1.40	0.00	0.00	0.00	0.00
1963-64	0.00	2.40	15.00	14.20	17.30	10.10	19.20	9.00	3.90	.90	.70	4.70
1964-65	7.40	18.40	10.70	73.90	18.80	18.20	10.30	4.20	.70	.20	0.00	0.00
1965-66	0.00	4.30	14.00	20.20	31.70	30.80	5.90	4.70	3.40	0.00	0.00	0.00
1966-67	10.60	5.00	12.50	21.70	29.70	17.80	19.00	.70	0.00	0.00	0.00	0.00
1967-68	.30	7.30	13.50	19.00	31.30	11.10	12.80	17.80	15.50	8.50	3.90	.70
1968-69	2.10	9.50	29.20	8.10	10.50	11.20	30.30	.80	.80	0.00	0.00	0.00
1969-70	.90	7.00	6.00	13.60	13.80	31.20	13.20	15.80	2.30	3.10	0.00	0.00
1970-71	2.80	9.70	22.30	33.30	37.10	21.00	11.80	7.50	6.10	1.00	0.00	0.00
1971-72	6.40	8.90	7.20	40.40	11.20	40.50	8.20	.80	0.00	0.00	0.00	0.00
1972-73	0.00	4.60	10.80	27.40	19.70	18.00	24.10	22.40	5.90	4.00	.30	5.60

TABLE D-6

MODEL INPUT DATA

SERVICE AREA MONTHLY RAINFALL (mm)

Month Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	151	255	245	251	227	232	273	145	26	56	13	7
1953-54	32	236	254	473	322	180	167	239	113	91	137	143
1954-55	174	422	283	205	376	241	205	151	72	138	136	74
1955-56	158	288	265	421	273	177	93	97	117	63	126	106
1956-57	209	181	322	256	234	274	206	51	33	129	51	17
1957-58	83	167	306	182	519	332	210	127	74	104	236	96
1958-59	126	155	434	322	178	181	267	121	53	137	14	70
1959-60	65	197	279	452	364	212	156	120	40	27	0	54
1960-61	86	367	224	651	259	181	207	314	20	3	0	1
1961-62	34	139	243	624	458	303	283	26	38	76	111	14
1962-63	140	163	259	764	429	164	250	10	4	0	0	1
1963-64	43	93	336	228	170	263	266	130	73	17	36	183
1964-65	275	193	325	604	295	202	120	99	63	10	0	0
1965-66	12	204	272	274	361	203	139	111	109	4	4	29
1966-67	264	127	230	460	367	213	220	30	3	0	12	3
1967-68	109	205	331	595	370	228	160	240	122	189	96	117
1968-69	187	355	376	202	325	259	178	40	44	16	8	51
1969-70	105	173	220	295	297	281	218	191	37	81	2	68
1970-71	110	215	299	391	464	292	239	226	128	7	2	44
1971-72	191	288	316	621	200	412	128	124	5	0	17	10
1972-73	3	331	296	367	316	414	219	324	123	74	56	202

TABLE D-7

MODEL INPUT DATA

JRAGUNG MONTHLY IRRIGATION DEMANDS IN $10^6 m^3$

RECOMMENDED CROPPING PATTERN - NOVEMBER START

Year \ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	0.00	29.69	5.42	3.60	0.00	22.63	3.70	14.39	21.13	32.13	30.12	32.38
1953-54	6.09	31.22	4.70	0.00	0.00	26.97	12.45	6.41	11.94	28.53	16.96	17.77
1954-55	0.00	17.04	2.41	7.36	0.00	21.90	9.21	13.86	15.97	24.11	17.05	24.34
1955-56	0.00	27.08	3.82	0.00	0.00	27.23	19.24	18.86	11.57	31.38	17.97	21.19
1956-57	0.00	35.81	0.00	2.40	0.00	19.26	9.13	23.59	20.27	24.93	25.44	30.90
1957-58	0.55	37.01	0.62	9.30	0.00	14.78	8.79	16.02	15.75	27.27	8.51	22.15
1958-59	0.00	38.07	0.00	0.00	4.10	26.89	4.17	16.58	17.98	24.20	29.97	24.75
1959-60	2.39	34.45	2.72	0.00	0.00	24.28	13.41	16.67	19.44	35.48	32.47	26.45
1960-61	0.25	21.07	7.13	0.00	0.00	26.89	9.04	0.51	21.91	38.98	32.47	33.52
1961-62	5.85	39.50	5.59	0.00	0.00	17.00	2.91	26.52	19.68	30.03	19.37	31.32
1962-63	0.00	37.36	4.30	0.00	0.00	28.36	5.53	28.71	24.32	39.71	32.47	33.52
1963-64	4.80	43.81	0.00	5.46	4.79	20.14	4.25	15.75	15.86	36.79	27.15	14.27
1964-65	0.00	34.78	0.00	0.00	0.00	25.11	16.67	18.66	16.91	37.80	32.47	33.82
1965-66	8.73	33.86	3.27	1.77	0.00	25.03	14.93	17.52	12.32	38.79	31.55	29.34
1966-67	0.00	40.59	6.64	0.00	0.00	24.19	7.97	26.02	24.51	39.71	30.26	33.09
1967-68	0.00	33.76	0.00	0.00	0.00	22.96	13.06	6.33	11.10	19.64	20.80	20.15
1968-69	0.00	21.97	0.00	7.61	0.00	20.45	11.50	24.83	18.99	36.92	30.87	26.78
1969-70	0.00	36.49	7.46	0.12	0.00	18.71	9.13	10.39	19.80	29.52	31.94	24.96
1970-71	0.00	32.94	1.16	0.00	0.00	17.35	6.41	7.47	10.55	38.27	31.94	27.57
1971-72	0.00	27.08	0.00	0.00	2.23	8.85	15.93	16.30	24.14	39.71	29.55	31.91
1972-73	10.21	23.77	1.39	0.00	0.00	8.70	8.05	0.00	11.01	30.23	24.89	12.66

TABLE D-8

MODEL INPUT DATA

JRAGUNG (11,625 ha) MONTHLY IRRIGATION DEMAND IN $10^6 m^3$

CROPPING PATTERN 2 RICE + 1 UPLAND CROP - OCTOBER START

Month / Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	11.80	20.00	6.10	.60	7.50	0.00	0.00	0.00	25.00	45.40	35.30	23.80
1953-54	23.70	21.60	5.40	0.00	0.00	0.00	2.20	0.00	15.80	41.80	22.10	9.20
1954-55	9.80	7.40	3.10	4.30	0.00	0.00	0.00	0.00	19.80	37.40	22.20	15.80
1955-56	11.20	17.40	4.50	0.00	3.80	0.00	9.00	2.40	15.40	44.70	23.10	12.60
1956-57	6.80	26.10	.10	0.00	6.90	0.00	0.00	7.10	24.10	38.20	30.60	22.30
1957-58	18.20	27.40	1.30	6.30	0.00	0.00	0.00	0.00	19.60	40.60	13.70	13.60
1958-59	14.10	28.40	0.00	0.00	11.60	0.00	0.00	.10	21.80	37.50	35.20	16.20
1959-60	20.00	24.80	3.40	0.00	0.00	0.00	3.20	.20	23.30	48.80	37.70	17.90
1960-61	17.90	11.40	7.80	0.00	4.90	0.00	0.00	0.00	25.70	52.30	37.70	24.90
1961-62	23.50	29.80	6.30	0.00	0.00	0.00	0.00	10.00	23.50	43.30	24.50	22.70
1962-63	12.80	27.70	5.00	0.00	0.00	0.00	0.00	12.20	28.20	53.00	37.70	24.90
1963-64	22.40	34.20	0.00	2.40	12.30	0.00	0.00	0.00	19.70	50.10	32.30	5.70
1964-65	1.50	25.10	0.00	0.00	2.00	0.00	6.40	2.20	20.70	51.10	37.70	25.20
1965-66	26.40	24.20	3.90	0.00	0.00	0.00	4.70	1.00	16.20	52.10	36.70	20.80
1966-67	2.40	30.90	7.30	0.00	0.00	0.00	0.00	9.50	28.30	53.00	35.40	24.50
1967-68	15.70	24.10	0.00	0.00	0.00	0.00	2.80	0.00	14.90	32.90	26.00	11.60
1968-69	8.70	12.30	0.00	4.60	0.00	0.00	1.30	8.30	22.80	50.20	36.10	18.20
1969-70	16.00	26.80	8.10	0.00	1.90	0.00	0.00	0.00	23.60	42.80	37.10	16.40
1970-71	15.60	23.30	1.80	0.00	0.00	0.00	0.00	0.00	14.40	51.60	37.10	19.00
1971-72	8.30	17.40	.50	0.00	9.70	0.00	5.70	0.00	28.00	53.00	34.70	23.30
1972-73	27.80	14.10	2.10	0.00	.40	0.00	0.00	0.00	14.80	43.50	30.10	4.10

TABLE D-9

MODEL INPUT DATA

TUNTANG MONTHLY IRRIGATION DEMANDS IN $10^6 m^3$

RECOMMENDED CROPPING PATTERN - NOVEMBER START

Year \ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	0.00	59.82	10.93	7.25	0.00	45.60	7.45	29.00	42.58	64.73	60.68	65.24
1953-54	12.27	62.91	9.47	0.00	0.00	54.35	25.08	12.92	24.06	57.48	34.18	35.80
1954-55	0.00	34.33	4.85	14.83	0.00	44.12	18.56	27.92	32.17	48.57	34.36	49.05
1955-56	0.00	54.57	7.71	0.00	0.00	54.87	38.78	37.99	23.31	63.22	36.20	42.59
1956-57	0.00	72.14	0.00	4.83	0.00	38.82	18.39	47.52	40.84	50.22	51.25	62.25
1957-58	1.11	74.58	1.25	18.75	0.00	29.78	17.72	32.29	31.76	54.94	17.14	44.63
1958-59	0.00	76.70	0.00	0.00	8.25	54.18	8.40	33.40	36.23	48.75	60.39	49.88
1959-60	4.82	69.40	5.48	0.00	0.00	48.91	27.03	33.59	39.18	71.48	65.43	53.30
1960-61	0.50	42.45	14.37	0.00	0.00	54.18	18.22	1.02	44.15	78.53	65.43	67.53
1961-62	11.79	79.58	11.25	0.00	0.00	34.26	5.86	53.43	39.65	60.50	39.02	63.10
1962-63	0.00	75.28	8.67	0.00	0.00	57.14	11.14	57.85	49.00	80.00	65.43	67.53
1963-64	9.67	88.27	0.00	11.00	9.64	40.57	8.56	31.73	31.96	74.12	54.70	28.74
1964-65	0.00	70.08	0.00	0.00	0.00	50.59	33.59	37.60	34.06	76.15	65.43	68.14
1965-66	17.58	68.22	6.59	3.56	0.00	50.42	30.08	35.29	24.82	78.15	63.58	59.12
1966-67	0.00	81.78	13.38	0.00	0.00	48.74	16.05	52.43	49.38	80.00	60.97	66.67
1967-68	0.00	68.05	0.00	0.00	0.00	46.26	26.32	12.76	22.37	39.58	41.92	40.60
1968-69	0.00	44.26	0.00	15.34	0.00	41.21	23.17	50.03	38.25	74.40	62.21	53.96
1969-70	0.00	73.53	15.03	0.25	0.00	37.71	16.38	20.93	39.88	59.48	64.36	50.30
1970-71	0.00	66.38	2.34	0.00	0.00	35.97	12.92	15.06	21.25	77.11	64.36	55.54
1971-72	0.00	54.57	0.00	0.00	4.49	17.82	32.10	32.64	48.64	80.00	59.54	64.29
1972-73	20.57	47.90	2.80	0.00	0.00	17.53	16.22	0.00	22.18	60.91	50.15	25.51

TABLE D-10

MODEL INPUT DATA

TUNTANG (23,375 ha) MONTHLY IRRIGATION DEMAND IN $10^6 m^3$

CROPPING PATTERN 2 RICE + 1 UPLAND CROP - OCTOBER START

Month / Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1952-53	23.20	40.40	12.30	1.10	15.00	0.00	0.00	0.00	50.30	91.50	71.10	48.00
1953-54	47.80	43.40	10.80	0.00	00.00	0.00	4.50	0.00	31.80	84.30	44.60	18.50
1954-55	19.70	14.90	6.20	8.70	0.00	0.00	0.00	0.00	39.90	75.40	44.80	31.80
1955-56	22.50	35.10	9.10	0.00	7.60	0.00	18.20	4.80	31.00	90.00	46.60	25.40
1956-57	13.80	52.70	.10	0.00	13.90	0.00	0.00	14.30	48.60	77.00	61.70	45.00
1957-58	36.60	55.10	2.60	12.60	0.00	0.00	0.00	0.00	39.50	81.70	27.60	27.30
1958-59	28.30	57.20	0.00	0.00	23.30	0.00	0.00	0.20	44.00	75.50	70.80	32.60
1959-60	40.40	49.90	6.80	0.00	0.00	0.00	6.40	.40	46.90	98.30	75.90	36.00
1960-61	36.00	23.00	15.70	0.00	9.80	0.00	0.00	0.00	51.90	105.30	75.90	50.20
1961-62	47.30	60.10	10.30	0.00	0.00	0.00	0.00	20.20	47.40	87.30	49.50	45.80
1962-63	25.80	55.80	10.00	0.00	0.00	0.00	0.00	24.60	56.70	106.80	75.90	50.20
1963-64	45.20	68.80	0.00	4.90	24.70	0.00	0.00	0.00	39.70	100.90	65.10	11.50
1964-65	30.00	50.60	0.00	0.00	4.10	0.00	13.00	4.40	41.80	102.90	75.90	50.80
1965-66	53.10	48.80	7.90	0.00	0.00	0.00	9.50	2.10	32.60	104.90	74.00	41.80
1966-67	4.70	62.30	14.70	0.00	0.00	0.00	0.00	19.20	57.10	106.80	71.40	49.40
1967-68	31.50	48.60	0.00	0.00	0.00	0.00	5.70	0.00	30.10	66.40	52.40	23.30
1968-69	17.50	24.80	0.00	9.20	0.00	0.00	0.60	16.80	46.00	101.20	72.60	36.70
1969-70	32.30	54.10	16.40	0.00	3.80	0.00	0.00	0.00	47.60	86.30	74.80	33.00
1970-71	31.30	46.90	3.70	0.00	0.00	0.00	0.00	0.00	29.00	103.90	74.80	38.30
1971-72	16.80	35.10	1.10	0.00	19.50	0.00	11.50	0.00	56.40	106.80	70.00	47.00
1972-73	56.10	28.40	4.20	0.00	.80	0.00	0.00	0.00	29.90	87.70	60.60	8.20

D.6. SPECIAL OPERATION STUDIES

This section describes a number of special runs conducted for specific purposes other than evaluation of an element or array of elements.

D.6.1. Effect of Different Cropping Patterns on Area Irrigated at 95 Percent Firmness

The cropping pattern developed and recommended for the project area in Appendix B-Part I was used in nearly all operation studies. The Jratunseluna Project staff requested a comparison of areas which could be irrigated if Rawa Pening were raised under the PRC/ECI recommended cropping pattern with a November start and a cropping pattern consisting of two rice crops and one upland crop.

Assuming the delivery of municipal and industrial water from Muncul Springs to be 2,000 l/s and Rawa Pening raised to 100×10^6 m^3 both cropping patterns were imposed on the system. Reference to Table D-13 shows that with the recommended cropping pattern 11,000 ha can be irrigated with 95 percent firmness if 2,000 l/s of municipal and industrial water is diverted from Muncul Spring. Reference to Figure D-4 shows that with the (2 + 1)-cropping pattern only 9,727 ha can be irrigated at 95 percent firmness.

This can be explained by examination of Tables D-9 and D-10. The (2 + 1)-cropping pattern discussed in Appendix B-Part I imposes much higher irrigation demands in July and August than does the recommended cropping pattern. The recommended cropping pattern avoids high use in late dry season thus making run-of-river or transbasin diversion flows in those two months more effective in meeting dry season demands.

Thus only the recommended cropping pattern was considered in the major part of this study as potential benefits are significantly greater with the recommended cropping.

D.6.2. Effectiveness of Local Inflow Between Gunung Wulan Damsite and the Glapan Weir

A second assumption made in all studies discussed in the following sections, with exception of those incorporating Glapan Barrage, was that local inflow between the Gunung Wulan damsite and the Glapan Weir was ineffective for irrigation diversion. In actuality a relatively large percent of the dry season monthly discharge (insignificant in volume) and a very small percent of the wet season flows would be divertable. Some conservatism in the studies results from this assumption. Table D-11 compares two conditions, both with, and without consideration of runoff from the lower 127 km^2 on the watershed. Fifty percent of the run-of-river flow is considered divertable.

Consideration of the local inflow is insignificant with respect to affecting the irrigation firmness established by the model.

TABLE D-11

EFFECTS OF CONSIDERATION OF LOCAL INFLOWS BETWEEN GUNUNG WULAN AND GLAPAN

Run No.	Storage Provided			Local Flow Considered	Area Irrigated		Irrigation Firmness	
	Rawa Pening (10^6 m^3)	Gunung Wulan (10^6 m^3)	Jragung (10^6 m^3)		Tuntang (ha)	Jragung (ha)	Tuntang (%)	Jragung (%)
917	43	0	0	No	23,375	11,625	77.4	42.5
919	43	0	0	Yes	23,375	11,625	77.4	42.5
918	125	260	0	No	23,375	11,625	98.4	98.4
920	125	260	0	Yes	23,375	11,625	98.4	98.4

D.7. EVALUATION OF INDIVIDUAL PROJECTS ON THE TUNTANG

Carrying out all works necessary for full development of the basin's water resources would constitute a project of considerable magnitude. Phasing of development will be a necessity.

Special governmental constraints in Indonesia at the present time pose to delay the construction of larger dams to an unspecified future date.

One step utilized in the planning process was then to isolate two of the smaller and the largest project component and analyze them as individual projects. All of the projects, as will be shown later, fit as a component in an overall development plan analyzed.

D.7.1. Raising of Rawa Pening Reservoir

Rawa Pening has been raised in 1912, 1932 and again in 1966. Further raising was studied in 1972 and 1975. Details are discussed and past studies cited in Appendix C-Part I. Previous studies have considered raising Rawa Pening assuming releases would be based primarily on hydroelectric power demands. The present study, however, assumes releases based on irrigation with resulting decrease in firm power but no significant reduction in average annual energy production.

This project, or development component appears particularly attractive with respect to allowing an early relief with respect to supply of municipal and industrial water supply to Semarang. It is also attractive from the standpoint of fitting into a number of total development schemes.

D.7.1.a. Procedures

A large number of operation studies were conducted to investigate Rawa Pening alone in order to arrive at the optimum development of this element. The raising of Rawa Pening to provide live storage volumes of 100, 125, 150, 200 and 250 x 10^6 m^3 was considered. Each of these storage volumes were then investigated with an M & I diversion from Muncul Springs of 250, 500, 1,000, 1,500 and 2,000 l/s. The irrigation area on the Tuntang for each set of conditions was varied in order to determine the area which could be irrigated at 95 percent firmness. To arrive at a combination which would result in precisely 95 percent firmness would be very time consuming.

Some pertinent applicable operation studies are summarized in Table D-12 as an example. As may be noted from Table D-12, in some cases percent firmness failed to change with an increase or decrease in M & I diversion rate when storage and irrigation area were held constant. Compare runs 696 and 697 for example. It should be noted, however, that the average annual shortage volume always increased with increased Muncul diversion, and decreased with decreased Muncul diversion. This is due to the manner in which firmness is computed as previously explained. In order to assess actual conditions, firmnesses were normalized with shortages by the following procedure:

For each irrigation area considered, the values of shortage and firmness were plotted from the computer output for various combinations of storage and M & I diversions. A regression analysis was then performed to fit a curve through the plotted points. From this curve, the value of shortage was determined which corresponds to 95 percent firmness. An index value of shortage times firmness was then computed for 95 percent firmness. Figure D-5 presents an example of this procedure.

This procedure was repeated for a number of irrigated areas resulting in ability to establish an "index value" versus irrigated area relationship. This is presented as Figure D-6. For any area shortages were thus normalized to 95 percent firmness.

Using the index values, the curve representing shortage volume versus irrigated area at an irrigation firmness of 95 percent was derived. Utilizing the results of numerous operation studies including those as summarized in Table D-12, the relationship of shortage versus irrigation area for each diversion rate associated with each live storage volume was plotted. The shortage volume versus irrigated area curve at 95 percent irrigation firmness was then superimposed on each set of plots establishing the area which could be irrigated at 95 percent firmness under each set of conditions.

These plots for Rawa Pening live storage volumes of 100, 150, 200 and 250 x 10^6 m^3 appear at Figure D-7, D-8, D-9 and D-10 respectively.

For 125 x 10^6 m^3 of live storage at Rawa Pening, only the case of a 1,500 l/s diversion at Muncul Springs was considered. The operation studies conducted were in a range to allow the setting of the irrigated area by straight line interpolation. The curves and regression analysis are presented in Figure D-11.

D.7.1.b. Results

The results of the computer studies and subsequent analysis are summarized in Table D-13 which shows for each height of Rawa Pening the irrigation area served for five different M & I diversion rates at Muncul Springs.

Similar data are graphically presented in Figure D-12. Effectiveness of additional storage at Rawa Pening decreases rapidly as the storage volumes increase. As an example, if one assumes an M & I diversion rate of 1,000 l/s and storage volumes of 150 and 200 x 10^6 m^3 the irrigation area served increases from 17,080 ha to 20,580 ha. This additional 50 x 10^6 m^3 of live storage increases the potential service area by 3,580 ha. If, however, the M & I diversion is maintained at 1,000 l/s and an additional 50 x 10^6 m^3 of storage is added (200 to 250 x 10^6 m^3) total service area increases to only 21,800 ha. The second 50 x 10^6 m^3 increment considered increased the area served by only 1,220 ha whereas the same incremental storage in a lower total volume range increased the potential area served by 3,580 ha.

Providing that all Rawa Pening releases are governed by downstream irrigation demand, the energy which can be generated at the two existing power plants (Jelok and Timo) on the upper Tuntang decreases as a result of three factors - increase in storage at Rawa Pening, increase in the size of the irrigation areas served and increased M & I diversion from Muncul Springs (Increased storage at Rawa Pening would increase power potential if release of that storage were governed by power). Large areas require dry season releases in excess of the capacity of these power plants. Therefore, the power plants do not make maximum use of the stored water. Larger storage reservoirs spill less during the wet season reducing wet season power generation.

Figure D-13 shows the reduction in power production at the Jelok and Timo plants as a function of M & I diversion and the storage provided at Rawa Pening.

The DGWRD has indicated in their review of the Interim Report on this project that power reductions of up to 10 percent would probably be acceptable. Schemes resulting in power reductions of between 10 and 20 percent, if economically viable when the negative benefit of power loss is considered, should probably be seriously considered for implementation.

Examination of Figure D-13 shows then, that consideration of Rawa Pening storages greater than 150 x 10^6 m^3 have little merit for further consideration based on this constraint.

As discussed in Appendix G and Appendix C-Part I, there are two other factors limiting the height to which Rawa Pening can be raised. These are the foundation materials on which the levees are to be constructed and the serious problems caused by raising the lake level.

These three consideration coupled with the fact that a given increase in storage becomes less effective with increased volume indicate that the consideration of raising of Rawa Pening should be limited to a range of 100 to 125 x 10^6 m^3.

In both the cases of raising to 100 or 125 x 10^6 m^3, a four-year construction period is assumed. Reservoir area would be purchased at $ 9,600 (Rp. 5.952 x 10^6) per hectare and irrigation system rehabilitation costs were estimated at $ 328.00 (Rp. 203,360) per hectare. The detailed cost estimates for the embankments are contained in Appendix C-Part I.

The operation and maintenance costs at the dam are set as a function of the total cost and the annual operation and maintenance costs for the irrigation system are set at $ 10.00 (Rp. 6,200) per hectare.

The power losses at the existing Jelok and Timo power plants on the upper Tuntang are considered a negative benefit and benefits for municipal and industrial water are taken in accordance with the values established in Appendix E-Part I. A five-year development period to achieve full production after project implementation is assumed.

The irrigation benefits as established in Appendix E are used. The results of the Internal Rate of Return determinations for the two cases involving this single element are summarized in Table D-14.

D.7.1.c. Summary

The raising of Rawa Pening as an individual project is very attractive. As will be discussed later, it also is an important element in the total development array and is worthy of full future consideration in development of the Tuntang/Jragung Basin.

D.7.2. Construction of Glapan Barrage

In the Jratunseluna Basin Development Plan prepared by NEDECO [1] in 1973, a damsite was identified at Glapan. This site was studied by NEDECO to feasibility level [7]. The structure proposed as a result of that study had a gross storage capacity of 320 x 10^6 m^3 with a reservoir area of 3,000 ha. Twenty one thousand people would have been displaced from the reservoir area, and the town of Kedungjati inundated.

This site, as indicated in PRC/ECI's Interim Report [2] on this study was considered as a potential storage site. Since a suitable damsite which provided greater live storage was identified upstream at Gunung Wulan and the problems associated with inundation were fewer at that site, the Glapan site was not given further consideration. Undefined but relatively severe sedimentation problems were also associated with the site at Glapan which has an upstream catchment area of approximately 800 km^2.

However, in view of the previously mentioned governmental constraints with respect to construction of large dams, it was proposed that a small storage facility should be considered at the Glapan site. Such a development must be designed to mitigate potential sedimentation deposition.

The concept developed was to build a barrage type structure to provide a gross storage of about 125 x 10^6 m^3 and allow run-of-river flow through all gates during the period of October 1 through March 31. A large percent of the annual sediment load would thus be passed through the proposed structure. Details on sedimentation considerations at the site may be found in Appendix A-Part I of this report. the proposed structure is described in detail in Appendix C-Part I. While the primary purpose of the storage would be for the providing of dry season irrigation water, the structure would be operated so as to allow the diversion of up to 1,500 l/s of municipal and industrial water from Muncul Springs. If such a project were attractive on its merit it could possibly be considered in conjunction with other elements in one or more overall development schemes.

D.7.2.a. Procedures

Operation studies were conducted using applicable components of the basin model. The resulting live storage of 87 x 10^6 m^3 was considered with three different municipal and industrial diversion rates from Muncul Springs. Municipal and industrial supplies of 500, 1,000 and 1,500 l/s were considered. The irrigated area on the Tuntang for each condition was varied by model run and the irrigable area at 95 percent firmness for each diversion rate was subsequently established.

Pertinent applicable operation studies are summarized in Table D-15. As may be noted in Table D-15 in most cases firmness of precisely 95 percent and the corresponding irrigable areas were not established. The areas at 95 percent firmness were established by linear regression analyses utilizing data sets from model results. For municipal and industrial water diversion rates of 500, 1,000 and 1,500 l/s, the 95 percent firm irrigated areas were computed as shown in Figures D-14, D-15 and D-16 respectively and as previously described for Rawa Pening.

D.7.2.b. Results

The results of the computer basin model runs and subsequent analyses are summarized in Table D-16 which shows the irrigation area served for each of the three municipal and industrial diversion rates at Muncul Springs. A graphical representation of these data are presented in Figure D-17.

Figure D-18 shows the reduction in energy generated at the Jelok and Timo Plants as a function of M & I diversion with the Glapan Barrage in place. As previously stated the DGWRD has indicated in their review of PRC/ECI's Interm Report [2] that power reduction of 10 percent would be acceptable. It is thought, however, that schemes resulting in power reductions of between 10 and 20 percent should not be discarded provided the element is economically viable with the negative benefit of power loss considered in the analysis.

In the economic analysis performed on this particular element a four-year construction period was assumed. A flow rate of 1,500 l/s from Muncul was selected as the required municipal and industrial water supply for the city of Semarang at completion of the project.

Determination of right-of-way costs was somewhat complex for this element as the reservoir inundates land exhibiting four land uses, i.e. villages, riceland, plantations and forest.

Since the barrage gates will be opened from October 1 through March 31 each year it is considered to be possible to raise one crop of rice on the ricelands presently existing in the reservoir area. Outright government purchase of all lands was assumed. The affected people are expected to relocate at higher elevations around the maximum pool level and settle there. After acquiring the proprietary rights, the government would lease back those ricelands in return for one-third of the rice produced over the thirty-year life of the project.

Using crop values projected for the project area in the future without project, one-third of the present worth of future (one crop) rice production over a thirty year period is $ .86 x 10^6. This value was subtracted from the financial cost of land purchased to result in an economic cost.

Right of way acquisition costs are summarized in Table D-17. Semarang Regency guidelines were utilized in setting the purchase price of land falling into the four land use categories outlined above.

The barrage construction cost of 23.9 million dollars is documented in detail in Appendix C-Part I. Irrigation system rehabilitation costs were estimated at $ 328.00 (Rp. 203,360) per hectare. Operation and maintenance costs at the dams are set as a function of total cost and annual operation and maintenance costs of the rehabilitated delivery and distribution system are estimated at $ 10.00 (Rp. 6,200) per hectare.

Power losses at the existing Jelok and Timo power plants on the Upper Tuntang are considered a negative benefit and benefits for municipal and industrial water are taken in accordance with the value established in Appendix E-Part I. A five-year development period to full production after project implementation is used.

Irrigation benefits are established in Appendix E - Part I of this report. A summary of the economic analysis performed on this element is presented in Table D-18.

It should, however, be noted that if both Rawa Pening and Glapan are constructed in stages, the benefits which will then accrue will be different from the cumulative benefits derived from the Glapan Barrage and the raising of Rawa Pening. In that case the M & I benefits will depend upon the maximum limit of water that can be drawn from the Muncul Springs for that purpose and for which the needed storage has been provided. Also, the irrigated area will not be a sum of the areas presented for the two cases in the foregoing. The total area which will be irrigated in that case will be 20,907 ha as discussed in paragraph D.9.3.6.

D.7.3. Construction of Gunung Wulan Dam Alone

As indicated in the Interim Report [2] the construction of Gunung Wulan Dam serves as a development nucleus if the full potential of water resources is to be realized in the basin. The site, appurtenant problems, and dam configuration are presented in detail in Appendix C-Part I.

As individual projects eventually to become array elements were evaluated, it was deemed advisable to evaluate Gunung Wulan alone without transbasin diversion and without the raising of Rawa Pening. The first exercise was to evaluate the storage required to irrigate the full 23,375 ha assigned to the Tuntang as a study norm while allowing the diversion of 2,000 l/s of municipal and industrial water from Muncul Spring.

Results of applicable model studies are summarized in Table D-19. The area was held constant for a number of trials to establish the live storage volume required. Full storage of all sediment for the 50-year project life is incorporated as a condition.

From Table D-19 it can be seen that construction of Gunung Wulan alone to provide a live storage of 190 x 10^6 m^3, or a gross storage of 450 x 10^6 m^3 would irrigate the 23,375 ha service area at just over 95 percent firmness while allowing the diversion of 2,000 l/s of M & I water from Muncul Springs.

As discussed Appendix C-Part I, it is now believed that the maximum live storage which can be provided at the Gunung Wulan Site is 260×10^6 m^3. The resulting gross storage for this condition is set at approximately 520×10^6 m^3. The live storage was set at 260×10^6 m^3, Muncul Springs M & I diversion at 2,000 l/s and the irrigation area on the Tuntang varied to reach 95 percent firmness. Pertinent applicable operation studies are summarized in Table D-20. Unfortunately the series of runs failed to reach an area sufficient in size to produce a resulting firmness of 95 percent. Projections by regression analysis shown in Figure D-18 set the area which could be irrigated at 95 percent firmness at 32,920. Only 30,900 ha of the total area of 35,000 ha could be served from the Glapan Weir without pumping. If Gunung Wulan were constructed so as to provide 260×10^6 m^3 live storage it may safely be assumed that 30,900 ha of the service area could be irrigated.

In the first case, with 190×10^6 m^3 live storage provided and 23,375 ha served, the power reduction at the existing Jelok and Timo powerplants is 16 percent with a total loss of firm power and a gain of 24 Gwh annually of secondary energy. An additional 65 Gwh of secondary energy results from the power plant installation at Gunung Wulan for a net gain of 85 Gwh of secondary energy annually.

In the case of the construction of 260×10^6 m^3 live storage at Gunung Wulan and the subsequent irrigation of 30,900 ha of land it was necessary to project the energy generated by linear regression from the Gunung Wulan energy data presented in Table D-20. The average annual total energy generated at Gunung Wulan under these conditions is estimated to be 63 Gwh annually. Generation of energy on the existing upper Tuntang system is estimated at 134 Gwh annually. Again there is complete loss of 50 Gwh annually of firm energy. A gain of 24 Gwh annually of secondary energy results on the upper Tuntang and with the 63 Gwh at Gunung Wulan there is a net gain of 87 Gwh annually.

In both the cases of providing 190×10^6 m^3 and 260×10^6 m^3 of live storage at Gunung Wulan a four-year construction period is assumed. Population in the reservoir area is concentrated in the lower lands and it is estimated that for either case some 2,850 families would of necessity be transmigrated at a cost of \$ 2,800 per family or a total of \$ 7.98×10^6. Irrigation system rehabilitation costs are estimated at \$ 328.00 per hectare for Case 1 (190×10^6 m^3 of live storage) and also for Case 2 (260×10^6 m^3 of live storage). At that point 33 percent of the water would be discharged into the Kali Cabean from where it would flow to the confluence of the Glapan and the Kali Gemboyo to be rediverted at the Guntur Weir. The project cost including Row and irrigation rehabilitation costs is estimated at \$ 117.2×10^6 for 190×10^6 m^3 live storage and \$ 132.7×10^6 for 260×10^6 m^3 live storage. Gunung Wulan Power Plant Costs, which are in addition to the dam cost, are estimated at \$ 13.2×10^6. Detailed cost estimates for the two sizes of dams and the power plant appear in Appendix C - Part I.

Operation and maintenance costs at the dam are set as a function of total cost and annual operation and maintenance costs for the irrigation system are set at \$ 10.00 per hectare.

Power losses at the existing Jelok and Timo power plants on the Upper Tuntang are considered a negative benefit and benefits for municipal and industrial water are taken in accordance with the values established in Appendix E - Part I. A five-year development period to full production after project implementation is assumed.

Irrigation benefits as established in Appendix E - Part I are used. Results of the internal rate of return determinations for the two cases involving this single element are summarized in Table D-21.

TABLE D-12

SUMMARY OF SOME OPERATION STUDIES PERTINENT TO THE RAISING OF RAWA PENING TO PROVIDE FOR MUNCUL M & I DIVERSION AND INCREASED IRRIGATION FROM THE TUNTANG

(RECOMMENDED CROPPING PATTERN)

Run No.	Irrigated Area Jragung (ha)	Irrigated Area Tuntang (ha)	Live Storage at Rawa Pening (10^6 m^3)	Controlled Average Annual Release (10^6 m^3)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)	M & I Diversion from Muncul (l/s)	Average Annual Total Energy U T S (Gwh)
626	0	10,518	100	104.2	3.2	98.4	250	159.0
631	0	12,856	100	122.8	9.8	95.6	250	155.8
696	0	15,194	100	138.1	20.0	92.9	250	152.2
622	0	8,181	100	82.5	0.0	100.0	500	156.0
632	0	12,856	100	121.7	10.8	94.8	500	152.8
697	0	15,194	100	137.6	21.2	92.9	500	149.7
623	0	8,181	100	82.2	.2	99.2	1,000	150.8
628	0	10,518	100	102.1	5.1	96.4	1,000	150.8
633	0	12,856	100	119.3	13.0	94.8	1,000	147.2
624	0	8,181	100	81.2	1.2	98.8	1,500	144.6
629	0	10,518	100	100.6	6.6	96.4	1,500	144.2
634	0	12,856	100	117.4	15.1	94.4	1,500	141.8
630	0	10,518	100	99.1	8.1	96.4	2,000	137.6
700	0	15,194	100	128.7	30.1	90.9	2,000	132.1
876	0	12,858	125	123.8	8.9	96.4	1,500	141.0
877	0	14,025	125	132.7	13.0	95.2	1,500	138.7
878	0	15,193	125	141.2	17.7	94.0	1,500	136.5
711	0	15,193	150	152.0	7.3	96.8	250	149.4
716	0	18,700	150	180.0	19.7	94.8	250	141.8
712	0	15,193	150	151.2	8.1	96.4	500	146.7
717	0	18,700	150	178.7	20.9	94.4	500	139.0
713	0	15,193	150	149.6	9.7	96.4	1,000	141.1
718	0	18,700	150	176.3	23.3	93.7	1,000	133.0
714	0	15,193	150	147.9	11.4	96.4	1,500	135.4
719	0	18,700	150	173.7	25.8	93.3	1,500	127.6
715	0	15,193	150	146.0	13.3	96.0	2,000	128.9
720	0	18,700	150	170.8	28.7	92.5	2,000	122.0

TABLE D-12 (Cont.)

SUMMARY OF SOME OPERATION STUDIES PERTINENT TO THE RAISING OF RAWA PENING
TO PROVIDE FOR MUNCUL M & I DIVERSION AND INCREASED IRRIGATION FROM THE TUNTANG
(RECOMMENDED CROPPING PATTERN)

Run No.	Irrigated Area Jragung (ha)	Irrigated Area Tuntang (ha)	Live Storage at Rawa Pening (10^6 m^3)	Controlled Average Annual Release (10^6 m^3)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)	M & I Diversion from Muncul (l/s)	Average Annual Total Energy U T S (Gwh)
731	0	18,700	200	191.4	8.6	97.6	250	139.1
736	0	23,375	200	228.8	27.4	93.7	250	128.1
732	0	18,700	200	190.4	9.5	96.8	500	136.0
737	0	23,375	200	226.3	29.9	93.7	500	125.2
733	0	18,700	200	188.1	11.8	96.4	1,000	129.9
738	0	23,375	200	221.1	35.0	92.5	1,000	119.8
734	0	18,700	200	185.1	14.7	96.0	1,500	124.7
739	0	23,375	200	214.9	41.0	90.9	1,500	114.6
735	0	18,700	200	180.7	19.9	95.6	2,000	128.1
740	0	23,375	200	208.7	47.1	89.7	2,000	100.5
746	0	19,869	250	207.3	6.7	98.4	250	133.8
751	0	23,375	250	232.7	23.7	95.2	250	126.5
747	0	19,869	250	205.2	8.7	97.6	500	130.9
752	0	23,375	250	230.3	26.0	95.1	500	123.6
748	0	19,869	250	200.5	13.2	96.4	1,000	126.2
753	0	23,375	250	225.6	30.6	94.0	1,000	117.6
744	0	16,362	250	170.3	2.7	99.2	1,500	129.5
754	0	23,375	250	220.9	35.2	93.3	1,500	111.7
745	0	16,362	250	167.1	5.8	98.0	2,000	122.4
755	0	23,375	250	216.3	39.7	92.5	2,000	106.4

TABLE D-13

SUMMARY OF POSSIBLE M & I DELIVERY FROM MUNCUL SPRINGS AND IRRIGATION SERVICE AREAS BELOW GLAPAN RESULTING FROM RAISING RAWA PENING TO VARIOUS HEIGHTS

Live Storage at Rawa Pening (10^6 m^3)	M & I Supply from Muncul (1/s)	Irrigation Area (ha)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)	Average Annual Energy U T S (Gwh)
100	250	13,640	13.2	95	154.0
100	500	13,290	12.7	95	152.0
100	1,000	12,450	11.8	95	148.0
100	1,500	11,640	10.8	95	143.0
100	2,000	11,000	10.0	95	137.0
125	1,500	14,204	14.0	95	138.7
150	250	18,400	18.6	95	141.5
150	500	17,840	18.0	95	140.7
150	1,000	17,080	17.1	95	137.0
150	1,500	16,480	16.4	95	132.5
150	2,000	16,640	15.4	95	128.0
200	250	22,320	23.1	95	130.5
200	500	21,600	22.2	95	129.0
200	1,000	20.580	21.1	95	125.5
200	1,500	19,640	20.0	95	122.5
200	2,000	18,640	18.8	95	119.5
250	250	23,640	24.8	95	126.0
250	500	23,000	24.0	95	124.5
250	1,000	21,800	22.7	95	121.5
250	1,500	20,520	21.2	95	120.5
250	2,000	19,280	19.7	95	117.0

TABLE D-14

SUMMARY OF RESULTING INTERNAL RATES OF RETURNS
FOR RAISING RAWA PENING ALONE

Live Storage	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Water (1/s)	Project Cost ($ x 10^6)	Annual O & M Cost ($ x 10^6)	Internal Rate of Return (%)
100	11,640	5,640	1,500	23.69	0.10	21.3
125	14,204	8,204	1,500	31.00	0.14	21.5

TABLE D-15

SUMMARY OF OPERATION STUDIES PERTINENT TO THE CONSTRUCTION OF GLAPAN BARRAGE TO PROVIDE FOR MUNCUL M & I DIVERSION AND INCREASED IRRIGATION FROM THE TUNTANG

Run No.	Irrigated Area Jragung (ha)	Irrigated Area Tuntang (ha)	Live Storage at Glapan (10^6 m^3)	Controlled Average Annual Release (10^6 m^3)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)	M & I Diversion from Muncul (1/s)	Average Annual Total Energy UTS (Gwh)
940	0	1,167	87	187.9	5.0	96.8	1,000	148.3
941	0	9,350	87	154.2	.8	98.8	1,000	147.9
942	0	14,025	87	217.5	13.3	95.6	1,000	148.0
943	0	16,362	87	245.4	23.4	93.3	1,000	148.2
944	0	11,687	87	186.4	6.5	97.2	1,500	142.0
945	0	9,350	87	153.6	1.3	98.8	1,500	141.7
946	0	14,025	87	215.5	15.4	94.0	1,500	141.8
947	0	16,362	87	242.8	26.0	92.5	1,500	141.7
948	0	11,687	87	189.1	3.8	98.0	500	154.2
948 B	0	14,025	87	219.8	11.1	96.6	500	154.2
949	0	16,362	87	248.0	20.8	94.0	500	153.9
950	0	18,700	87	273.7	33.0	91.7	500	153.0

TABLE D-16

SUMMARY OF POSSIBLE M & I DELIVERIES FROM MUNCUL SPRINGS AND IRRIGATION SERVICE AREAS RESULTING FROM THE CONSTRUCTION OF GLAPAN BARRAGE

Live Storage at Glapan (10^6 m^3)	M & I Supply from Muncul (l/s)	Irrigation Area (ha)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)	Average Annual Energy UTS (Gwh)
87	500	15,275	17.5	95	154.0
87	1,000	14,341	15.5	95	148.0
87	1,500	13,517	14.6	95	142.0

TABLE D-17

RIGHT OF WAY ACQUISITION COSTS AT GLAPAN

Land Use	Area (ha)	Unit Cost (R x 10^6)	Total Cost ($ x 10^6)
Villages	280	3	1.35
Riceland	575	5	3.78 [1]
Plantations	230	2	.74
Forest	350	1	.56
River Bed & Other	65	-	-
Totals:	1,500	-	6.43 [1]

1. Economic costs considering rice leaseback. Financial Cost is $ .86 x 10^6 greater and represents the present worth of one third of the future production for the next thirty years at 12 percent.

TABLE D-18

SUMMARY OF ECONOMIC ANALYSIS - GLAPAN BARRAGE CONSTRUCTION

Live Storage (10^6 m^3)	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Water (l/s)	Project Cost (\$ x 10^6)	Annual O & M Cost (\$ x 10^6)	Internal Rate of Return (%)
87	13,517	7,517	1,500	32.77	.14	20.8

TABLE D-19

SUMMARY OF OPERATION STUDIES PERTINENT TO THE CONSTRUCTION OF GUNUNG WULAN ALONE TO ALLOW M & I DIVERSION AND IRRIGATION OF 23,375 ha ON THE TUNTANG

Run No.	Irrigated Area		Live Storage		Gunung Wulan			M & I	Average Annual Total Energy	
	Jragung (ha)	Tuntang (ha)	Rawa Pening (10^6 m^3)	Gunung Wulan (10^6 m^3)	Average Annual Release (10^6 m^3)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)	Diversion Muncul (l/s)	UTS (Gwh)	Gunung Wulan (Gwh)
1018	0	23,375	43	175	369.2	29.0	93.7	2,000	133.7	54.4
1019	0	23,375	43	190	373.9	24.3	95.2	2,000	134.1	60.7
921	0	23,375	43	260	388.5	9.7	98.4	2,000	134.6	64.9
1012	0	23,375	43	150	345.2	38.8	92.1	2,000	134.4	57.2
1011	0	23,375	43	200	376.6	21.6	96.0	2,000	134.1	62.0

TABLE D-20

SUMMARY OF OPERATION STUDIES PERTINENT TO THE CONSTRUCTION OF GUNUNG WULAN ALONE TO ALLOW M & I DIVERSION AND IRRIGATION OF A MAXIMUM AREA FROM THE TUNTANG

Run No.	Irrigated Area		Live Storage		Gunung Wulan			M & I Diversion Muncul (l/s)	Average Annual Total Energy	
	Jragung (ha)	Tuntang (ha)	Rawa Pening (10^6 m^3)	Gunung Wulan (10^6 m^3)	Average Annual Release (10^6 m^3)	Average Annual Irrigation Shortage (10^6 m^3)	Irrigation Firmness (%)		UTS (Gwh)	Gunung Wulan (Gwh)
921	0	23,375	43	260	388.5	9.7	98.4	2,000	134.6	64.9
922	0	21,037	43	260	356.5	3.7	98.8	2,000	134.4	65.4
923	0	18,700	43	260	322.3	0.0	100.0	2,000	134.6	66.1

TABLE D-21

SUMMARY OF RESULTING INTERNAL RATES OF RETURNS RESULTING FROM CONSTRUCTION OF GUNUNG WULAN TO TWO DIFFERENT HEIGHTS

Live Storage (m^3x10^6)	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Water (l/s)	Project Cost ($ x 10^6)	Annual O & M Cost ($ x 10^6)	Internal Rate of Return (%)
190	23,375	17,375	2,000	130.38	.48	14.1
260	30,900	24,900	2,000	145.85	.50	16.1

D.8. EVALUATION OF INDIVIDUAL PROJECTS ON THE JRAGUNG

D.8.1. Comments on Jragung Dam

In these planning studies no consideration was given to the development of Jragung Dam alone, although consideration is given to incorporate a small Jragung Dam with sediment passing as a part of the phased development with the constraints, imposed by the DGWRD.

The final design of the Jragung Dam Project including all investigation, design criteria, standards and codes were presented in the Final Design Report submitted by PRC/ECI in April of 1979 [8].

D.9. BASIN DEVELOPMENT WITH DGWRD CONSTRAINTS

D.9.1. Background

On September 24, 1979 a meeting was held to discuss the DGWRD's review of the Tuntang/Jragung Rivers Basins Integrated Development Plan - Interim Report submitted by PRC/ECI in August of 1979. Because of several reasons certain constraints were placed on the basin development plan by the reviewing officials. These are briefly summarized as follows:

1. It is improbable that the Government of Indonesia will consider the construction of any "large" dams in the Jratunseluna Basin within the next ten to twenty years. Sedimentation measurements are just commencing on the Tuntang River during the present wet season so it will be considerable time before any length of record will be available to serve as a data base in reliably estimating reservoir sedimentation rates at Gunung Wulan. If then, as stated in the Interim Report, Gunung Wulan is the major element in total basin development it should be constructed as the final phase of the total plan.

2. Based on the constraint given above, consideration was given in the plan with DGWRD constraints to a small Jragung Dam with 50 to 75 x 10^6 m^3 of live storage as phase 2 of basin development to increase M & I water supplies to Semarang and irrigate additional area.

3. In initial phases of development prior to the installation of additional hydropower facilities average annual total energy generated at the present time at the Jelok and Timo Power Plants on the upper Tuntang should not be reduced by more than 10 to 20 percent.

It was with these constraints and agreement with the client that the first total development plan was formulated.

D.9.2. The Development Plan with DGWRD Constraints and Scenario

The major objectives of this development plan are to provide 4,000 l/s of municipal and industrial water to the city of Semarang and maximize the irrigated area up to the 35,000 ha of irrigable land at an acceptable Internal Rate of Return.

D.9.2.a. Development Elements

The elements comprising this development plan were selected after considering numerous combinations of elements within the constraints outlined above on the basin. It was assumed that the storage at Rawa Pening would be 100 x 10^6 m^3 for all cases and that 4,000 l/s of M & I water would ultimately be supplied by the project. At the time studies on this array were initiated the severe foundation restraints at Rawa Pening were not recognized and unfortunately most operation studies were conducted with Rawa Pening raised to provide 150 x 10^6 m^3 storage. From a minimum number of runs, estimates of area irrigable are made in the following sections.

The components selected for maximum development include:

1. The raising of Rawa Pening to 100 x 10^6 m^3 live storage.
2. Transbasin diversion/Tuntang to Jragung.
3. Construction of Jragung Reservoir to 75 x 10^6 m^3 live storage with sediment by passing in December, January and February.
4. Construction of Jragung Power Plant (6 MW).
5. Construction of Gunung Wulan Reservoir to 260 x 10^6 m^3.
6. Construction of Gunung Wulan Power Plant (10 MW).
7. Service area rehabilitation.

In their ultimate configuration this scheme is best represented by model runs 867 and 868. These are summarized in Table D-22.

From the data presented in Table D-22 it may be seen that a live storage of 260 x 10^6 m^3 at Gunung Wulan would result in firmnesses of approximately 93.8 percent on the Jragung and 93.5 percent on the Tuntang.

Time did not allow additional runs for area projection to 95 percent firmness. Based on observation of other projections irrigable areas are estimated at 22,206 ha of the Tuntang and 11,045 ha on the Jragung.

D.9.2.b. Phasing

It is recommended that the total project be constructed in three phases. The first phase would include components 1 and a portion of 7 as listed in paragraph D.9.2.a. The second phase would include items 2, 3, 4 and a portion of 7 and the third phase would include elements 5, 6 and the remainder of 7.

The conditions existing between completion of phases 1 and 2 are derived in the previously analyzed case of Rawa Pening alone at $100 \times 10^6\ m^3$. Conditions existing between phases 2 and 3 are represented by model runs 786, 787 and 788. Unfortunately the Tuntang area was held constant at 8,181 in these runs rather than at the 11,640 ha service area on the Tuntang established for Phase 1. (See Table D-13). Results of runs 786, 787 and 788 are shown in Table D-23.

Adjusting the above data, area is assumed interchangeable provided the operating rule at diversion is modified accordingly. At 95 percent firmness 17,976 ha could be irrigated. The 11,640 ha irrigated as a result of phase 1 remains and an additional 6,336 ha is added on the Jragung.

Municipal and industrial water supply benefits are not taken until required. The municipal and industrial requirements as developed in Special Report No. 1 [3] are shown in the projections in Figure D-20.

The phasing, interim and final municipal and industrial deliveries and irrigation service areas are shown in Table D-24.

The economic analysis of Phase 1 alone is presented in Paragraph D.7.1. of this appendix. The resulting internal rate of return was 21.5 percent.

An economic analysis using a fifty-year project life was conducted on the total scheme (Phases 1, 2 and 3). Results of the economic analyses are presented in Table D-25. Capital investment is considerably greater in this plan than in the other plans of development presented in the following sections. The corresponding internal rate of return is lower as are the net average annual benefits.

Total costs for the development plan here considered in Section D.9.2. are estimated to be \$ 243.01 million. Further consideration is not given to this plan because its combination of elements results in lower annual benefits and higher investment costs than the plans subsequently evaluated and designated in this appendix as Cases I, II, and III. (Cases II and III are very similar, the principal difference being the quantity of M & I water to be supplied.

D.9.3. The Development Plan with DGWRD Constraints - Case I

Total development cost of the development plan - designated as "Case I" which is analyzed in this section is \$ 179.6×10^6. With the DGWRD constraints a grouping of elements was considered, again including two smaller projects as first and second phase development. Jragung Dam was replaced by the Glapan Barrage as phase 2 of this development plan.

D.9.3.a. Development Elements

The elements comprising this development plan were selected after imposing numerous combinations of elements within the constraints outlined above on the basin. It was assumed that Rawa Pening could be raised to 125×10^6 m^3 and that 2,000 l/s of municipal and industrial water would eventually be supplied to the city of Semarang by the projects comprising the development package.

The components selected for development include:

1. The raising of Rawa Pening to provide 125 x 10^6 m^3 live storage.
2. Construction of Glapan Barrage to provide 87 x 10^6 m^3 live storage on the lower Tuntang.
3. Transbasin diversion/Tuntang to Jragung.
4. Construction of Gunung Wulan Reservoir to 190 x 10^6 m^3.
5. Construction of Gunung Wulan Power Plant (10 MW).
6. Service area rehabilitation.

D.9.3.b. Phasing

It is recommended that the total project be constructed in three phases. The first two phases would be limited to component 1 and 2 and a portion of 6 as listed in paragraph D.9.3.a. The third phase would include elements 3, 4, 5 and the remainder of 7.

Conditions existing between completion of phases 1 and 2 are derived in the previously analyzed case of Rawa Pening alone at 125 x 10^6 m^3. Conditions existing between phases 2 and 3 are represented by basin model runs 965, 966 and 967. Results are summarized in Table D-26.

By linear regression analysis the area irrigated on the Tuntang at 95 percent firmness is 20,907 ha. The 14,204 ha irrigated as a result of phase 1 remains and an additional 6,703 ha is added on the Tuntang.

The full service area of 35,000 ha would receive a year-round water supply after Phase 3 implementation.

The phasing, interim and final municipal and industrial deliveries and irrigation service area are shown in Table D-27.

The economic analysis of Case I, Phase 1 alone (i.e., raising Rawa Pening to 125 x 10^6 m^3) is presented in paragraph D.7.1. of this Appendix. The resulting rate of return was 21.5 percent.

Economic analyses using a fifty year project life were conducted on Phases 1 and 2 alone and on the total development plan (Phases 1, 2 and 3). The IRR for full development is 17.3 percent. Results are presented in Table D-28.

Cash flow values used in determining the internal rate of return for Phase 1 & 2 combined and for the total development are summarized in Tables D-29 and D-30 respectively.

TABLE D-22

SUMMARY OF MODEL RUNS 867 AND 868[1]

Run No.	Storage			Area Irrigated		Irrigation Firmness	
	Rawa Pening (10^6 m^3)	Jragung (10^6 m^3)	Gunung Wulan (10^6 m^3)	Jragung (ha)	Tuntang (ha)	Jragung (%)	Tuntang (%)
867	100	75	250	11,625	23,375	93.7	93.3
868	100	75	270	11,625	23,375	94.0	93.7

1. Both runs consider 2,000 l/s from Muncul and 2,000 l/s from Jragung for M & I.

TABLE D-23

SUMMARY OF MODEL RUNS 786, 787 AND 788

Run No.	Storage Provided		Area Irrigated		Irrigation Firmness		Average Annual Energy	
	Rawa Pening (10^6 m^3)	Jragung (10^6 m^3)	Tuntang (ha)	Jragung (ha)	Tuntang (%)	Jragung (%)	UTS (Gwh)	Jragung (Gwh)
786	100	75	8,181	11,625	92.9	92.1	127.1	19.2
787	100	75	8,181	8,719	96.4	96.4	131.3	16.4
788	100	75	8,181	5,812	97.6	98.8	133.4	12.1

TABLE D-24

PHASING - DEVELOPMENT WITH DGWRD CONSTRAINTS

Year	Construction Start	Construction Complete	M & I Supplied Muncul (l/s)	M & I Supplied Jragung (l/s)	Irrigated Area Tuntang (ha)	Irrigated Area Jragung (ha)	Net M & I Requirement (l/s)
1982	Rawa Pening	↓	0	0	0	0	500
1983	↓		↓	↓	↓	↓	600
1984							700
1985		Rawa Pening					800
1986	Jragung & Diversion		1,500	0	11,640	0	1,000
1987		↓	↓	↓	↓	↓	1,150
1988							1,300
1989	↓						1,450
1990		Jragung					1,600
1991	Gunung Wulan		2,000	0	11,640	6,336	1,860
1992	↓	↓	↓	↓	↓	↓	2,120
1993							2,380
1994		Gunung Wulan					2,900
1996			2,000	2,000	22,206	11,045	3,360
1997			↓	↓	↓	↓	3,820
1998							4,280

TABLE D-25

ECONOMIC ANALYSIS - INTERIM AND TOTAL DEVELOPMENT WITH DGWRD SCENARIO

Item	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Delivered (l/s)	Project Cost ($ x 10^6)	Annual Benefits ($ x 10^6)	IRR (%)
Phase 1	14,204	8,204	1,500	31.01	12.98	21.5
Total Development (Phase 1, 2, and 3)	33,251	27,251	4,000	243.01	47.05	12.6

TABLE D-26

SUMMARY OF MODEL RUNS 965, 966 AND 967

Run No.	Storage Provided: Rawa Pening (10^6 m^3)	Storage Provided: Glapan (10^6 m^3)	Area Irrigated: Tuntang (ha)	Area Irrigated: Jragung (ha)	Irrigation Firmness: Tuntang (%)	Irrigation Firmness: Jragung (%)	Average Annual Energy: UTS (Gwh)
965	125	87	16,362	-	97.6	-	129.7
966	125	87	18,700	-	96.0	-	127.4
967	125	87	14,025	-	98.4	-	131.2

TABLE D-27

PHASING - DEVELOPMENT WITH DGWRD CONSTRAINTS

CASE I

Year	Construction Start	Construction Complete	M & I Supplied: Muncul (l/s)	M & I Supplied: Jragung (l/s)	Irrigated Area: Tuntang (ha)	Irrigated Area: Jragung (ha)	Net M & I Requirement (l/s)
1982	Rawa Pening ↓	↓	0 ↓	0 ↓	0 ↓	0 ↓	500
1983							600
1984							700
1985		Rawa Pening					800
1986	Glapan ↓	↓	1,500 ↓	0 ↓	14,204 ↓	0 ↓	1,000
1987							1,150
1988							1,300
1989		Glapan					1,450
1990	Gunung Wulan & Diversion ↓		2,000 ↓	0 ↓	20,907 ↓	0 ↓	1,600
1991							1,860
1992							2,120 **
1993							2,380
1994		Gunung Wulan					2,900
1995			2,000 ↓	0 ↓	23,375 ↓	11,625 ↓	3,100
1996							3,360
1997							3,820

** M & I requirements after 1992 met with water from other sources.

TABLE D-28

ECONOMIC ANALYSIS - INTERIM AND TOTAL
DEVELOPMENT WITH DGWRD CONSTRAINTS - CASE I

Item	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Delivered (l/s)	Project Cost ($ x 10^6)	Annual Benefits ($ x 10^6)	IRR (%)
Phase 1	14,204	8,204	1,500	31.01	12.98	21.5
Phase 1 & 2	20,907	14,907	2,000	63.51	23.54	20.3
Total Development (Phase 1, 2 and 3)	35,000	29,000	2,000	179.61	46.21	17.3

TABLE D-29

PHASES 1 AND 2

BASIN DEVELOPMENT PLAN CASE I

INTERNAL RATE OF RETURN

US Dollars 10^6

Year	No. of Years	Cost		Benefits				Cash Flow
		Construction	Total	Irrigation	Power	M & I	Total	
1	1	9.53	9.53	-	-	-	-	- 9.53
2	1	19.05	19.05	-	-	-	-	-19.05
3	1	19.05	19.05	-	-	-	-	-19.05
4	1	15.88	15.88	-	-	-	-	-15.88
5	1	-	.27	4.19	-2.39	4.96	6.76	+ 6.49
6	1	-	.27	8.38	-2.39	4.96	10.95	+10.68
7	1	-	.27	12.57	-2.39	4.96	15.14	+14.87
8	1	-	.27	16.76	-2.39	4.96	19.33	+19.06
9-50	1	-	.27	20.96	- .47	4.96	23.53	+23.26

IRR = 20.3 %

TABLE D-30

BASIN DEVELOPMENT PLAN CASE I

INTERNAL RATE OF RETURN

US Dollars 10^6

Year	No. of Years	Cost		Benefits					Cash Flow
		Construction	Total	Irrigation	Power	M & I	Flood Control	Total	
1	1	8.98	8.98	-	-	-	-	-	- 8.98
2	1	17.96	17.96	-	-	-	-	-	-17.96
3	1	17.96	17.96	-	-	-	-	-	-17.96
4	1	14.37	14.37	-	-	-	-	-	-14.37
5	1	12.57	12.83	4.08	-2.39	4.96	-	6.65	- 6.18
6	1	30.17	30.43	8.15	-2.39	4.96	-	10.72	-19.71
7	1	30.17	30.43	12.64	-2.39	4.96	-	15.21	-15.22
8	1	30.17	30.43	16.72	-2.39	4.96	-	19.29	-11.14
9	1	17.26	17.52	20.79	-2.39	4.96	-	23.36	+ 5.84
10	1	-	.72	24.87	- .47	4.96	.95	30.31	+29.59
11	1	-	.72	28.95	- .47	4.96	.95	34.39	33.67
12	1	-	.72	33.02	- .47	4.96	.95	38.46	37.74
13	1	-	.72	36.69	- .47	4.96	.95	42.13	41.41
14-45	33	-	.72	40.77	- .47	4.96	.95	46.21	45.49
46	1	4.62	5.34	40.77	- .47	4.96	.95	46.21	40.87
47-50	3	-	.72	40.77	- .47	4.96	.95	46.21	45.49

IRR = 17.3%

D.10. BASIN DEVELOPMENT PLAN WITHOUT DGWRD CONSTRAINTS

The objective of this proposed plan is to develop to the maximum, beneficial utilization of the basins water resources to the extent that it is physically feasible and economically viable. Following ultimate development either 2,000 l/s or 4,000 l/s of municipal and industrial water are to be supplied to the city of Semarang and the irrigation area maximized up to the available 35,000 ha at an attractive economic return.

D.10.1. The Development Plan

The development elements selected below were combined to form the system design. Ultimate delivery of 2,000 or 4,000 l/s of municipal and industrial water to the city of Semarang from the project is questionable at this time. It is quite possible that surface water from outside the basin or groundwater could be utilized to provide the balance of the supply. The groundwater resources of a limited part of the volcanic uplands are now under investigation by Nihon Suido Consultants Co., Ltd. of Tokyo, Japan. The Semarang Groundwater Investigation and Development Project is financed by the Asian Development Bank. Although an Inception Report was issued by the Consultants in June of 1979 no conclusions as to development potential will be available until the completion of this study and others. Conditions of ultimate municipal and industrial deliveries of both 2,000 l/s and 4,000 l/s are considered.

A second variable affecting this series of plans is the lack of subsurface information at Rawa Pening. Conditions are such that 125×10^6 m^3 of live storage appears the maximum which could be developed. Should foundation conditions be found less desirable during future investigation live storage at Rawa Pening might be reduced to 100×10^6 m^3 or less.

Two alternative plans (here designated as Cases II and III were considered. These cases are as follows:

Case II : Ultimate municipal and industrial delivery of 2,000 l/s with Rawa Pening at 125 x 10^6 m^3 live storage.

Case III : Ultimate municipal and industrial delivery of 4,000 l/s with Rawa Pening at 125 x 10^6 m^3 live storage.

D.10.2. Project Components

The combination of elements comprising this development plan was selected from among numerous combinations of elements under varying conditions, all of which were analyzed by use of the computerized model of the basin. Many runs are summarized in Table D-52.

The components selected are:

1. The raising of Rawa Pening to 125 x 10^6 m^3.
2. Transbasin diversion/Tuntang to Jragung.
3. Construction of Gunung Wulan Reservoir with live storage of 260 x 10^6 m^3.
4. Construction of Gunung Wulan Power Plant.
5. Service area rehabilitation.

These elements form what appears to be one of the best combinations to maximize development. Jragung Dam was eliminated as an element when it was found that the Jragung area could be fully or neraly fully served by transbasin diversion alone and by providing adequate storage on the Tuntang below the diversion point. In this plan, raising Rawa Pening was selected in lieu of additional downstream storage at the Glapan Barrage for a number of reasons. First, the internal rate of return generated by raising Rawa Pening is greater than that of Glapan and providing Rawa Pening can be raised to accomodate 125 x 10^6 m^3 live storage, the area irrigated in the interim period before completion of phase 2 would be greater thus generating greater average annual benefit. Storage below Gunung Wulan is not necessary for maximization of irrigated area. Storage above the diversion point is much more beneficial. This is shown in Table D-31 by comparing the results of model runs 999 and 918.

The benefit of storage at Rawa Pening was discussed in Section D.7.1. The effectiveness of storage at all three points, Rawa Pening, Gunung Wulan and Glapan has been evaluated in the previous section.

D.10.3. The Development Plan - Case II

In this case Rawa Pening is raised to accomodate 125 x 10^6 m^3 live storage, the transbasin diversion is sized at 16.0 m^3/s, and Gunung Wulan is constructed to elevation 75.6 to afford 260 x 10^6 m^3 of live storage. Municipal and industrial water is diverted at a rate of 2,000 l/s from Muncul Spring and the full 35,000 ha of area is irrigated with a firmness of 94.8 percent. Complete operational data for the system appears in the computer printout for run no. 918 given at the end of Part I of this appendix.

D.10.3.a. Phasing

It is recommended that the project be constructed in two phases. The phasing, interim and final municipal and industrial deliveries, and irrigation service areas are shown in Table D-32.

D.10.3.b. Economics

The economic analyses for Phase 1 alone is presented in D.7.1. of this appendix. The resulting Internal Rate of Return (IRR) was 21.5 percent.

An economic analysis based on fifty-year operation was then conducted on the total scheme (Phase 1 & Phase 2) and the resulting IRR was 17.6 percent. Results of the economic analysis of Case II are presented in Table D-33.

From Table D-34 it should be noted that Gunung Wulan provides about 70 percent of the average annual benefits. A summary of cash flow for the development is presented in Table D-34.

The development plan outlined as Case II is considered excellent as it allows year-round firm irrigation delivery to the 35,000 ha of irrigable land.

D.10.4. The Development Plan - Case III

The development plan - Case III assumes that Rawa Pening can be raised to provide 125 x 10^6 m^3 live storage, and that additional 2,000 l/s of municipal and industrial water for the city of Semarang are not located outside the basin or available from the upper basins groundwa-er resources.

All development features and costs remain identical to Case II except for increased diversion costs and lower irrigation system rehabilitation costs. Benefits are reallocated in that the irrigation area is decreased to accomodate the eventual supply of 2,000 l/s municipal and industrial water from Muncul Springs and 2,000 l/s from the Jragung River.

A number of operation studies were conducted specifically to determine the reduction in irrigated area if the 4,000 l/s of municipal and industrial water was required. These are summarized in Table D-35.

Irrigated area at 95 percent firmness in Case III is set at 10,172 ha on Jragung and 20,452 ha on the Tuntang. Total irrigated area is 30,624 ha.

D.10.4.a. Phasing

The proposed phasing for Case III, interim and final municipal and industrial deliveries and irrigation service areas are shown in Table D-36.

D.10.4.b. Economics of Case III

The economic analyses for Phase I (Rawa Pening raised to 125×10^6 m^3) are presented in Section D.7.1. of this appendix. The resulting IRR was 21.5 percent.

In the economic analysis of the total scheme municipal and industrial water benefits were foregone until actually required based on the projections presented in Figure D-20. The rate of 1,500 l/s was used in 1986 and 500 l/s increments added in 1991, 1992 and 1994 with the benefits for the final 1,000 l/s being claimed from 1995 forward.

An economic analysis based on fifty-year operation was then conducted on the total development (Phase 1 and Phase 2) and the resulting IRR was 15 percent. Results of the economic analyses of Case III are presented in Table D-37 and the cash flow in Table D-38.

TABLE D-31

COMPARISON OF MODEL RUNS 999 AND 918 SHOWING IMPROVED EFFECTIVENESS OF STORAGE UPSTREAM OF THE DIVERSION POINT [1]

Run No.	Storage Provided			Area Irrigated		Irrigation Firmness	
	Rawa Pening (10^6 m^3)	Gunung Wulan (10^6 m^3)	Glapan (10^6 m^3)	Tuntang (ha)	Jragung (ha)	Tuntang (%)	Jragung (%)
999	43	260	116	23,375	11,625	96.8	84.5
918	125	260	0	23,375	11,625	94.8	94.8

1. Both runs consider Muncul M & I diversion of 2,000 l/s

TABLE D-32

PHASING - THE DEVELOPMENT PLAN

CASE II

Year	Construction Start	Construction Complete	M & I Supplied		Irrigation Area		*Net M & I Water	
			Muncul (l/s)	Jragung (l/s)	Tuntang (ha)	Jragung (ha)	Supply (l/s)	Demand (l/s)
1982	Rawa Pening (125)	↓	0	0	0	0	0	500
1983	↓		↓	↓	↓	↓	0	600
1984							0	700
1985		Rawa Pening					0	800
1986	Gunung Wulan (260)		1,500	0	14,024	0	1,500	1,000
1987	&	↓					1,500	1,150
1988	Diversion (16.0)		↓	↓	↓	↓	1,500	1,300
1989							1,500	1,450
1990	↓	Gunung Wulan					1,500	1,600
1991			2,000	0	23,375	11,625	2,000	1,860
1992			↓	↓		↓	↓	2,120 **
1993								2,380
1994								2,640

* Does not include present availability of 800 l/s

** M & I Water from 1992 forward assumed to come from other sources proven and developed by that time.

TABLE D-33

ECONOMIC ANALYSES - INTERIM AND TOTAL
FOR OPTIMUM DEVELOPMENT PLAN - CADE II

Item	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Delivered (l/s)	Project Cost ($ x 10^6)	Annual Benefit ($ x 10^6)	IRR (%)
Phase 1	14,204	8,204	1,500	31.01	12.98	21.47
Total Development (Phase 1 & 2)	35,000	29,000	2,000	162.51	46.49	17.7

TABLE D-34

BASIN DEVELOPMENT PLAN - CASE II

INTERNAL RATE OF RETURN

US Dollars 10^6

Year	No. of Years	Cost		Benefits				Cash Flow
		Construction	Total	Irrigation	Power	M & I	Total	
1	1	4.65	4.65	-	-	-	-	- 4.65
2	1	9.30	9.30	-	-	-	-	- 9.30
3	1	9.30	9.30	-	-	-	-	- 9.30
4	1	7.76	7.76	-	-	-	-	- 7.76
5	1	13.15	13.29	-	-	-	-	- 9.39
6	1	32.88	33.02	2.45	-2.27	3.72	3.90	-27.09
7	1	32.88	33.02	4.48	-2.27	3.72	5.93	-24.64
8	1	32.88	33.02	6.93	-2.27	3.72	8.38	-22.19
9	1	19.72	19.72	9.38	-2.27	3.72	10.83	- 6.85
10	1	-	.69	11.42	-2.27	3.72	12.87	+22.56
11	1	-	.69	17.53	- .58	4.96	23.25	+28.27
12	1	-	.69	23.24	- .58	4.96	28.96	+33.98
13	1	-	.69	28.95	- .58	4.96	34.67	40.09
14-45	33	-	.69	35.06	- .58	4.96	40.78	45.80
46	1	4.62	5.19	40.77	- .58	4.96	46.49	41.30
47-50	3	-	.69	40.77	- .58	4.96	46.49	45.80
				40.77	- .58	4.96	46.49	

IRR = 17.6%

TABLE D-35

SUMMARY OF OPERATION STUDIES CONDUCTED TO SHOW REDUCTION IN IRRIGATED AREA DUE TO INCREASED M & I WATER REQUIREMENTS

DEVELOPMENT PLAN - CASE III

Run No.	Area Irrigated		Irrigation Firmness		M & I Water	
	Jragung (ha)	Tuntang (ha)	Jragung (%)	Tuntang (%)	Muncul (l/s)	Jragung (l/s)
883	11,625	23,375	90.9	91.7	2,000	2,000
884	11,043	22,206	93.7	93.7	2,000	2,000
885	10,462	21,037	94.8	94.8	2,000	2,000
886	9,881	19,868	95.2	95.2	2,000	2,000
887	9,300	18,700	96.3	97.6	2,000	2,000

TABLE D-36

PHASING - THE DEVELOPMENT PLAN CASE III

Year	Construction Start	Construction Complete	M & I Supplied Muncul (l/s)	M & I Supplied Jragung (l/s)	Irrigated Area Tuntang (ha)	Irrigated Area Jragung (ha)
1982	Rawa Pening	↓	0	0	0	0
1983	↓					
1984						
1985		Rawa Pening				
1986	Gunung Wulan & Diversion	↓	1,500	0	14,024	0
1987			↓	↓	↓	↓
1988						
1989	↓					
1990		Gunung Wulan				
1991			2,000 ↓	2,000* ↓	20,452	10,172

* Available - See text for utilization schedule.

TABLE D-37

ECONOMIC ANALYSES - INTERIM AND TOTAL FOR THE DEVELOPMENT PLAN CASE III

Item	Irrigated Area Total (ha)	Irrigated Area Net (ha)	M & I Delivered (l/s)	Project Cost ($ x 10^6)	Annual Benefits ($ x 10^6)	IRR (%)
Phase 1	14,204	8,204	1,500	31.01	12.98	21.5
Total Development Phase 1 & 2	30,624	24,624	4,000	174.10	45.26	14.8

TABLE D-38

BASIN DEVELOPMENT PLAN CASE III

INTERNAL RATE OF RETURN

US Dollars 10^6

Year	No. of Years	Cost		Benefits				Cash Flow
		Construction	Total	Irrigation	Power	M & I	Total	
1	1	5.46	5.46	-	-	-	-	-
2	1	10.93	10.93	-	-	-	-	-
3	1	10.93	10.93	-	-	-	-	-
4	1	9.10	9.1	-	-	-	-	-
5	1	16.6	16.99	2.31	-2.27	3.72	3.74	-13.25
6	1	41.5	41.89	4.62	-2.27	3.72	6.05	-35.84
7	1	41.5	41.89	6.93	-2.27	3.72	8.36	-33.53
8	1	41.5	41.89	9.24	-2.27	3.72	10.67	-31.22
9	1	24.9	25.29	11.53	-2.27	3.72	12.96	-12.33
10	1	-	.63	16.19	- .58	5.0	21.95	-21.32
11	1	-	.63	20.85	- .58	6.2	27 81	-27.18
12	1	-	.63	25.51	- .58	7.44	33.71	+33.08
13	1	-	.63	30.17	- .58	9.92	40.83	40.20
14	1	-	.63	34. 6	- .58	9.92	45.26	44.63
15-45	31	-	.63	34.6	- .58	9.92	45.26	44.63
46	1	4.62	5.28	34.6	- .58	9.92	45.26	39.98
47-50	4	-	.63	34.6	- .58	9.92	45.26	44.63

IRR = 14.8%

D.11. IDENTIFIED MINOR PROJECTS COMPLIMENTARY TO MAJOR DEVELOPMENT

D.11.1. General

The Ministry of Public Works, in accordance with the latest Government policy, has decided that more emphasis should be placed on small projects, particularly those like the tertiary construction program that will benefit many small farmers. Since the entire left bank area of the Tuntang River from Semarang to Gubug has been rehabilitated, the major drainage network is being presently upgraded and the tertiary system program is being implemented,there are only a few viable small projects that can be considered.

D.11.2. Small Construction Projects

There are two small projects that could be implemented in the Tuntang/Jragung area that would improve irrigation and rice production; (1) Development of the Grogol area (3,950 ha) and (2) the study and construction of some drainage improvement/reuse facilities.

D.11.2.a. Grogol Subproject Area

The development of the Grogol Subproject area would bring the last area in the Tuntang Project area under irrigation. Under the present system where direct run-of-river diversions are made, development will be limited to supplemental irrigation of the wet season rice crop only as all dry season flows have already been appropriated for other subproject areas, namely Singon Kidul, Gubug and Dangi portions of the Tuntang Project. The construction and implementation of irrigation and drainage facilities for the supplemental irrigation of the wet season rice crop would essentially guarantee the local farmers one full crop of rice each year. Detailed studies of demand versus the historical wet season flows at Glapan Weir have not been made to determine the reliability of the irrigation supply. Rice yields in the Grogol area could be lower than the present estimated average project yield of 2.8 t/ha and are probably on the order of 1.9 t/ha. The supplemental water would allow future yields to average 3.6 t/ha. The increased yield may average from 1.0 t/ha to 1.2 t/ha. The Grogol Subproject area is estimated to include 3,940 ha net irrigable land.

Development of the area will be somewhat easier than might be expected because the combined capacity of the T-1 and T-21 canals at the km 33 control structure is reportedly 10.261 m^3/s. The T-21 canal has been over-sized to carry 5.016 m^3/s. At the present time it is doubtfull that the canal could carry that much water but proper maintenance would bring the canal back to design capacity. Development of the Grogol area would require increasing the capacity of the T-39 canal from 4.93 m^3/s to 10.5 m^3/s at the km 33 turn-out down to 7.5 m^3/s at the turnout for Grogol secondary canal at Boundary 5 which serves the Grogol East area. Topography of the area was not available but it was estimated that 29 km of secondary canal would be required to serve the area with a canal running down both sides of the area serving some 20 turnouts. Drainage would be provided down the center of the area to the coast. A salinity control structure on the drain would be required since the estimated elevation of the area ranges from only 1.5 m M.S.L. to 0.5 m M.S.L. The total cost of enlarging the T-39 canal and constructing the secondary irrigation system was estimated to be Rp. 485 x 10^6. The tertiary development was estimated to be Rp. 300 x 10^6 including minor structures and construction of the ditches for a total project cost of Rp. 785 x 10^6. Benefits resulting from a net increase in rice production of 1.5 t/ha would value Rp. 178,940 or $ 289 per hectare for an annual project benefit of Rp. 705 x 10^6 or $ 1.14 x 10^6 per year after development. This appears to be a viable project. The above cost does not include aerial mapping costs.

L.11.2.b. Drainage Improvement and Reuse Projects

The reuse of drainage water has not been adequately developed in the Tuntang/Jragung Area. Diversion structures like the Guntur, Gaji and Karangroto Weirs have been constructed to utilize drainage flows on the larger drains but many more could be constructed to reuse water in the smaller drains. The reuse of water could contribute to the irrigation of many areas away from the main diversion weirs and could contribute to reducing the canal carrying capacities serving the areas. These structures would replace the temporary structure that local farmers build each year in the drains to irrigate small areas. An example of this is the local diversion structure in the drain near Golang along the T-21 canal.

The design of reuse structures located in the drains would have to allow the passage of design floods without causing local flooding. The use of automatic upstream constant head gates could be considered. These structures would cost between Rp. 1.5×10^6 and Rp. 15×10^6. Associated canal and ditch systems would pose additional cost.

The Gaji Weir should be rehabilitated and equipped with automatic gates to reduce the local flooding now caused by the use of flash-boards. Even vertical hand operated slide gates would reduce the local flooding. This water could be used to supply part of the requirements of the Glapan-Setu area and might reduce the carrying capacity requirements of the Glapan Barat canal.

No estimate of the number or location of reuse structures can be made until adequate mapping is available. Elevations and topography are extremely critical to the design and evaluation of such structures. As a result, no cost estimates have been made herein. The Gaji Weir will require foundation exploration and a subsequent testing program on foundation materials. Estimates at this time are not warranted.

D.11.3. Assistance Programs/Projects

There are a number of assistance programs that should be developed and implemented which could improve irrigation and rice production in the basin. Some of them would involve reinforcing existing programs which are not presently functioning at efficient levels. Others would be new. These programs would require consultants, both local and expatriate, to provide training and to keep the program on schedule.

Anyone of the programs outlined in the following sections will require firm commitment on the part of the Government of Indonesia to provide operational funds after program establishment. The Government must commit financial support for irrigation project operation and maintenance to perpetuate the project thru its economic life. The following are a series of programs that should be implemented with expatriate assistance to get the staff trained, programs planned and to increase the production from irrigated lands in the basin.

D.11.3.a. Mapping

The entire service area and adjacent areas should be mapped at a scale of 1:2,000 with suitable contour intervals. Efforts should be made to spot elevate the paddies. The photo should supply the base with elevations and all other features placed on them in white. Paddy bunds should be shown as they will affect irrigation design. Inadequate mapping is a constraint to effective irrigation planning and project implementation in the basin.

D.11.3.b. Operation and Maintenance

Additional assistance is required in order to get subprojects operational and adequate maintenance funded and scheduled. Funding levels sufficient to develop an effective O & M organization should be reviewed. The organization lacks adequately trained field staff. There is a need for better maintenance records in the Semarang area. A commitment for adequate funding and a desire to establish an effective O & M is required as are expatriates to help plan, train, solve problems and provide the stimulus necessary to get the organization running smoothly.

D.11.3.c. Tertiary Development

Additional assistance is required in order to implement the Tertiary Irrigation Project. The project is understaffed, lacks adequate topography, and requires additional staff with surveying and design experience. Many of the ditches do not adequately serve the intended command area. The improved mapping recommended in D.11.3.a. will be required to strengthen the program. Particular emphasis in this assistance program would be training of the field staff to properly locate and design ditches. Tertiary irrigation should be designed in the field and not at office desks. The designers will require field training. The supervisor of construction will have to be trained in making field changes from the construction drawings so that errors in topography can be corrected and adjusted for at the time of construction. Local surveying techniques can also be improved through training.

D.11.3.d. Integrated Agriculture and Water Management Program

A water management program is required to train the farmer in the more efficient use of water thus increasing his production. Water management will have to be put forth as a necessary tool to obtain high yields. The two constraints of high yields are fertility and water management. Better and more economic use of fertilizers will have to be developed for each paddy, rice variety, land use intensity etc. The general recommendations by BIMAS and others do not appear valid for high yields and the farmers are aware of this. More progressive farmers are already using larger amounts of fertilizer to obtain higher yields but no data is available to help the farmers get maximum crop response for Rupiah spent or for his local conditions. Programs for insect and disease control must be developed and used by the farmers. Today, if a farmer goes into the field, discovers an insect infestation and sprays; there is a 95 percent chance that he is already too late and extensive damage will result. The use of agricultural scouts and fieldmen will become more and more important.

The local farmers have demonstrated that they are ready for the technology that an integrated agricultural program will provide. Assistance is required to set up such a program.

D.11.3.e. Regional Agricultural Laboratory

A regional agricultural laboratory with associated field services is necessary to support the integrated agricultural program. The laboratory should be designed to support the local farmers in improving yields. It should have a soils section that will conduct routine soils testing for fertility recommendations. Experimental work will be limited to obtaining correlation between all the various soils in the basin and yield levels so that specific recommendation can be made. The fertility requirement of new variety introductions will be established. Corrections or variety selection for nutrient deficiencies will be made.

In addition to soil fertility testing the laboratory should be equipped to make leaf analyses fertility requirements. Both entomology and plant pathology facilities should be provided to control insects and diseases.

The agricultural fieldman and [illegible] would operate from the facility. If the insect levels start to build towards critical levels, warnings can be given in time for the farmers to organize and get a preventive program into operation before damage progresses to unmanageable proportions.

This assistance program will require the expertise to plan, build, equip and operate the facility. An extensive program to train the senior staff and technician staff would be a part of the consultants program.

D.11.3.f. Research and Development to Establish Design Criteria for Reduction or Passage in Canals with Cohesive Sediments

There are no proven design criteria for canals located in cohesive clayey-silty sediments such as those in the Tuntang and Jragung Rivers. The only criteria available is for sandy sediments developed in the United States, Pakistan and India. These may not be completely applicable in Indonesia. A major problem in the conveyance system is the annual accumulation of sediment. If properly maintained, thousands of tons of sediment must be removed each year. Present sediment control systems do not work efficiently as presently designed. New criteria are needed to reduce the sediment load in the canals. A research program should be initiated that would provide the answers necessary to minimize the problem. A program of suspended sediment measuring, profile measurement, bed load sampling, detailed study of clay and silt particles including X-ray defraction should be formulated. Assistance is required to set up the program, to plan and guide it, and to train the staff after the criteria have been developed.

D.12. CONCLUSIONS AND RECOMMENDATIONS

The conclusions drawn herein and the subsequent recommendations are based on several analyses of individual project components and different combinations of project components. Many such analyses are not discussed in this section of the Appendix which deals principally with conclusions drawn from the many studies and puts forth recommendations based on those conclusions. The analyses were previously discussed however.

One array of elements noticeably missing from this section is that array based on the development scenario put forth by the Directorate General of Water Resources Development which included the raising of Rawa Pening with subsequent transbasin diversion, a small storage provided at Jragung and finally construction of Gunung Wulan. This particular path of basin development is fully explored and analyzed in Section D.9. of this Appendix. This array of elements resulted in lower annual net benefit, a lower internal rate of return and required greater capital investment than the development plans described in the following sections.

D.12.1. Conclusions With Respect to Individual Projects Within the Tuntang/Jragung Basin

Four individual projects, or plan elements, have been identified in the basin, three of which are compatible with a total development array. These elements are: Rawa Pening, Gunung Wulan, Tuntang/Jragung transbasin diversion and Glapan. They are technically feasible and economically attractive. Considering each of the three storage sites on their own merit, they are discussed in the following paragraphs.

D.12.1.a. Rawa Pening

The raising of Rawa Pening appears to have the greatest merit as an individual project for early implementation. Raising of Rawa Pening so as to provide 125 x 10^6 m^3 of live storage would result in the following:

1. A timely supply of 1,500 l/s of municipal and industrial water to the city of Semarang from Muncul Springs.
2. A year-round irrigation water supply for 14,204 ha of land in the Tuntang service area.
3. Annual net benefits of $ 12.98 x 10^6 at full development.
4. An internal rate of return of 21.5 percent.

Capital cost associated with the project in 1979 dollars is $ 31.01 x 10^6. A negative benefit associated with project construction and reservoir operation based on irrigation demands results from a loss of 5.2 MW of firm power. The average annual firm energy loss would be 50 Gwh at the existing Jelok and Timo power plants on the upper Tuntang. However, there would be an increase in secondary energy production of 29 Gwh annually resulting in a total average annual energy generation of 135 Gwh which is a decrease of 13.5 percent of existing energy generation.

The project appears technically feasible and economically viable. There are, however, two major constraints:

1. Poor subsurface foundation conditions along the levee centerline.
2. Sociological Impact on the Rawa Pening area.

It appears that the first constraint can be overcome by prudent design techniques and the second with well planned mitigation efforts. Should either constraint limit the magnitude of the project such that only 100 x 10^6 m^3 of live storage could be provided the 1,500 l/s of municipal and industrial water could still be supplied and 11,640 ha provided with a year-round supply of irrigation water. Capital costs would drop to $ 23.69 x 10^6 and the resulting internal rate of return would be 21.3 percent. Annual net benefits at full development would be $ 9.57×10^6.

D.12.1.b. Glapan Barrage

A second small-size project which on an individual basis would result in attractive benefits is the construction of Glapan Barrage. The construction of the barrage on the Tuntang to provide a storage capacity of 87×10^6 m^3 and operating it such that all water and sediment is bypassed from October 1 to March 31 would result in the following[1] :

1. A timely supply of 1,500 l/s of municipal and industrial water to the city of Semarang from Muncul Springs.
2. A year-round irrigation water supply for 13,517 ha of land in the Tuntang service area.
3. Annual net benefits at full development of $ 12.15×10^6.
4. An internal rate of return of 20.8 percent.

Capital cost associated with the project in 1979 dollars is $ 32.77×10^6. A negative benefit associated with the construction of the barrage and operation of Rawa Pening based on irrigation demands results from a 5.2 MW loss in firm power.

The average annual firm energy loss would be 50 Gwh at the existing Jelok and Timo power plants on the upper Tuntang. There would however be an increase in secondary energy generation of 32 Gwh annually at the two plants resulting in a total average annual energy generation of 142 Gwh as compared to the existing 160 Gwh.

1. Assuming the 43×10^6 m^3 of existing live storage at Rawa Pening is released in accordance with irrigation priority.

The project appears technically feasible and economically viable. Under the present policy of the Government not to build large-size projects, it is suggested that consideration should be given to the near-term construction of Glapan with the construction of Gunung Wulan at a much later date. Capital costs of complete development would be increased. If such consideration is given it appears possible to assess a future function of Glapan as a reregulation reservoir for Gunung Wulan allowing some firm power generation at that site.

D.12.1.c. Gunung Wulan

A third project which could be implemented on an individual basis is the Gunung Wulan Dam. This project would require a large amount of capital for implementation.

Construction of the dam to the height required to provide $190 \times 10^6 m^3$ of live storage and a 10-MW power plant would produce the following results:

1. A supply of 2,000 l/s of municipal and industrial water would become available for diversion to the city of Semarang from Muncul Springs.
2. A year-round irrigation water supply for 23,375 ha of irrigated land in the Tuntang service area.
3. Average annual net benefits of $\$ 30.27 \times 10^6$.
4. An internal rate of return of 14.1 percent.
5. Production of 65 Gwh annually of secondary energy.

Capital cost associated with the project in 1979 dollars is $\$ 130.38 \times 10^6$. Again a negative benefit associated with implementation is the loss of 5.2 MW of firm power on the existing upper Tuntang system.

The project appears technically feasible and economically attractive. The project constructed to only $190 \times 10^6 m^3$ of live storage is compatible with the development plan including Glapan. The project is not compatible with current GOI policy on larger dams.

Construction of Gunung Wulan alone to afford 260×10^6 m^3 of live storage, therefore becoming compatible as an element in the development plan without Glapan increases the irrigated area to 30,900 ha and brings the internal rate of return up to 15.7 percent. Capital costs increase to $ 145.85×10^6. Because of the current GOI policy on large dams, and more costly rehabilitation of the irrigation systems it is not as attractive as a first phase project in total development as is Rawa Pening.

D.12.1.d. Jragung

Jragung Dam is not required for optimum development of the Tuntang/Jragung Basin and is, therefore, not considered a viable individual project.

D.12.1.e. Tuntang/Jragung Diversion

The Tuntang/Jragung transbasin diversion plays a major role in integrated development of the two basins. This study shows that without storage provided on the Jragung significant benefits from diversion occur only when storage is provided at Gunung Wulan allowing diversion of Tuntang dry season flows to meet dry season irrigation demands in the Jragung service area.

Therefore, transbasin diversion is considered as an element to be constructed simultaneously with Gunung Wulan for optimum development.

D.12.2. Conclusions with Respect to Total Development

D.12.2.a. Potential for Full Development

Considering ultimate development of the basins water resources to result in the ability to provide 2,000 l/s of municipal and industrial water and provide a year-round irrigation water supply to 35,000 ha of land, potential for near maximum development is both technically possible and economically attractive. The most serious physical constraint to total development is the lack of reservoir sites allowing adequate storage volumes. One major contributing factor is the estimated severe erosion on the upper watersheds and the subsequent high reservoir sedimentation rates.

It is, however, possible to maximize the utilization of the basins water resources with an economical grouping of projects.

D.12.3. Selected Arrays of Elements Constituting Maximum Development

Two near optimum development plans are presented in the following sections.

D.12.3.a. Development Plan - Case I

The raising of Rawa Pening to provide 125 x 10^6 m^3 live storage, construction of the Glapan Barrage to provide 87 x 10^6 m^3 live storage and as a final phase the construction of Gunung Wulan Dam with 190 x 10^6 m^3 live storage will meet the basins projected water needs provided that this basin development need provide only 2,000 l/s of municipal and industrial water.

The full 35,000 ha would be served with year-round irrigation supplies. This group of projects is referred to in the text of this appendix as Case I of the development plan. A thirteen year construction period is assumed. Total capital costs associated with development are $ 180 x 10^6. This investment results in average annual net benefits of $ 46.2 x 10^6 and produces an internal rate of return of 17.3 percent.

Table D-39 summarizes the salient and economic features of Case I. Data for each stage of development are presented. The internal rates of return for Phase 1 and Phase 1 plus Phase 2 were computed assuming no further development after that particular phase.

D.12.3.b. Development Plan - Case II

The raising of Rawa Pening to provide 125 x 10^6 m^3 live storage with subsequent construction of Gunung Wulan Dam to provide 260 x 10^6 m^3 live storage and construction of the transbasin diversion with a capacity of 16 m^3/s will meet the basin's projected water needs provided that this basin development need provide only 2,000 l/s of municipal and industrial water. The full 35,000 ha would be provided with a year-round irrigation supply. This array is referred to in the text of this appendix as Case II of the development plan.

Total capital cost associated with development is $ 162.5 x 10^6. This investment results in average annual net benefits of $ 46.49 x 10^6 and produces an internal rate of return of 17.6 percent.

The effects of foundation and/or sociological constraints as well as the effect of possible necessity to eventually provide 4,000 l/s of municipal and industrial water to the city of Semarang from the basin on this development project were evaluated. The sensitivity of development economics to these variables is insignificant. Full details are given in Section 10 of this report.

Table D-40 summarizes the salient and economic features of Case II. Data for both phase 1 and total development are presented. The internal rate of return for phase 1 was computed assuming no further development after implementation.

D.12.4. Recommended Development Plan

Comparing Case I and Case II, it is noted that 1) Case I costs $ 17.1 million more than Case II, and 2) that the internal rates of return are about the same. Either plan is attractive and basically no difference exists, except the difference in project costs. The recommended development plan considers both alternatives.

If the current policy of the Government with respect to large dams prevails Case I would certainly be favored as it allows greater interim development without large dam construction. Feasibility level studies should consider Gunung Wulan/Glapan Barrage as a unit as well as the larger Gunung Wulan storage without Glapan and when more definite information is generated a more logical choice could be made.

The development plan herein recommended serves the full 35,000 ha of irrigated land and provides 2,000 l/s for municipal and industrial water from Muncul Springs.

D.12.5. Recommendation for Full Development

Providing that full feasibility level studies confirm the findings presented herein it may be recommended that the total development plan be implemented as the benefits to the people of the basin are badly needed and the benefits to the entire of Indonesia would be highly significant.

To assure timely basin development, it may be recommended that a staged feasibility study with respect to the raising of Rawa Pening be initiated at the earliest possible date. This is a key element in total basin development as herein envisioned but also offers excellent financial returns and economic viability as a "smaller" individual project. To avoid possible unnecessary expenditure by commencing with full feasibility immediately it is further recommended that feasibility level studies concentrating only on the major physical constraint be initiated as a first stage. That constraint is foundation conditions along the embankment centerline. One additional item, worthy of inclusion in the first stage of such a feasibility study would be a study of groundwater conditions in the areas around Rawa Pening to establish the reliability of Muncul Springs flows under existing conditions and in the case of future exploitation of groundwater resources in the area, as well as to identify and possibly quantify the additional groundwater inflow to Rawa Pening itself.

It is estimated that the first stage effort would require some 8 months to complete but that preliminary results available at the end of 6 months would allow a decision as to the advisability of going to full feasibility. Providing the initial feasibility level studies indicate that major recognized constraints can be overcome the study would be converted to a full feasibility study.

Concurrently with the staged feasibility study of Rawa Pening outlined above it is recommended that the DGWRD encourage the city of Semarang to initiate additional studies of possible sources of municipal and industrial water. In addition to the "Semarang Groundwater Investigation and Development Project" funded by a loan from the Asian Development Bank and described in Section D.10.1. of this Appendix a number of other efforts with regard to identifying potential should be undertaken. These include but are not necessarily limited to the following:

1. Burns and McDonnell/Trans-Asia [9] reported a groundwater potential of 1,000 to 1,500 l/s from the basins of the Kali Babon, Kali Garang, Kali Mangkang and Kali Blorong. The current study will provide valuable information on the groundwater potential of the Kali Garang. Similar programs should be initiated immediately in the uplands of the Kali Babon, Kali Mangkang, Kali Blorong, Kali Pengkol, and Kali Lana Basins.

2. Surface water sources outside the Tuntang/Jragung River Basins should be considered as municipal and industrial water supply sources to allow full irrigation development on the Tuntang/Jragung. In 1976 Burns and McDonnell/Trans-Asia [9] analyzed in some detail these reservoir sites for water supply potential. Penggaron Dam was identified as the most feasible source and further consideration of this supply will be undertaken as a component of Part II of this study.

Design should follow the feasibility immediately and construction could commence in 1982.

The implementation of Rawa Pening is scheduled as a first phase to allow timely development and the earliest possible delivery of 1,500 l/s of municipal and industrial water to Semarang. The second phase, ideally to commence immediately after Phase 1 would include construction of either Glapan or Gunung Wulan Dam.

Table D-41 summarizes the recommended time frame for further study and subsequent basin development.

With or without Government constraints, feasibility level studies should commence on Gunung Wulan with and without Glapan as soon as studies at Rawa Pening are completed. When the feasibility of Rawa Pening is completely established and the city of Semarang has identified and proven other sources for their supply, operational requirements at Gunung Wulan/Glapan can be more firmly set. In addition to the items which would normally be included in such a feasibility study it is strongly recommended that Glapan Barrage be re-evaluated serving a major function of re-regulation of power releases at Gunung Wulan. By utilizing Glapan for re-regulation, and allowing the generation of some firm power at Gunung Wulan in addition to affording storage of local inflows, its attractiveness as a component in a development array might possibly be improved even more. If this was to be the case and the position of the Indonesian Government with respect to delaying large dam construction prevails it would provide a second "intermediate size project" compatible with total development of the basin which might be undertaken at an early date.

If financial, sociological or other constraints restrict timely commencement of total basin development as envisioned in this appendix, attention might be directed toward those minor projects outlined in Section D.11.2. as they would be compatible with future basin development efforts. If a timely effort at basin development as outlined in the proceeding section were undertaken these minor projects would need not be undertaken as separate projects but would be included as a part of irrigation system rehabilitation leading to full basin development. The assistance programs and projects summarized in Section D.11.3. will of course complement any level of development and could be initiated at any time. As sedimentation resulting from what appears to be an ever increasing degree of erosion on the basins watersheds is a major problem, implementation of upstream watershed management programs and erosion control measures as outlined and recommended in Appendix F, are a high priority activity regardless of the configuration or timing of downstream development.

TABLE D-39

THE DEVELOPMENT PLAN - CASE I

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 (%)	Jragung (%)	UTS (GWh)	Gunung Wulan (GWh)	Water (l/s)	Cost ($ x 10^6)	Net Benefits ($ x 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 D-40

THE DEVELOPMENT PLAN - CASE II

Phase	Storage Provided			Area Irrigated		Irrigation Firmness		Average Annual Energy		M & I	Project	Average Annual	IRR
	Rawa Pening	Gunung Wulan	Glapan	Tuntang	Jragung	Tuntang	Jragung	UTS	Gunung Wulan	Water	Cost	Net Benefits	
	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(ha)	(ha)	(ha)	(ha)	(GWh)	(GWh)	(l/s)	($\$ \times 10^6$)	($\$ \times 10^6$)	(%)
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 D-41

RECOMMENDED STUDY AND DEVELOPMENT

SCHEDULE - TOTAL BASIN DEVELOPMENT

Year	Quarter	
1980	1	Commence Staged Feasibility Study - Rawa Pening
1980	1	City of Semarang intensifies efforts to identify and prove other supply sources.
1980	3	Phase 2 - Rawa Pening Feasibility Study
1981	1	Design Studies - Rawa Pening
1982	1	Construction start - Rawa Pening
1982	1	Commence Feasibility Study on Gunung Wulan and/or Gunung Wulan/Glapan
1983	4	Complete Gunung Wulan Feasibility
1984	1	Commence Gunung Wulan Design Phase
1985	3	Complete Rawa Pening Construction
1986	1	Commence Gunung Wulan and Transbasin Diversion Construction or Glapan Construction
1990	3	Complete Gunung Wulan or Glapan Construction
1991	1	In the case of three phase development construction starts on Gunung Wulan
1995	4	In the case of three phase development construction ends at Gunung Wulan.

TABLE D-42

SUMMARY OF SELECTED BASIN MODEL RUNS

Run No.	Irrigated Area: Tuntang (ha)	Irrigated Area: Jragung (ha)	Live Storage Capacities: Rawa Pening (10^6 m^3)	Live Storage Capacities: Gunung Wulan (10^6 m^3)	Live Storage Capacities: Jragung (10^6 m^3)	Live Storage Capacities: Glapan (10^6 m^3)	Average Annual Rawa Pening Release (10^6 m^3)	Tuntang/Jragung Diversion: Max Q (m^3/s)	Tuntang/Jragung Diversion: Average Annual Volume (10^6 m^3)	Gunung Wulan: Releases Average (10^6 m^3)	Gunung Wulan: Shortage Average (10^6 m^3)	Gunung Wulan: Spill Average (10^6 m^3)	Jragung: Releases Average (10^6 m^3)	Jragung: Shortage Average (10^6 m^3)	Jragung: Spill Average (10^6 m^3)	Glapan: Releases Average (10^6 m^3)	Glapan: Shortage Average (10^6 m^3)	Glapan: Spill Average (10^6 m^3)	Irrigation Firmness: Tuntang (%)	Irrigation Firmness: Jragung (%)	M & I Water: Muncul (l/s)	M & I Water: Jragung (l/s)	Average Annual Energy: JTS (GWh)	Average Annual Energy: Gunung Wulan (GWh)	Average Annual Energy: Jragung (GWh)
622	8,181	-	100	-	-	-	82.5	-	-	151.5	0.0	618.8	-	-	-	-	-	-	100.0	-	500	-	156.0	-	-
623	8,181	-	100	-	-	-	82.2	-	-	151.3	0.2	596.1	-	-	-	-	-	-	99.2	-	1,000	-	150.0	-	-
624	8,181	-	100	-	-	-	81.2	-	-	150.3	1.2	581.7	-	-	-	-	-	-	98.8	-	1,500	-	144.6	-	-
626	10,518	-	100	-	-	-	104.2	-	-	186.3	3.2	584.5	-	-	-	-	-	-	98.4	-	250	-	159.0	-	-
628	10,518	-	100	-	-	-	102.1	-	-	184.3	5.1	563.5	-	-	-	-	-	-	96.4	-	1,000	-	150.0	-	-
629	10,518	-	100	-	-	-	100.6	-	-	182.9	6.6	549.7	-	-	-	-	-	-	96.4	-	1,500	-	144.2	-	-
630	10,518	-	100	-	-	-	99.1	-	-	181.4	8.1	535.9	-	-	-	-	-	-	96.4	-	2,000	-	137.6	-	-
631	12,856	-	100	-	-	-	12[illegible].8	-	-	217.7	9.8	553.5	-	-	-	-	-	-	95.6	-	250	-	155.0	-	-
632	12,856	-	100	-	-	-	12[illegible].7	-	-	216.6	10.8	547.0	-	-	-	-	-	-	94.8	-	500	-	158.0	-	-
633	12,856	-	100	-	-	-	119.3	-	-	214.4	13.0	533.9	-	-	-	-	-	-	94.8	-	1,000	-	147.2	-	-
634	12,856	-	100	-	-	-	117.4	-	-	212.3	15.1	520.6	-	-	-	-	-	-	94.4	-	1,500	-	141.0	-	-
696	15,194	-	100	-	-	-	138.1	-	-	245.6	20.0	526.0	-	-	-	-	-	-	92.9	-	250	-	132.2	-	-
697	15,194	-	100	-	-	-	137.6	-	-	244.2	21.2	519.8	-	-	-	-	-	-	92.9	-	500	-	149.7	-	-
700	15,194	-	100	-	-	-	128.7	-	-	235.6	30.0	482.8	-	-	-	-	-	-	90.9	-	2,000	-	132.1	-	-
711	15,194	-	150	-	-	-	152.0	-	-	258.1	7.3	510.8	-	-	-	-	-	-	96.8	-	250	-	149.4	-	-
712	15,194	-	150	-	-	-	151.2	-	-	257.3	8.1	504.1	-	-	-	-	-	-	96.4	-	500	-	146.7	-	-
713	15,194	-	150	-	-	-	149.6	-	-	255.6	9.7	490.3	-	-	-	-	-	-	96.4	-	1,000	-	141.4	-	-
714	15,194	-	150	-	-	-	147.9	-	-	254.0	11.4	476.7	-	-	-	-	-	-	96.6	-	1,500	-	135.4	-	-
715	15,194	-	150	-	-	-	146.0	-	-	252.1	13.3	463.3	-	-	-	-	-	-	96.0	-	2,000	-	128.9	-	-
716	18,700	-	150	-	-	-	180.0	-	-	302.6	19.7	467.2	-	-	-	-	-	-	94.8	-	250	-	141.0	-	-
717	18,700	-	150	-	-	-	178.7	-	-	301.4	20.9	460.9	-	-	-	-	-	-	94.4	-	500	-	130.0	-	-
718	18,700	-	150	-	-	-	176.3	-	-	299.0	23.3	448.1	-	-	-	-	-	-	93.7	-	1,000	-	133.0	-	-
719	18,700	-	150	-	-	-	173.7	-	-	296.5	25.8	435.4	-	-	-	-	-	-	93.3	-	1,500	-	127.6	-	-
720	18,700	-	150	-	-	-	170.8	-	-	293.6	28.7	423.4	-	-	-	-	-	-	92.5	-	2,000	-	122.0	-	-
731	18,700	-	200	-	-	-	191.4	-	-	313.7	8.6	453.6	-	-	-	-	-	-	97.6	-	250	-	139.1	-	-
732	18,700	-	200	-	-	-	190.4	-	-	312.8	9.5	447.0	-	-	-	-	-	-	96.8	-	500	-	136.0	-	-
733	18,700	-	200	-	-	-	188.1	-	-	310.5	11.8	434.2	-	-	-	-	-	-	96.4	-	1,000	-	129.9	-	-
734	18,700	-	200	-	-	-	185.1	-	-	307.6	14.7	421.8	-	-	-	-	-	-	96.0	-	1,500	-	126.7	-	-
735	18,700	-	200	-	-	-	180.7	-	-	303.2	19.1	411.3	-	-	-	-	-	-	95.6	-	2,000	-	119.6	-	-
736	23,375	-	200	-	-	-	208.0	-	-	370.8	27.4	398.4	-	-	-	-	-	-	93.7	-	250	-	128.1	-	-

Notes: 1. In all cases Rawa Pening is operated for irrigation
2. In all cases the Recommended Cropping Pattern is assumed unless otherwise noted
3. Average annual energy is totally secondary.

TABLE D-42
(Cont.)

SUMMARY OF SELECTED BASIN MODEL RUNS

Run	Irrigated Area		Live Storage Capacities				Average Annual	Tuntang/Jragung Diversion		Gunung Wulan			Jragung			Glapan			Irrigation Firmness		N & I Water		Average Annual Energy		
No.	Tuntang	Jragung	Rawa Pening	Gunung Wulan	Jragung	Glapan	Rawa Pening Release	Max Q	Average Annual Volume	Releases Average	Shortage Average	Spill Average	Releases Average	Shortage Average	Spill Average	Releases Average	Shortage Average	Spill Average	Tuntang	Jragung	[illegible]	Jragung	[illegible]	Gunung Wulan	Jragung
	(ha)	(ha)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(m^3/s)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(10^6 m^3)	(%)	(%)	(l/s)	(l/s)	(GWh)	(GWh)	(GWh)
738	23,375	-	200	-	-	-	221.1	-	-	363.3	35.0	363.2	-	-	-	-	-	-	92.5	-	1,000	-	110.8	-	-
739	23,375	-	200	-	-	-	214.9	-	-	357.3	41.0	374.1	-	-	-	-	-	-	90.9	-	1,500	-	114.6	-	-
740	23,375	-	200	-	-	-	208.7	-	-	351.2	47.1	365.2	-	-	-	-	-	-	89.7	-	2,000	-	100.5	-	-
744	16,362	-	250	-	-	-	170.3	-	-	281.7	2.7	444.3	-	-	-	-	-	-	99.2	-	1,500	-	129.9	-	-
745	16,362	-	250	-	-	-	167.1	-	-	278.6	5.8	432.4	-	-	-	-	-	-	98.0	-	2,000	-	122.4	-	-
746	19,869	-	250	-	-	-	207.3	-	-	334.6	6.7	430.6	-	-	-	-	-	-	98.4	-	250	-	133.8	-	-
747	19,869	-	250	-	-	-	265.2	-	-	332.6	8.7	425.3	-	-	-	-	-	-	97.6	-	500	-	130.9	-	-
748	19,869	-	250	-	-	-	200.5	-	-	328.0	13.2	414.6	-	-	-	-	-	-	96.4	-	1,000	-	126.2	-	-
751	23,375	-	250	-	-	-	232.7	-	-	374.5	23.7	392.3	-	-	-	-	-	-	95.2	-	250	-	126.9	-	-
752	23,375	-	250	-	-	-	230.3	-	-	372.2	26.0	387.0	-	-	-	-	-	-	93.2	-	500	-	123.6	-	-
753	23,375	-	250	-	-	-	225.6	-	-	367.6	30.6	376.4	-	-	-	-	-	-	94.0	-	1,000	-	117.6	-	-
754	23,375	-	250	-	-	-	220.9	-	-	363.0	35.2	365.9	-	-	-	-	-	-	93,3	-	1,500	-	111.7	-	-
755	23,375	-	250	-	-	-	216.3	-	-	358.5	39.7	355.9	-	-	-	-	-	-	92.5	-	2,000	-	106.4	-	-
786	8,181	11,625	100	-	75	-	189.2	20.0	121.1	138.0	13.5	459.5	176.3	15.2	64.6	-	-	-	92.9	92.1	2,000	-	127.1	-	19.8
787	8,181	8,719	100	-	75	-	164.8	20.0	91.0	143.4	8.1	483.7	138.1	6.3	66.7	-	-	-	96.4	96.4	2,000	-	131.3	-	16.4
788	8,181	5,812	100	-	75	-	145.0	20.0	67.1	147.1	4.4	503.5	96.3	1.0	69.5	-	-	-	97.6	98.8	2,000	-	133.4	-	18.1
789	8,181	11,625	150	-	75	-	197.0	20.0	125.3	141.3	10.2	449.3	180.3	11.2	64.6	-	-	-	94.8	94.8	2,000	-	125.5	-	20.1
790	8,181	8,719	150	-	75	-	172.6	20.0	94.3	147.7	3.8	473.6	141.4	3.0	66.7	-	-	-	98.0	98.4	2,000	-	129.2	-	16.6
791	8,181	5,812	150	-	75	-	150.6	20.0	68.3	151.4	.1	495.5	97.3	0.0	69.5	-	-	-	99.6	100.0	2,000	-	132.6	-	13.3
805	8,181	4,068	100	-	75	-	139.5	20.0	60.7	148.1	3.4	508.8	69.0	0.0	72.8	-	-	-	98.0	100.0	2,000	-	133.5	-	9.1
806	8,181	3,487	100	-	75	-	149.2	20.0	71.4	147.1	4.4	499.3	121.2	0.7	52.8	-	-	-	97.6	98.8	2,000	2,000	133.3	-	13.0
809	8,181	5,228	100	-	50	-	128.5	20.0	51.6	146.3	5.2	519.7	85.8	2.0	77.1	-	-	-	96.6	96.8	2,000	-	133.2	-	20.3
810	8,181	4,068	100	-	50	-	123.0	20.0	43.9	148.3	3.2	525.3	68.2	.8	80.0	-	-	-	98.4	98.8	2,000	-	136.3	-	8.6
811	8,181	2,906	100	-	50	-	131.7	20.0	54.4	146.7	4.8	516.5	110.4	2.8	58.5	-	-	-	96.8	97.2	2,000	2,000	130.1	-	20.6
823	23,375	11,625	100	250	50	-	184.3	20.0	163.8	365.5	32.7	168.0	235.6	18.1	49.7	-	-	-	92.9	92.9	2,000	2,000	132.1	-	13.1
824	23,375	11,625	100	220	50	-	186.9	20.0	160.0	360.1	38.1	179.8	231.8	21.9	49.7	-	-	-	90.9	90.5	2,000	2,000	134.6	48.2	21.4
825	23,375	11,625	300	180	50	-	191.5	20.0	150.6	350.3	47.9	198.3	226.6	27.1	49.7	-	-	-	88.1	88.1	2,000	2,000	122.6	43.6	20.7
826	23,375	11,625	100	230	75	-	190.1	20.0	162.9	365.6	32.6	168.9	235.9	17.8	48.4	-	-	-	92.9	92.9	2,000	2,000	122.4	45.6	23.6
827	23,375	11,625	100	200	75	-	193.2	20.0	159.1	359.9	38.4	181.0	232.1	21.6	48.6	-	-	-	90.5	90.5	2,000	2,000	120.8	44.3	23.7
828	23,375	11,625	100	170	75	-	196.3	20.0	154.6	352.0	46.3	196.1	277.7	26.0	48.4	-	-	-	88.5	88.5	2,000	2,000	119.3	43.0	22.1

Notes: 1. In all cases Rawa Pening is operated for irrigation
2. In all cases the Recommended Cropping Pattern is assumed unless otherwise noted
3. Average annual energy is totally secondary.

TABLE D-42

(Cont.)

SUMMARY OF SELECTED BASIN MODEL RUNS

Run No.	Irrigated Area: Tuntang (ha)	Irrigated Area: Jragung (ha)	Live Storage Capacities: Rawa Pening (10^6 m^3)	Live Storage Capacities: Gunung Wulan (10^6 m^3)	Live Storage Capacities: Jragung (10^6 m^3)	Live Storage Capacities: Glapan (10^6 m^3)	Average Annual Rawa Pening Release (10^6 m^3)	Tuntang/Jragung Diversion: Max Q (m^3/s)	Tuntang/Jragung Diversion: Average Annual Volume (10^6 m^3)	Gunung Wulan: Releases Average (10^6 m^3)	Gunung Wulan: Shortage Average (10^6 m^3)	Gunung Wulan: Spill Average (10^6 m^3)
853	23,375	11,625	125	260	-	-	161.3	16.0	136.6	369.7	28.5	190.0
854	23,375	11,625	125	265	-	-	160.8	16.0	137.0	370.5	27.7	188.5
855	23,375	11,625	125	270	-	-	160.3	16.0	137.3	371.4	26.9	187.0
856	23,375	11,625	125	255	-	-	161.7	16.0	136.2	368.9	29.3	191.5
857	23,375	11,625	125	250	-	-	162.4	16.0	135.9	368.2	30.0	193.2
858	23,375	11,625	125	245	-	-	163.1	16.0	135.5	367.5	30.7	194.7
859	23,375	11,625	100	270	-	-	150.1	16.0	134.9	367.8	30.4	194.0
866	23,375	11,625	100	270	50	-	182.7	20.0	165.3	368.0	30.3	162.7
867	23,375	11,625	100	250	75	-	187.3	20.0	164.5	367.8	30.4	163.8
868	23,375	11,625	100	270	75	-	185.0	20.0	165.5	369.8	28.4	159.2
876	12,856	-	125	-	-	-	123.8	-	-	218.5	8.9	513.1
877	14,025	-	125	-	-	-	132.7	-	-	233.4	13.0	498.4
878	15,193	-	125	-	-	-	141.2	-	-	247.6	17.7	484.4
879	16,362	-	125	-	-	-	149.2	-	-	261.3	23.1	471.1
880	17,531	-	125	-	-	-	156.2	-	-	273.8	29.5	459.1
881	18,700	-	125	-	-	-	162.6	-	-	285.6	36.7	447.8
882	23,375	11,625	125	260	-	-	161.3	16.0	136.6	369.7	28.5	190.0
883	23,375	11,625	125	260	-	-	187.6	18.0	168.7	361.5	36.4	167.2
884	22,206	11,043	125	260	-	-	181.2	17.2	165.0	350.9	28.3	180.7
885	21,037	10,462	125	260	-	-	172.7	16.5	160.0	338.9	21.3	196.8
886	19,868	9,881	125	260	-	-	162.2	15.7	154.1	326.0	15.3	214.5
887	18,700	9,300	125	260	-	-	154.1	14.9	148.5	311.2	11.1	233.6
888	17,531	8,718	125	260	-	-	147.1	14.1	142.3	296.3	7.0	253.3
889	16,326	8,137	125	260	-	-	139.6	13.4	135.5	281.2	3.1	273.8
890	15,193	7,556	125	260	-	-	130.9	12.6	128.4	264.6	.8	296.3
910	23,375	11,625	100	260	-	-	150.1	16.0	134.9	367.8	30.4	194.0
911	22,206	11,043	100	260	-	-	150.5	15.2	129.3	356.4	22.8	210.0
912	21,038	10,462	100	260	-	-	131.1	14.5	123.7	343.5	16.8	227.5
913	19,868	9,881	100	250	-	-	123.0	13.7	117.7	328.7	12.6	247.0
914	22,206	11,043	100	260	-	-	169.9	17.2	161.1	350.3	28.9	185.7

Run No.	Jragung: Releases Average (10^6 m^3)	Jragung: Shortage Average (10^6 m^3)	Jragung: Spill Average (10^6 m^3)	Glapan: Releases Average (10^6 m^3)	Glapan: Shortage Average (10^6 m^3)	Glapan: Spill Average (10^6 m^3)	Irrigation Firmness: Tuntang (%)	Irrigation Firmness: Jragung (%)	M & I Water: Muncul (1/s)	M & I Water: Jragung (1/s)	Average Annual Energy: UTS (GWh)	Average Annual Energy: Gunung Wulan (GWh)	Average Annual Energy: Jragung (GWh)
853	178.1	13.4	81.8	-	-	-	94.8	94.8	2,000	-	133.1	40.0	-
854	178.4	13.1	81.9	-	-	-	94.8	94.8	2,000	-	133.4	40.0	-
855	178.8	12.7	81.8	-	-	-	94.8	94.8	2,000	-	133.0	40.1	-
856	177.8	13.8	81.8	-	-	-	94.4	94.4	2,000	-	132.3	40.0	-
857	177.4	14.1	81.8	-	-	-	94.4	94.4	2,000	-	131.6	40.9	-
858	177.0	14.3	18.8	-	-	-	94.4	94.4	2,000	-	130.9	40.7	-
859	176.5	15.0	81.7	-	-	-	94.4	94.4	2,000	-	126.6	30.4	-
866	237.0	16.7	49.7	-	-	-	93.7	93.3	2,000	2,000	120.9	44.3	22.0
867	237.4	16.3	48.4	-	-	-	94.0	93.7	2,000	2,000	124.7	45.0	23.6
868	238.4	15.3	46.4	-	-	-	94.6	94.4	2,000	2,000	125.1	40.2	23.0
876	-	-	-	-	-	-	96.4	-	1,500	-	141.0	-	-
877	-	-	-	-	-	-	95.2	-	1,500	-	138.7	-	-
878	-	-	-	-	-	-	94.0	-	1,560	-	136.3	-	-
879	-	-	-	-	-	-	92.9	-	1,500	-	134.5	-	-
880	-	-	-	-	-	-	91.3	-	1,500	-	132.3	-	-
881	-	-	-	-	-	-	90.9	-	1,500	-	130.1	-	-
882	178.1	13.4	81.8	-	-	-	94.8	94.8	2,000	-	132.9	42.0	-
883	232.1	21.6	59.8	-	-	-	91.7	90.9	2,000	2,000	131.2	43.2	-
884	227.7	16.6	60.5	-	-	-	93.7	93.7	2,000	2,000	133.6	44.5	-
885	220.0	12.8	61.2	-	-	-	94.8	94.6	2,000	2,000	136.1	47.3	-
886	213.5	9.9	61.8	-	-	-	95.2	95.2	2,000	2,000	137.1	40.4	-
887	209.0	6.7	62.5	-	-	-	97.6	96.3	2,000	2,000	138.1	40.6	-
888	202.2	4.4	63.3	-	-	-	98.0	98.0	2,000	2,000	136.5	30.5	-
889	194.7	2.5	64.2	-	-	-	98.8	98.8	2,000	2,000	138.0	31.5	-
890	186.7	1.0	65.2	-	-	-	99.6	99.2	2,000	2,000	138.1	32.4	-
910	176.5	15.0	81.7	-	-	-	94.4	94.4	2,000	-	136.6	30.4	-
911	170.1	12.0	82.6	-	-	-	94.8	94.8	2,000	-	130.4	30.0	-
912	163.6	9.0	83.5	-	-	-	96.0	95.6	2,000	-	138.0	36.9	-
913	156.6	6.6	84.6	-	-	-	96.8	96.4	1,000	-	138.6	38.9	-
914	224.0	20.2	60.3	-	-	-	93.3	90.9	2,000	2,000	136.6	47.8	-

Notes: 1. In all cases Rawa Pening is operated for irrigation

2. In all cases the Recommended Cropping Pattern is assumed unless otherwise noted

3. Average annual energy is totally secondary.

TABLE D-42

(Cont.)

SUMMARY OF SELECTED BASIN MODEL RUNS

Run No.	Irrigated Area Tuntang (ha)	Irrigated Area Jragung (ha)	Live Storage Capacities Rawa Pening (10^6 m^3)	Live Storage Capacities Gunung Wulan (10^6 m^3)	Live Storage Capacities Jragung (10^6 m^3)	Live Storage Capacities Glapan (10^6 m^3)	Average Annual Rawa Pening Release (10^6 m^3)	Tuntang/Jragung Diversion Max Q (m^3/s)	Tuntang/Jragung Diversion Average Annual Volume (10^6 m^3)	Gunung Wulan Releases Average (10^6 m^3)	Gunung Wulan Shortage Average (10^6 m^3)	Gunung Wulan Spill Average (10^6 m^3)
917	23,375	11,625	43	-	-	-	133.6	-	-	269.1	110.6	518.0
918	23,375	11,625	125	260	-	-	161.3	16.0	136.6	369.7	28.5	190.0
B 919	23,375	11,625	43	-	-	-	128.2	-	-	209.6	108.0	577.3
A 920	23,375	11,625	125	260	-	-	155.7	16.0	138.1	311.9	24.6	243.1
921	23,375	-	43	260	-	-	12.0	-	-	368.5	9.7	304.5
922	21,307	-	43	260	-	-	9.3	-	-	356.5	3.7	334.5
923	18,700	-	43	260	-	-	5.7	-	-	322.3	0.0	367.4
924	16,362	-	43	260	-	-	.5	-	-	284.3	0.0	403.6
B 932	14,025	-	125	-	-	-	137.6	-	-	199.4	19.6	518.2
B 933	11,687	-	125	-	-	-	119.6	-	-	175.7	10.0	540.8
A 934	9,350	-	125	-	-	-	99.9	-	-	149.2	3.1	566.9
B 935	16,362	-	100	-	-	-	133.8	-	-	201.4	31.0	518.9
B 936	14,025	-	100	-	-	-	125.4	-	-	187.7	31.4	531.5
B 937	11,687	-	100	-	-	-	122.7	-	-	169.1	16.5	548.9
B 938	9,350	-	100	-	-	-	116.3	-	-	144.8	7.4	572.6
A 939	7,012	-	100	-	-	-	75.4	-	-	117.4	1.5	599.4
940	11,687	-	43	-	-	87	25.7	-	-	-	-	-
941	9,350	-	43	-	-	87	16.3	-	-	-	-	-
942	14,025	-	43	-	-	87	35.1	-	-	-	-	-
943	16,362	-	43	-	-	87	45.9	-	-	-	-	-
944	11,687	-	43	-	-	87	25.7	-	-	-	-	-
945	9,350	-	43	-	-	87	16.5	-	-	-	-	-
946	14,025	-	43	-	-	87	34.9	-	-	-	-	-
947	16,362	-	43	-	-	87	25.6	-	-	-	-	-
948	11,687	-	43	-	-	87	35.2	-	-	-	-	-

Run No.	Jragung Releases Average (10^6 m^3)	Jragung Shortage Average (10^6 m^3)	Jragung Spill Average (10^6 m^3)	Glapan Releases Average (10^6 m^3)	Glapan Shortage Average (10^6 m^3)	Glapan Spill Average (10^6 m^3)	Irrigation Firmness Tuntang (%)	Irrigation Firmness Jragung (%)	M & I Water [illegible] (l/s)	M & I Water Jragung (l/s)	Average Annual Energy UTS (GWh)	Average Annual Energy Gunung Wulan (GWh)	Average Annual Energy Jragung (GWh)
917	47.4	141.0	76.4	-	-	-	77.4	42.5	-	-	135.1	-	-
918	178.1	13.4	81.8	-	-	-	94.8	94.8	2,000	-	132.9	49.0	-
B 919	67.4	141.0	76.6	-	-	-	77.4	42.5	-	-	134.9	-	-
A 920	179.6	11.9	81.8	-	-	-	94.8	94.8	2,000	-	135.0	31.0	-
921	-	-	-	-	-	-	98.4	-	2,000	-	134.6	64.0	-
922	-	-	-	-	-	-	98.6	-	2,000	-	134.4	65.4	-
923	-	-	-	-	-	-	100.0	-	2,000	-	134.6	66.1	-
924	-	-	-	-	-	-	100.0	-	2,000	-	134.7	66.0	-
B 932	-	-	-	-	-	-	92.1	-	2,000	-	126.2	-	-
B 933	-	-	-	-	-	-	93.6	-	2,000	-	130.0	-	-
A 934	-	-	-	-	-	-	97.6	-	2,000	-	133.6	-	-
B 935	-	-	-	-	-	-	83.3	-	2,000	-	123.7	-	-
B 936	-	-	-	-	-	-	88.5	-	2,000	-	128.0	-	-
B 937	-	-	-	-	-	-	92.5	-	2,000	-	131.5	-	-
B 938	-	-	-	-	-	-	15.6	-	2,000	-	135.6	-	-
A 939	-	-	-	-	-	-	98.8	-	2,000	-	137.0	-	-
940	-	-	-	187.9	5.0	647.4	96.8	-	1,000	-	144.3	-	-
941	-	-	-	154.2	.8	601.7	98.8	-	1,000	-	147.9	-	-
942	-	-	-	217.5	13.3	617.8	93.6	-	1,000	-	148.0	-	-
943	-	-	-	245.4	23.4	509.1	93.3	-	1,000	-	140.2	-	-
944	-	-	-	186.4	6.5	633.6	97.2	-	1,300	-	142.0	-	-
945	-	-	-	153.6	1.3	657.0	98.8	-	1,300	-	141.7	-	-
946	-	-	-	215.5	15.4	604.0	94.0	-	1,300	-	141.8	-	-
947	-	-	-	243.8	26.0	376.4	92.5	-	1,300	-	141.7	-	-
948	-	-	-	189.1	3.8	661.5	98.0	-	900	-	154.2	-	-

Notes: 1. In all cases Rawa Pening is operated for irrigation
2. In all cases the Recommended Cropping Pattern is assumed unless otherwise noted
3. Average annual energy is totally secondary.

A. Local Inflow between Gunung Wulan and Glapan introduced

B. Cropping Pattern is 2 + 1

TABLE D-42

(Cont.)

SUMMARY OF SELECTED BASIN MODEL RUNS

Run No.	Irrigated Area: Tuntang (ha)	Irrigated Area: Jragung (ha)	Live Storage Capacities: Rawa Pening (10^6 m^3)	Live Storage Capacities: Gunung Wulan (10^6 m^3)	Live Storage Capacities: Jragung (10^6 m^3)	Live Storage Capacities: Glapan (10^6 m^3)	Average Annual Rawa Pening Release (10^6 m^3)	Tuntang/Jragung Diversion: Max Q (m^3/s)	Tuntang/Jragung Diversion: Average Annual Volume (10^6 m^3)	Gunung Wulan: Releases Average (10^6 m^3)	Gunung Wulan: Shortage Average (10^6 m^3)	Gunung Wulan: Spill Average (10^6 m^3)
948	14,025	-	43	-	-	87	35.2	-	-	-	-	-
949	16,362	-	43	-	-	87	46.3	-	-	-	-	-
950	18,700	-	43	-	-	87	48.9	-	-	-	-	-
954	18,700	-	100	-	-	87	78.0	-	-	-	-	-
958	16,362	-	100	-	-	87	61.3	-	-	-	-	-
962	19,868	-	125	-	-	87	93.1	-	-	-	-	-
966	18,700	-	125	-	-	87	84.5	-	-	-	-	-
975	11,687	5,812	100	-	-	87	96.4	8.3	63.0	-	-	-
999	23,375	11,625	43	260	-	116	117.1	15.7	114.5	212.8	13.6	381.5
1019	23,375	-	43	190	-	-	26.7	-	-	373.9	24.3	325.9

Run No.	Jragung: Releases Average (10^6 m^3)	Jragung: Shortage Average (10^6 m^3)	Jragung: Spill Average (10^6 m^3)	Glapan: Releases Average (10^6 m^3)	Glapan: Shortage Average (10^6 m^3)	Glapan: Spill Average (10^6 m^3)	Irrigation Firmness: Tuntang (%)	Irrigation Firmness: Jragung (%)	M & I Water: Manual (l/s)	M & I Water: Jragung (l/s)	Average Annual Energy: PLN (GWh)	Average Annual Energy: Gunung Wulan (GWh)	Average Annual Energy: Jragung (GWh)
948	-	-	-	219.8	11.1	638.2	96.6	-	500	-	134.8	-	-
949	-	-	-	248.0	20.8	601.4	94.0	-	500	-	133.6	-	-
950	-	-	-	273.7	33.0	515.6	91.7	-	500	-	133.9	-	-
954	-	-	-	286.6	30.2	537.8	95.6	-	1,500	-	130.8	-	-
958	-	-	-	255.5	13.3	553.5	96.0	-	2,000	-	131.6	-	-
962	-	-	-	306.6	19.1	516.7	95.6	-	1,500	-	128.5	-	-
966	-	-	-	290.1	16.6	517.8	96.0	-	2,000	-	127.4	-	-
975	92.6	4.7	94.1	180.9	12.0	567.9	95.2	95.2	2,000	-	133.3	-	-
999	157.3	34.2	80.7	368.1	14.1	310.4	88.5	84.5	2,000	-	130.1	-	-
1019	-	-	-	-	-	-	95.2	-	2,000	-	134.1	80.7	-

Notes: 1. In all cases Rawa Pening is operated for irrigation
2. In all cases the Recommended Cropping Pattern is assumed unless otherwise
3. Average Annual Energy is totally secondary.

COMPUTER PRINTOUT

RUN NUMBER 918

OPERATIONAL DATA


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// JOB RC179055                                              DATE 11/10/79,CLOCK 09/30/18
// EXEC INTANGPF

                                   RUN NUMBER    918

   IN THIS RUN STORAGE CAPACITIES OF RAWA PENING, G-WULAN AND JRAGUNG ARE    125.   260.     0. MCM
               TRANSBASIN DIVERSION MAX DISCH CAPACITY =  50.00 CMS
               WATER SUPPLY FOR SEMARANG FROM MUNCUL = 2.000 AND FROM JRAGUNG = 0.0   CMS

   IN THIS RUN SEDIMENT IS PASSED THROUGH JRAGUNG DURING DECEMBER,JANUARY AND FEBRUARY

                                        CONDITIONS

 1. IRRIGATION SHORTAGES LESS THAN FIVE PERCENT BY VOLUME OF IRRIGATION DEMANDS ARE ACCOUNTED FOR BUT NOT COUNTED

 2. MAXIMUM MONTHLY DIVERSION OVER PERIOD OF RUN IS SHOWN

 3. FIRM POWER AND ENERGY AND SECONDARY POWER AND ENERGY ARE COMPUTED AND SHOWN

 4. TRANSBASIN DIVERSIONS ARE MADE TO MEET REQUIREMENTS AT BOTH JRAGUNG AND GUNUNGWULAN WITH OUT SPILL AT JRAGUNG

 IRRIGATED AREA ON THE TUNTANG IS23375.00 HA. AND ON THE JRAGUNG11625.00 HA.
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JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 1 RUN NUMBER 918

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	20.1	0.0	0.0	0.0	11.8	462.5	0.0	1.5	0.0	9.7	0.0	1.6	0.0	0.0	7.2	55.4	0.0	3.4	0.0	0.3	0.0	2.8	0.0	90.0	0.0
NOV	45.6	24.7	0.0	0.0	23.7	463.0	18.5	36.3	24.7	78.5	59.8	61.4	0.0	0.0	23.0	57.7	5.9	31.4	29.7	29.9	0.0	1.0	0.0	90.0	0.0
DEC	41.0	0.0	0.0	0.0	55.6	464.3	0.0	9.9	0.0	66.9	10.9	12.5	0.0	0.0	76.3	62.2	0.6	10.1	5.4	5.7	0.0	4.1	0.0	90.0	0.0
JAN	41.0	0.0	0.0	0.0	87.6	465.6	0.0	13.7	0.0	92.7	7.3	6.8	0.0	0.0	157.9	67.1	0.5	11.7	3.6	3.9	0.0	7.5	0.0	90.0	0.0
FEB	30.9	0.0	0.0	0.0	117.5	466.8	0.0	11.0	0.0	74.5	0.0	1.6	0.0	0.0	227.7	70.5	0.0	9.4	0.0	0.3	0.0	8.7	0.0	90.0	0.0
MAR	61.6	6.6	0.0	38.5	125.0	467.1	26.0	55.1	6.6	106.3	45.6	47.2	0.0	23.6	260.0	71.1	9.9	24.4	22.6	22.9	0.0	1.1	0.0	90.0	0.0
APR	70.2	0.0	0.0	61.0	125.0	467.1	26.0	79.9	0.0	189.2	7.4	9.0	0.0	177.0	260.0	71.1	10.0	13.3	3.7	4.0	0.0	9.0	0.0	90.0	0.0
MAY	68.6	3.4	0.0	56.1	125.0	467.1	26.0	76.2	3.4	168.9	29.0	30.6	0.0	135.1	260.0	71.1	10.0	16.1	14.4	14.6	0.0	1.1	0.0	90.0	0.0
JUN	31.9	22.8	0.0	0.1	125.0	467.1	17.2	25.0	22.8	14.2	42.6	44.1	0.0	0.0	226.9	70.4	6.1	22.9	21.1	21.4	0.0	1.1	0.0	90.0	0.0
JUL	26.0	32.7	0.0	0.0	109.3	466.5	25.7	33.0	32.7	7.3	64.7	66.3	0.0	0.0	164.7	67.5	8.7	33.9	32.1	32.4	0.0	1.0	0.0	90.0	0.0
AUG	16.9	31.9	0.0	0.0	85.2	465.5	24.9	31.9	31.9	-0.3	60.7	62.2	0.0	0.0	99.9	63.6	7.3	31.9	30.1	30.4	0.0	1.0	0.0	90.0	0.0
SEP	13.7	34.1	0.0	0.0	55.0	464.3	26.0	34.3	34.1	1.1	65.2	66.8	0.0	0.0	32.0	59.0	6.0	34.1	32.4	32.6	0.0	1.0	0.0	90.0	0.0
TOTALS	475.2	156.3	0.0	155.6					156.3			411.9	0.0	335.8						198.3	0.0	35.3			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 137.0 GWH
AT GUNUNG WULAN= 68.5 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 2 RUN NUMBER 91a

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	ENJ ELE	POW AVG (MW)	DIVERSION VOL AVD (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	ENJ ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	9.9	7.8	0.0	0.0	40.8	464.1	3.8	8.1	7.8	1.7	12.3	13.8	0.0	0.0	18.7	57.0	0.7	7.0	6.1	6.3	0.0	1.1	0.0	90.0	0.0
NOV	29.9	44.8	0.0	0.0	15.0	462.6	26.0	46.8	23.6	47.7	62.9	64.5	0.0	0.0	0.9	51.0	4.7	33.0	31.2	31.5	0.0	2.0	0.0	90.0	0.0
DEC	28.4	0.0	0.0	0.0	34.3	463.5	0.0	7.0	0.0	47.6	9.5	11.0	0.0	0.0	36.4	59.6	0.5	7.9	4.7	5.3	0.3	2.6	0.0	90.0	0.0
JAN	41.8	0.0	0.0	0.0	67.1	464.8	0.0	11.0	0.0	74.5	0.0	1.6	0.0	0.0	107.0	54.0	0.0	12.5	0.0	0.3	0.0	11.9	0.0	90.0	0.0
FEB	39.2	0.0	0.0	0.0	97.2	466.0	0.0	12.0	0.0	81.6	0.0	1.6	0.0	0.0	164.7	68.7	0.0	23.0	0.0	0.3	0.0	22.4	0.0	90.0	0.0
MAR	45.0	15.0	0.0	0.0	118.2	466.0	10.0	26.1	15.0	75.2	54.3	55.9	0.0	0.0	200.8	69.7	7.7	28.7	27.0	27.2	0.0	1.0	0.0	90.0	0.0
APR	47.4	6.6	0.0	18.0	125.0	467.1	18.7	33.8	6.6	80.2	25.1	26.6	0.0	0.0	251.2	70.5	3.4	14.2	12.4	12.7	0.0	1.1	0.0	90.0	0.0
MAY	39.9	0.0	0.0	30.9	125.0	467.1	24.2	37.4	0.0	74.6	12.9	14.5	0.0	48.1	260.0	71.1	8.9	11.6	6.4	6.7	0.0	4.6	0.0	90.0	0.0
JUN	27.0	12.2	0.0	5.7	125.0	467.1	12.6	21.4	12.2	29.3	24.1	25.6	0.0	0.5	260.0	71.1	3.3	13.7	11.9	12.2	0.0	1.1	0.0	90.0	0.0
JUL	22.8	29.3	0.0	0.0	109.5	466.5	22.7	31.1	29.3	12.0	57.5	59.0	0.0	0.0	209.8	70.1	6.2	30.3	20.5	20.8	0.0	1.0	0.0	90.0	0.0
AUG	30.3	16.7	0.0	0.0	114.0	466.7	11.5	18.8	16.7	14.0	34.2	35.7	0.0	0.0	184.8	68.7	4.6	18.7	17.0	17.2	0.0	1.1	0.0	90.0	0.0
SEP	18.7	14.3	0.0	0.0	109.3	466.5	9.3	15.4	14.3	7.1	35.8	37.4	0.0	0.0	152.2	66.8	4.6	19.5	17.8	18.0	0.0	1.1	0.0	90.0	0.0
TOTALS	363.9	146.8	0.0	54.6					125.6			347.2	0.0	48.6						166.1	0.0	50.0			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 99.9 GWH
AT GUNUNG WULAN= 33.5 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN – TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. – ENGLEWOOD, COLORADO, U.S.A.

YEAR 3 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVG (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	17.9	0.0	0.0	0.0	118.2	466.8	0.0	2.0	0.0	18.9	0.0	1.6	0.0	0.0	167.3	67.7	0.0	4.4	0.0	0.3	0.0	3.8	0.0	90.0	0.0
NOV	45.9	0.0	0.0	30.1	125.0	467.1	23.4	40.2	0.0	101.5	34.3	35.9	0.0	0.0	229.7	70.5	4.8	28.1	17.0	17.3	0.0	10.3	0.0	90.0	0.0
DEC	43.7	0.0	0.0	34.6	125.0	467.1	26.0	43.1	0.0	92.1	4.8	6.4	0.0	52.1	260.0	71.1	8.4	10.1	2.4	2.7	0.0	7.1	0.0	90.0	0.0
JAN	42.3	0.0	0.0	33.3	125.0	467.1	26.0	44.2	0.0	107.3	14.8	16.4	0.0	87.7	260.0	71.1	10.0	17.4	7.4	7.6	0.0	4.4	0.0	90.0	0.0
FEB	32.7	0.0	0.0	23.6	125.0	467.1	17.0	31.8	0.0	78.7	0.0	1.6	0.0	74.0	260.0	71.1	10.0	32.5	0.0	0.3	0.0	31.7	0.0	90.0	0.0
MAR	52.5	11.2	0.0	32.3	125.0	467.1	26.0	51.7	11.2	60.1	44.1	45.7	0.0	39.2	260.0	71.1	10.0	23.7	21.9	22.2	0.0	1.1	0.0	90.0	0.0
APR	52.8	0.0	0.0	43.7	125.0	467.1	26.0	51.3	0.0	95.0	18.6	20.1	0.0	71.7	260.0	71.1	10.0	16.0	9.2	9.5	0.0	6.2	0.0	90.0	0.0
MAY	50.3	0.9	0.0	40.4	125.0	467.1	26.0	46.3	0.9	74.0	27.9	29.5	0.0	41.3	260.0	71.1	9.9	15.6	13.9	14.1	0.0	1.1	0.0	90.0	0.0
JUN	30.1	14.4	0.3	6.6	125.0	467.1	15.5	23.3	14.4	21.7	32.2	33.7	0.0	0.0	244.6	70.8	4.5	17.7	16.0	16.2	0.0	1.1	0.0	90.0	0.0
JUL	51.7	19.3	0.0	23.4	125.0	467.1	26.0	48.7	19.3	64.1	48.6	50.1	0.0	0.0	255.5	71.0	7.1	25.9	24.1	24.4	0.0	1.0	0.0	90.0	0.0
AUG	33.8	15.6	0.0	9.1	125.0	467.1	18.8	26.8	15.6	23.0	34.4	35.9	0.0	0.0	239.4	70.7	4.9	16.8	17.0	17.3	0.0	1.1	0.0	90.0	0.0
SEP	25.7	23.9	0.0	0.0	117.7	466.6	18.0	24.4	23.9	3.4	49.0	50.6	0.0	0.0	189.0	69.0	6.9	26.1	24.3	24.6	0.0	1.0	0.0	90.0	0.0
TOTALS	479.7	85.3	0.0	277.2					85.3			327.4	0.0	366.0						156.4	0.0	70.0			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 179.7 GWH
AT GUNUNG WULAN= 69.3 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 4 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVD (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	23.8	0.0	0.0	7.0	125.0	467.1	3.6	8.9	0.0	16.3	0.0	1.6	0.0	0.0	200.6	69.7	0.0	6.6	0.0	0.3	0.0	6.0	0.0	90.0	0.0
NOV	30.1	15.8	0.0	5.2	125.0	467.1	15.5	29.7	15.8	64.0	54.6	56.1	0.0	0.0	205.2	69.9	7.8	20.8	27.1	27.3	0.0	1.0	0.0	90.0	0.0
DEC	32.4	0.0	0.0	23.4	125.0	467.1	17.6	29.9	0.0	67.3	7.7	9.3	0.0	0.1	260.0	71.1	0.7	14.6	3.0	4.1	0.0	10.2	0.0	90.0	0.0
JAN	67.2	0.0	0.0	50.2	125.0	467.1	26.0	75.8	0.0	177.1	0.0	1.6	0.0	172.4	260.0	71.1	10.0	70.9	0.0	0.1	0.0	70.0	0.0	30.0	0.0
FEB	50.9	0.0	0.0	41.8	125.0	467.1	26.0	53.8	0.0	123.0	0.0	1.6	0.0	118.2	260.0	71.1	10.0	21.8	0.0	0.3	0.0	21.2	0.0	90.0	0.0
MAR	40.2	13.2	0.0	16.0	125.0	467.1	24.4	36.5	13.2	53.9	54.9	56.4	0.0	0.0	254.1	71.0	8.0	27.0	27.2	27.5	0.0	1.0	0.0	90.0	0.0
APR	28.0	16.7	0.0	2.1	125.0	467.1	11.5	20.1	16.9	9.6	38.8	40.3	0.0	0.0	220.1	70.3	5.5	21.0	19.2	19.5	0.0	1.1	0.0	90.0	0.0
MAY	24.9	9.6	0.0	6.3	125.0	467.1	10.8	17.5	9.6	16.2	38.0	39.5	0.0	0.0	193.8	69.3	5.2	20.6	18.9	19.1	0.0	1.1	0.0	90.0	0.0
JUN	44.6	7.2	0.0	28.3	125.0	467.1	26.0	40.9	7.2	64.5	23.3	24.9	0.0	0.0	230.2	70.5	3.0	13.3	11.6	11.8	0.0	1.7	0.0	90.0	0.0
JUL	22.9	37.2	0.0	0.0	106.5	466.4	25.3	32.5	32.2	1.9	63.2	64.8	0.0	0.0	164.1	67.5	8.5	31.1	31.4	31.6	0.0	1.0	0.0	90.0	0.0
AUG	27.9	15.6	0.0	0.0	109.7	466.5	10.5	17.4	15.6	12.0	36.2	37.8	0.0	0.0	136.0	65.8	4.5	19.7	18.0	18.2	0.0	1.1	0.0	90.0	0.0
SEP	18.1	22.9	0.0	0.0	95.9	465.9	17.2	23.6	22.9	4.1	42.7	44.2	0.0	0.0	93.6	63.2	4.9	22.9	21.2	21.4	0.0	1.1	0.0	90.0	0.0
TOTALS	410.8	133.6	0.0	190.8					133.6			378.0	0.0	290.7						181.4	0.0	116.0			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 155.9 GWH
AT GUNUNG WULAN= 64.2 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 5 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVB (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	16.9	0.6	0.0	0.0	103.2	466.2	0.0	1.2	0.6	4.5	0.0	1.6	0.0	0.0	95.4	63.3	0.0	1.8	0.0	0.3	0.0	1.1	0.0	90.0	0.0
NOV	21.0	33.8	0.0	0.0	81.4	465.4	26.0	37.0	33.8	21.9	72.1	73.7	0.0	0.0	41.3	60.1	7.8	37.6	35.8	36.1	0.0	1.0	0.0	90.0	0.0
DEC	39.6	0.0	0.0	0.0	112.0	466.6	0.0	10.1	0.0	68.3	0.0	1.6	0.0	0.0	105.8	64.0	0.0	17.8	0.0	0.3	0.0	17.2	0.0	90.0	0.0
JAN	46.9	0.0	0.0	24.8	125.0	467.1	18.9	32.3	0.0	75.4	4.8	6.4	0.0	0.0	172.6	68.0	0.3	16.1	2.4	2.7	0.0	13.1	0.0	90.0	0.0
FEB	27.6	0.0	0.0	18.6	125.0	467.1	13.1	23.6	0.0	48.2	0.0	1.6	0.0	0.0	216.0	70.2	0.0	14.3	0.0	0.3	0.0	13.7	0.0	90.0	0.0
MAR	74.2	0.6	0.0	64.3	125.0	467.1	26.0	32.7	0.0	103.3	38.8	40.4	0.0	95.7	260.0	71.1	10.0	21.0	19.3	19.5	0.0	1.1	0.0	90.0	0.0
APR	50.7	3.8	0.0	33.8	125.0	467.1	26.0	46.3	3.8	97.4	18.4	19.9	0.0	69.3	260.0	71.1	10.0	10.9	9.1	9.4	0.0	1.1	0.0	90.0	0.0
MAY	37.8	20.6	0.0	8.1	125.0	467.1	22.3	31.0	20.6	27.0	47.5	49.1	0.0	0.0	240.7	70.5	6.9	25.3	23.6	23.8	0.0	1.0	0.0	90.0	0.0
JUN	17.6	18.2	0.0	0.0	115.4	466.7	12.0	18.8	10.2	3.6	40.8	42.4	0.0	0.0	188.7	69.0	5.6	22.0	20.3	20.5	0.0	1.1	0.0	90.0	0.0
JUL	47.8	21.5	0.0	2.7	125.0	467.1	18.3	27.2	21.5	22.6	50.2	51.8	0.0	0.0	156.3	67.0	6.7	26.7	24.9	25.2	0.0	1.0	0.0	90.0	0.0
AUG	16.5	25.8	0.0	0.0	108.7	466.4	19.6	25.4	25.4	-2.7	51.3	52.8	0.0	0.0	98.5	63.5	6.1	26.8	25.4	25.7	0.0	0.8	0.0	90.0	0.0
SEP	16.8	32.7	0.0	0.0	83.8	465.5	25.6	31.9	31.9	-4.9	62.3	63.8	0.0	0.0	28.7	58.5	6.4	31.9	30.9	31.2	0.0	0.2	0.0	90.0	0.0
TOTALS	406.4	157.8	0.0	152.4					156.5			404.9	0.0	165.0						196.0	0.0	52.2			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 150.2 GWH
AT GUNUNG WULAN= 51.3 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 6 RUN NUMBER 918

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	13.4	0.0	0.0	0.0	88.2	465.6	0.0	-0.3	-0.3	-1.9	1.1	2.7	0.0	0.0	23.1	57.7	0.0	2.0	0.5	0.8	0.0	0.9	0.0	90.0	0.0
NOV	15.8	78.8	0.0	0.0	16.2	462.7	26.0	80.0	31.3	55.1	74.6	76.1	0.0	0.0	0.9	51.0	5.6	38.8	37.0	37.3	0.0	1.0	0.0	90.0	0.0
DEC	45.8	0.0	0.0	0.0	52.9	464.2	0.0	10.6	0.0	71.9	1.3	2.8	0.0	0.0	68.9	61.7	0.0	32.9	0.6	0.9	0.0	31.5	0.0	90.0	0.0
JAN	45.8	0.0	0.0	0.0	69.7	465.7	0.0	8.3	0.0	55.8	18.8	20.3	0.0	0.0	102.1	63.7	1.8	15.5	9.1	9.6	0.0	5.6	0.0	90.0	0.0
FEB	71.8	0.0	0.0	27.5	125.0	467.1	21.2	48.4	0.0	169.2	0.0	1.6	0.0	6.5	260.0	71.1	0.5	34.1	0.0	0.3	0.0	33.3	0.0	90.0	0.0
MAR	65.3	0.0	0.0	56.3	125.0	467.1	26.0	76.9	0.0	195.8	29.8	31.3	0.0	161.3	260.0	71.1	10.0	19.9	14.8	15.0	0.0	4.5	0.0	90.0	0.0
APR	76.2	0.0	0.0	67.2	125.0	467.1	26.0	83.5	0.0	177.9	17.7	19.4	0.0	155.4	260.0	71.1	10.0	17.6	8.8	9.6	0.0	8.2	0.0	90.0	0.0
MAY	58.1	7.2	0.0	41.9	125.0	467.1	26.0	61.7	7.2	127.5	32.3	33.8	0.0	90.5	260.0	71.1	10.0	17.8	16.0	16.3	0.0	1.1	0.0	90.0	0.0
JUN	31.6	12.4	0.0	10.2	125.0	467.1	17.0	26.3	12.4	35.3	31.8	33.3	0.0	0.0	258.8	71.1	4.5	17.5	15.8	16.0	0.0	1.1	0.0	90.0	0.0
JUL	45.5	16.7	0.0	19.8	125.0	467.1	26.0	43.1	16.7	64.5	54.9	56.5	0.0	3.6	260.0	71.1	8.4	29.0	27.3	27.5	0.0	1.0	0.0	90.0	0.0
AUG	35.3	0.9	0.0	25.5	125.0	467.1	20.1	34.4	0.9	80.1	17.1	18.7	0.0	58.2	260.0	71.1	10.0	10.3	8.5	8.8	0.0	1.1	0.0	90.0	0.0
SEP	22.8	23.6	0.0	0.0	115.2	466.7	17.8	25.4	23.6	11.6	44.6	46.2	0.0	0.0	222.3	70.3	6.4	23.9	22.1	22.4	0.0	1.1	0.0	90.0	0.0
TOTALS	577.6	139.6	0.0	248.4					91.8			342.6	0.0	475.4						163.9	0.0	90.5			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 148.4 GWH
AT GUNUNG WULAN= 77.0 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 7 RUN NUMBER 918

	KAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	28.7	0.0	0.0	9.8	125.0	467.1	5.7	12.0	0.0	24.7	0.0	1.6	0.0	0.0	242.2	70.8	0.0	1.7	0.0	0.3	0.0	3.1	0.0	90.0	0.0
NOV	23.1	34.8	0.0	0.0	104.2	466.3	26.0	37.6	34.8	18.5	76.7	78.3	0.0	0.0	179.2	68.4	10.0	39.8	38.1	38.3	0.0	1.0	0.0	90.0	0.0
DEC	59.7	0.0	0.0	29.9	125.0	467.1	23.3	50.8	0.0	171.6	0.0	1.6	0.0	86.0	260.0	71.1	10.0	16.6	0.0	0.3	0.0	16.0	0.0	90.0	0.0
JAN	50.3	0.0	0.0	41.3	125.0	467.1	26.0	59.5	0.0	164.2	0.0	1.6	0.0	159.4	260.0	71.1	10.0	23.6	0.0	0.3	0.0	23.0	0.0	90.0	0.0
FEB	62.4	0.0	0.0	53.4	125.0	467.1	26.0	64.1	0.0	126.0	8.3	9.8	0.0	113.0	260.0	71.1	10.0	12.2	4.1	4.4	0.0	7.5	0.0	90.0	0.0
MAR	57.0	18.4	0.0	29.6	125.0	467.1	26.0	55.9	18.4	83.0	54.2	55.7	0.0	24.1	260.0	71.1	10.0	28.6	26.9	27.1	0.0	1.0	0.0	90.0	0.0
APR	53.1	0.0	0.0	44.1	125.0	467.1	26.0	59.5	0.0	148.7	8.6	10.0	0.0	135.5	260.0	71.1	10.0	16.3	6.2	6.4	0.0	11.5	0.0	90.0	0.0
MAY	67.5	3.5	0.0	54.9	125.0	467.1	26.0	72.0	3.5	146.7	33.4	35.0	0.0	108.5	260.0	71.1	10.0	18.3	16.6	16.8	0.0	1.1	0.0	90.0	0.0
JUN	42.5	17.4	0.0	16.0	125.0	467.1	26.0	38.4	17.4	49.4	36.2	37.8	0.0	8.4	260.0	71.1	6.6	19.7	18.0	18.2	0.0	1.1	0.0	90.0	0.0
JUL	44.5	21.2	0.0	19.4	125.0	467.1	26.0	49.4	21.2	79.2	48.8	50.3	0.0	25.7	260.0	71.1	10.0	26.0	26.2	26.5	0.0	1.0	0.0	90.0	0.0
AUG	21.4	31.7	0.0	0.0	105.7	466.3	24.9	33.4	31.7	11.1	60.4	61.9	0.0	0.0	205.9	70.0	8.6	31.7	30.0	30.2	0.0	1.0	0.0	90.0	0.0
SEP	16.1	24.9	0.0	0.0	87.8	465.0	18.8	25.1	24.9	1.4	49.9	51.4	0.0	0.0	152.7	66.8	6.6	26.5	24.8	25.0	0.0	1.0	0.0	90.0	0.0
TOTALS		152.1		298.5								394.8		660.7						189.8		68.2			
	531.5		0.0						152.1				0.0								0.0				

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 202.0 GWH
AT GUNUNG WULAN= 105.1 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 8 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVB (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	21.7	2.4	0.0	0.0	98.0	466.0	0.4	3.8	2.4	9.2	4.8	6.4	0.0	0.0	153.2	66.8	0.3	4.1	2.4	2.6	0.0	1.1	0.0	90.0	0.0
NOV	20.0	33.5	0.0	0.0	75.5	465.1	26.0	34.7	33.5	21.3	69.4	71.0	0.0	0.0	101.2	63.7	8.4	36.2	34.4	34.7	0.0	1.0	0.0	90.0	0.0
DEC	41.3	0.0	0.0	0.0	107.7	466.4	0.0	16.4	0.0	111.1	5.5	7.0	0.0	0.0	202.1	69.8	0.4	18.2	2.7	3.0	0.0	14.9	0.0	90.0	0.0
JAN	41.3	0.0	0.0	14.9	125.0	467.1	9.9	24.6	0.0	74.6	0.0	1.6	0.0	11.9	260.0	71.1	1.4	20.0	0.0	0.3	0.0	19.6	0.0	90.0	0.0
FEB	57.1	0.0	0.0	48.1	125.0	467.1	26.0	60.9	0.0	134.7	0.0	1.6	0.0	130.0	260.0	71.1	10.0	25.9	0.0	0.3	0.0	25.1	0.0	90.0	0.0
MAR	43.9	18.6	0.0	16.3	125.0	467.1	26.0	44.7	18.6	62.7	48.9	50.5	0.0	29.0	260.0	71.1	10.0	26.0	24.3	24.5	0.0	1.0	0.0	90.0	0.0
APR	53.6	5.2	0.0	39.5	125.0	467.1	26.0	53.5	5.2	99.2	27.0	28.6	0.0	67.4	260.0	71.1	10.0	15.2	13.6	13.7	0.0	1.1	0.0	90.0	0.0
MAY	55.4	8.5	0.0	37.9	125.0	467.1	26.0	32.9	8.5	81.6	33.6	35.1	0.0	43.3	260.0	71.1	10.0	18.4	16.7	16.9	0.0	1.1	0.0	90.0	0.0
JUN	27.7	20.0	0.0	0.0	123.7	467.0	14.5	23.9	20.0	5.9	39.2	40.7	0.0	0.0	222.0	70.4	5.6	21.2	19.4	19.7	0.0	1.1	0.0	90.0	0.0
JUL	31.6	36.5	0.0	0.0	109.8	466.5	26.0	38.1	36.5	10.6	71.5	73.0	0.0	0.0	156.4	67.0	9.2	37.2	35.5	35.7	0.0	1.0	0.0	90.0	0.0
AUG	17.1	34.2	0.0	0.0	83.6	465.4	26.0	34.1	34 1	-1.1	65.4	67.0	0.0	0.0	86.0	62.8	7.7	34.1	32.5	32.7	0.0	0.9	0.0	90.0	0.0
SEP	14.8	28.2	0.0	0.0	61.2	464.5	21.5	27.7	27.7	-3.4	53.3	54.9	0.0	0.0	26.7	58.2	5.3	27.7	26.4	26.7	0.0	0.5	0.0	90.0	0.0
TOTALS		187.3		156.6								437.3		281.5						210.9		68.2			
	475.6		0.0						186.6				0.0								0.0				

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 164.4 GWH
AT GUNUNG WULAN= 66.3 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 9 RUN NUMBER 918

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	18.8	1.5	0.0	0.0	69.4	464.9	0.1	1.9	1.5	2.6	0.5	2.1	0.0	0.0	26.1	58.1	0.0	2.0	0.3	0.5	0.0	1.1	0.0	90.0	0.0
NOV	34.2	2.0	0.0	0.0	92.6	465.8	0.3	8.4	2.0	42.8	42.4	44.0	0.0	0.0	23.8	57.8	4.0	22.8	21.1	21.3	0.0	1.1	0.0	90.0	0.0
DEC	30.8	0.4	0.0	0.0	113.9	466.7	0.0	5.2	0.4	32.6	14.4	15.9	0.0	0.0	39.3	60.0	1.1	8.9	7.1	7.4	0.0	1.1	0.0	90.0	0.0
JAN	49.5	0.0	0.0	29.5	125.0	467.1	22.9	42.5	0.0	117.4	0.0	1.6	0.0	0.0	152.9	66.8	0.0	77.3	0.0	0.3	0.0	76.6	0.0	90.0	0.0
FEB	30.5	0.0	0.0	21.5	125.0	467.1	15.9	27.8	0.0	64.1	0.0	1.6	0.0	0.0	212.3	70.1	0.0	9.2	0.0	0.3	0.0	8.6	0.0	90.0	0.0
MAR	39.1	6.1	0.0	23.9	125.0	467.1	23.4	41.5	6.1	101.5	54.2	55.7	0.0	0.0	254.8	71.0	7.9	28.6	26.9	27.1	0.0	1.0	0.0	90.0	0.0
APR	30.0	6.4	0.0	14.5	125.0	467.1	15.4	27.0	6.4	55.2	18.2	19.8	0.0	27.1	260.0	71.1	6.7	10.8	9.0	9.3	0.0	1.1	0.0	90.0	0.0
MAY	40.6	0.0	0.0	37.6	125.0	467.1	26.0	45.9	0.0	94.1	1.0	2.6	0.0	80.3	260.0	71.1	10.0	13.8	0.5	0.8	0.0	12.7	0.0	90.0	0.0
JUN	23.3	23.7	0.0	0.0	115.6	466.7	17.8	24.4	23.7	4.6	44.1	45.7	0.0	0.0	215.6	70.2	6.4	23.7	21.9	22.2	0.0	1.1	0.0	90.0	0.0
JUL	73.0	40.7	0.0	0.0	88.9	465.7	26.0	40.7	40.7	-0.3	78.5	80.1	0.0	0.0	132.1	65.5	9.7	40.7	39.0	39.2	0.0	1.0	0.0	90.0	0.0
AUG	16.6	34.2	0.0	0.0	62.3	464.6	26.0	33.9	33.9	-2.3	65.4	67.0	0.0	0.0	60.5	61.2	7.4	33.9	32.5	32.7	0.0	0.6	0.0	90.0	0.0
SEP	11.4	51.6	0.0	0.0	13.1	462.6	26.0	50.8	35.3	10.5	67.5	69.1	0.0	0.0	0.9	51.0	5.1	33.3	33.5	33.8	0.0	1.0	0.0	90.0	0.0
TOTALS	353.6	166.7	0.0	127.0					150.0			405.0	0.0	115.6						194.9	0.0	107.0			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 144.0 GWH
AT GUNUNG WULAN= 43.9 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 10 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVB (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	11.8	16.6	0.0	0.0	0.0	461.9	11.1	17.2	7.1	13.8	11.8	13.3	0.0	0.0	0.3	50.3	0.4	7.1	5.8	6.1	0.0	0.7	0.0	90.0	0.0
NOV	15.8	7.5	0.0	0.0	0.0	461.9	3.5	8.1	2.4	9.0	79.6	8.2	72.9	0.0	0.0	50.0	0.0	7.6	39.5	7.2	32.6	0.0	0.0	90.0	0.0
DEC	17.8	7.3	0.0	0.0	4.3	462.1	3.2	8.4	0.0	14.8	11.3	12.8	0.0	0.0	0.9	51.0	0.4	11.4	5.6	5.8	0.0	5.2	0.0	90.0	0.0
JAN	38.0	0.0	0.0	0.0	33.3	463.4	0.0	7.0	0.0	47.0	0.0	1.6	0.0	0.0	45.3	60.3	0.0	40.4	0.0	0.3	0.0	39.4	0.0	90.0	0.0
FEB	33.9	0.0	0.0	0.0	58.1	465.4	0.0	7.7	0.0	52.3	0.0	1.6	0.0	0.0	94.9	63.3	0.0	32.0	0.0	0.3	0.0	31.2	0.0	90.0	0.0
MAR	41.8	0.0	0.0	0.0	90.9	465.7	0.0	13.2	0.0	88.0	34.3	35.8	0.0	0.0	144.8	66.3	4.3	36.1	17.0	17.3	0.0	18.3	0.0	90.0	0.0
APR	58.6	0.0	0.0	15.4	125.0	467.1	10.4	30.9	0.0	120.0	5.9	7.4	0.0	0.0	254.1	71.0	0.4	26.7	2.9	3.2	0.0	23.0	0.0	90.0	0.0
MAY	33.5	24.9	0.0	0.0	124.6	467.1	18.9	28.5	24.9	24.6	53.4	55.0	0.0	0.0	220.5	70.3	7.7	28.3	26.5	26.8	0.0	1.0	0.0	90.0	0.0
JUN	25.7	18.8	0.0	0.0	122.4	467.0	13.4	19.2	18.8	2.3	39.6	41.2	0.0	0.0	178.4	68.4	5.3	21.4	19.7	19.9	0.0	1.1	0.0	90.0	0.0
JUL	21.4	27.7	0.0	0.0	107.1	466.4	21.3	28.3	27.7	4.0	60.5	62.1	0.0	0.0	118.0	64.7	7.3	31.8	30.0	30.3	0.0	1.0	0.0	90.0	0.0
AUG	24.1	18.4	0.0	0.0	103.7	466.2	13.0	19.6	18.4	8.0	39.0	40.6	0.0	0.0	83.2	62.6	4.4	21.1	19.4	19.6	0.0	1.1	0.0	90.0	0.0
SEP	11.9	33.1	0.0	0.0	73.6	465.0	25.9	32.6	32.6	-3.0	63.1	64.7	0.0	0.0	14.4	56.4	6.0	32.6	31.3	31.6	0.0	0.5	0.0	90.0	0.0
TOTALS	336.3	154.3	0.0	15.4					131.9			344.2	72.9	0.0						168.3	32.6	122.9			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 86.8 GWH
AT GUNUNG WULAN= 26.2 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 11 RUN NUMBER 918

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	18.8	0.0	0.0	0.0	83.3	465.4	0.0	0.4	0.0	2.1	0.0	1.6	0.0	0.0	14.1	56.4	0.0	6.1	0.0	0.3	0.0	5.5	0.0	90.0	0.0
NOV	23.1	54.5	0.0	0.0	42.6	463.8	26.0	61.0	33.3	64.7	75.3	76.8	0.0	0.0	0.9	51.0	5.7	39.1	37.4	37.6	0.0	1.0	0.0	90.0	0.0
DEC	31.3	0.0	0.0	0.0	65.1	464.7	0.0	10.3	0.0	69.7	8.7	10.2	0.0	0.0	59.3	61.2	0.5	13.2	4.3	4.6	0.0	8.3	0.0	90.0	0.0
JAN	38.3	0.0	0.0	0.0	94.4	465.9	0.0	15.5	0.0	105.0	0.0	1.6	0.0	0.0	160.4	67.3	0.0	63.7	0.0	0.3	0.0	62.8	0.0	90.0	0.0
FEB	33.4	0.0	0.0	0.0	118.7	466.8	0.0	6.6	0.0	44.8	0.0	1.6	0.0	0.0	200.5	69.7	0.0	13.5	0.0	0.3	0.0	12.9	0.0	90.0	0.0
MAR	54.1	5.9	0.0	32.9	125.0	467.1	26.0	54.1	5.9	136.2	57.1	58.7	0.0	14.8	260.0	71.1	10.0	30.1	28.4	28.6	0.0	1.0	0.0	90.0	0.0
APR	40.7	0.0	0.0	31.7	125.0	467.1	24.9	38.9	0.0	80.8	11.1	12.7	0.0	65.0	260.0	71.1	10.0	11.0	5.5	5.8	0.0	4.8	0.0	90.0	0.0
MAY	28.4	29.1	0.0	0.0	115.3	466.7	22.5	30.5	29.1	9.4	57.8	59.4	0.0	0.0	206.8	70.0	8.3	30.5	28.7	29.0	0.0	1.0	0.0	90.0	0.0
JUN	17.9	26.1	0.0	0.0	98.1	466.0	19.8	26.1	26.1	-0.3	49.0	50.6	0.0	0.0	152.8	66.8	6.4	26.1	24.3	24.6	0.0	1.0	0.0	90.0	0.0
JUL	14.7	41.5	0.0	0.0	62.3	464.6	26.0	41.4	41.4	-0.5	80.0	81.6	0.0	0.0	66.5	61.7	9.1	41.6	39.7	40.0	0.0	1.0	0.0	90.0	0.0
AUG	11.8	35.9	0.0	0.0	29.1	463.3	26.0	35.8	34.2	0.5	65.4	67.0	0.0	0.0	0.9	51.0	4.9	34.2	32.5	32.7	0.0	1.0	0.0	90.0	0.0
SEP	14.8	34.9	0.0	0.0	0.0	461.9	26.0	34.6	11.5	21.6	67.5	21.4	47.7	0.0	0.0	50.0	0.0	11.5	33.5	11.1	22.7	0.0	0.0	90.0	0.0
TOTALS	377.7	227.9	0.0	66.6					181.5			443.0	47.7	79.8						216.7	22.7	100.2			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 142.0 GWH
AT GUNUNG WULAN= 40.4 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 12 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVA (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	12.9	5.1	0.0	0.0	0.0	461.9	1.6	4.6	1.4	-0.1	9.7	-1.2	12.5	0.0	0.0	50.0	0.0	1.4	4.8	1.0	4.0	0.0	0.0	90.0	0.0
NOV	15.0	7.2	0.0	0.0	0.0	461.9	3.2	7.7	2.4	7.6	88.3	6.5	83.3	0.0	0.0	50.0	0.0	4.8	43.8	4.4	39.7	0.0	0.0	90.0	0.0
DEC	20.1	0.0	0.0	0.0	11.8	462.5	0.0	5.5	0.0	36.9	0.0	1.6	0.0	0.0	34.2	59.3	0.0	15.0	0.0	0.3	0.0	14.4	0.0	90.0	0.0
JAN	23.8	0.0	0.0	0.0	26.6	463.2	0.0	3.8	0.0	25.3	11.0	12.6	0.0	0.0	45.6	60.4	0.7	14.2	5.5	5.7	0.0	8.1	0.0	90.0	0.0
FEB	31.6	0.0	0.0	0.0	49.2	464.1	0.0	7.0	0.0	47.6	9.6	11.2	0.0	0.0	81.1	62.5	0.6	17.3	4.8	5.0	0.0	11.9	0.0	90.0	0.0
MAR	32.7	11.8	0.0	0.0	61.0	464.5	7.1	19.3	11.8	51.1	40.6	42.1	0.0	0.0	87.0	62.9	4.0	21.9	20.1	20.4	0.0	1.1	0.0	90.0	0.0
APR	35.5	0.0	0.0	0.0	87.8	465.6	0.0	6.0	0.0	54.2	8.6	10.1	0.0	0.0	129.0	65.4	0.6	19.2	4.4	6.3	0.0	14.3	0.0	90.0	0.0
MAY	31.9	8.5	0.0	0.0	102.1	466.2	4.6	16.0	8.5	50.5	31.7	43.3	0.0	0.0	144.2	66.3	3.9	17.5	15.8	16.0	0.0	1.1	0.0	90.0	0.0
JUN	23.1	13.7	0.0	0.0	102.4	466.2	8.8	15.7	13.7	13.0	32.0	33.5	0.0	0.0	121.7	64.9	3.7	17.6	15.9	16.1	0.0	1.1	0.0	90.0	0.0
JUL	16.9	37.6	0.0	0.0	72.6	465.0	26.0	37.6	37.6	0.7	74.1	75.7	0.0	0.0	44.4	60.3	8.1	36.5	36.6	37.0	0.0	1.0	0.0	90.0	0.0
AUG	15.5	43.1	0.0	0.0	36.1	463.5	26.0	43.0	28.2	13.9	54.7	56.3	0.0	0.0	0.9	51.0	4.0	28.9	27.1	27.4	0.0	1.0	0.0	90.0	0.0
SEP	15.5	42.6	0.0	0.0	0.0	461.9	26.0	42.6	11.2	30.9	28.7	30.3	0.0	0.0	0.4	50.5	1.7	15.9	14.3	14.5	0.0	1.0	0.0	90.0	0.0
TOTALS		169.7		0.0								311.8		0.0						152.5		55.0			
	774.7		0.0						114.8				95.8								43.7				

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 74.4 GWH
AT GUNUNG WULAN= 20.1 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 13 RUN NUMBER 910

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVG (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	33.5	0.0	0.0	0.0	21.5	463.0	0.0	3.7	0.0	25.0	0.0	1.6	0.0	0.0	22.7	57.0	0.0	7.4	0.0	0.4	0.0	6.8	0.0	90.0	0.0
NOV	35.5	25.1	0.0	0.0	22.9	463.0	18.8	31.6	18.1	50.9	70.1	71.6	0.0	0.0	0.9	51.0	5.3	36.5	34.8	35.0	0.0	1.0	0.0	90.0	0.0
DEC	27.6	0.0	0.0	0.0	41.4	463.8	0.0	3.0	0.0	20.3	0.0	1.6	0.0	0.0	16.6	57.0	0.0	10.7	0.0	0.3	0.0	10.1	0.0	90.0	0.0
JAN	42.8	0.0	0.0	0.0	75.3	465.1	0.0	10.5	0.0	70.9	0.0	1.6	0.0	0.0	86.8	67.8	0.0	73.9	0.0	0.4	0.0	73.0	0.0	90.0	0.0
FEB	36.8	0.0	0.0	0.0	103.0	466.2	0.0	9.4	0.0	63.4	0.0	1.6	0.0	0.0	146.4	66.4	0.0	18.8	0.0	0.3	0.0	18.2	0.0	90.0	0.0
MAR	37.0	6.7	0.0	0.0	122.3	467.0	4.8	20.4	8.7	79.7	50.6	52.1	0.0	0.0	170.7	67.9	6.9	26.9	25.1	25.4	0.0	1.0	0.0	90.0	0.0
APR	32.7	9.1	0.0	12.8	125.0	467.1	15.4	27.9	8.1	60.1	33.6	35.1	0.0	0.0	192.5	69.2	4.6	18.4	16.7	16.9	0.0	1.1	0.0	90.0	0.0
MAY	19.3	16.2	0.0	0.0	119.0	466.9	11.0	16.3	16.2	0.5	37.6	39.2	0.0	0.0	151.5	66.7	4.8	20.4	18.7	18.9	0.0	1.1	0.0	90.0	0.0
JUN	14.3	18.0	0.0	0.0	106.3	466.4	12.6	18.2	18.0	1.6	34.1	35.6	0.0	0.0	115.2	64.5	4.0	18.7	16.9	17.2	0.0	1.1	0.0	90.0	0.0
JUL	14.7	39.4	0.0	0.0	72.7	465.0	26.0	39.6	39.4	1.4	76.1	77.7	0.0	0.0	36.6	59.6	8.1	39.6	37.8	38.1	0.0	1.0	0.0	90.0	0.0
AUG	13.1	67.4	0.0	0.0	9.4	462.4	26.0	67.3	34.2	32.4	65.4	67.0	0.0	0.0	0.9	51.0	4.9	34.2	32.5	32.7	0.0	1.0	0.0	90.0	0.0
SEP	9.8	10.9	0.0	0.0	0.0	461.9	6.3	10.6	3.6	5.0	68.1	4.8	64.9	0.0	0.0	50.0	0.0	3.6	33.8	3.2	30.9	0.0	0.0	90.0	0.0
TOTALS		193.8		12.8								369.4		0.0						188.5		115.4			
	314.1		0.0						146.3				64.9								30.9				

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 87.0 GWH
AT GUNUNG WULAN= 27.8 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 14 RUN NUMBER 916

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVG (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	10.4	2.7	0.0	0.0	0.0	461.9	0.4	2.3	0.6	-0.6	17.6	-1.9	21.0	0.0	0.0	50.0	0.0	0.8	8.7	0.4	[illegible]	0.0	0.0	40.0	0.0
NOV	14.6	7.0	0.0	0.0	0.0	461.5	3.0	10.0	2.1	5.9	60.2	4.8	65.0	0.0	0.[illegible]	50.0	0.0	6.4	43.9	[illegible].1	28.6	0.0	0.0	90.0	0.0
DEC	25.2	0.0	0.0	0.0	16.9	462.7	0.0	2.6	0.0	18.9	6.6	8.1	0.0	0.0	9.7	55.7	0.2	14.0	3.5	3.5	0.0	10.1	0.0	90.0	0.2
JAN	3[illegible].6	0.0	0.0	0.0	44.3	463.9	0.0	6.3	0.0	42.3	3.6	5.1	0.0	0.0	45.6	60.3	0.1	20.2	1.8	2.0	0.0	17.4	0.0	90.0	0.0
FEB	43.3	0.0	0.0	0.0	78.6	465.2	0.0	6.0	0.0	40.3	0.0	1.6	0.0	0.0	83.[illegible]	62.6	0.0	31.7	0.0	0.3	0.0	30.9	0.0	90.0	0.0
MAR	57.3	0.0	0.0	1.9	125.0	467.1	0.2	18.4	0.0	113.7	50.4	52.0	0.0	0.0	142.9	66.2	0.5	32.8	25.0	25.3	0.0	5.0	0.0	90.0	0.0
APR	37.8	10.8	0.0	16.0	125.0	467.1	22.3	33.6	10.8	51.9	30.1	31.6	0.0	0.0	160.8	67.3	3.7	16.7	14.9	15.2	0.0	1.1	0.0	90.0	0.0
MAY	26.5	14.6	0.0	2.9	125.0	467.1	12.2	19.0	14.6	13.1	35.3	36.8	0.0	0.0	134.7	65.7	4.4	19.3	17.5	17.6	0.0	1.1	0.0	90.0	0.0
JUN	22.0	10.7	0.0	2.3	125.0	467.1	8.2	14.5	10.7	12.4	24.8	26.4	0.0	0.0	118.4	64.7	2.7	14.1	12.3	12.6	0.0	1.1	0.0	90.0	0.0
JUL	15.0	40.5	0.0	0.0	90.4	465.7	26.0	41.2	40.5	4.2	78.1	79.7	0.0	0.0	40.6	60.0	8.5	40.5	34.8	39.0	0.0	1.0	0.0	90.0	0.0
AUG	7.5	64.1	0.0	0.0	24.8	463.1	26.0	63.5	33.3	26.5	63.6	65.1	0.0	0.0	0.9	51.0	4.7	33.3	31.5	31.8	0.0	1.0	0.0	90.0	0.0
SEP	11.7	27.5	0.0	0.0	0.0	461.9	20.7	27.3	9.1	17.0	39.1	16.8	43.9	0.0	0.0	50.0	0.0	9.1	29.3	8.7	20.4	0.0	0.0	90.0	0.0
TOTALS	308.0	177.8	0.0	25.1					121.9			326.2	129.9	0.0						162.7	57.5	69.2			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 85.7 GWH
AT GUNUNG WULAN= 22.2 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 15 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVS (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	29.9	0.0	0.0	0.0	12.6	462.5	0.0	1.6	0.0	10.4	0.0	1.6	0.0	0.0	7.7	55.5	0.0	10.6	0.0	0.3	0.0	10.0	0.0	90.0	0.0
NOV	19.2	22.8	0.0	0.0	0.0	461.9	16.7	24.6	8.3	26.8	81.8	33.4	49.9	0.0	0.0	50.0	0.0	13.3	40.6	12.9	27.9	0.0	0.0	90.0	0.0
DEC	42.3	0.0	0.0	0.0	33.3	463.4	0.0	11.6	0.0	78.3	13.4	14.9	0.0	0.0	62.2	61.3	1.0	17.5	6.6	6.9	0.0	10.2	0.0	90.0	0.0
JAN	43.1	0.0	0.0	0.0	67.4	464.8	0.0	9.1	0.0	61.7	0.0	1.6	0.0	0.0	120.1	64.8	0.0	21.7	0.0	0.3	0.0	21.1	0.0	90.0	0.0
FEB	48.2	0.0	0.0	0.0	106.5	466.4	0.0	11.6	0.0	70.4	0.0	1.6	0.0	0.0	194.6	69.3	0.0	29.7	0.0	0.3	0.0	28.9	0.0	90.0	0.0
MAR	37.0	8.1	0.0	1.3	125.0	467.1	5.4	16.2	8.1	46.9	46.7	50.3	0.0	0.0	138.0	66.9	6.8	25.9	24.2	24.4	0.0	1.0	0.0	90.0	0.0
APR	66.1	0.0	0.0	57.1	125.0	467.1	26.0	65.1	0.0	111.1	16.0	17.6	0.0	10.3	260.0	71.1	6.9	19.0	8.0	8.2	0.0	10.6	0.0	90.0	0.0
MAY	31.0	27.1	0.0	0.0	120.2	466.9	20.8	27.9	27.1	5.7	52.4	54.0	0.0	0.0	208.5	70.1	7.5	27.8	26.0	26.3	0.0	1.0	0.0	90.0	0.0
JUN	16.8	26.3	0.0	0.0	101.8	466.2	20.0	27.3	26.3	6.6	49.4	50.9	0.0	0.0	160.9	67.4	6.6	26.3	24.5	24.8	0.0	1.0	0.0	90.0	0.0
JUL	13.9	41.5	0.0	0.0	65.2	464.7	26.0	42.8	41.5	0.5	80.0	81.6	0.0	0.0	65.6	62.7	9.[illegible]	41.5	39.7	40.0	0.0	1.0	0.0	90.0	0.0
AUG	12.0	32.0	0.0	0.0	36.2	463.5	24.8	30.3	30.3	-10.1	61.0	62.5	0.0	0.0	11.8	56.1	5.7	30.3	30.3	29.8	0.7	0.0	0.0	90.0	0.0
SEP	11.9	39.1	0.0	0.0	0.0	461.9	26.0	37.8	13.3	16.4	66.7	27.1	41.1	0.0	0.0	50.0	0.0	13.3	33.1	12.9	20.4	0.0	0.0	90.0	0.0
TOTALS	367.8	196.9	0.0	58.4					154.8			397.1	91.0	16.3						187.0	49.1	84.6			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 119.3 GWH
AT GUNUNG WULAN= 30.0 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 16 RUN NUMBER 918

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVA (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	11.9	3.2	0.0	0.0	0.0	461.9	0.6	3.0	1.1	2.8	0.0	1.6	0.0	0.0	0.2	50.2	0.0	1.4	0.0	0.3	0.0	0.8	0.0	90.0	0.0
NOV	13.0	5.2	0.0	0.0	0.0	461.9	1.6	5.3	1.5	4.4	68.0	3.4	66.2	0.0	0.0	50.0	0.0	8.8	33.8	8.4	25.6	0.0	0.0	90.0	0.0
DEC	27.9	0.0	0.0	0.0	19.6	462.9	0.0	4.3	0.0	29.1	0.0	1.6	0.0	0.0	26.4	58.2	0.0	13.5	0.0	0.3	0.0	12.9	0.0	90.0	0.0
JAN	43.4	0.0	0.0	0.0	51.0	464.1	0.0	11.6	0.0	78.7	0.0	1.6	0.0	0.0	101.3	63.7	0.0	19.0	0.0	0.3	0.0	18.6	0.0	90.0	0.0
FEB	45.3	0.0	0.0	0.0	88.3	465.6	0.0	7.6	0.0	51.4	0.0	1.6	0.0	0.0	140.9	66.6	0.0	31.3	0.0	0.3	0.0	30.5	0.0	90.0	0.0
MAR	47.9	13.6	0.0	0.0	113.6	466.6	8.7	23.9	13.6	69.0	46.3	47.0	0.0	0.0	167.6	67.7	6.2	24.7	23.0	23.2	0.0	1.3	0.0	90.0	0.0
APR	40.7	2.0	0.0	13.3	125.0	467.1	14.8	29.2	2.0	78.7	26.3	27.9	0.0	0.0	215.2	70.2	3.5	14.8	13.1	13.1	0.0	1.1	0.0	90.0	0.0
MAY	54.1	0.0	0.0	45.1	125.0	467.1	26.0	56.6	0.0	136.6	12.8	14.3	0.0	74.2	260.0	71.1	10.0	17.8	6.3	6.6	0.0	10.8	0.0	90.0	0.0
JUN	43.0	0.0	0.0	34.0	125.0	467.1	26.0	42.6	0.0	92.3	22.4	23.9	0.0	65.2	260.0	71.1	10.0	15.5	11.1	11.4	0.0	3.8	0.0	90.0	0.0
JUL	44.2	12.9	0.0	22.3	125.0	467.1	26.0	40.8	12.9	60.3	39.6	41.1	0.0	16.0	260.0	71.1	8.2	21.4	19.6	19.9	0.0	1.1	0.0	90.0	10.0
AUG	48.2	18.7	0.0	20.5	125.0	467.[illegible]	26.0	41.7	18.7	37.5	41.9	43.5	0.0	0.0	250.9	70.9	6.1	22.6	20.8	21.1	0.0	1.1	0.0	90.0	0.0
SEP	21.0	21.2	0.0	0.0	115.8	466.7	15.7	21.1	21.1	-0.6	40.6	42.2	0.0	0.0	204.8	69.9	5.7	21.8	20.1	20.4	0.0	1.1	0.0	90.0	0.0
TOTALS	437.7	76.8	0.0	140.1					70.9			250.4	66.2	155.4						125.3	25.6	82.7			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 104.7 GWH
AT GUNUNG WULAN= 39.2 AND AT JRAGUNG = 0.C GWH

JRATUNSELUNA BASIN – TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. – ENGLEWOOD, COLORADO, U.S.A.

YEAR 17 RUN NUMBER 918

	RAWA PENING							DIVERSION		GUNUNG MULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	[illegible]	0.0	0.0	4.2	125.0	467.1	1.2	6.9	0.0	22.2	0.0	1.6	0.0	0.0	222.3	70.3	0.0	2.1	0.0	0.3	0.0	1.5	0.0	90.0	0.0
NOV	31.9	14.2	0.0	8.6	125.0	467.1	17.2	31.2	14.2	65.1	44.3	45.8	0.0	0.0	238.4	70.7	6.4	23.7	22.0	22.2	0.0	1.1	0.0	90.0	0.0
DEC	45.8	0.0	0.0	36.8	125.0	467.1	26.0	43.7	0.0	83.6	0.0	1.6	0.0	57.2	260.0	71.1	8.4	29.2	0.0	0.3	0.0	26.4	0.0	90.0	0.0
JAN	53.0	1.3	0.0	42.7	125.0	467.1	26.0	51.7	1.3	94.5	15.3	16.9	0.0	74.4	260.0	71.1	10.0	9.4	7.6	7.9	0.0	1.1	0.0	90.0	0.0
FEB	59.0	0.0	0.0	50.0	125.0	467.1	26.0	63.2	0.0	152.9	0.0	1.6	0.0	148.2	260.0	71.1	10.0	10.5	0.0	0.3	0.0	9.9	0.0	90.0	0.0
MAR	59.5	11.0	0.0	39.4	125.0	467.1	26.0	65.8	11.0	143.7	41.2	42.8	0.0	97.7	260.0	71.1	10.0	22.2	20.4	20.7	0.0	1.1	0.0	90.0	0.0
APR	72.6	0.0	0.0	63.6	125.0	467.1	26.0	83.6	0.0	199.5	23.2	24.7	0.0	171.6	260.0	71.1	10.0	30.3	11.5	11.8	0.0	18.0	0.0	90.0	0.0
MAY	39.4	25.8	0.0	4.6	125.0	467.1	23.7	32.9	25.8	21.5	50.0	51.6	0.0	0.0	226.8	70.4	7.2	26.6	24.8	25.1	0.0	1.0	0.0	90.0	0.0
JUN	32.9	19.9	0.0	3.9	125.0	467.1	18.0	25.3	19.9	13.5	38.3	39.8	0.0	0.0	197.3	69.5	5.3	20.7	19.0	19.2	0.0	1.1	0.0	90.0	0.0
JUL	22.8	38.7	0.0	0.0	100.1	466.1	26.0	39.5	38.7	5.4	74.4	76.0	0.0	0.0	123.5	65.0	9.1	36.7	36.9	37.2	0.0	1.0	0.0	90.0	0.0
AUG	15.5	32.6	0.0	0.0	73.9	465.1	25.5	32.1	32.1	-3.5	62.2	63.8	0.0	0.0	54.0	60.8	6.9	32.1	30.9	31.1	0.0	0.4	0.0	90.0	0.0
SEP	12.7	36.0	0.0	0.0	41.6	463.8	26.0	35.4	28.5	3.5	54.0	55.5	0.0	0.0	0.9	51.0	3.9	28.5	26.8	27.0	0.0	1.0	0.0	90.0	0.0
TOTALS	467.6	179.5	0.0	253.9					171.5			421.5	0.0	549.1						203.0	0.0	65.8			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 192.7 GWH
AT GUNUNG HULAN= 92.2 AND AT JHAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 18 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVA (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	13.4	3.1	0.0	0.0	43.0	463.8	0.6	3.2	0.9	2.7	0.0	1.6	0.0	0.0	0.9	51.0	0.0	1.8	0.0	0.1	0.0	1.1	0.0	90.0	0.0
NOV	27.2	61.2	0.0	0.0	0.0	461.9	26.0	62.9	20.0	53.0	73.5	52.8	22.3	0.0	0.0	50.0	0.0	27.0	36.3	26.5	10.3	0.0	0.0	90.0	0.0
DEC	43.4	3.2	0.0	0.0	31.1	463.3	0.6	8.3	3.2	34.0	15.0	16.6	0.0	0.0	16.3	56.7	1.0	9.2	7.5	7.7	0.0	1.1	0.0	90.0	0.0
JAN	31.3	0.0	0.0	0.0	53.5	464.2	0.0	3.5	0.0	23.6	0.3	1.8	0.0	0.0	37.1	59.7	0.0	13.6	0.1	0.4	0.0	12.9	0.0	90.0	0.0
FEB	35.6	0.0	0.0	0.0	80.3	465.3	0.0	2.7	0.0	18.3	0.0	1.6	0.0	0.0	52.7	60.8	0.0	13.8	0.0	0.3	0.0	13.2	0.0	90.0	0.0
MAR	54.6	0.0	0.0	0.6	125.0	467.1	0.0	14.0	0.0	91.4	37.7	39.3	0.0	0.0	102.6	63.8	4.4	31.2	18.7	19.0	0.0	11.7	0.0	90.0	0.0
APR	47.9	0.0	0.0	38.9	125.0	467.1	26.0	44.3	0.0	75.5	16.4	17.9	0.0	0.0	157.9	67.1	1.8	13.2	8.1	[illegible]	0.0	4.4	0.0	90.0	0.0
MAY	46.3	0.0	0.0	37.3	125.0	467.1	26.0	41.5	0.0	65.7	20.9	22.5	0.0	0.0	197.5	69.5	2.6	15.6	10.4	10.6	0.0	4.8	0.0	90.0	0.0
JUN	27.7	19.3	0.0	0.0	124.4	467.1	13.8	20.6	19.3	8.9	39.9	41.4	0.0	0.0	162.1	67.4	3.2	21.6	19.8	20.1	0.0	1.1	0.0	90.0	0.0
JUL	31.9	78.2	0.0	0.0	119.1	466.9	21.7	29.0	28.2	5.4	59.5	61.0	0.0	0.0	104.2	63.9	7.2	31.3	29.5	29.8	0.0	1.0	0.0	90.0	0.0
AUG	15.3	33.7	0.0	0.0	91.7	465.8	26.0	33.7	33.7	-0.3	64.4	65.9	0.0	0.0	35.7	59.3	6.9	33.7	31.9	32.2	0.0	1.0	0.0	90.0	0.0
SEP	15.0	39.2	0.0	0.0	58.5	464.4	26.0	40.0	26.7	18.1	50.3	51.9	0.0	0.0	0.9	51.0	3.6	26.7	25.0	25.2	0.0	1.0	0.0	90.0	0.0
TOTALS	389.7	187.7	0.0	76.9					131.9			374.2	22.3	0.0						180.6	10.3	53.6			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 120.1 GWH
AT GUNUNG WULAN= 23.5 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 19 RUN NUMBER 910

	RAWA PENING							DIVERSION		GUNUNG WULAN								JRAGUNG							
MONTH	INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	VOL AVB (MCM)	VOL DIV (MCM)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	13.9	0.0	0.0	0.0	63.4	464.6	0.0	0.6	0.0	3.8	0.0	1.6	0.0	0.0	2.0	52.2	0.0	2.8	0.0	0.3	0.0	2.2	0.0	90.0	0.0
NOV	26.2	73.7	0.0	0.0	6.8	462.2	26.0	76.6	25.0	67.9	66.4	67.9	0.0	0.0	0.9	51.6	5.0	34.7	32.9	33.2	0.0	1.0	0.0	90.0	0.0
DEC	31.1	0.0	0.0	0.0	28.9	463.3	0.0	5.4	0.0	36.2	2.3	3.9	0.0	0.0	32.1	59.0	0.1	22.3	1.2	1.4	0.0	20.5	0.0	90.0	0.0
JAN	31.9	0.0	0.0	0.0	51.7	464.2	0.0	6.2	0.0	42.1	0.0	1.6	0.0	0.0	71.5	61.9	0.0	33.3	0.0	0.4	0.0	32.5	0.0	90.0	0.0
FEB	30.5	0.0	0.0	0.0	81.2	465.3	0.0	8.7	0.0	59.1	0.0	1.6	0.0	0.0	126.7	65.2	0.0	37.1	0.0	0.3	0.0	36.3	0.0	90.0	0.0
MAR	40.4	0.0	0.0	0.0	112.6	466.6	0.0	9.4	0.0	63.4	36.0	37.5	0.0	0.0	150.2	66.6	4.6	21.0	17.8	18.1	0.0	2.5	0.0	90.0	0.0
APR	43.0	0.0	0.0	21.6	125.0	467.1	16.1	30.7	0.0	83.5	12.9	14.5	0.0	0.0	216.1	70.2	1.5	11.8	6.6	6.7	0.0	6.8	0.0	90.0	0.0
MAY	44.7	1.7	0.0	34.0	125.0	467.1	26.0	42.1	1.7	77.2	15.1	16.6	0.0	13.5	260.0	71.1	4.0	9.2	7.5	7.7	0.0	1.1	0.0	90.0	0.0
JUN	30.5	6.2	0.0	21.3	125.0	467.1	21.2	31.3	6.2	46.9	21.3	22.8	0.0	20.9	260.0	71.1	6.1	12.3	10.5	10.8	0.0	1.1	0.0	90.0	0.0
JUL	73.6	39.0	0.0	0.0	100.5	466.1	26.0	39.5	39.0	2.8	77.1	78.7	0.0	0.0	180.9	68.5	10.0	40.0	38.3	38.5	0.0	1.0	0.0	90.0	0.0
AUG	13.7	33.7	0.0	0.0	71.5	465.0	26.0	33.3	33.3	-2.7	64.4	65.9	0.0	0.0	113.1	64.2	7.9	33.3	31.9	32.2	0.0	0.6	0.0	90.0	0.0
SEP	13.7	29.3	0.0	0.0	46.8	465.0	22.5	28.6	28.6	-4.4	55.5	57.1	0.0	0.0	46.3	60.4	6.0	28.6	27.6	27.8	0.0	0.3	0.0	90.0	0.0
TOTALS	357.7	183.7	0.0	70.9					133.9			369.6	0.0	34.4						177.3	0.0	106.0			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 117.9 GWH
AT GUNUNG WULAN= 32.7 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORA , U.S.A.

YEAR 70 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVB (MCM)	VOL DIV (MCM)	GUNUNG MULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	24.1	9.0	0.0	0.0	61.9	464.6	0.0	1.5	0.0	9.9	0.0	1.6	0.0	0.0	53.6	60.8	0.0	[illegible]	0.0	0.3	0.0	5.8	0.0	90.0	0.0
NOV	45.0	17.9	0.0	0.0	76.0	465.1	14.3	24.7	19.9	32.2	54.6	56.1	0.0	0.0	28.6	58.5	5.5	20.8	27.1	27.3	0.0	1.0	0.0	90.0	0.0
DEC	54.4	0.0	0.0	0.0	121.3	467.0	0.0	11.0	0.0	74.5	[illegible]	1.6	0.0	0.0	99.2	63.6	0.0	7.2	0.0	0.3	0.0	6.6	0.0	90.0	0.0
JAN	39.9	0.3	0.0	27.2	125.0	467.1	20.9	41.7	0.0	125.3	0.0	1.6	0.0	0.0	219.4	70.3	0.0	40.6	0.0	0.1	0.0	39.6	0.0	90.0	0.0
FEB	41.6	0.0	0.0	32.6	125.0	467.1	25.7	36.7	0.0	60.5	4.5	6.0	0.0	11.0	260.0	71.1	1.9	11.2	2.2	2.5	0.0	6.3	0.0	90.0	0.0
MAR	57.[illegible]	0.0	0.0	48.3	125.0	467.1	26.0	56.8	0.0	105.7	17.8	19.4	0.0	83.2	260.0	71.1	10.0	40.5	8.6	9.1	0.0	30.9	0.0	90.0	0.0
APR	42.3	9.5	0.0	23.7	125.0	467.1	26.0	45.7	9.5	104.7	32.1	33.7	0.0	67.9	260.0	71.1	10.0	17.7	15.4	16.2	0.0	1.1	0.0	90.0	0.0
MAY	46.6	17.3	0.0	20.3	125.0	467.1	26.0	42.8	17.3	55.5	32.8	34.4	0.0	17.9	260.0	71.1	7.5	16.1	16.3	16.6	0.0	1.1	0.0	90.0	0.0
JUN	22.3	25.9	0.0	0.0	112.1	466.6	19.7	25.8	25.8	0.3	48.6	50.2	0.0	0.0	206.9	70.0	7.0	25.8	24.1	24.4	0.0	0.9	0.0	90.0	0.0
JUL	19.3	41.5	0.0	0.0	80.9	465.3	26.0	42.2	41.5	4.5	80.0	81.6	0.0	0.0	126.6	65.2	9.4	41.5	39.7	40.0	0.0	1.0	0.0	90.0	0.0
AUG	15.8	31.3	0.0	0.0	56.4	464.4	24.3	31.1	31.1	-1.3	59.5	61.1	0.0	0.0	62.0	61.3	6.7	31.1	29.5	29.8	0.0	0.8	0.0	90.0	0.0
SEP	13.2	45.1	0.0	0.0	15.5	462.7	26.0	44.1	33.7	5.9	64.3	65.8	0.0	0.0	0.9	51.0	4.8	33.7	31.9	32.2	0.0	1.0	0.0	90.0	0.0
TOTALS	419.5	190.4	0.0	152.1					178.8			412.9	0.0	180.0						198.8	0.0	98.2			

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 169.1 GWH
AT GUNUNG MULAN= 51.6 AND AT JRAGUNG = 0.0 GWH

JRATUNSELUNA BASIN - TUNTANG AND JRAGUNG RIVER SYSTEMS

RESERVOIR OPERATION STUDIES

PRC ENGINEERING CONSULTANTS, INC. - ENGLEWOOD, COLORADO, U.S.A.

YEAR 21 RUN NUMBER 918

MONTH	RAWA PENING INF VOL (MCM)	OUT VOL (MCM)	SHG VOL (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	DIVERSION VOL AVG (MCM)	VOL DIV (MCM)	GUNUNG WULAN INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)	JRAGUNG INF VOL (MCM)	IRR REQ (MCM)	TOT OUT (MCM)	TOT SHG (MCM)	SPL VOL (MCM)	END STG (MCM)	END ELE	POW AVG (MW)
OCT	40.4	31.8	0.0	0.0	15.1	462.7	24.5	31.0	12.0	23.2	20.6	22.1	0.0	0.0	0.4	51.0	1.1	12.0	10.2	10.5	0.0	1.1	0.0	90.0	0.0
NOV	14.3	20.8	0.0	0.0	0.0	461.9	14.9	25.5	10.9	41.3	47.9	41.1	8.4	0.0	0.0	50.0	0.0	15.5	23.8	15.1	8.9	0.0	0.0	90.0	0.0
DEC	74.4	0.0	0.0	0.0	16.1	462.7	0.0	9.3	0.0	62.9	2.8	4.4	0.0	0.0	57.4	61.0	0.1	10.8	1.4	1.6	0.0	6.8	0.0	90.0	0.0
JAN	42.0	0.0	0.0	0.0	49.1	464.1	0.0	9.3	0.0	62.7	0.0	1.6	0.0	0.0	116.2	64.6	0.0	27.4	0.0	0.3	0.0	26.6	0.0	90.0	0.0
FEB	41.6	0.0	0.0	0.0	81.7	465.4	0.0	6.1	0.0	41.2	0.0	1.6	0.0	0.0	153.6	66.8	0.0	19.7	0.0	0.3	0.0	19.1	0.0	90.0	0.0
MAR	39.8	0.0	0.0	0.0	112.4	466.6	0.0	10.4	0.0	70.5	17.5	19.1	0.0	0.0	201.7	69.7	2.1	18.0	8.7	9.0	0.0	8.7	0.0	90.0	0.0
APR	44.1	0.0	0.0	22.5	125.0	467.1	16.9	33.9	0.0	120.4	16.2	17.8	0.0	41.2	260.0	71.1	8.4	24.1	8.0	8.3	0.0	15.6	0.0	90.0	0.0
MAY	63.5	0.0	0.0	54.5	125.0	467.1	26.0	72.7	0.0	178.4	0.0	1.6	0.0	173.6	260.0	71.1	10.0	22.4	0.0	0.3	0.0	21.8	0.0	90.0	0.0
JUN	39.9	6.9	0.0	24.0	125.0	467.1	24.2	34.2	6.9	46.2	22.2	23.7	0.0	19.3	260.0	71.1	6.0	12.8	11.0	11.3	0.0	1.1	0.0	90.0	0.0
JUL	31.1	28.0	0.0	0.0	119.1	466.9	21.6	31.2	28.0	21.7	60.9	62.5	0.0	0.0	216.1	70.2	8.7	32.0	30.2	30.5	0.0	1.0	0.0	90.0	0.0
AUG	21.2	26.3	0.0	0.0	104.6	466.3	20.1	26.8	26.3	2.6	50.1	51.7	0.0	0.0	163.8	67.4	6.7	26.6	24.9	25.1	0.0	1.0	0.0	90.0	0.0
SEP	35.5	8.8	0.0	0.0	122.5	467.0	4.9	11.1	8.8	15.1	25.5	27.1	0.0	0.0	149.5	66.6	3.0	14.9	12.7	12.9	0.0	1.1	0.0	90.0	0.0
TOTALS		122.6		101.0								274.1		234.0						125.1		105.7			
	437.4		0.0						97.8				8.4								8.9				

DURING THIS YEAR TOTAL ENERGY GENERATED AT UPPER TUNTANG SYSTEM = 110.2 GWH
AT GUNUNG WULAN= 43.7 AND AT JRAGUNG = 0.0 GWH

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                          SUMMARY OF RESULTS FOR PERIOD OF RUN NUMBER   916FOLLOWS

SHORTAGES OCCURED DURING THIS RUN AT GUNUGG WULAN =   5.2 AND AT JRAGUNG =   5.2 PERCENT OF THE TIME OF RUN

    YEARLY AVERAGES FOR THE PERIOD OF RUN

        161.3     125.6                               369.7     190.0                          178.1     81.8
   400.3     0.0                    136.6                  28.5                                     13.4

    CORRESPONDING AVG ENERGY AT UTS =132.93 AT GUNUNG WULAN = 49.00 AT JRAGUNG =  0.0  GWH

    FIRM POWER AT UTS =  0.0   AT GUNUNGWULAN =  0.0   AND AT JRAGUNG =  0.0  MW

    ANNUAL FIRM ENERGY GENERATED AT UTS =  0.0   AT GUNUNGWULAN =  0.0   AND AT JRAGUNG =  0.0  GWH

    ANNUAL SECONDARY ENERGY GENERATED AT UTS =132.93  AT GUNUNGWULAN = 49.00  AND AT JRAGUNG =  0.0 , GWH

    MAXIMUM MONTHLY DIVERSION DURING PERIOD OF THIS RUN = 16.00 CMS
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2.	PRC/ECI. Tuntang/Jragung Rivers Basins - Integrated Development Plan - Interim Report. August 1979.
3.	PRC/ECI. Tuntang/Jragung Rivers Basins - Special Report No. I- Municipal and Industrial Water Supply. November 1979.
4.	PRC/ECI. Tuntang/Jragung Rivers Basins - Special Report No. II- Geology. November 1979.
5.	PRC/ECI. Tuntang/Jragung Rivers Basins - Special Report No. III- Flood Control and Drainage. November 1979.
6.	PRC/ECI. Jragung Dam Multipurpose Irrigation Flood Control & Industrial Water Supply Project - Upgraded Feasibility Report. December 1976.
7.	NEDECO. Jratunseluna Basin Development Plan Central Java - Glapan Dam - Irrigation, Flood Control & Hydropower Project. Feasibility Study Vol. 1 - Main Report. July 1975.
8.	PRC/ECI. Jragung Dam Final Design Report. April 1979.
9.	Burns and McDonnell/Trans-Asia. Water Supply Master Plan for the City of Semarang. November 1976.

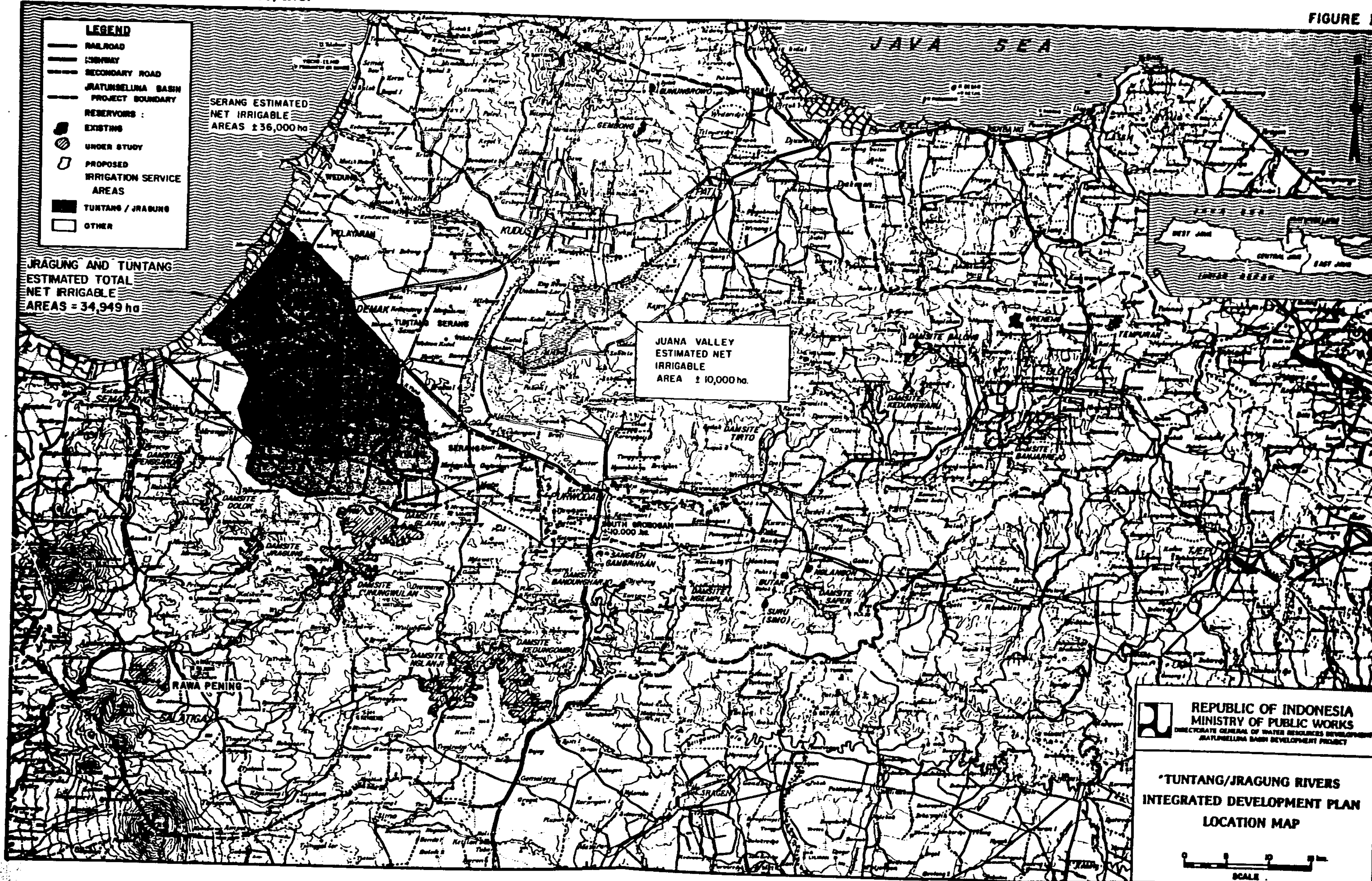
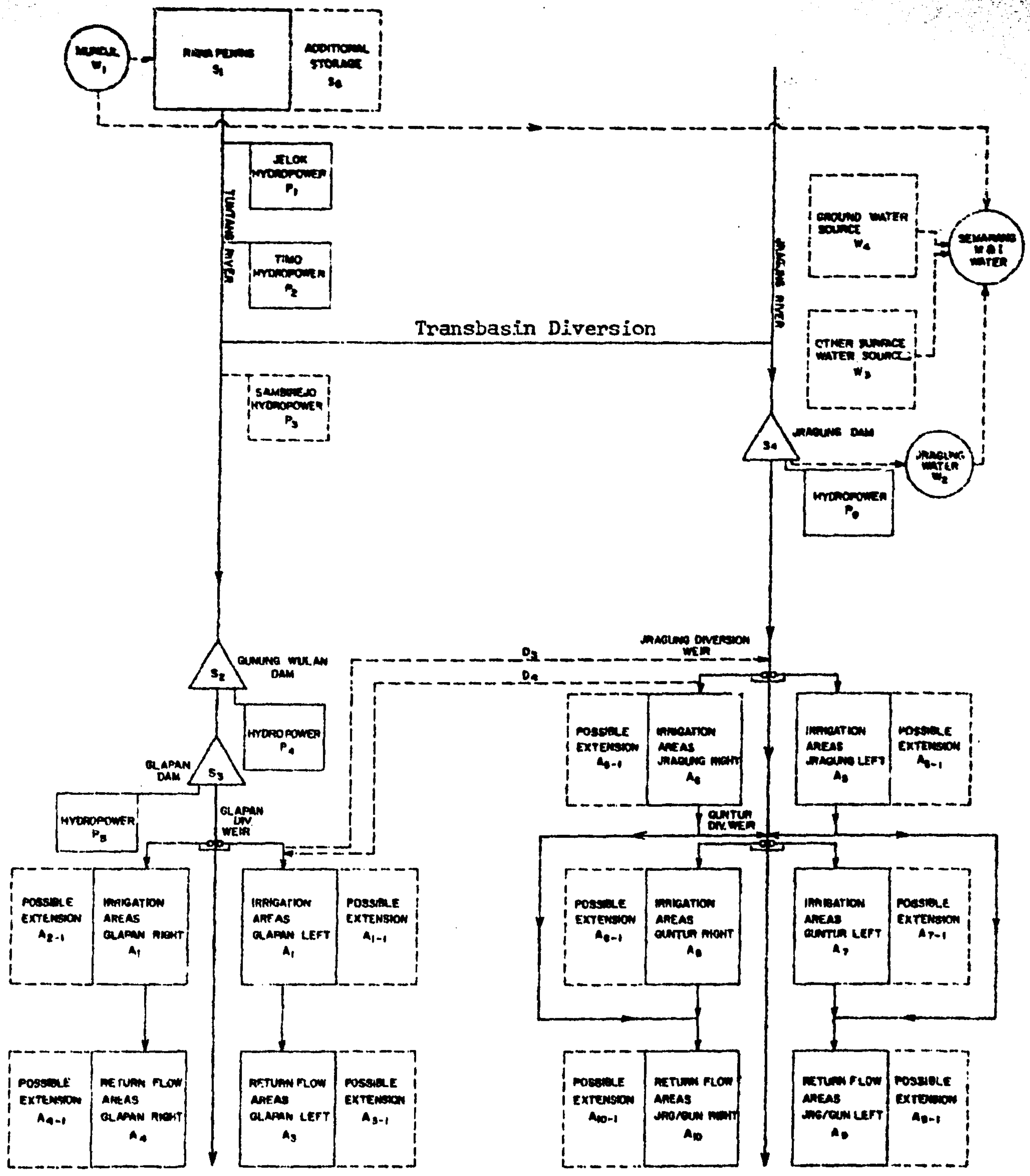


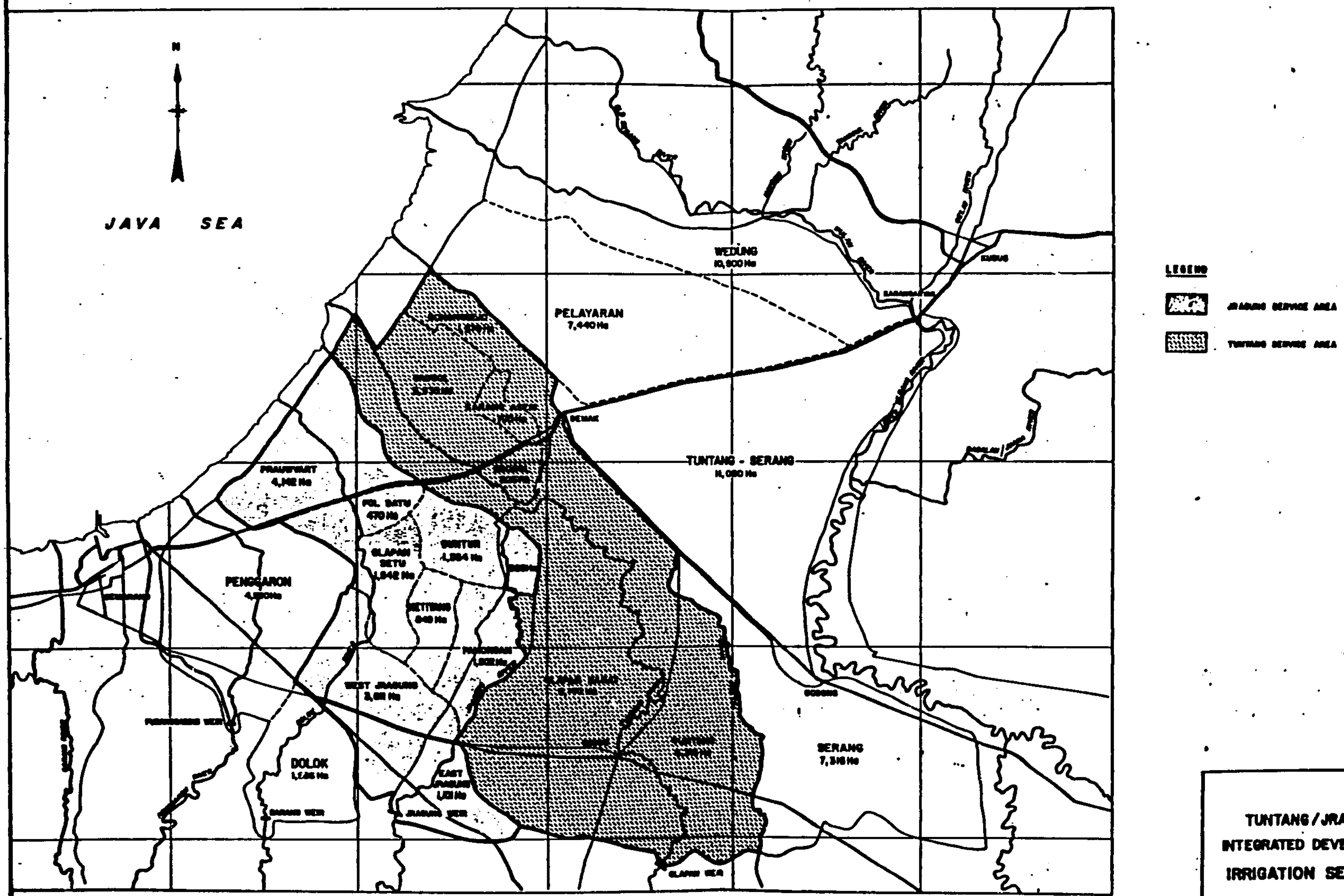
FIGURE
JAVA SEA
LEGEND
RAILROAD
HIGHWAY
SECONDARY ROAD
JRATUNSELUNA BASIN PROJECT BOUNDARY
RESERVOIRS :
EXISTING
UNDER STUDY
PROPOSED
IRRIGATION SERVICE AREAS
TUNTANG / JRAGUNG
OTHER
SERANG ESTIMATED NET IRRIGABLE AREAS ± 36,000 ha
JRAGUNG AND TUNTANG ESTIMATED TOTAL NET IRRIGABLE AREAS = 34,949 ha
JUANA VALLEY ESTIMATED NET IRRIGABLE AREA ± 10,000 ha.
DEMAK
KUDUS
PATI
PURWODADI
SEMARANG
SALATIGA
RAWA PENING
DAMSITE JRAGUNG
DAMSITE DOLOK
DAMSITE KEDUNGOMBO
DAMSITE TIRTO
SRAGEN
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
TUNTANG/JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN
LOCATION MAP
SCALE



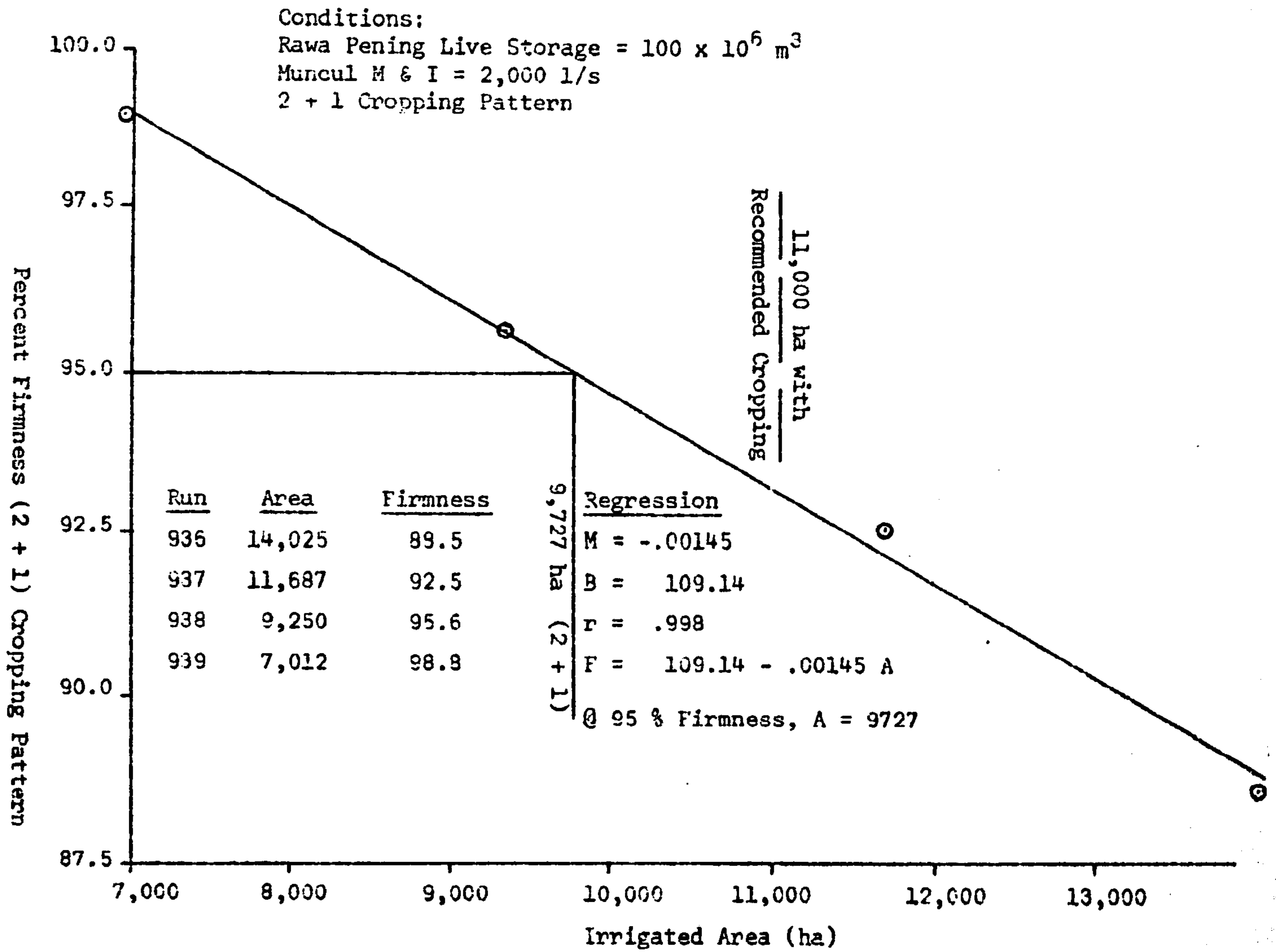
TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLAN

SCHEMATIC PRESENTATION OF BASIN MODEL



TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN
IRRIGATION SERVICE AREAS

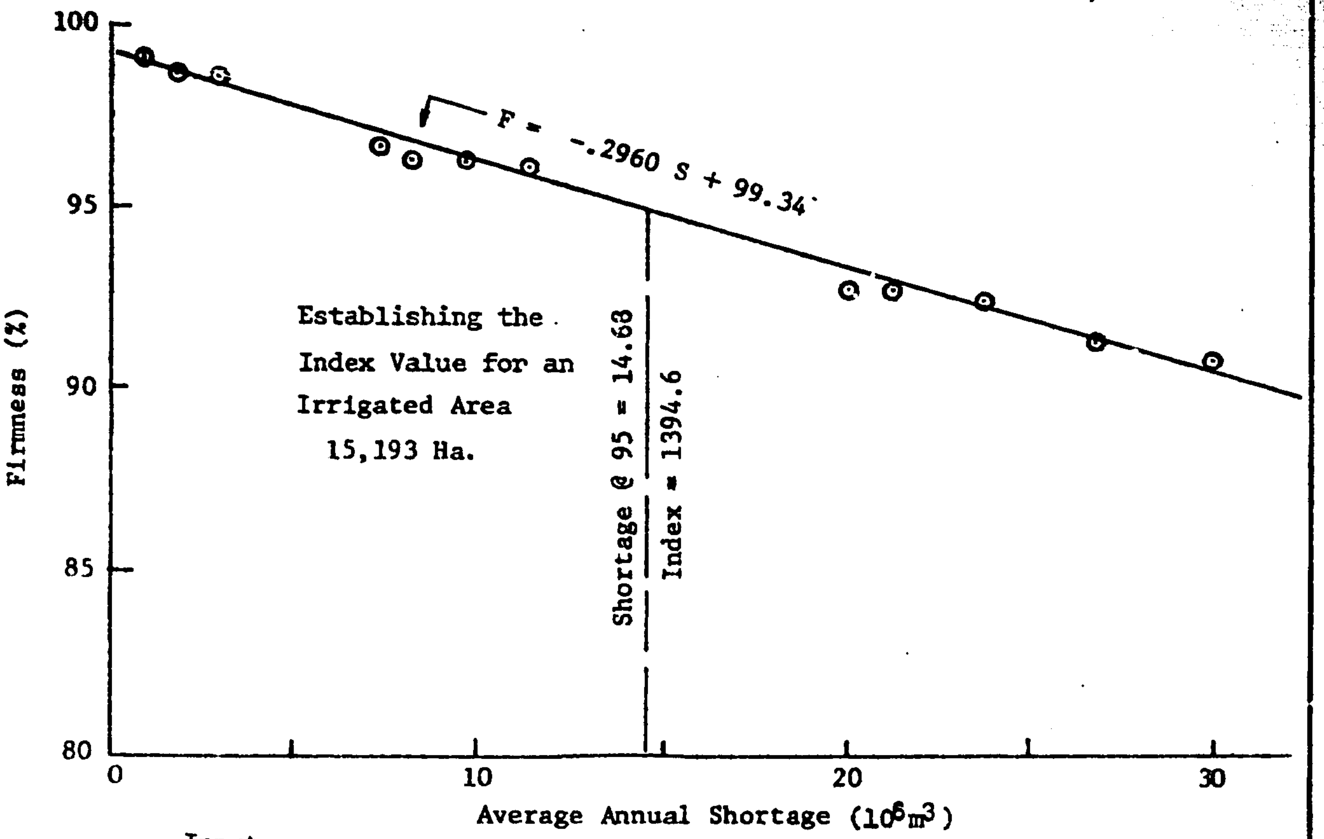


TUNTANG JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95 % FIRMNESS

PRC ENGINEERING CONSULTANTS, INC.

FIGURE D-



Input	
Firm (y)	Shortage (x)
92.9	20
92.9	21.2
92.5	23.9
91.3	26.9
90.9	30.0
96.8	7.3
96.4	8.1
96.4	9.7
96.4	11.4
99.6	.3
99.2	.7
98.8	1.7
98.8	3.0

Regression

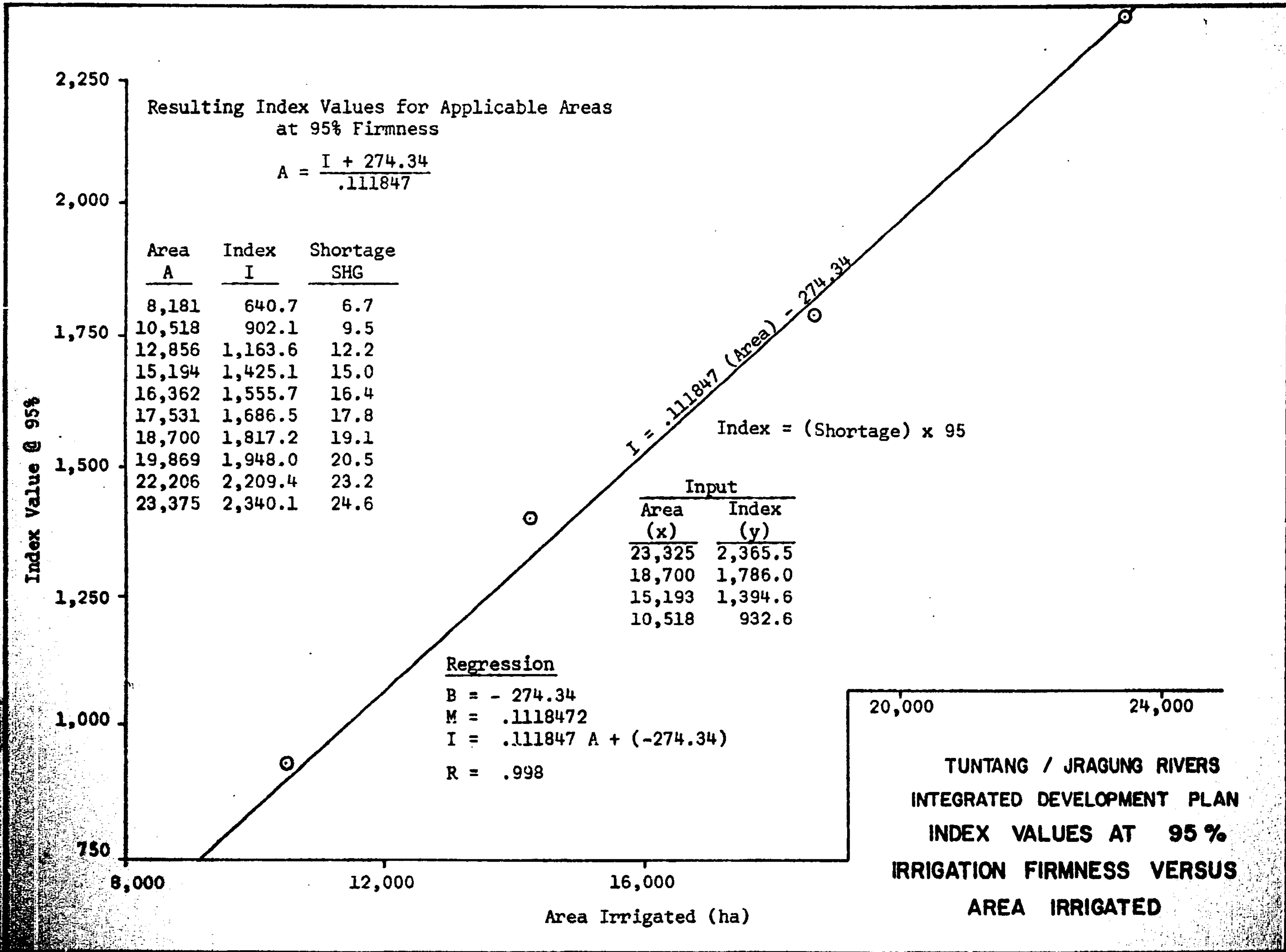
M = -.2960
B = 99.34
R = .994
F = -.2960 S + 99.34

Points	
(y)	(x)
100	-2.2
95	14.68
92	24.81

TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLAN

SHORTAGE VERSUS FIRMNESS RELATIONSHIP



Resulting Index Values for Applicable Areas at 95% Firmness

$$A = \frac{I + 274.34}{.111847}$$

Area A	Index I	Shortage SHG
8,181	640.7	6.7
10,518	902.1	9.5
12,856	1,163.6	12.2
15,194	1,425.1	15.0
16,362	1,555.7	16.4
17,531	1,686.5	17.8
18,700	1,817.2	19.1
19,869	1,948.0	20.5
22,206	2,209.4	23.2
23,375	2,340.1	24.6

Input

Area (x)	Index (y)
23,325	2,365.5
18,700	1,786.0
15,193	1,394.6
10,518	932.6

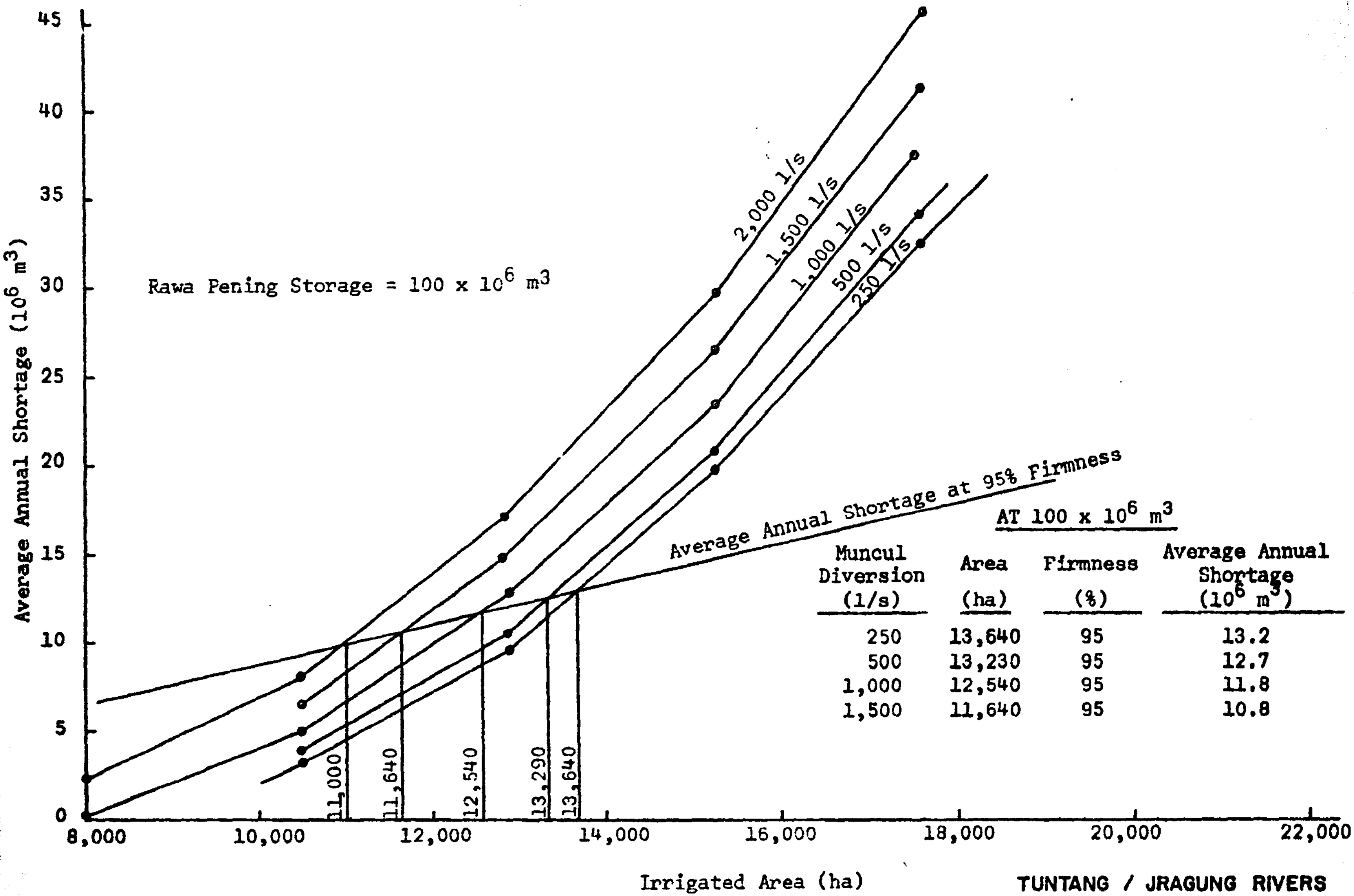
Regression

B = - 274.34
M = .1118472
I = .111847 A + (-274.34)
R = .998

TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN
INDEX VALUES AT 95 %
IRRIGATION FIRMNESS VERSUS
AREA IRRIGATED

PRC ENGINEERING CONSULTANTS, INC.

FIGURE D-6



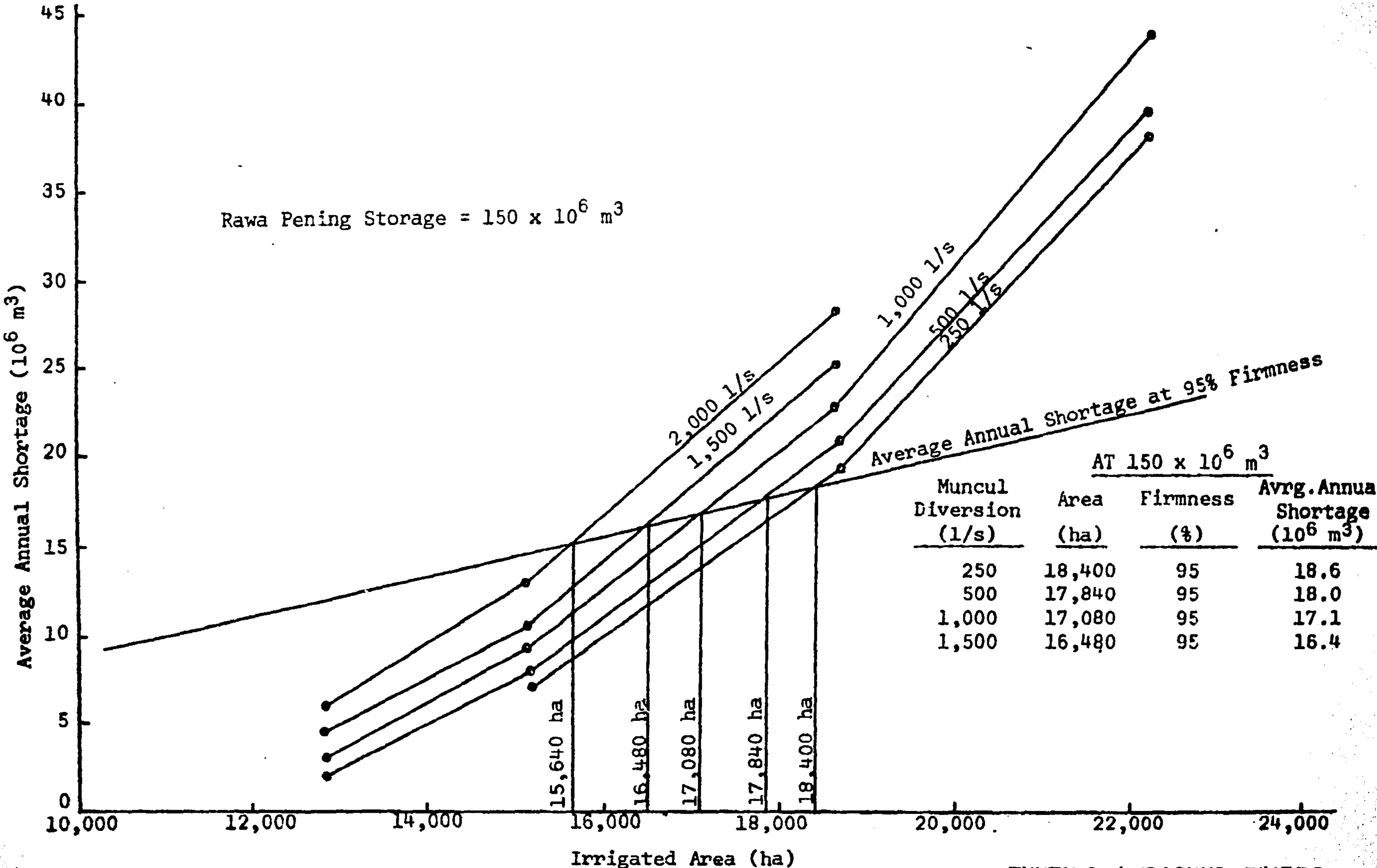
AT 100 x 10^6 m^3

Muncul Diversion (l/s)	Area (ha)	Firmness (%)	Average Annual Shortage (10^6 m^3)
250	13,640	95	13.2
500	13,230	95	12.7
1,000	12,540	95	11.8
1,500	11,640	95	10.8

TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95% FIRMNESS

FIGURE D-7



AT 150 x 10^6 m^3

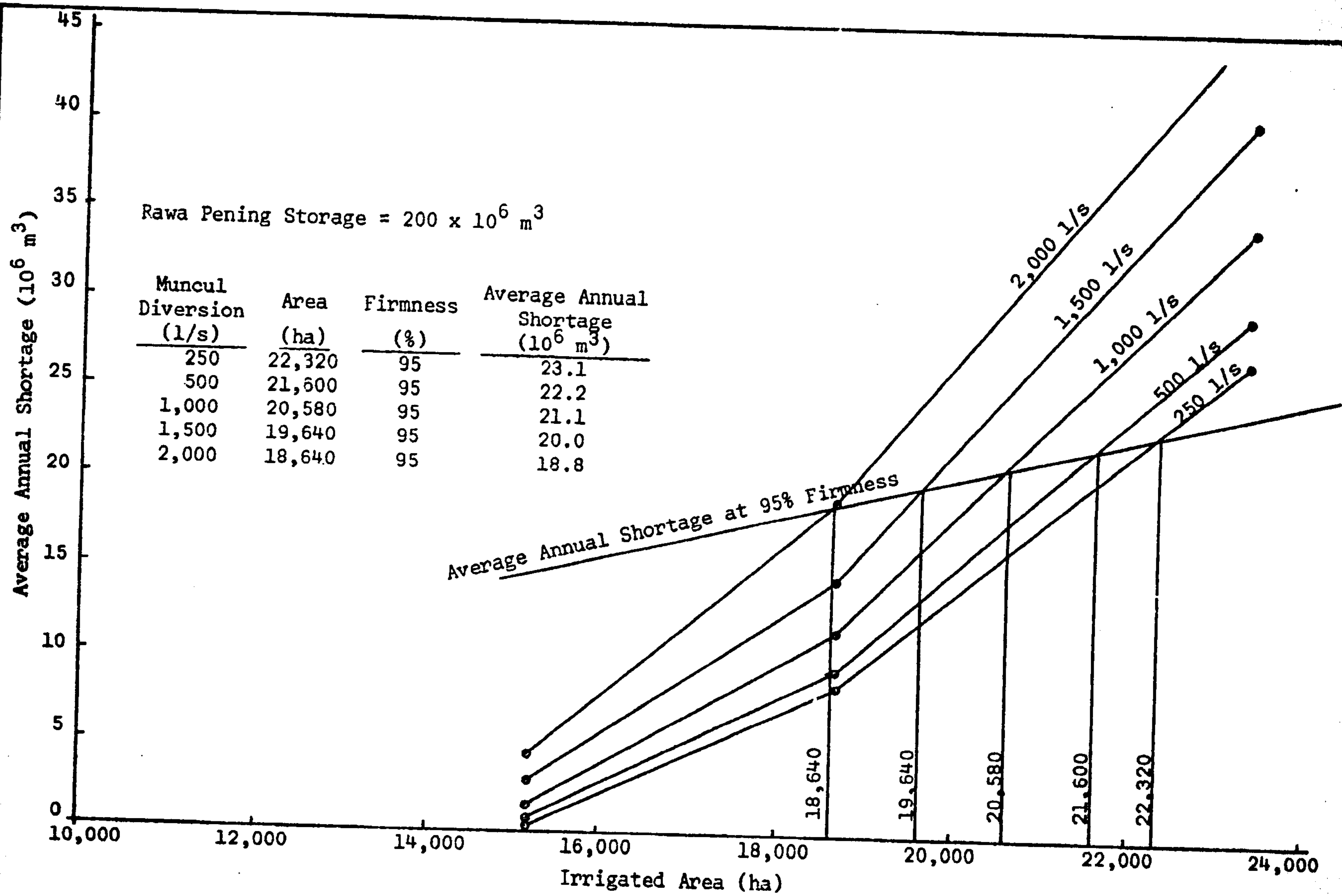
Muncul Diversion (l/s)	Area (ha)	Firmness (%)	Avrg. Annual Shortage (10^6 m^3)
250	18,400	95	18.6
500	17,840	95	18.0
1,000	17,080	95	17.1
1,500	16,480	95	16.4

TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95% FIRMNESS

PRC ENGINEERING CONSULTANTS, INC

FIGURE D-8



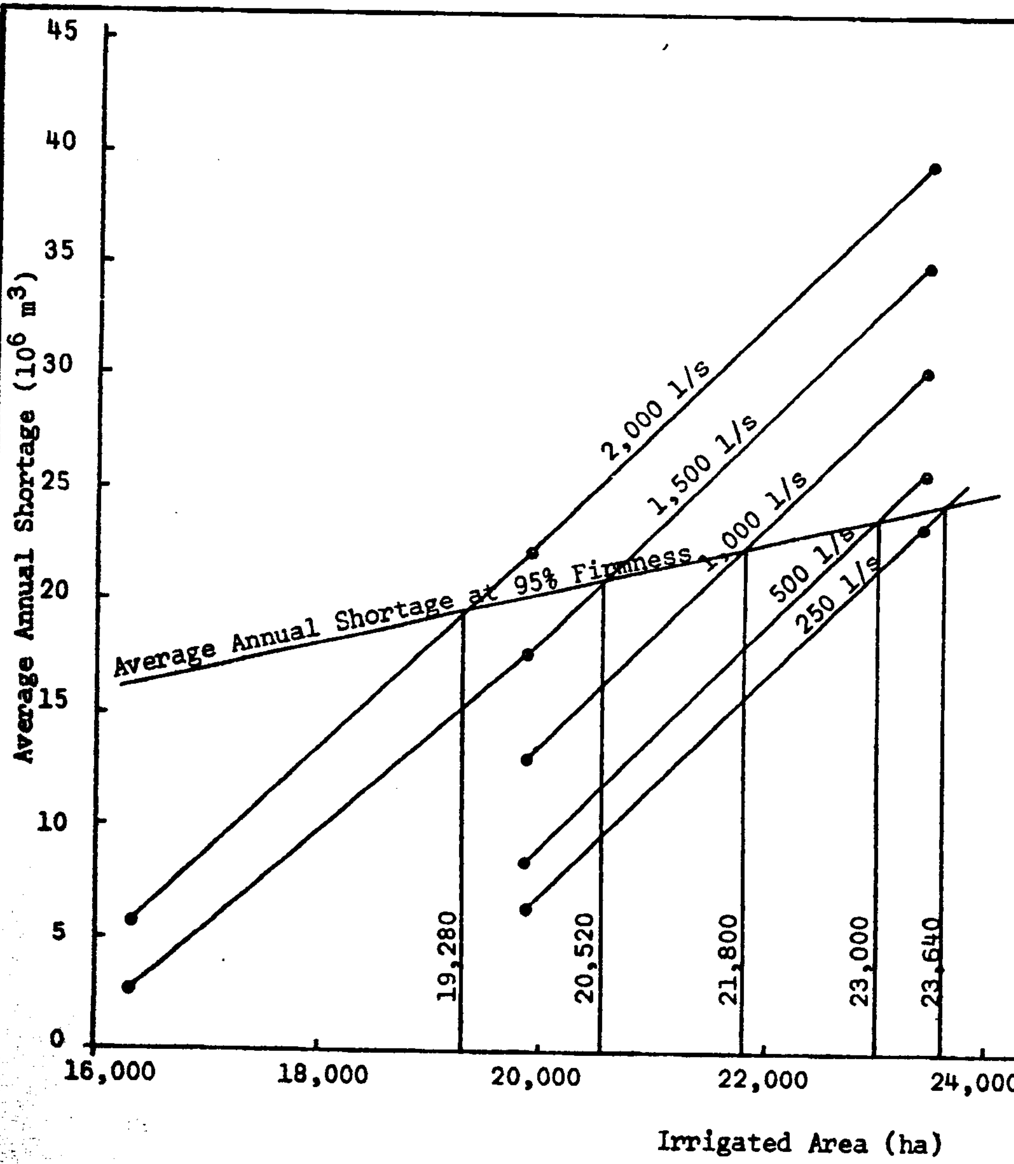
Rawa Pening Storage = 200 x 10^6 m^3

Muncul Diversion (l/s)	Area (ha)	Firmness (%)	Average Annual Shortage (10^6 m^3)
250	22,320	95	23.1
500	21,600	95	22.2
1,000	20,580	95	21.1
1,500	19,640	95	20.0
2,000	18,640	95	18.8

TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN
AREA ADJUSTMENT TO 95% FIRMNESS

FIGURE D-9

PRC ENGINEERING CONSULTANTS, INC



Rawa Pening Storage = 250×10^6 m^3

Muncul Diversion (1/s)	Area (ha)	Firmness (%)	Average Annual Shortage (10^6 m^3)
250	23,640	95	24.8
500	23,000	95	24.0
1,000	21,800	95	22.7
1,500	20,520	95	21.2
2,000	19,280	95	19.7

TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95 % FIRMNESS

FIGURE D-1

Run	Area (ha)	Firmness (%)	Average Annual Shortage (10^6 m^3)	Power UTS (Gwh)
876	12,850	96.4	8.9	141.0
877	14,025	95.2	13.0	138.7
878	15,193	94.0	17.7	136.5
879	16,362	92.9	23.1	134.5
880	17,531	91.3	29.5	132.3
881	18,700	10.9	36.7	130.1

Rawa Pening Storage = 125×10^6 m^3
Muncul M & I = 1,500 l/s

Regression-Firmness

M = .000985
B = 108.99

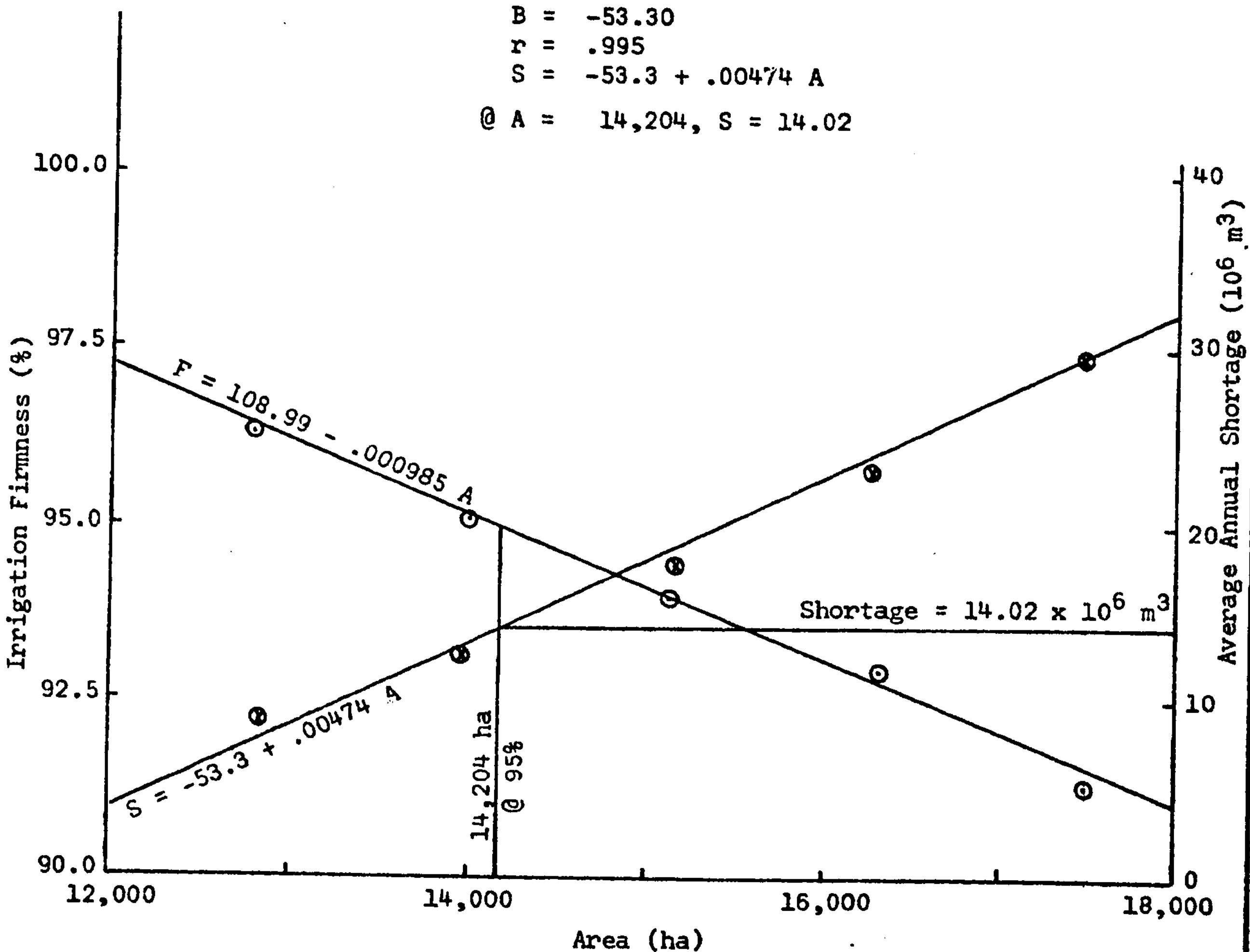
r = .994
F = 108.99-.000985 Area

@ 95% A = 14,204

Regression-Shortage

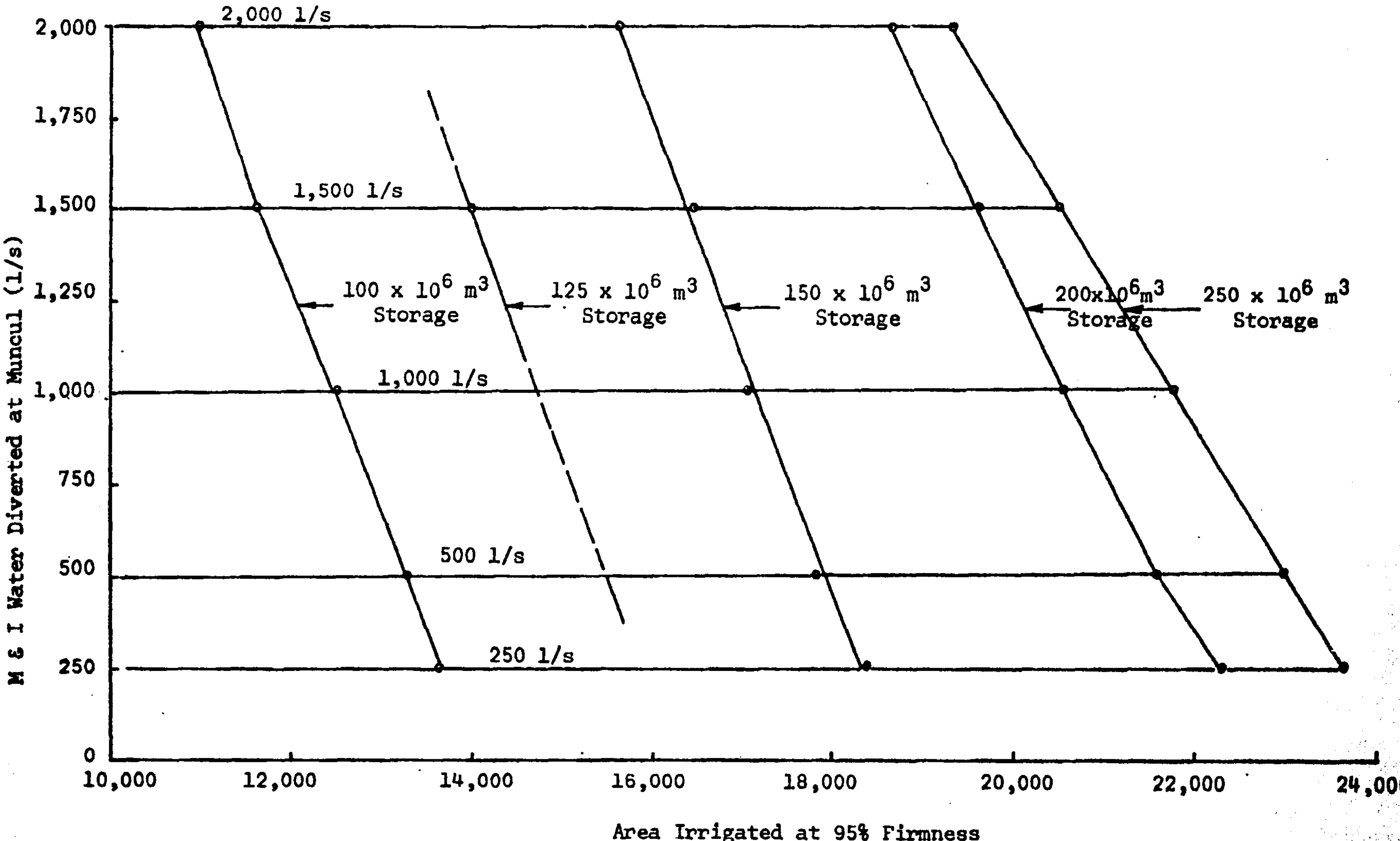
M = .00474
B = -53.30
r = .995
S = -53.3 + .00474 A

@ A = 14,204, S = 14.02



TUNTANG /JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95 % FIRMNESS

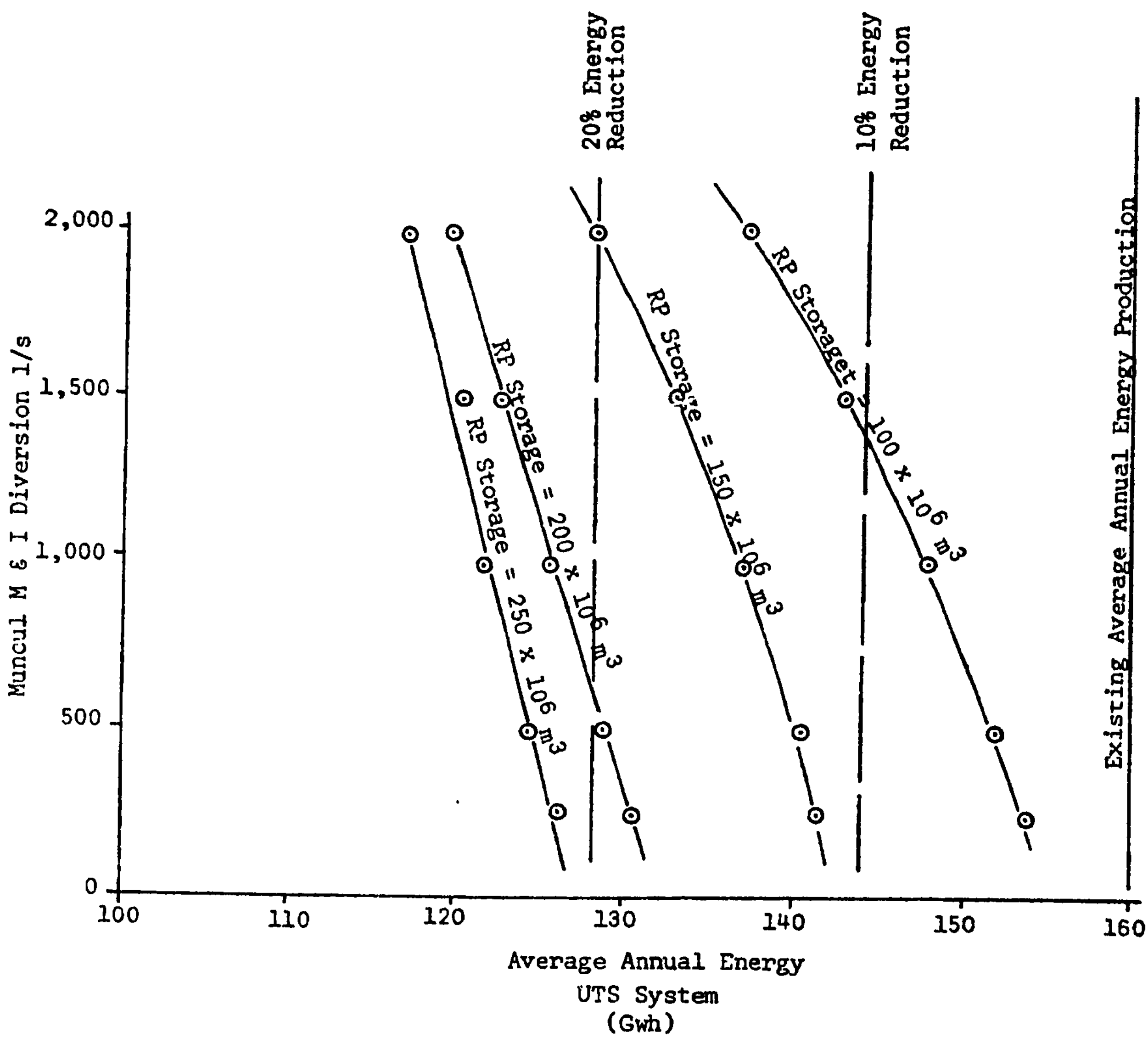


TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLANT

IRRIGATED AREAS VERSUS MUNCUL

M & I DIVERSION



TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLAN

ENERGY REDUCTION - PRESENT

UPPER TUNTANG SYSTEM

Live Storage = 87 x 106 m3
Barrage gates are open from October 1 through March 31 each year.
M & I = 500 l/s from Muncul Springs.

Run	Area (ha)	Firmness (%)	Average Annual Shortage ($m^3 x 10^6$)	Power UTS (Gwh)
948	11,687	98.0	3.8	154.2
948 B	14,025	96.6	11.1	154.0
949	16,362	94.0	20.8	153.9
950	18,700	91.7	33.0	153.0

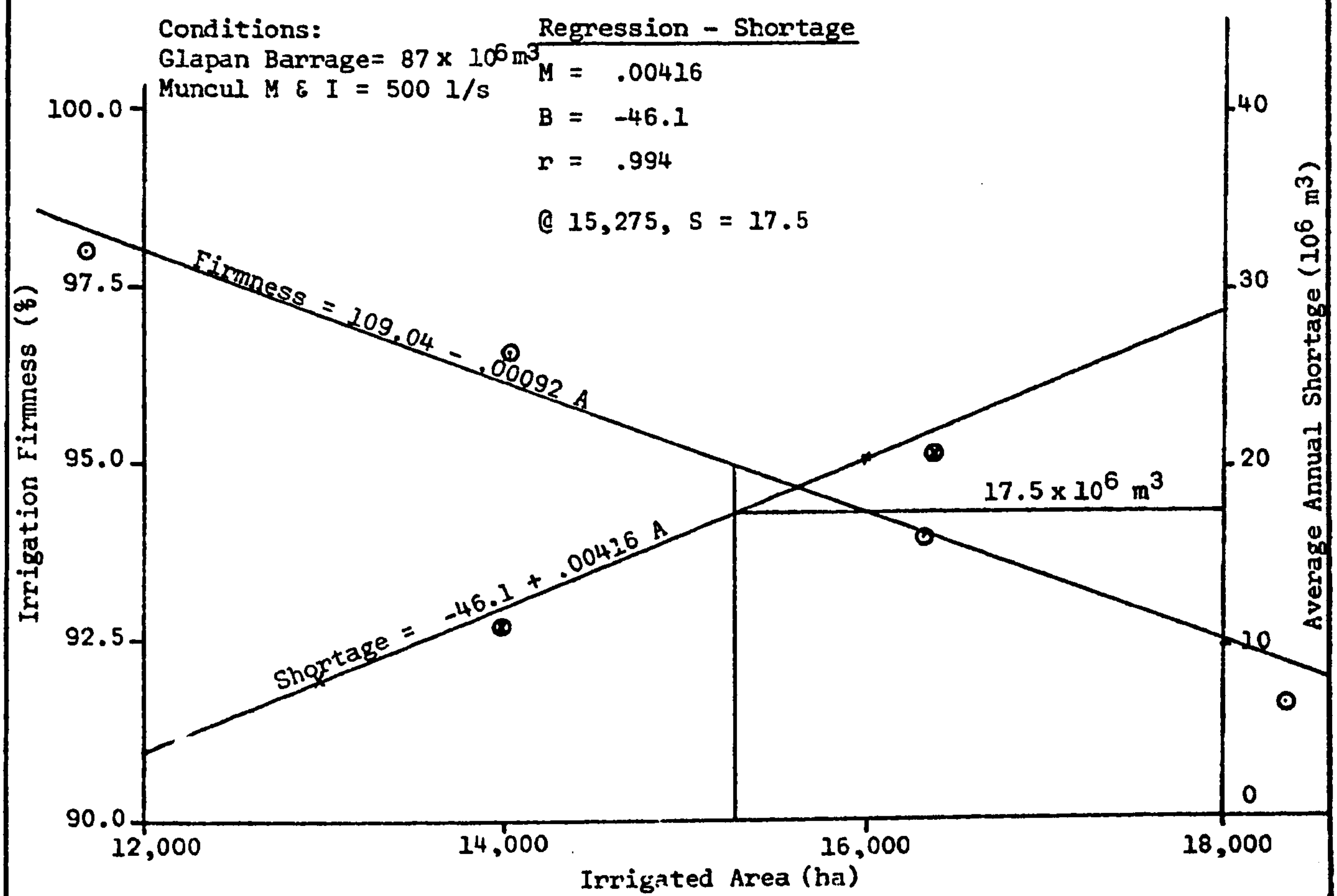
Regression - Firmness

M = -.00092

B = 109.04

r = .993

@ 95%, A = 15,274



TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95 % FIRMNESS

Live Storage = 87 x 10^6 m^3
Barrage gates are open from October 1 through March 31 each year
M & I = 1,000 l/s from Muncul Springs

Run	Area (ha)	Firmness (%)	Average Annual Shortage (10^6 m^3)	Power UTS (Gwh)
941	9,350	98.8	.8	147.9
940	11,687	96.8	5.0	148.3
942	14,025	95.6	13.3	148.0
943	16,362	93.3	23.4	148.2

Power UTS average: 148

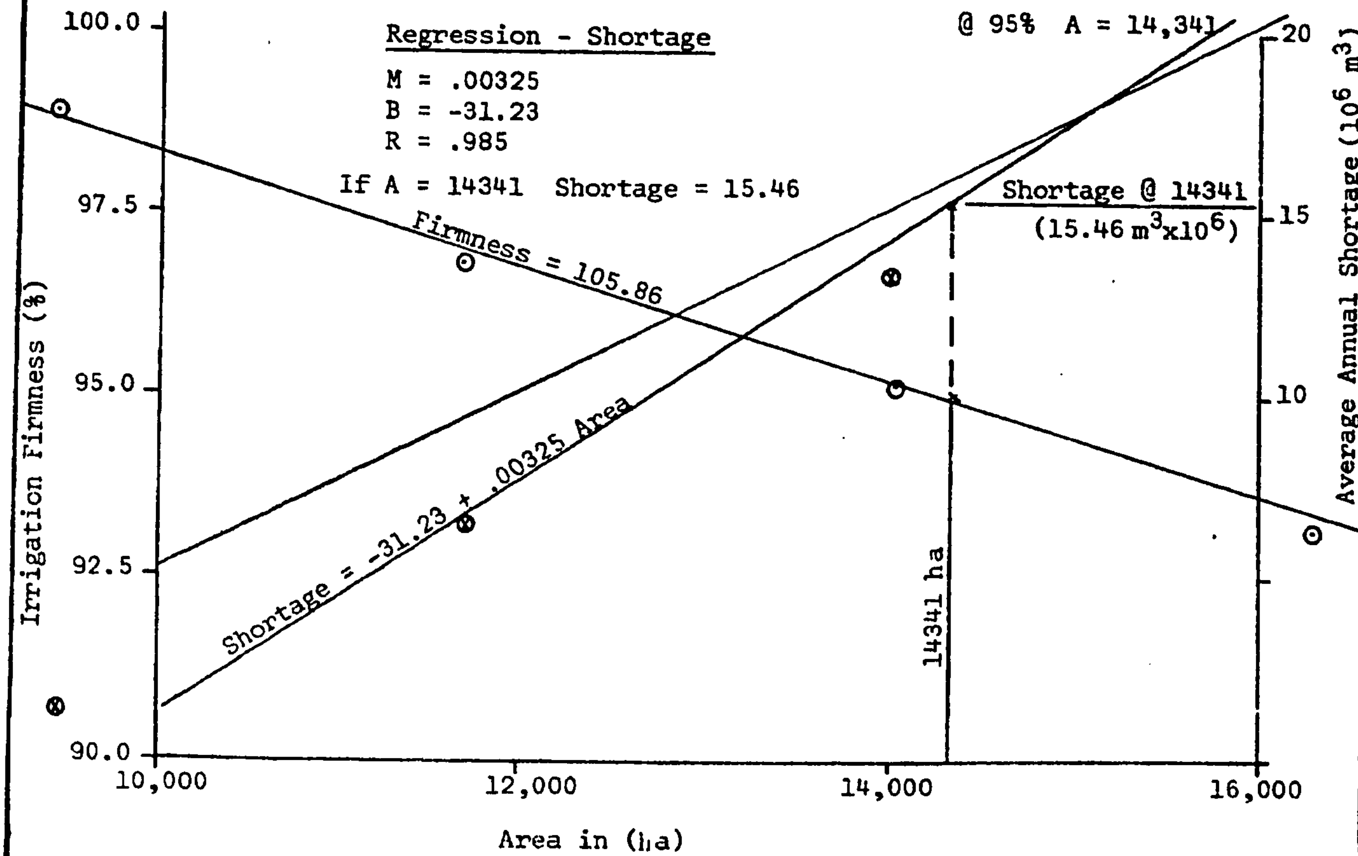
Regression - Firmness

M = -.000757

B = 105.86

r = .994

@ 95% A = 14,341



TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95% FIRMNESS

FIGURE D-

Live Storage = 87 x 10^6 m^3
Barrage gates are opened from October 1 through March 31 each year
M & I = 1,500 l/s from Muncul Springs.

Run	Area	Firmness	Average Annual Shortage	Power UTS
945	9,350	98.8	1.3	142.0
944	11,687	97.2	6.5	141.7
946	14.025	94.0	15.4	141.7
947	16,362	92.5	26.0	141.7

(Power UTS bracketed: 142)

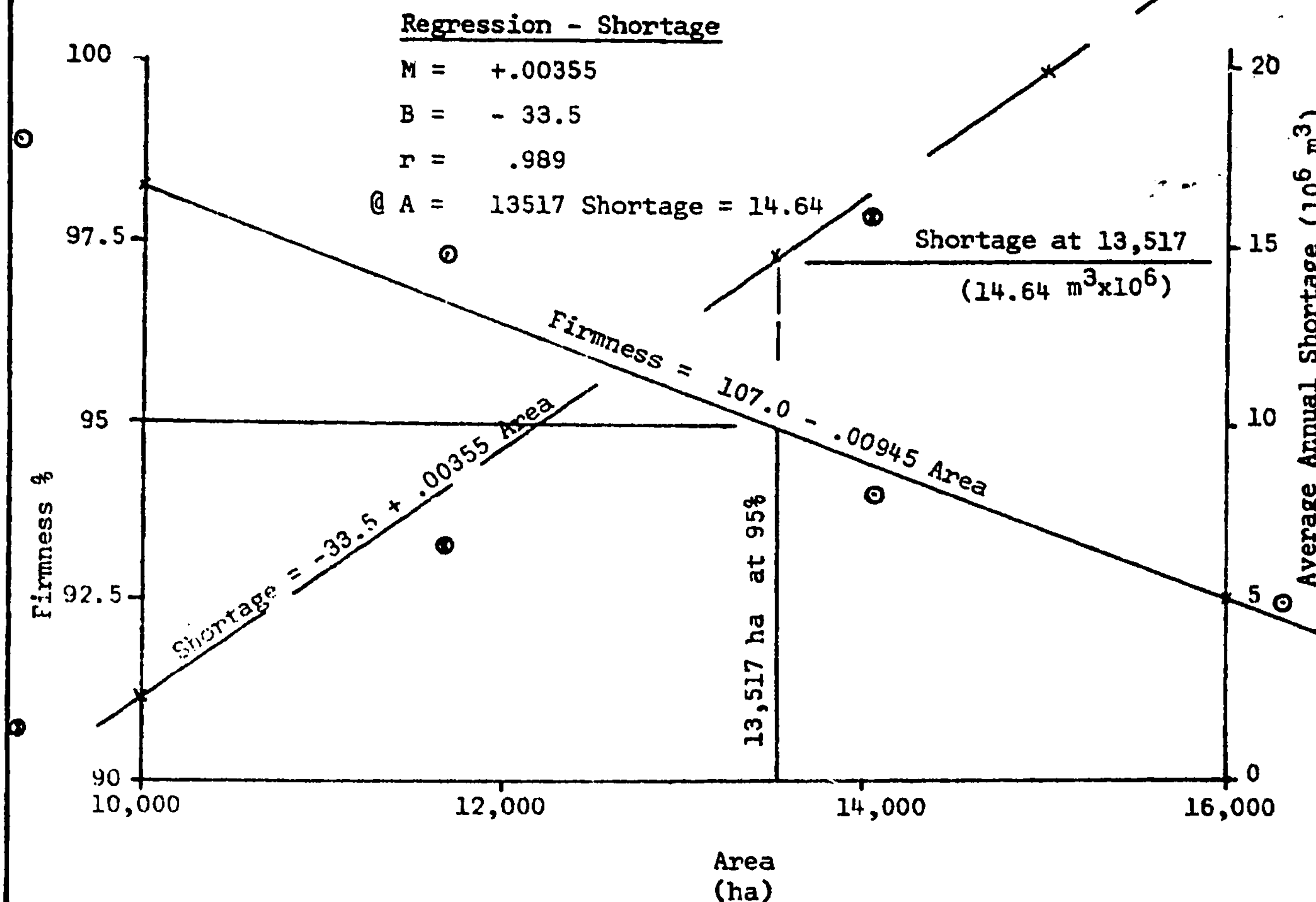
Regression - Firmness

M = -.000945

B = 107.0

r = .989

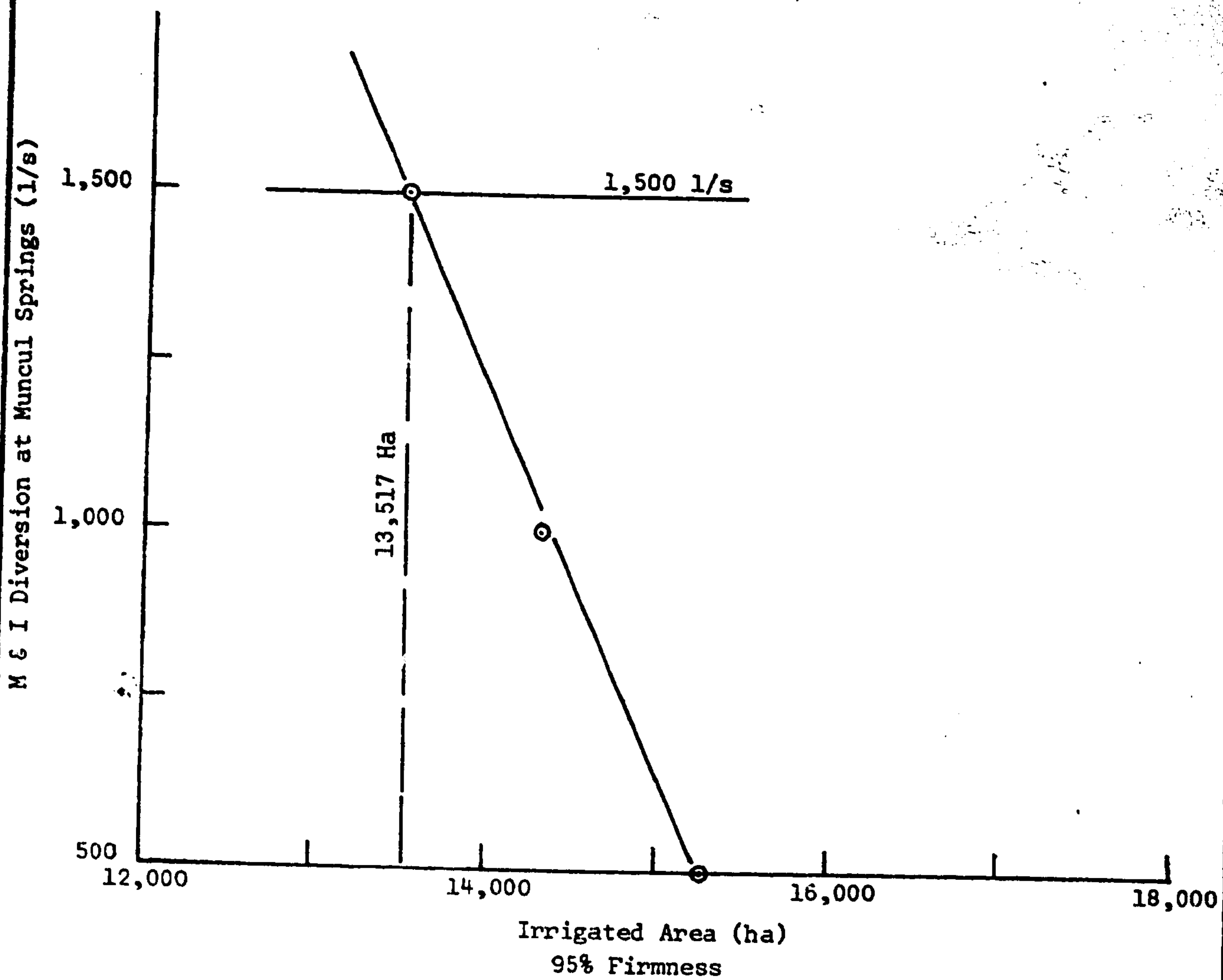
@ 95% A = 13,517



TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLAN

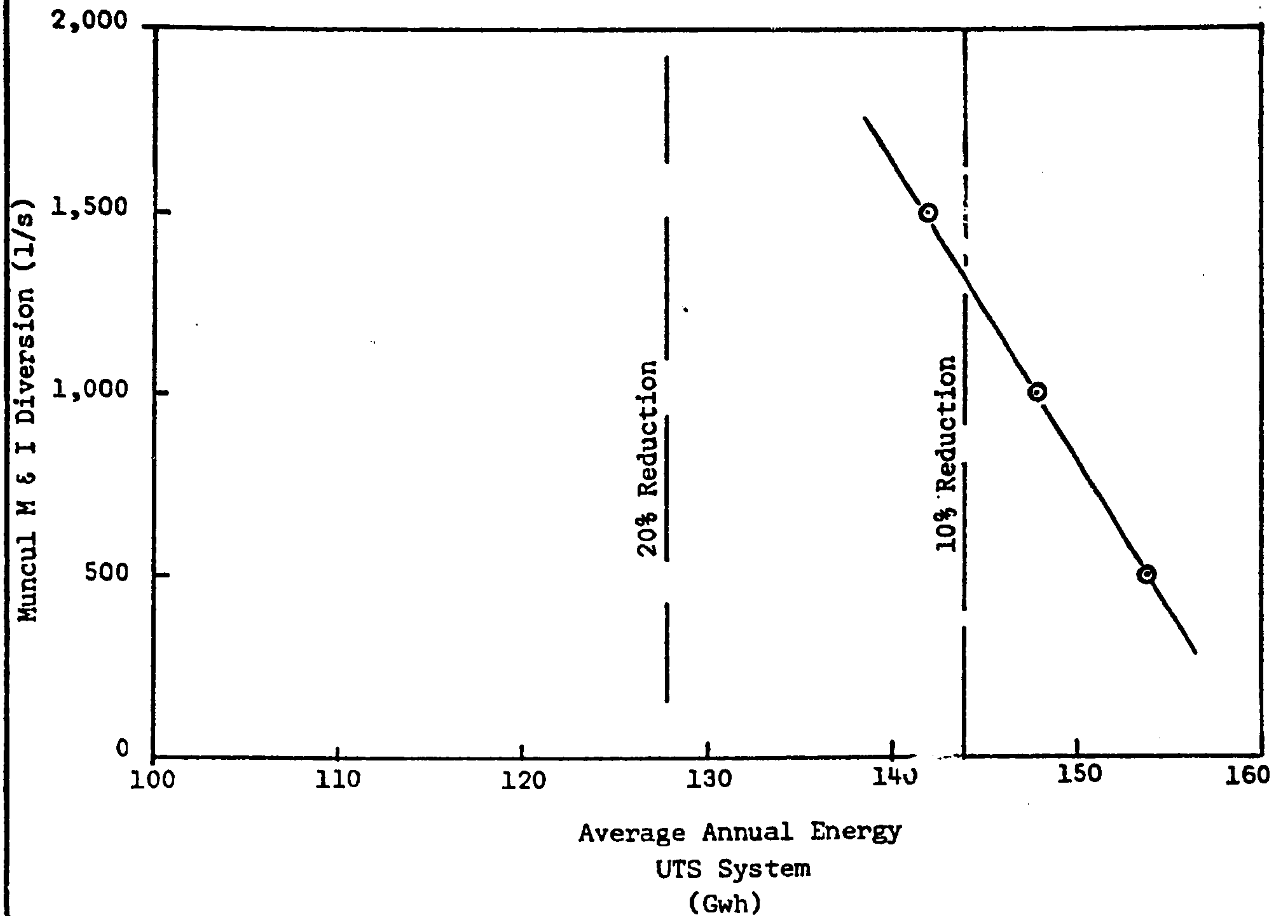
AREA ADJUSTMENT TO 95% FIRMNESS



TUNTANG / JRAGUNG RIVERS

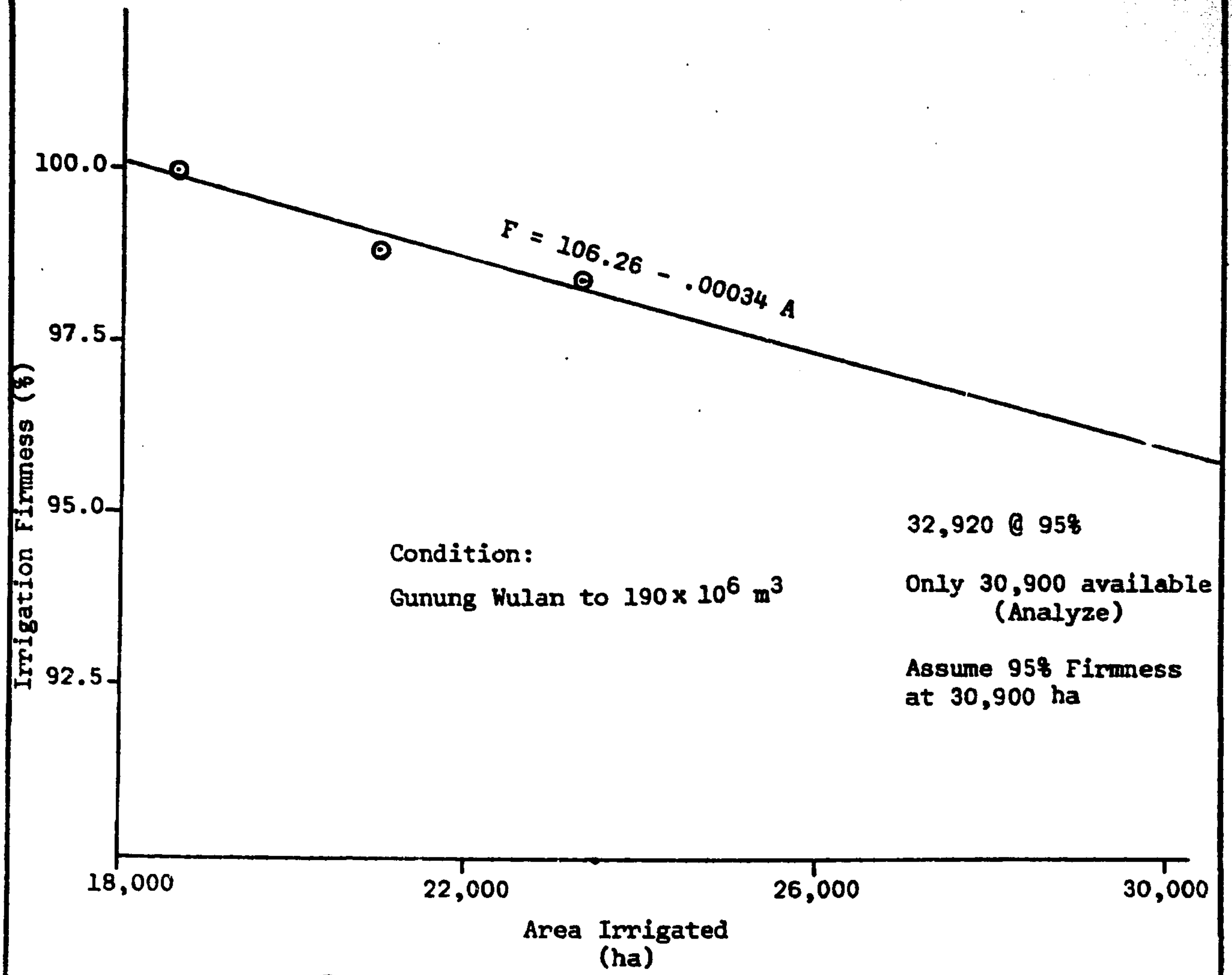
INTEGRATED DEVELOPMENT PLAN

IRRIGATED AREA VERSUS MUNCUL M & I DIVERSION WITH GLAPAN BARRAGE CONSTRUCTED



TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

POWER REDUCTION—PRESENT UPPER TUNTANG SYSTEM WITH GLAPAN BARRAGE CONSTRUCTED



Input	
Firmness	Area
100	18,700
98.4	23,375
98.8	21,037

Regression

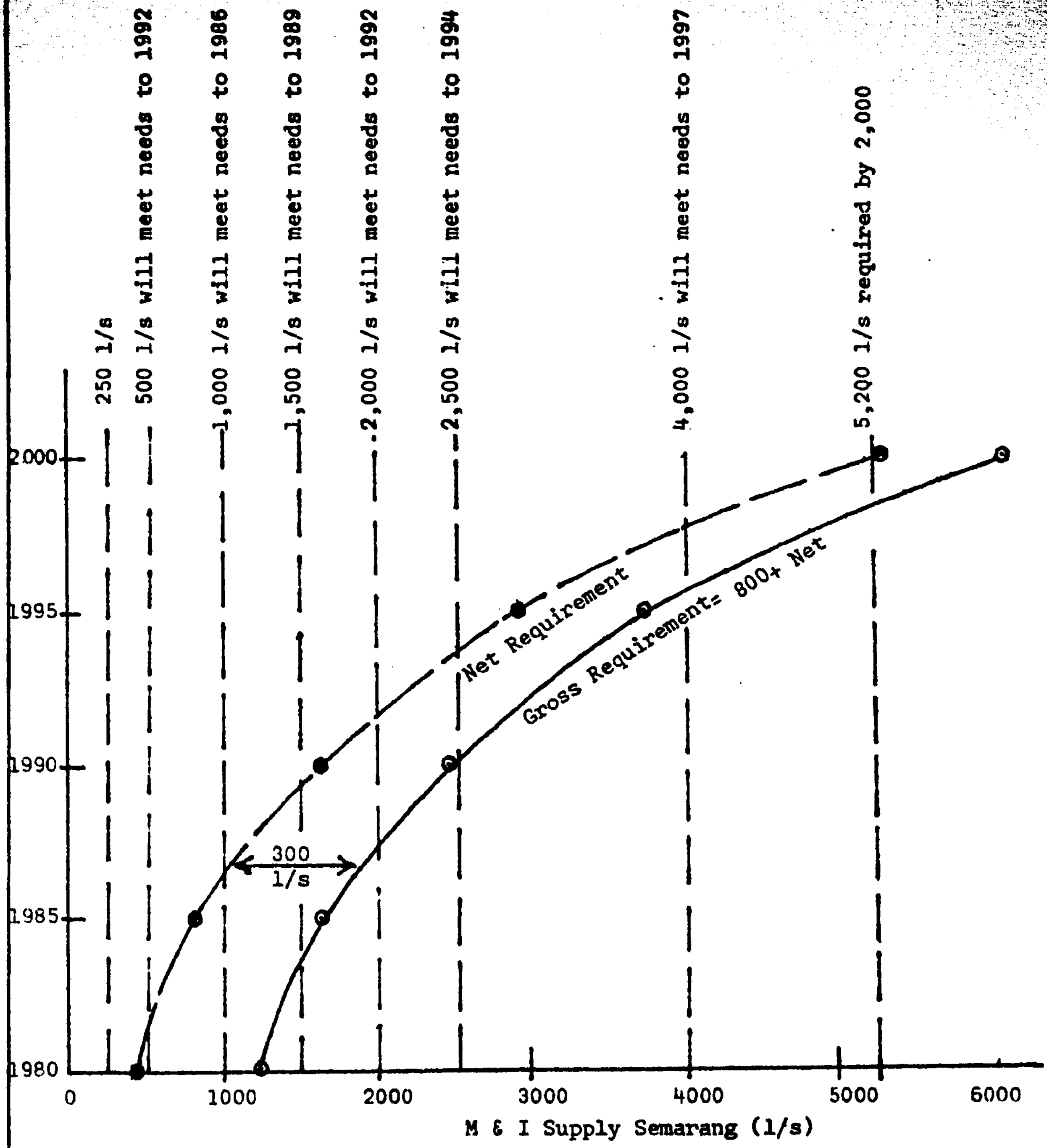
M = -.00034
B = 106.26

r = .961

@ 95%, Area = 32,920

TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

AREA ADJUSTMENT TO 95% FIRMNESS

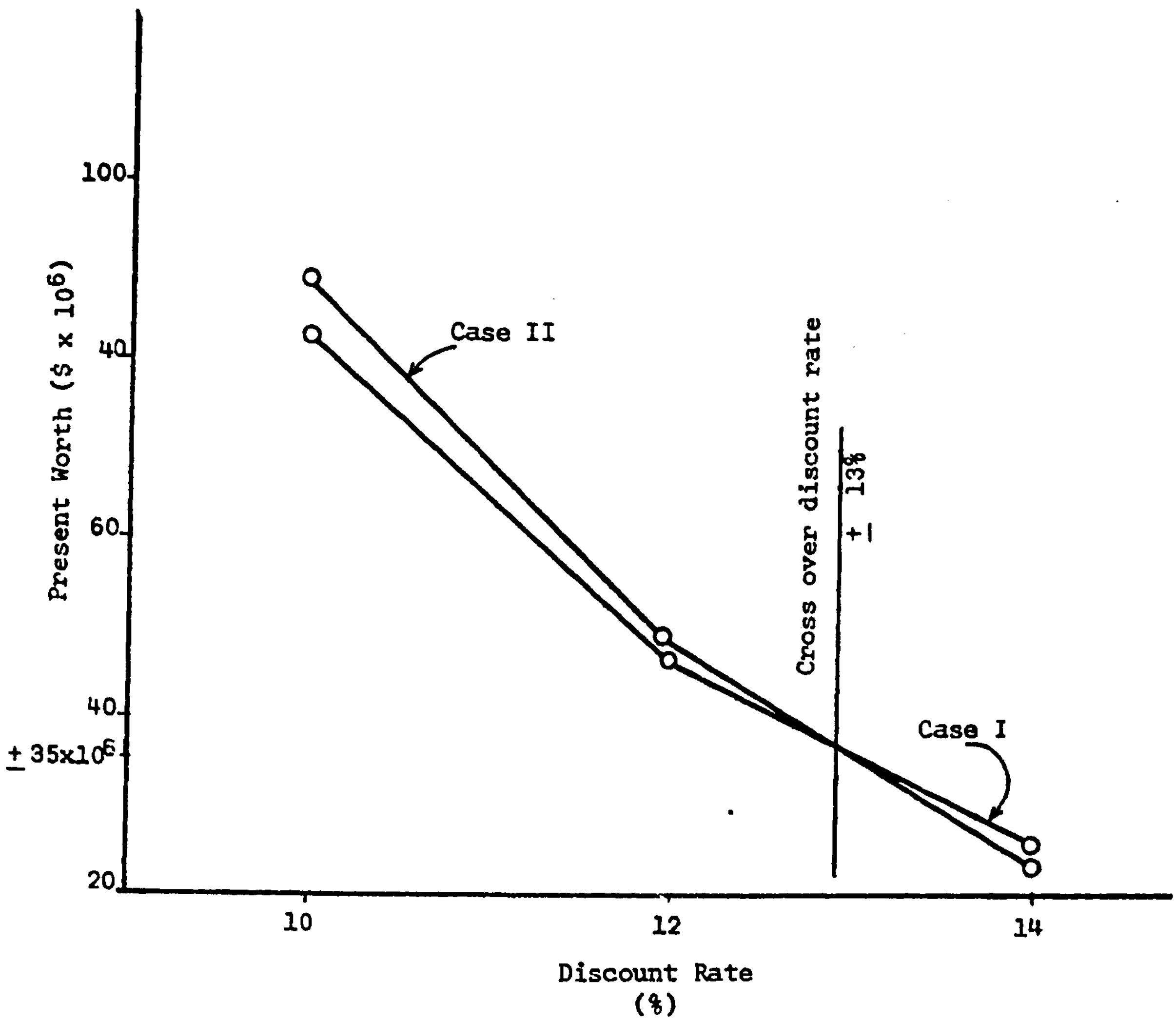


TUNTANG / JRAGUNG RIVERS

INTEGRATED DEVELOPMENT PLAN

PROJECTED CITY OF SEMARANG

WATER REQUIREMENT



TUNTANG / JRAGUNG RIVERS
INTEGRATED DEVELOPMENT PLAN

COMPARISON OF PRESENT WORTH OF DEVELOPMENT PLANS

PART II

TUNTANG AND RELATED RIVERS BASINS DEVELOPMENT PLAN

APPENDIX D

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PROJECT PLANNING

TUNTANG AND RELATED RIVERS BASINS

DEVELOPMENT PLAN

APPENDIX D - PART II

PROJECT PLANNING

D.1. INTRODUCTION

D.1.1. Scope of Study

Part II of this appendix describes the rationale behind and the methods used in the planning studies carried out in the Tuntang, Jragung, Dolok, Penggaron, Lusi, Juana Valley, and Serang Subbasins. These subbasins form what is called the "Jratunseluna Basin". As explained in Part I of this appendix the word Jratunseluna originates from the names of the five major rivers within the basin - JRAgung, TUNtang, SErang, LUsi and JuaNA.

Part I of this appendix deals entirely with planned integrated development of the Tuntang and Jragung Rivers. As a result of that development plan it was decided by the Directorate to extend the integrated planning effort to the whole of the Jratunseluna Basin. An earlier study of the total basin was completed in 1973 by NEDECO when they developed the "JRATUNSELUNA BASIN DEVELOPMENT PLAN" [1]. A number of single element developments were considered at that time and a number of these are included in this study. This plan updates previous planning efforts as it considers not only individual projects but the coordinated operation of these projects in conjunction with one another. As discussed in Part I, basin planning requires that each structure or project element proposed be technically and economically viable as an individual project, but even more important, that all planned elements eventually function together to obtain the optimum benefits from the water resources of the basin. Development of the water resources of the Jratunseluna Basin will of necessity require utilization of the basins' water resources for a number of purposes. Present and potential water uses within the basin include irrigation, municipal and industrial water for the city of Semarang and water for the generation of hydroelectric power.

This appendix deals specifically with plan formulation, that is, the procedure used to evaluate all pertinent information and to identify an economically and physically feasible array of elements so phased as to meet the growing water requirements of the basins population.

D.1.2. Basic Assumptions

Due to the limited time available for this study, it was possible only to prepare a conceptual plan for development which identifies the locations and probable sizes of storage reservoirs and diversions to derive optimum benefits by making a coordinated use of the water resources of all subbasins in the Jratunseluna Basin. The follow up to this study will consist of investigations to confirm the technical feasibility of the elements of the plan, and of detailed economic analyses. The basic assumptions made in the study are the following.

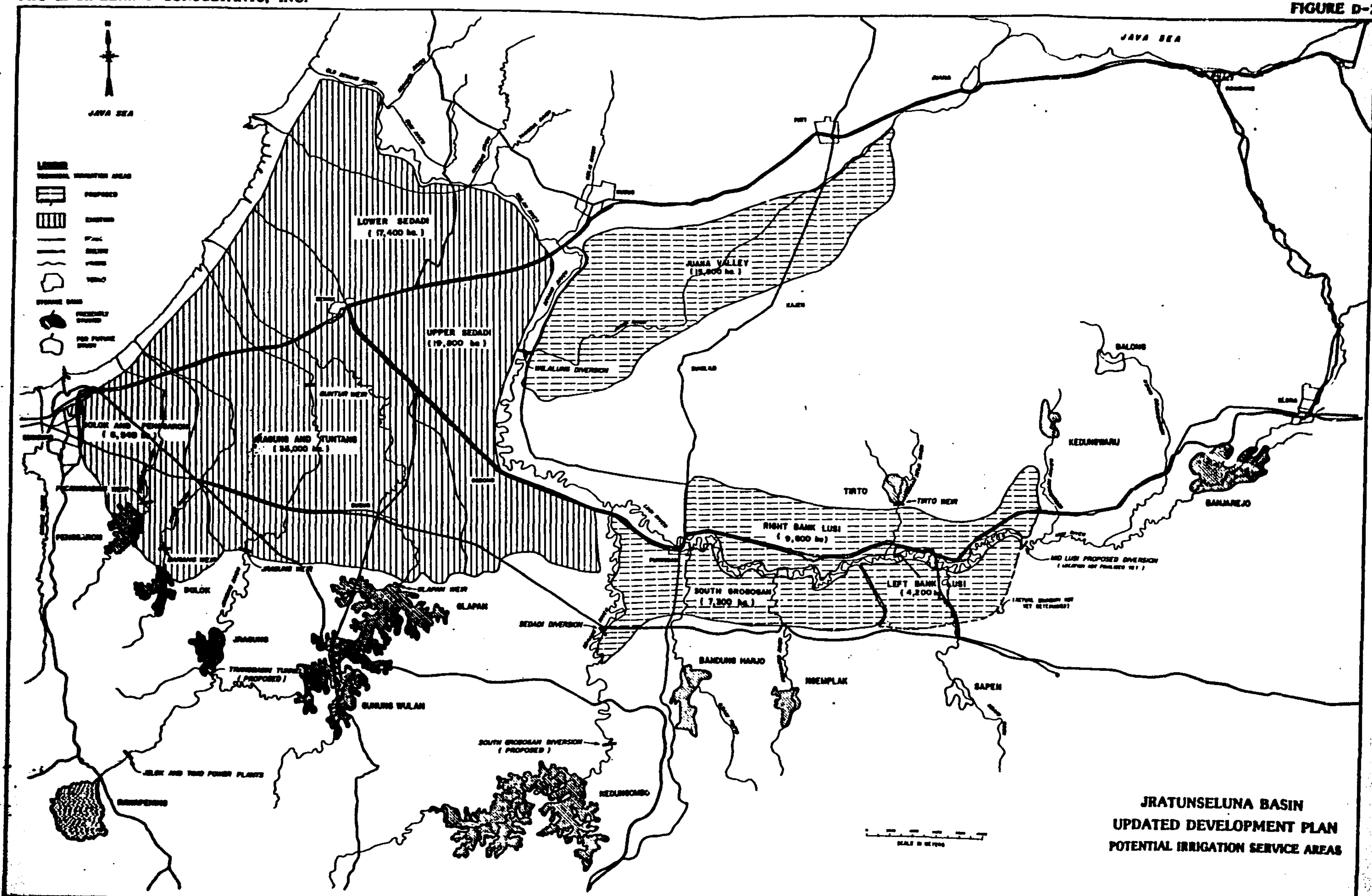
1. Emphasis should be laid on identifying small-size projects which can yield benefits in the near future and can also function as elements of an overall plan for the entire basin.

2. The development of irrigation and municipal and industrial water supply within the subbasins should begin in the near future, and irrigation and M & I water should be considered the primary benefits to be derived from any development plan.

3. Due to PLN's reported plans not to upgrade the existing Upper Tuntang System power generation or to add to the system, hydropower development in the basins should be given low priority. However, the existing hydropower generations should not be reduced significantly in the Upper Tuntang System by the implementation of future projects.

4. Hydropower potentials at all proposed damsites should be investigated.

5. No basic changes in the Serang River Plan as formulated by SMEC [3] will be made. However, irrigation of maximum area in the Juana Valley from all possible sources will be considered.



JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
POTENTIAL IRRIGATION SERVICE AREAS

D.2. BASIN DESCRIPTION

The Jratunseluna Basin, some 7,700 km^2 in size, is defined as the catchment area of five rivers in the northern part of Central Java. The five major rivers in the basin are the Jragung, Tuntang, Serang, Lusi and Juana. Two other small rivers within the basin but draining directly into the Java Sea are the Dolok and Penggaron Rivers. Besides this system of main rivers there are a number of tributary streams which contribute to the total water resources of the basin. All these main rivers, and the smaller streams originate from the slopes of the volcanoes Ungaran, Telomoyo, Merbabu and Muria and from the central mountain ranges. All water in the basin flows into the North Java Sea between Semarang and Rembang.

The main feature of the Jratunseluna Basin is its flat coastal plains. These plains are situated principally in the lower reaches of the Jragung, Tuntang and Serang Rivers. The Juana River runs to the east between the Muria slopes and the Kapur Utara Hills. Between these hills and the Kendeng Mountains which are a part of Java's central mountain range, is a wide flat valley through which the Lusi River flows from east to west to its confluence with the Serang.

The Serang River originates on the north slope of the volcano Merbabu and flows generally northeastward through hilly country toward the coastal plain. Below the confluence of the Lusi and Serang the river is called the Lower Serang and flows generally northward toward the Muria Volcano. At present the Lower Serang is divided into two watercourses at the Wilalung Structure. All river flows in excess of 350 m^3/s are diverted into the Juana Valley via the structure and drain ultimately into the Java Sea east of Muria. The main branch of the river, called the Wulan River below Wilalung continues in a northernly direction and discharges directly into the Java Sea.

The Tuntang and Jragung Rivers are described in Part I of this appendix.

The Penggaron and Dolok Rivers drain the northern slopes of the volcano Ungaran and flow generally northward to the Java Sea. A basin location map appears as Figure II-1.

D.2.1. Rainfall

Mean annual rainfall in the greatest part of the basin is between 2,000 and 2,500 mm. The northwestern slopes of the Ungaran, Telomoyo and the Merbabu Volcanoes and the southern slopes of Muria Volcano receive the greatest amount of rainfall.

The Lusi catchment receives the smallest amount of rain; the Kapur Utara Hills receive far less rainfall than the Kendeng Hills on the south side of the Lusi. The eastern portion of the Lusi catchment is by far the driest area in the basin with an average annual rainfall of only 1,800 mm.

D.2.2. Water Use in the Basin

D.2.2.a. Present Use - Irrigation

Irrigation water use in the Tuntang and Jragung Subbasins is discussed in Part I of this appendix.

For more than a century, waters from the Serang and Lusi Rivers have served as the principal source of irrigation water for the coastal plains east of the city of Semarang. A relatively sophisticated irrigation system has been constructed to serve the Upper and Lower Sedadi service areas and a part of the Juana Valley. No storage is provided so the system operates on a run-of-river basis with diversion at the existing Sedadi diversion and the Wilalung structures. This run-of-river system can provide only very limited irrigation water in the dry season, due to low flows in both the Serang and Lusi. SMEC [2] has estimated that of the total 37,200 ha of potentially irrigable land in the Upper and Lower Sedadi areas about 25,000 ha receive wet season irrigation water and about 4,500 ha receive a perennial supply.

In the past, an area of about 3,700 ha in the Juana Valley was supplied with perennial irrigation water from the Wilalung structure. As a result of ineffective maintenance and siltation only some 800 ha are presently served in the wet season and 400 ha in the dry season.

There are areas in other parts of the Juana Valley which are irrigated under smaller non-technical and semi-technical schemes. Between Prawoto and Sukolilo, water from springs in the Kapur Utara Hills is used for village type irrigation of about 300 hectares. Towards Pati there is a substantial area, 1,230 hectares mainly of semi-technical irrigation with water diverted from streams draining the Kapur Utara Hills [2].

At present the designated service areas at South Grobogan, Lusi Left and Lusi Right receive no irrigation supply. Wet season irrigation water is provided on the Dolok and Penggaron Systems.

D.2.2.b. Present Use - Municipal and Industrial Water

The city of Semarang presently uses 805 l/s to meet a part of its requirements, out of which 303 l/s is drived from springs, 17 l/s from wells and 485 l/s from the Kali Garang. Details are given in Special Report No. I, Tuntang/Jragung River Basins, Municipal and Industrial Water Supply [4].

D.2.2.c. Present Use - Hydropower

Two hydro plants are currently operated on the upper reaches of the Tuntang River below Rawa Pening. Combined installed capacity of the Jelok and Timo Power Plants is 32.5 MW, however, their maximum generating capacity is limited to about 26.0 MW. Current operation produces approximately 50 GWh of firm energy and 110 GWh of secondary energy annually. Details are presented in Part I of Appendix C.

D.3. NEED FOR WATER RESOURCES DEVELOPMENT

D.3.1. Irrigation

There are 35,000 hectares of irrigable land in the basin below the existing Glapan and Jragung Weirs. Accurate estimates of the number of hectares of land receiving a full (year-round) water supply are difficult to derive. Present cropping patterns presented in Appendix B - Part I, indicate that some 6,000 to 7,000 hectares could be considered to have firm water supplies for two to three rice crops per year. Optimum water resources development in the basin would be achieved when the entire 35,000 hectares are provided a full water supply.

SMEC has determined that the potential irrigable area in the Upper and Lower Serang systems is 37,200 hectares and that out of this area 4,500 hectares receive perennial irrigation water and 25,000 hectares wet season irrigation supplies at present [2]. Optimum water resources development in the basin would required that the full 37,200 hectares (19,800 hectares in the Upper Sedadi and 17,400 hectares in the lower Sedadi areas) receive perennial irrigation water supply at a firmness required for successful production of three rice crops per year on at least 75 percent of the area.

4,200 hectares of potentially irrigable land have been identified on the left bank of the Lusi River. This land is in addition to that which lies within the area previously identified as the South Grobogan service area [5]. Likewise 9,600 hectares of potentially irrigable land have been identified on the right bank of the Lusi River. Additional land suitable for irrigation may be located in the Upper Lusi Valley. It is not known at this time whether sites with sufficient storage capacity can be found in this part of the basin for an economic irrigation development of additional areas.

Optimum development, would also require firm perennial supplies for the existing Dolok (1,950 hectares) and Penggaron (4,950 hectares) service areas which now receive only wet season supplies.

All existing and proposed service areas are located on the basin map presented as Figure II-1. All potential technical irrigation developments in the Jratunseluna Basin (excepting small projects less than 1,000 hectares each) are summarized in Table D-1. This table shows that at best only 10,900 hectares in the basin receive perennial water supply presently, however an additional 58,200 hectares receive wet season irrigation. There are 46,100 hectares of potentially irrigable land which are identified; additional areas suitable for irrigation may be found in the future. Should sufficient storage be available at proper points within the basin and if the basin water resources are properly managed, potentially 114,840 hectares of land could be developed for perennial irrigation. This may not be accomplished in reality because of a number of constraints but this number does set a goal for maximum irrigation development in the Jratunseluna Basin.

D.3.2. Municipal and Industrial Water

One of the most serious water problems in the basin at present is the short supply of municipal and industrial water for the city of Semarang. Projections developed in Special Report No. I - Tuntang/Jragung River Basins, Muncipal and Industrial Water Supply [3] indicate a total need of 6,010 l/s by the year 2000 while the present supply is only 805 l/s. A portion of this municipal and industrial water demand should be developed within the basin. In part I of this study it was found that municipal and industrial water could be supplied through various project elements in quantities ranging from 2,000 to 4,000 l/s at or near optimum irrigation development.

Because of their proximity to the city of Semarang and their identification by previous investigators as potential sources of M & I supply for the city this extended study evaluates in detail the feasibility of supplying water from both the Dolok and Penggaron Reservoirs [6]. This is especially important because it was established in Part I of this study that a supply of 4,000 l/s that is 2,000 from Muncul Springs above Rawa Pening and 2,000 from the Jragung River, would require either:

a. A small reduction in the Jragung irrigation service area, or

b. Construction of a storage dam at Jragung.

TABLE D-1

FULL LARGE SCALE TECHNICAL PERENNIAL IRRIGATION DEVELOPMENT POTENTIAL IN THE JRATUNSELUNA BASIN

Service Area	Wet Season Area to Perennial (ha)	Existing Perennial Area (ha)	Unirrigated Area To Receive Perennial (ha)	Total Development Perennial Area (ha)
Dolok	1,950	-	-	1,950
Penggaron	4,590	-	-	4,590
Jragung	11,625	-	-	11,625
Tuntang	17,375	6,000	-	23,375
Lusi Left	-	-	4,200	4,200*
Lusi Right	-	-	9,600	9,600*
Upper Sedadi	15,300	4,500**	-	19,800
Lower Sedadi	6,200	-	11,200	17,400
South Grobogan	-	-	7,300	7,300
Juana Valley	800	400	13,800	15,000
Basin Totals	57,840	10,900	46,100	114,840

* Both Lusi Left and Lusi Right proposed irrigation service area will get water from the common source, namely, Mid Lusi Diversion. The boundaries of the service areas and their sizes may be adjusted based upon the location of the diversion structure and the full supply levels at the canal offtakes.

** Semi perennial.

D.4. PREVIOUSLY IDENTIFIED POTENTIAL FOR DEVELOPMENT

A number of past studies and Part I of this study served as the initial source of the list of potential projects which are discussed fully in Part II of Appendix C. In addition a complete and relatively complex plan for development of the water resources of the Serang River has recently been completed by the Snowy Mountains Engineering Corporation [2, 5, 7].

The main feature of the Serang Plan is the Kedungombo Dam, a central earth core, rockfill and random fill embankment, which affords 749 million cubic meters gross storage or 655 million cubic meters live storage on the Serang River at a point where the upstream catchment totals 612 km^2. A hydroelectric plant rated at 20 MW is incorporated in the dams' outlet works. The project as planned provides perennial irrigation water to 37,200 hectares in the Upper Sedadi and Lower Sedadi with river diversions at Sedadi and Wilalung, to 7,300 hectares of "new" land on the right bank of the Serang designated as the South Grobogan service area (see Figure II-1) and to ± 10,000 hectares of "new" land located in the Juana Valley. This plan, as agreed with the DGWRD was considered basically firm and only the following changes were considered in any simulation performed during this study:

1. Operational patterns at the reservoir were changed in that releases were based only on downstream irrigation demand precluding the possibility of firm power generation at the power plant.

2. Based on the consultants' studies and observations throughout the Jratunseluna Basin it has become apparent that wherever perennial irrigation water is supplied the majority of local farmers will try to produce three crops of rice per year. Thus the recommended cropping pattern derived in Part I of Appendix B was imposed on all lands proposed to be served by the Kedungombo Dam. Special studies outlined in Part I of this Appendix show that, total demands for 3 crops are not much greater than for a two-plus-one cropping pattern because of flexibility of starting dates, phasing and sequencing.

3. The eastern most 1,680 hectares in the South Grobogan service area were to be served from the South Grobogan Weir with a subsequent lift station at Boloh. The capacity of the pumping station is 2.3 m^3/s and the anticipated lift is 6.5 m. Alternate sources of gravity supply for this area are considered in this study for updating the Jratunseluna Basin Master Plan.

D.5. BASIN MODEL

D.5.1. General

The development of the water resources of the Jratunseluna Basin constitutes a highly complex system. Total development of the water resources can be accomplished with different combinations of system elements (reservoirs, diversions, power plants, canals, etc.). A computer model of the Jratunseluna Basin was developed to simulate multi-reservoir operation and inter-subbasin transfers of water as required.

As in the case of preparing the Tuntang/Jragung Rivers Basins Integrated Development Plan, described in Part I of this appendix, a basin model was essential to enable consideration of as many development schemes as possible in the time available for studying the entire Jratunseluna Basin. By utilizing the basin model it was possible to consider a large number of different project elements, a large number of different combinations of elements, and varying demands on the water resources of the basin.

The JRATUNSELUNA BASIN MODEL (JRAT) developed by PRC/ECI during this study, considers storage at eleven sites, diversion of river flows at four sites, upstream transbasin diversion from the Tuntang to Jragung and four different "service area to service area" diversion possibilities. In addition, the model allows the generation of hydroelectric power at two existing and three proposed hydroelectric plants. Municipal and industrial water for the city of Semarang can be supplied from any or all of six different points within the basin.

Nine potential irrigation service areas within the basin are an integral part of "JRAT". All studies of the basin model were performed on the IBM 370 computer system at the DPU computer complex in Jakarta. A general schematic diagram showing basin features and options included in the model is presented on Figure D-1.

D.5.2. Model Features

As with the earlier Tuntang/Jragung model, "JRAT" utilizes monthly inputs of streamflow and irrigation water requirements as well as municipal and industrial demand, and computes monthly volumes of reservoir inflows, reservoir evaporation, irrigation releases, and spill or shortage volumes at the reservoirs and diversion points. Ending reservoir storage and elevation are computed for each month as are firm and secondary energy for each site.

Twenty-one years of record were used in simulating operation of single elements as well as total development schemes which included varying numbers of individual projects. All model features are shown on the schematic diagram (Figure D-1).

D.5.3. Storage

The eleven sites within the Jratunseluna Basin where the model allows storage of water are as follows:

No.	Site	Maximum Live Storage (10^6 m^3)
1	Banjarejo	77
2	Kedungwaru	19
3	Bandungharjo	22
4	Kedungombo	655
5	Penggaron	57
6	Dolok	43
7	Rawa Pening	175
8	Jragung	100
9	Gunung Wulan	260
10	Glapan	87
11	Ngemplak	68

In the model, the capacity for storage at any site may be adjusted from zero (run-of-river condition) to the maximum feasible storage at the site. Releases from all storage points are governed strictly by irrigation and municipal and industrial water demands. Generation of hydroelectric power at any site is considered secondary and does not, in any case, dictate reservoir release patterns.

Sediment passing, as discussed in Part I of Appendices A and C is simulated at five of the eleven sites. At Banjarejo, Kedungwaru, Penggaron and Jragung Reservoirs, sediment is passed through during the months of December, January and February. At the Glapan Barrage the model is operated for run-of-river supply into the irrigation canals from October 1 to March 31 each year.

D.5.4. Reservoir Releases and Supply Shortages

As stated, releases from all reservoir sites are governed strictly by downstream irrigation demands, and, if applicable, the M & I demands.

At seven of the eleven storage sites the only demand recognized is for irrigation. If reservoir storage plus monthly inflow volume meet or exceed that demand then the controlled release is equal to that demand. If reservoir storage plus monthly inflow volume is not equal to the irrigation demand all water is released from the reservoir and a shortage is recorded.

Irrigation shortages as considered by the model occur when that months' irrigation demand cannot be met from the combination of inflow and storage at a given site. These monthly shortages in million cubic meters are totaled for each year; the annual totals are computed and the total annual shortage for the twenty one year simulation period is determined. If the shortage volume in any given month is greater than 5 percent of the irrigation demand volume, a month of shortage is counted. The total number of months during which shortages are counted is divided by 252 (number of months in the simulation period), the quotient represents the percent of time during which shortages occur. To compute irrigation firmness the percent of shortage is then subtracted from 100 percent.

For all eleven reservoir sites, monthly evaporation is estimated based on the water surface area and average free water surface evaporation as described in Appendix A, and is subtracted from reservoir storage and inflow to give true available water supply.

At Rawa Pening, Jragung, Penggaron and Dolok the primary demand remains the irrigation demand, but in addition these reservoirs are also called upon to supply municipal and industrial water at varying rates of up to 2,000 l/s in some alternatives. Actual outflows are handled by the model as for the other reservoirs. Using the stage storage relationship which is included in the model for each storage site the ending elevation of the reservoir water surface is computed for each month.

D.5.5. Municipal and Industrial Water

Provision is made in the model to allow delivery of municipal and industrial water in any amount from the following points:

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

In addition to municipal and industrial water for the city of Semarang the model also includes provision for river maintenance flows even when irrigation demands are zero. This assures that the population currently using river water would have continued use thereof in the event that storage is constructed on any of the rivers.

D.5.6. Irrigation Diversion Sites

Because of their proximity to the proposed storage sites, irrigation diversion is assumed to occur directly from the Bandungharjo, Glapan, Jragung, Dolok and Penggaron damsites. In addition, the model simulates irrigation diversion from proposed diversion on the middle Lusi, and at South Grobogan as well as at the existing Sedadi Weir and Wilalung structure.

D.5.7. Irrigation Service Areas

In development of the model all of the potential irrigation service area in the Jratunseluna Basin was assumed to be divided into 10 individual service area units. The size of each individual service unit may be increased, decreased or set to zero in any particular simulation run. The service areas and their normal sizes are as follows.

	Service Area	Area (ha)	
1.	Tuntang	23,375	
2.	Jragung	11,625	
3.	Dolok	1,950	
4.	Penggaron	4,590	
5.	Lusi Left Bank	4,200	
6.	Lusi Right Bank	9,600	
7.	South Grobogan	7,300	
8.	Upper Sedadi	19,800	
9.	Lower Sedadi	17,400	
10.	Juana Valley	15,000	(Maximum Possible)
	TOTAL:	114,860	

D.5.8. Service Areas and Water Sources

Although the model makes allowance for both transbasin and inter-service area diversions, the principal sources of water supply for each of the service areas are summarized below.

	Service Area	Source of Water Supply
1.	Tuntang	Rawa Pening, Gunung Wulan and Glapan
2.	Jragung	Jragung & Rawa Pening
3.	Dolok	Dolok
4.	Penggaron	Penggaron
5.	Lusi Left Bank	Banjarejo, Kedungwaru, Mid Lusi Diversion and Ngemplak
6.	Lusi Right Bank	Banjarejo, Kedungwaru and Mid Lusi Diversion
7.	South Grobogan	Kedungombo, South Grobogan Weir, Bandungharjo and Ngemplak
8.	Upper Sedadi	Kedungombo and the Sedadi Weir
9.	Lower Sedadi	Kedungombo and the Wilalung Structure
10.	Juana Valley	Kedungombo and the Wilalung Structure

D.5.9. Diversions and Diversion Rules

The transbasin diversion from the Tuntang River to the Jragung River is incorporated in the model. Two operational rules govern the diversion of water. With exception of the months of March, April and May, water is diverted to Jragung only if shortages exist within the Jragung service area. If storage is provided at Jragung, sediment would be bypassed during the months of December, January and February, and building up of storage in March, April and May is governed by the storage capacity remaining in the reservoir.

In cases where the flow available at the diversion site is of a magnitude less than the total irrigation demands at Jragung and Tuntang the available flow is distributed in direct proportion to the two demands.

shortages at Penggaron can be reduced by inter-service area diversion from Dolok and/or Jragung. The model calls for Dolok spills available for diversion to Penggaron and if shortage at Penggaron still exists then diversion from Rawa Pening via Jragung is called for. The water yield and the storage capacity at Dolok are enough to meet the irrigation requirements of the designated Dolok service area and no interbasin diversions are needed. However, if it is found feasible to divert M & I water from Dolok to low-lying eastern areas of Semarang, then some of the Dolok area which can be served from the Jragung diversion will be added to the Jragung service area. In that case Dolok will supply irrigation water to only that part of its area which cannot be served from any other source.

Shortages at Jragung can be overcome by diversion from the Tuntang in the model. If a shortage exists at Jragung and there is no shortage at Glapan, then the Glapan spill plus twenty percent of the ending storage at Gunung Wulan and Glapan are made available for diversion. Only the volume required to overcome the shortage is diverted.

The most significant inter-service area diversion considered by the model is the Serang-Tuntang/Jragung Diversion. The amount of Serang water available for diversion to the Tuntang/Jragung is based on spill volumes at both Wilalung and Sedadi. If the spill at Wilalung is greater than that at Sedadi the total Sedadi spill is considered available. If the Wilalung spill is less than that at Sedadi only the volume of the Wilalung spill is considered available. Only 60 percent of the spill during wet season months is considered divertable.

D.5.10. Hydropower Features

The model includes generation of hydroelectric power at five points. The existing Jelok and Timo plants on the Upper Tuntang are model elements. The availability of water for power generation at Jelok and Timo is limited to the irrigation releases from Rawa Pening plus spill, up to the present peaking capacity of 26 MW. The remaining excess water which cannot be released through the power plant is discharged to the Tuntang at the weir.

When storage is provided at Gunung Wulan, Jragung and Kedungombo, power plants of 10 MW, 6 MW and 20 MW respectively are introduced in the model. At each site the model uses the controlled releases and excess flows up to the capacity of the plant to compute hydropower generation. In the case of all five plants the energy in gegawatt hours (GWh) which can be generated each month is determined. The model also generates a record of the minimum power production and determines the firm power produced at each plant during the twenty-one year simulation period.

D.5.11. Model Inputs

Model input data include net monthly inflows at each control point for each month in the 21-year period and the irrigation demands for each of the 10 previously defined service areas.

In the case of sites where no storage or control point exists upstream of that site, the inflow values are the river discharge at that point. For sites which have control points and/or storage upstream, the inflow input is the inflow or runoff generated on the incremental catchment between the site and the upstream site. Spills and/or releases from the higher site are added to the incremental inflow in model operation.

Discharge from Rawa Pening, Jragung yield, and incremental yields at Gunung Wulan, Glapan and the transbasin diversion are presented in Part I of this appendix.

At the seven new storage sites and four new diversion sites introduced in "JRAT", yields were derived as follows:

1. At Banjarejo, Kedungwaru, Bandungharjo, Kedungombo, Dolok and Penggaron sites, yield is equal to river discharge at the site. These data are presented in Tables D-2 through D-7, respectively.

2. The Ngemplak site was introduced into the model at a late date and the yield at this site is computed internally by the model based on drainage area proportion with the Bandungharjo site on an adjacent catchment.

3. At the Mid Lusi Diversion, yield was derived by establishing monthly yield at the diversion site and subtracting the monthly yield at Kedungwaru and Banjarejo. These data are summarized in Table D-8.

4. At the South Grobogan Weir, yield was established from the total monthly yield at South Grobogan and subtracting the monthly yield at Kedungombo. These data are summarized in Table D-9.

5. At the Sedadi Weir, yield was obtained by establishing the total monthly yield of the Serang at Sedadi and subtracting the monthly yield at Kedungombo and the monthly yield at Sedadi. These data are summarized in Table D-10.

6. At the Wilalung Structure, yield was established by computing the total monthly yield of the Lower Serang at Wilalung and subtracting the total monthly yields at the Mid Lusi Diversion, Bandungharjo, and the Sedadi Weir. When Ngemplak appears on the model, its inflow is established from the total monthly yield of the Lower Serang as a part of model operation. These data, without Ngemplak inflows subtracted therefrom, appear in Table D-11.

The cropping patterns projected for all irrigated land in the basin were developed in Part I of Appendix B.

This cropping pattern assumes that 75 percent of the total irrigated land will be used to produce three crops of rice per year. Diversion demands expressed as monthly volumes were computed using additional computer programs which used as input the computed average monthly evapotranspiration and service area monthly rainfall for the period of record. Methodology utilized in generating service area monthly rainfall is described in Appendix A - Part II. Crop water requirements were reduced by effective rainfall (RE) which was estimated from monthly rainfall (RF) data using the relationship:

$$RE = 1.8\ (RF)^{.8}$$

Tuntang/Jragung demands and return flow considerations are fully explained in Part I of this appendix.

Overall efficiencies of 60 percent are assumed on all new service areas introduced. Fifty percent of the water lost in application, that is 20 percent of the total diverted, can be utilized as return flows in certain instances where physical conditions permit. The model accounts for Left Lusi, Right Lusi and South Grobogan return flows by allowing rediversion of return flows at Wilalung structure. Upper Sedadi return flow is utilized on the Lower Sedadi area.

Return flows from Dolok, Penggaron, Lower Sedadi and Juana Valley service areas are considered nonreclaimable.

Irrigation demands expressed as monthly volumes, resulting from imposition of the recommended cropping pattern on the new service areas, Lusi Left, Lusi Right, South Grobogan, Dolok, Penggaron, Upper Sedadi, Lower Sedadi, and Juana Valley are shown in Table D-12 through D-19, respectively. Irrigation demands expressed as monthly volumes, resulting from imposition of the two-plus-one cropping pattern on the same new service areas are shown in Tables D-20 through D-27, respectively. Similar data for the Tuntang/Jragung service areas are presented in Part I of this appendix.

TABLE D-2

MONTHLY YIELD - LUSI RIVER AT BANJAREJO DAMSITE

(units in $10^6 \times m^3$)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	-	-	-	82.5	100.4	95.6	11.1	23.3	3.6	0.8	7.7	9.0	-
1952-'53	9.6	45.9	44.2	87.6	55.4	59.2	72.8	40.7	1.6	10.1	1.0	0.1	428.2
1953-'54	1.3	32.9	79.8	88.9	108.4	49.6	44.8	35.2	10.9	15.2	8.2	4.9	480.1
1954-'55	13.9	37.1	38.3	80.4	92.4	66.7	73.1	45.8	24.1	8.1	8.7	3.2	491.8
1955-'56	11.5	59.9	61.9	72.0	5[illegible].7	47.1	38.4	34.2	33.2	10.3	23.6	5.2	450.0
1956-'57	13.1	17.4	44.2	44.2	46.0	110.9	31.9	16.4	11.4	26.5	5.9	0.1	368.0
1957-'58	2.6	16.8	85.7	65.1	117.3	89.5	38.6	7.6	15.3	13.7	11.0	4.6	467.8
1958-'59	12.6	19.4	85.2	34.0	76.4	72.0	34.0	62.5	13.2	8.3	0.9	1.8	420.3
1959-'60	2.1	20.7	90.8	77.7	63.4	56.5	46.7	36.4	9.8	2.6	2.2	2.8	411.2
1960-'61	3.5	45.6	64.8	70.4	83.2	46.9	48.0	18.7	7.8	0.9	0.0	0.6	390.4
1961-'62	1.6	16.1	68.6	72.3	92.9	43.4	81.1	6.6	10.1	9.8	6.9	1.5	410.9
1962-'63	21.4	34.0	45.8	80.4	106.0	50.4	24.1	8.9	2.6	0.0	0.0	1.4	375.0
1963-'64	3.2	8.8	74.2	32.1	41.1	50.6	46.4	35.7	7.3	12.2	4.6	19.0	335.2
1964-'65	7.5	46.1	50.1	81.2	49.8	67.0	41.2	19.7	1.8	5.1	0.6	0.0	370.1
1965-'66	1.6	12.7	90.5	46.9	33.9	79.8	18.1	31.1	12.7	0.9	0.4	5.7	334.3
1966-'67	6.4	23.8	80.4	72.9	33.6	44.5	44.1	6.3	0.0	3.6	0.0	1.9	317.5
1967-'68	6.2	21.0	85.2	69.9	56.1	51.2	41.0	68.8	36.3	31.0	12.7	3.6	483.0
1968-'69	7.8	29.7	62.4	62.9	72.1	79.8	35.8	10.6	8.0	1.3	0.4	6.9	377.7
1969-'70	6.2	21.3	34.0	60.0	47.9	88.7	54.2	23.5	10.9	4.7	0.6	4.5	356.5
1970-'71	7.8	19.2	49.0	85.4	53.2	47.4	22.8	77.9	20.5	13.1	0.0	6.3	402.6
1971-'72	13.7	33.7	59.5	76.3	44.8	76.3	28.5	49.6	2.6	0.0	3.5	0.2	389.1
1972-'73	0.5	22.6	50.6	57.0	44.5	57.0	57.3	60.5	22.3	17.1	6.9	6.5	402.8
1973	11.8	50.3	75.0	-	-	-	-	-	-	-	-	-	-
Mean	8.3	29.3	62.7	68.3	66.0	67.0	42.5	37.2	12.2	8.8	4.8	4.4	411.5

TABLE D-3

MONTHLY YIELD

KEDUNGWARU RIVER AT KEDUNGWARU DAMSITE

(Units in 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	-	-	-	14.5	12.0	13.4	5.6	2.7	1.0	0.2	1.0	1.8	61.0
1952-1953	1.6	7.5	6.2	9.2	8.2	8.0	12.0	4.0	2.9	1.0	0.1	0.3	61.0
1953-1954	0.9	5.5	8.4	11.1	16.3	6.5	9.6	3.8	3.8	1.9	4.9	1.9	74.6
1954-1955	2.6	6.7	11.2	14.4	19.4	13.3	15.3	9.2	4.8	5.3	1.5	0.2	103.9
1955-1956	2.5	8.0	11.6	10.7	10.4	10.5	4.5	4.4	11.4	1.1	3.9	2.1	82.2
1956-1957	3.4	5.0	7.6	6.0	8.1	15.4	7.0	3.7	3.1	9.6	0.9	0.1	76.9
1957-1958	1.5	4.0	13.0	8.5	13.9	25.2	8.9	2.9	1.7	5.5	4.1	0.7	89.9
1958-1959	3.0	2.3	17.4	11.8	18.7	25.4	4.0	14.3	2.2	3.6	0.5	0.5	103.7
1959-1960	1.1	3.3	10.0	18.4	12.8	5.4	10.6	3.7	0.3	0.6	1.2	0.7	68.2
1960-1961	0.8	9.3	13.5	20.2	10.5	7.2	7.6	6.4	1.5	0.1	0	0	79.1
1961-1962	0.6	3.7	7.5	22.6	13.4	10.0	10.3	1.7	2.0	5.6	5.2	1.3	81.9
1962-1963	2.7	6.4	9.8	16.4	14.8	9.7	4.8	3.5	0.7	0	0	0.2	69.0
1963-1964	1.1	2.4	12.5	11.2	11.9	10.5	9.9	7.3	2.4	0.4	1.2	4.5	75.3
1964-1965	4.0	6.3	8.6	19.7	10.2	13.3	4.3	3.4	0.4	0.9	0.2	0.1	71.4
1965-1966	0	1.0	11.8	15.0	11.7	18.0	3.0	5.1	2.7	0.2	0.4	0.8	69.7
1966-1967	1.4	4.0	7.5	19.1	7.3	8.4	11.6	1.1	0	0	0.1	0.2	60.7
1967-1968	1.4	3.1	16.0	13.0	8.7	11.5	7.5	10.5	3.6	9.0	4.5	2.1	90.9
1968-1969	1.5	6.7	11.7	9.1	12.5	17.5	9.3	3.6	1.3	1.3	0.6	0.7	75.8
1969-1970	1.5	3.5	9.5	12.4	8.2	13.9	9.8	6.3	1.8	0.8	0	1.4	69.1
1970-1971	0.6	5.2	8.0	16.7	14.8	14.1	8.6	9.3	5.7	0.4	0	1.1	84.5
1971-1972	4.2	4.8	10.2	18.6	8.7	16.9	5.4	5.7	0	0	1.6	0	76.1
1972-1973	0.2	4.8	9.6	10.4	11.0	16.7	13.3	15.5	3.4	2.2	1.0	2.5	90.6
1973	2.4	9.5	23.0	-	-	-	-	-	-	-	-	-	-
Mean	1.8	5.1	11.1	14.0	12.0	13.2	8.3	5.8	2.6	2.3	1.5	1.1	78.8

TABLE D-4

MONTHLY YIELD - GLUGU RIVER AT BANDUNGHARJO DAMSITE

(Units in 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952	-	-	-	8.2	6.2	9.6	3.2	1.4	0.5	0.4	1.1	0.4	-
1952-'53	1.3	5.3	4.6	8.0	7.7	5.4	7.0	2.7	0.8	0.9	0.1	1.7	45.5
1953-'54	0.2	2.7	4.3	8.1	7.4	5.8	5.9	2.8	0.9	2.0	1.3	0.6	41.9
1954-'55	1.1	5.6	3.2	8.2	6.5	3.3	4.2	2.4	1.4	2.7	0.4	0.6	39.4
1955-'56	2.2	2.9	4.0	7.2	6.1	5.8	1.9	2.4	4.8	0.2	1.1	0.6	39.2
1956-'57	0.8	2.2	6.1	5.2	5.3	13.2	4.9	0.7	1.0	1.6	0.1	0.0	41.1
1957-'58	1.0	2.6	6.1	6.1	9.2	9.6	3.9	2.5	2.0	3.4	1.5	1.1	42.9
1958-'59	2.6	3.2	7.2	8.7	5.2	6.4	4.6	4.9	2.9	0.8	0.2	0.1	46.7
1959-'60	0.8	2.7	4.5	5.3	5.2	3.3	2.6	3.2	1.2	0.5	0.1	0.6	29.7
1960-'61	0.5	3.8	4.8	5.9	5.5	8.0	2.0	6.3	0.4	0.0	0.0	0.1	37.1
1961-'62	0.6	3.2	3.1	9.2	4.4	4.6	8.0	1.0	2.4	1.0	1.0	1.1	37.0
1962-'63	1.8	2.5	5.4	9.7	6.3	4.9	3.3	0.3	0.3	0.0	0.0	0.0	34.6
1963-'64	0.7	1.7	6.5	2.5	8.2	4.3	3.1	3.0	1.5	0.3	0.5	0.7	33.0
1964-'65	1.6	0.9	3.1	5.4	6.1	6.0	7.8	0.9	0.8	0.3	0.0	0.0	33.0
1965-'66	0.9	2.7	4.8	5.3	3.8	6.2	1.4	1.1	2.4	0.0	0.1	0.0	28.7
1966-'67	1.8	2.7	3.4	8.3	4.7	6.1	4.3	0.6	0.0	0.0	0.4	0.0	32.6
1967-'68	0.6	2.8	8.0	6.8	9.5	4.7	4.1	5.5	1.2	3.6	1.2	0.8	51.5
1968-'69	1.2	4.9	3.4	2.8	6.8	5.6	1.7	0.0	0.3	0.9	0.0	0.0	27.6
1969-'70	2.5	2.4	6.0	7.2	6.1	9.7	3.6	3.9	0.4	0.8	0.0	1.0	43.7
1970-'71	1.9	2.9	5.3	11.9	5.5	5.8	4.3	4.7	3.3	0.1	0.5	0.3	40.7
1971-'72	3.2	3.0	5.4	10.9	5.9	5.8	3.8	3.0	0.9	0.0	0.3	0.0	43.6
1972-'73	0.5	3.9	6.0	7.9	7.4	8.3	3.8	8.6	1.3	2.4	1.1	1.3	56.7
1973	1.5	4.3	6.9	-	-	-	-	-	-	-	-	-	-
Mean	1.3	3.1	5.1	7.2	6.3	6.4	4.2	2.8	1.3	1.0	0.5	0.5	39.7

TABLE D-5

MONTHLY YIELD

SERANG RIVER AT KEDUNGOMBO

(Units 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952-'53	17.1	115.9	117.4	93.3	77.3	72.1	92.0	55.6	9.4	17.5	1.8	1.3	670.7
1953-'54	0.7	15.7	54.3	108.8	135.3	77.8	116.3	82.5	16.4	21.4	7.2	11.2	647.6
1954-'55	27.6	139.1	91.3	182.4	107.5	84.7	114.8	25.8	14.0	35.6	12.9	14.0	849.7
1955-'56	26.1	82.6	74.2	150.0	172.8	92.7	25.8	31.8	31.1	11.0	14.7	10.3	723.1
1956-'57	21.5	38.5	135.1	111.1	67.0	173.5	99.7	25.9	8.5	23.2	4.6	3.1	711.7
1957-'58	2.8	9.2	81.9	93.9	205.9	182.0	121.6	115.9	23.6	58.5	65.1	10.9	971.3
1958-'59	58.7	66.1	171.1	187.9	143.0	139.7	105.3	102.2	28.5	40.3	4.2	2.6	1,049.6
1959-'60	6.6	49.0	161.8	71.8	145.6	78.4	77.8	87.6	18.4	14.4	2.8	1.5	715.7
1960-'61	6.1	59.1	52.3	88.2	86.5	102.9	46.6	108.4	13.0	3.5	0.7	0.4	567.7
1961-'62	0.5	44.9	52.8	121.5	106.4	75.6	122.2	34.1	16.7	13.8	10.7	1.1	600.3
1962-'63	6.2	58.9	105.4	151.6	109.3	146.3	39.4	11.0	3.0	1.8	0.6	0.2	683.7
1963-'64	1.2	15.3	49.9	43.1	116.5	104.5	126.8	55.0	25.4	16.2	9.9	0.7	564.5
1964-'65	42.1	44.2	37.5	127.2	135.5	143.5	78.2	18.0	6.1	4.2	0.5	0.4	637.4
1965-'66	4.4	29.4	53.0	109.3	148.0	214.6	63.9	28.7	48.8	13.4	10.7	2.8	727.0
1966-'67	37.5	45.3	83.9	173.2	176.9	87.8	73.4	14.0	2.0	0.2	0.2	0.2	694.6
1967-'68	0.2	21.9	95.9	120.2	179.4	126.6	105.4	103.4	26.1	45.5	31.1	7.9	863.6
1968-'69	25.2	91.8	108.9	102.2	130.5	94.6	73.8	16.4	15.1	6.6	1.8	0.9	667.8
1969-'70	20.1	18.9	96.1	57.0	64.6	97.2	40.8	65.5	18.8	13.6	9.2	29.8	531.6
1970-'71	14.5	35.7	90.7	154.0	105.8	108.6	75.6	83.9	49.9	1.1	0.2	0.2	720.2
1971-'72	9.7	25.8	82.8	131.8	81.5	63.1	41.0	30.4	10.5	9.9	1.8	0.2	493.5
1972-'73	0.2	24.9	67.2	98.1	132.9	111.1	61.1	120.2	41.0	56.1	8.5	52.1	773.4
Mean	15.7	49.2	88.7	117.9	125.2	113.4	83.4	57.9	20.3	19.4	9.5	7.2	707.8

TABLE D-6

MONTHLY YIELD DOLOK RIVER AT BARANG WEIR

(Units in 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total Annual
1952	-	-	-	13.8	10.4	9.0	3.4	2.6	0.0	0.0	1.9	0.0	-
1952-'53	1.7	3.2	4.3	3.2	3.1	7.3	3.2	2.9	0.0	0.0	0.0	0.7	29.6
1953-'54	0.0	3.4	3.4	7.0	6.9	5.4	2.4	5.6	0.6	0.4	0.4	0.2	35.7
1954-'55	3.4	9.0	3.4	5.9	10.0	5.9	8.0	5.6	0.7	3.1	1.0	0.0	56.0
1955-'56	1.9	5.8	4.3	16.5	6.0	4.5	2.3	1.1	2.0	0.2	1.0	0.0	44.7
1956-'57	1.2	0.2	6.9	6.1	6.0	7.3	5.4	0.9	0.8	1.7	0.7	0.0	37.2
1957-'58	0.7	1.9	8.7	3.1	17.8	7.1	9.2	3.8	0.8	4.1	3.3	0.3	60.8
1958-'59	1.1	2.0	4.3	8.3	4.9	3.9	6.1	4.1	0.5	2.7	0.0	0.0	37.9
1959-'60	0.5	1.1	5.6	8.0	1[illegible].3	2.9	3.8	3.5	0.9	0.0	0.0	0.0	36.6
1960-'61	0.3	6.1	2.9	18.1	3.1	9.0	3.2	8.2	0.0	0.0	0.0	0.0	50.9
1961-'62	0.0	2.0	3.2	12.2	9.1	17.3	11.2	1.7	0.5	0.6	1.5	0.0	59.3
1962-'63	1.6	1.2	3.4	12.7	5.9	2.7	3.3	0.0	0.0	0.0	0.0	0.5	32.3
1963-'64	0.0	1.2	6.4	3.9	4.2	3.7	7.6	6.0	0.3	0.2	0.3	0.0	44.6
1964-'65	4.6	4.3	5.4	24.2	8.6	8.1	4.5	1.5	1.9	0.0	0.0	0.0	63.1
1965-'66	0.0	2.3	4.2	5.9	12.0	7.7	2.6	2.4	1.9	0.0	0.0	0.0	39.0
1966-'67	2.9	2.3	4.3	11.7	8.8	5.8	6.6	0.4	0.0	0.0	0.0	0.0	42.8
1967-'68	0.3	2.9	7.3	16.6	9.8	5.1	3.1	6.1	2.3	2.5	0.9	0.0	56.9
1968-'69	1.1	9.2	11.7	2.7	7.2	4.8	7.2	0.0	0.5	0.0	0.0	0.0	44.4
1969-'70	0.4	3.9	2.7	5.1	4.9	11.7	6.0	11.0	0.7	0.7	0.0	0.0	47.0
1970-'71	0.7	3.8	7.8	9.8	11.2	8.1	7.5	4.8	2.7	0.2	0.0	0.0	56.6
1971-'72	2.2	4.4	2.1	13.8	4.4	9.9	3.7	3.4	0.0	0.0	0.0	0.0	43.9
1972-'73	0.0	1.8	5.1	9.1	5.2	6.8	7.6	7.1	2.2	1.7	0.0	2.2	48.8
1973	2.6	7.3	8.1	-	-	-	-	-	-	-	-	-	-
Mean	1.2	3.6	5.1	9.9	7.7	7.0	5.4	3.8	0.9	0.8	0.5	0.2	46.1

TABLE D-7

MONTHLY YIELD : PENGGARON RIVER AT PUCANGGADING

(Units in $m^3 \times 10^6$)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total Annual
1952	-	-	-	21.5	21.8	20.7	6.2	7.3	0.0	0.1	2.3	1.4	-
1952-'53	4.5	12.5	10.6	14.0	6.4	13.9	10.1	7.4	0.6	1.5	0.0	0.0	81.5
1953-'54	0.0	5.7	11.3	12.9	12.4	13.4	8.9	9.3	4.2	1.0	0.9	1.6	81.6
1954-'55	2.7	13.2	7.5	13.9	19.7	11.7	10.4	8.3	3.4	3.6	2.8	1.0	98.2
1955-'56	6.3	13.5	5.1	25.3	15.5	10.3	6.6	2.8	3.7	0.4	1.0	0.0	90.5
1956-'57	3.6	2.6	24.1	21.5	21.6	36.2	14.4	3.0	0.9	4.8	0.2	0.0	132.9
1957-'58	0.2	2.7	23.3	6.1	36.6	19.7	19.2	9.4	2.2	8.2	4.9	0.4	132.9
1958-'59	1.8	5.7	13.9	35.2	18.8	15.6	15.9	11.6	3.3	6.0	0.0	0.9	128.5
1959-'60	1.3	2.3	14.9	17.8	19.3	14.5	10.9	7.8	1.4	0.2	0.0	0.0	90.4
1960-'61	0.4	10.7	8.6	31.0	7.5	19.3	6.2	15.8	0.0	0.2	0.0	0.0	93.6
1961-'62	0.0	5.3	5.3	23.1	23.1	26.0	25.0	5.2	3.3	1.2	1.2	0.0	118.7
1962-'63	3.9	4.3	9.9	34.0	13.2	11.8	7.6	1.4	0.0	0.0	0.0	0.0	86.1
1963-'64	0.0	1.2	12.4	9.7	19.6	6.1	13.6	8.2	1.7	0.0	0.0	3.2	75.7
1964-'65	9.3	25.0	9.6	31.9	10.8	20.9	14.1	4.5	2.2	0.0	0.0	0.0	128.3
1965-'66	0.0	4.1	11.3	15.7	20.9	18.1	10.3	4.4	1.2	0.0	0.0	0.0	86.0
1966-'67	7.1	3.5	7.5	16.1	4.0	16.2	17.8	0.9	0.0	0.0	0.0	0.0	73.1
1967-'68	0.1	3.8	19.4	25.0	27.9	17.2	7.9	14.1	8.2	6.4	2.3	1.9	134.2
1968-'69	0.5	8.4	17.4	7.2	29.9	21.8	14.8	0.4	3.3	0.8	0.0	0.0	104.5
1969-'70	1.9	2.8	7.1	9.8	11.3	18.6	16.2	16.9	2.1	3.3	0.0	0.0	90.0
1970-'71	1.2	6.8	13.4	27.7	22.9	15.7	16.9	8.1	6.9	0.3	0.0	0.0	119.9
1971-'72	4.5	7.9	11.7	29.0	11.3	22.1	4.8	5.4	0.0	0.0	0.0	0.0	96.7
1972-'73	0.0	4.0	7.5	14.1	6.8	9.3	10.6	15.5	4.2	1.3	0.0	4.3	77.6
1973	4.1	11.6	14.0	-	-	-	-	-	-	-	-	-	-
Mean	2.4	7.2	12.1	20.1	17.3	17.2	12.2	7.6	2.4	1.8	0.7	0.7	101.7

TABLE D-8

NET MONTHLY YIELD OF LUSI RIVER AT MID LUSI DIVERSION SITE

(Units 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952-'53	9.4	40.2	39.8	82.0	82.9	53.6	63.7	38.3	0.0	9.5	0.9	0.0	420.3
1953-'54	0.5	29.7	74.6	81.4	96.4	45.1	37.0	32.8	7.5	13.9	3.6	3.2	425.7
1954-'55	11.9	31.9	28.6	69.2	76.7	56.1	60.7	38.4	20.3	3.1	7.5	3.1	407.5
1955-'56	9.5	54.3	52.9	64.2	44.4	38.5	35.4	31.2	23.1	9.6	20.6	2.3	386.0
1956-'57	10.2	13.1	39.4	40.0	39.7	96.9	26.2	13.4	8.8	18.0	5.2	0.0	310.9
1957-'58	1.2	13.5	76.1	59.2	108.1	67.9	31.2	5.0	14.2	8.7	7.3	4.1	396.5
1958-'59	10.1	17.9	71.2	23.6	60.8	49.5	31.4	50.7	11.5	5.8	0.4	1.4	334.3
1959-'60	1.1	18.2	24.4	62.4	53.1	53.4	38.0	34.2	9.9	2.1	1.1	2.2	300.1
1960-'61	2.8	38.1	53.9	53.0	76.0	41.6	42.3	13.0	6.6	0.8	0.0	0.6	328.7
1961-'62	1.1	13.0	57.8	52.6	83.2	35.1	74.0	5.2	8.5	4.6	2.0	0.3	337.4
1962-'63	19.6	19.0	37.8	67.2	95.4	42.7	20.3	5.8	2.0	0.0	0.0	1.3	311.1
1963-'64	2.0	6.8	64.7	22.2	30.8	42.1	38.4	29.8	5.2	12.3	3.6	15.7	273.6
1964-'65	2.8	11.6	43.5	64.7	41.6	56.4	38.5	17.1	1.5	4.4	0.4	0.0	282.5
1965-'66	1.7	12.2	82.3	33.8	23.6	65.0	15.8	27.2	10.5	0.7	0.0	5.1	277.9
1966-'67	6.6	24.2	53.2	56.3	62.5	65.5	27.9	7.4	7.0	0.1	0.0	6.5	317.2
1967-'68	5.3	20.9	76.1	56.7	27.6	37.9	34.3	5.5	0.0	3.7	0.0	1.8	269.8
1968-'69	5.0	16.9	72.6	59.7	49.6	41.7	35.1	61.1	34.2	23.2	8.7	1.6	409.4
1969-'70	4.9	18.7	25.7	50.0	41.6	78.3	46.6	18.1	9.5	4.1	0.6	3.3	301.4
1970-'71	7.5	14.9	43.0	72.1	40.5	35.2	15.1	71.7	15.6	13.2	0.0	5.5	334.3
1971-'72	10.0	30.2	51.7	60.8	37.9	62.5	24.2	45.9	2.7	0.0	2.0	0.2	328.1
1972-'73	8.8	18.7	43.0	49.9	35.3	42.6	46.3	47.4	19.9	15.6	6.2	4.3	338.0
Mean	6.3	22.1	53.0	56.3	57.5	52.7	37.3	28.5	10.4	7.3	3.3	3.0	337.7

TABLE D-9

NET MONTHLY YIELD SERANG RIVER AT SOUTH GROBOGAN DIVERSION

(Units 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952-'53	2.6	17.4	17.6	14.0	11.6	10.8	13.8	8.3	1.4	2.6	0.3	0.2	100.6
1953-'54	0.1	2.4	8.2	16.3	23.3	11.7	17.5	12.4	2.5	3.2	1.0	1.7	100.3
1954-'55	4.1	20.9	13.7	27.4	16.2	12.7	17.2	3.9	2.1	5.3	1.9	2.1	127.5
1955-'56	3.9	12.4	11.1	22.5	25.9	13.9	3.9	4.8	4.7	1.7	2.2	1.6	108.6
1956-'57	3.2	5.8	20.3	16.7	10.1	26.0	15.0	3.9	1.3	3.5	0.7	0.5	107.0
1957-'58	0.4	1.4	12.3	14.1	30.9	27.3	18.2	17.4	3.5	8.8	9.8	1.6	145.7
1958-'59	8.8	9.9	25.7	28.2	21.5	21.0	15.8	15.3	4.3	6.0	0.6	0.4	157.5
1959-'60	1.0	7.4	24.3	10.8	21.8	11.8	11.7	13.1	2.8	2.2	0.4	0.2	107.5
1960-'61	0.9	9.9	7.9	13.2	13.0	15.4	7.0	16.3	2.0	0.5	0.1	0.1	86.3
1961-'62	0.1	6.7	7.9	19.2	16.0	11.3	18.3	5.1	2.5	2.1	1.6	0.2	91.0
1962-'63	0.9	8.8	15.8	22.7	16.4	22.0	13.4	1.7	0.5	0.3	0.1	0.0	102.6
1963-'64	0.2	2.3	7.5	6.5	17.5	15.7	19.0	8.3	3.8	2.4	1.5	0.1	84.8
1964-'65	6.3	6.6	5.6	19.1	20.3	21.5	11.7	2.7	0.9	0.6	0.1	0.1	95.5
1965-'66	0.7	4.4	6.0	16.4	22.2	32.2	9.6	4.3	7.3	2.0	1.6	0.4	107.1
1966-'67	5.6	6.8	12.6	26.0	26.5	13.2	11.0	2.1	0.3	0.0	0.0	0.0	104.1
1967-'68	0.0	3.3	14.4	18.0	26.9	19.0	15.8	15.5	3.9	6.9	4.7	1.2	129.6
1968-'69	3.9	13.8	16.3	15.3	19.6	14.2	11.1	2.5	2.3	1.0	0.3	0.1	100.4
1969-'70	3.0	2.8	14.4	8.6	9.7	14.6	6.1	9.8	2.8	2.0	1.4	4.5	79.7
1970-'71	2.2	5.4	13.6	23.1	15.9	16.3	11.3	12.6	7.5	0.2	0.0	0.0	108.1
1971-'72	1.5	3.9	12.4	19.8	12.2	10.2	6.2	4.6	1.6	1.5	0.3	0.0	74.2
1972-'73	0.0	3.7	10.1	14.7	19.9	16.7	9.2	18.0	6.2	8.4	1.3	7.6	115.8
Mean	2.4	7.4	13.2	17.8	18.9	17.0	12.5	8.7	3.1	2.9	1.4	1.1	106.4

TABLE D-10

AVERAGE MONTHLY FLOW OF THE SERANG AT SEDADI

(Units 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952-'53	4.4	30.0	30.4	24.1	19.9	18.7	23.8	14.4	67.5	4.5	0.5	0.3	238.5
1953-'54	0.2	4.0	14.0	28.1	71.9	20.1	30.0	21.2	4.2	5.5	1.9	2.9	204.0
1954-'55	7.2	36.0	23.6	47.1	27.7	21.8	0.0	6.6	3.6	9.4	1.3	3.6	187.9
1955-'56	6.8	21.4	19.2	37.7	44.7	24.0	6.6	8.2	8.0	2.9	3.8	2.6	185.9
1956-'57	5.6	9.9	34.8	28.7	17.2	43.6	25.7	6.8	2.2	6.0	1.2	0.8	182.5
1957-'58	0.7	2.4	21.2	24.2	53.2	47.1	31.5	30.1	6.1	15.1	16.9	2.8	251.3
1958-'59	15.2	17.0	44.3	48.5	36.9	36.0	27.2	26.4	7.4	10.5	1.2	0.7	271.3
1959-'60	1.8	12.6	41.7	18.5	37.9	20.2	20.1	22.7	4.7	3.6	0.7	0.4	184.9
1960-'61	1.6	14.2	13.4	22.8	22.3	26.6	12.0	27.5	3.4	0.9	0.2	0.0	144.9
1961-'62	0.2	11.6	13.6	30.4	27.4	19.6	31.6	8.8	4.4	3.6	2.7	0.3	154.2
1962-'63	1.7	15.1	0.0	0.0	87.9	0.0	103.2	2.9	0.7	0.5	0.3	0.1	212.4
1963-'64	0.3	3.9	12.8	11.0	107.8	27.0	32.8	14.2	6.6	4.2	2.6	11.4	234.6
1964-'65	11.0	11.4	9.7	0.0	35.0	37.2	20.3	4.7	1.6	1.2	0.2	0.8	133.1
1965-'66	1.1	36.7	15.6	28.2	33.2	55.4	23.7	7.5	12.6	3.5	2.7	0.7	220.9
1966-'67	9.7	12.7	21.7	44.7	45.7	22.6	19.0	3.6	0.5	0.1	0.1	0.1	180.5
1967-'68	0.1	5.6	24.7	31.1	46.4	32.7	27.3	26.8	6.8	11.3	8.0	2.1	222.9
1968-'69	6.4	23.7	28.2	26.4	33.7	24.4	19.0	4.2	3.8	1.8	0.5	0.3	172.4
1969-'70	6.2	5.0	24.8	14.8	16.7	25.1	10.6	17.0	4.8	3.6	2.4	7.7	138.7
1970-'71	3.8	9.2	23.5	38.3	27.4	28.8	19.6	19.7	12.8	0.3	0.1	0.1	183.6
1971-'72	3.5	6.6	21.4	0.0	21.1	17.6	10.6	7.8	2.7	2.6	0.5	0.1	94.5
1972-'73	0.1	6.4	17.3	25.4	34.3	20.7	15.7	31.1	10.6	14.6	2.1	13.7	192.0
Mean	4.2	14.1	21.7	25.2	40.4	27.1	24.3	14.9	8.3	5.0	2.4	2.5	190.1

TABLE D-11

NET MONTHLY YIELDS OF THE SERANG AT SEDADI

(Units 10^6 m^3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1952-'53	45.1	144.4	121.1	118.7	130.3	87.4	238.3	35.2	68.8	33.4	0.9	2.3	1,025.9
1953-'54	12.8	92.0	147.6	167.5	124.9	132.7	129.7	73.4	47.7	27.3	40.3	285.3	1,281.2
1954-'55	38.9	123.4	95.2	224.8	256.8	114.6	85.7	74.4	57.7	112.4	17.5	7.9	1,209.3
1955-'56	53.2	109.1	154.7	172.0	155.2	110.2	31.4	29.6	111.6	10.6	25.0	18.6	981.2
1956-'57	36.2	51.6	114.2	70.0	123.7	59.1	136.5	31.0	100.5	93.3	9.6	1.3	827.0
1957-'58	25.9	71.6	167.5	124.9	273.4	273.6	145.5	65.3	53.5	93.7	49.9	21.0	1,365.8
1958-'59	69.2	96.7	231.7	186.2	235.2	162.9	87.5	147.0	74.4	48.9	13.2	19.4	1,372.3
1959-'60	28.9	74.2	251.0	166.7	205.5	117.6	120.7	52.4	20.6	8.9	8.4	11.1	1,066.0
1960-'61	18.7	129.7	117.0	205.3	178.2	143.6	121.7	134.9	12.5	7.6	0.2	2.0	1,071.4
1961-'62	20.1	72.9	101.7	252.5	238.5	129.6	173.3	19.1	58.7	39.9	30.9	15.4	1,152.6
1962-'63	60.2	100.4	94.0	204.3	112.1	180.8	15.3	30.3	21.1	1.2	0.3	1.1	821.1
1963-'64	41.1	64.7	122.1	123.5	93.5	183.3	45.6	17.8	61.2	19.3	31.2	56.6	859.9
1964-'65	104.6	56.7	98.3	159.4	173.7	167.5	33.2	23.4	33.4	3.3	0.2	0.0	853.7
1965-'66	23.2	94.1	72.9	175.1	176.2	243.7	49.8	41.7	69.6	3.4	12.7	5.0	967.4
1966-'67	51.1	73.7	57.2	253.4	132.1	168.4	140.2	10.7	6.4	0.0	7.7	1.3	902.2
1967-'68	13.5	69.0	175.7	194.5	244.2	153.9	145.9	132.9	69.9	134.2	65.4	25.9	1,425.0
1968-'69	50.4	162.0	0.0	172.8	234.6	199.8	81.0	19.3	26.9	0.0	6.5	32.8	986.1
1969-'70	49.1	86.8	149.7	199.9	158.5	238.2	118.0	123.9	40.6	15.0	4.3	41.1	1,225.1
1970-'71	41.6	115.0	106.8	211.2	208.6	147.6	106.5	137.3	26.0	0.0	7.2	11.5	1,119.3
1971-'72	81.2	79.3	155.7	260.1	136.5	157.4	77.7	61.9	13.8	2.1	11.9	0.0	1,037.6
1972-'73	9.5	97.4	142.6	151.6	209.8	299.9	116.8	214.0	84.9	56.9	31.0	51.6	1,466.0
Mean	43.8	93.6	127.5	180.9	181.1	165.3	104.8	70.3	50.6	33.9	17.8	26.4	1,096.0

TABLE D-12

LUSI LEFT BANK SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START - 4,000 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	9.42	3.15	1.78	0.39	11.45	2.41	6.02	3.29	12.14	12.43	12.70	75.19
2	1.90	12.15	1.26	0.0	0.0	10.08	4.39	6.42	6.91	12.18	7.71	9.97	72.98
3	0.0	11.48	4.53	0.0	0.0	10.28	2.93	5.28	6.00	8.57	9.86	11.43	70.36
4	0.0	10.55	0.34	0.83	1.55	11.17	8.22	8.14	2.32	13.81	7.79	9.60	74.31
5	0.0	16.27	3.55	5.95	2.10	5.31	4.49	9.09	4.44	7.38	10.90	13.11	82.58
6	0.18	14.39	0.0	2.52	0.0	4.34	4.12	8.62	6.53	8.43	7.60	9.32	66.05
7	0.0	13.35	0.0	2.07	0.0	8.58	6.42	1.94	5.61	11.30	11.04	9.81	70.12
8	0.0	14.60	0.0	0.23	0.0	10.52	4.42	7.39	8.32	14.69	11.39	10.66	82.22
9	1.24	9.72	1.70	0.0	0.0	9.92	5.35	4.42	8.84	14.86	12.87	12.77	81.69
10	0.58	14.87	2.63	0.0	0.0	10.49	1.28	10.51	6.91	11.62	8.75	10.35	77.99
11	0.0	12.89	2.66	0.70	0.0	10.25	6.50	9.39	8.42	15.61	12.87	12.70	92.00
12	0.02	15.54	0.43	3.65	0.85	10.15	4.56	5.14	6.41	14.01	8.95	5.59	75.29
13	0.0	14.32	3.25	0.0	0.72	8.64	8.26	9.22	7.75	14.80	12.66	13.28	92.89
14	0.62	13.72	1.08	1.46	1.52	6.03	8.75	7.70	6.08	15.44	11.34	11.38	85.13
15	0.0	14.36	2.79	0.0	3.13	9.03	4.05	10.87	9.50	15.73	11.60	12.58	93.64
16	0.46	14.74	0.0	0.0	0.0	9.68	3.82	2.25	5.30	5.00	5.74	8.78	55.76
17	0.0	9.63	1.23	0.95	0.0	6.67	6.46	10.12	8.13	14.36	11.82	7.40	76.77
18	0.0	13.25	1.99	0.0	0.75	4.93	3.92	4.39	7.26	13.91	12.30	7.43	70.12
19	0.0	11.80	3.35	0.0	0.0	9.85	5.92	1.62	7.98	14.69	11.71	10.14	77.05
20	0.0	13.12	0.46	0.0	1.76	8.10	6.61	5.70	8.95	15.73	10.80	13.28	84.52
21	2.66	12.50	1.26	1.71	0.0	5.88	4.02	0.0	5.11	10.54	8.71	6.34	58.73
Tot	7.66	272.66	35.68	21.84	12.77	181.35	106.85	134.23	140.07	264.81	218.84	218.64	1,615.39
Avg	0.36	12.98	1.70	1.04	0.61	8.64	5.09	6.39	6.67	12.61	10.42	10.41	76.92

TABLE D-13

LUSI RIGHT BANK SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START - 5,000 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	11.78	3.94	2.22	0.48	14.31	3.02	7.53	4.11	15.18	15.54	15.88	93.98
2	2.38	15.18	1.58	0.0	0.0	12.60	5.48	8.03	8.64	15.23	9.64	12.47	91.23
3	0.0	14.35	5.63	0.0	0.0	12.85	3.66	6.60	7.50	10.71	12.33	14.29	87.96
4	0.0	13.18	0.42	1.03	1.94	13.96	10.27	10.17	2.90	17.27	9.75	12.01	92.89
5	0.0	20.33	4.44	7.43	2.63	6.64	5.61	11.36	5.54	9.23	13.62	16.39	103.22
6	0.22	17.99	0.0	3.15	0.0	5.42	5.15	10.76	8.17	10.54	9.50	11.66	82.57
7	0.0	16.69	0.0	2.58	0.0	10.72	8.03	2.42	7.01	14.13	13.60	12.26	87.65
8	0.0	18.25	0.0	0.29	0.0	13.15	5.53	9.24	10.41	18.36	14.24	13.32	102.78
9	1.55	12.15	2.13	0.0	0.0	12.39	6.69	5.53	11.05	18.57	16.08	15.96	102.11
10	0.72	18.59	3.29	0.0	0.0	13.11	1.60	13.13	8.64	14.52	10.94	12.94	97.48
11	0.0	16.11	3.33	0.88	0.0	12.81	8.12	11.74	10.53	19.52	16.08	15.88	115.00
12	0.03	19.43	0.54	4.57	1.06	12.69	5.69	6.43	8.01	17.51	11.91	6.98	94.11
13	0.0	17.90	4.06	0.0	0.90	10.80	10.32	11.52	9.69	18.50	15.82	16.60	116.12
14	0.77	17.14	1.35	1.82	1.90	7.54	10.94	9.63	7.60	19.31	14.18	14.23	106.41
15	0.0	17.95	3.49	0.0	3.91	11.29	5.06	13.59	11.87	19.67	14.50	15.73	117.05
16	0.57	18.42	0.0	0.0	0.0	12.10	4.77	2.82	6.62	6.25	7.17	10.97	69.70
17	0.0	12.04	1.54	1.19	0.0	8.34	8.07	12.65	10.16	17.95	14.77	9.25	95.96
18	0.0	16.56	2.49	0.0	0.94	6.16	4.89	5.48	9.07	17.39	15.37	9.29	87.64
19	0.0	14.75	4.19	0.0	0.0	12.31	7.40	2.03	9.98	18.36	14.64	12.68	96.32
20	0.0	16.40	0.57	0.0	2.20	10.13	8.26	7.13	11.19	19.67	13.50	16.60	105.65
21	3.32	15.63	1.58	2.14	0.0	7.35	5.02	0.0	6.39	13.18	10.89	7.92	73.41
Tot	9.57	340.82	44.60	27.30	15.96	226.68	133.57	167.79	175.09	331.02	273.55	273.30	2,019.23
Avg	0.46	16.23	2.12	1.30	0.76	10.79	6.36	7.99	8.34	15.76	13.03	13.01	96.15

TABLE D-14

SOUTH GROBOGAN SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START - 7,300 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	17.47	4.21	1.45	0.53	15.54	2.56	5.88	14.83	17.30	23.48	22.96	126.22
2	4.06	22.70	1.97	0.0	0.0	15.36	4.93	5.94	9.88	21.35	14.90	13.04	114.13
3	0.0	11.33	2.54	0.0	0.0	19.94	6.66	9.45	12.00	19.17	17.69	14.98	113.75
4	0.0	16.64	0.0	0.0	0.89	20.26	12.46	13.85	6.38	25.47	13.94	17.68	127.57
5	0.0	25.34	0.0	8.87	0.0	5.12	9.76	17.67	13.08	15.95	21.27	23.79	140.82
6	0.0	22.99	0.0	0.0	0.0	8.24	4.23	13.99	11.32	15.38	13.19	16.09	105.43
7	0.0	28.04	0.0	0.71	0.0	19.26	7.94	1.99	11.85	21.06	19.55	17.02	127.41
8	0.0	24.30	0.0	1.62	0.0	10.90	8.07	11.72	14.66	24.86	20.61	18.51	135.24
9	0.0	17.36	0.95	0.0	1.31	27.93	7.21	5.64	16.34	27.11	23.26	23.30	150.41
10	0.0	27.65	8.57	0.0	0.0	19.51	3.13	18.47	11.25	22.69	14.00	21.49	146.76
11	0.0	24.30	4.04	1.74	1.01	19.20	5.29	17.87	16.55	28.71	23.48	21.31	163.48
12	0.0	24.67	0.0	7.98	1.98	16.66	10.08	10.34	11.92	24.03	15.68	9.21	132.55
13	0.0	24.85	4.51	0.0	1.79	11.50	16.50	17.14	15.19	26.21	22.95	23.79	164.44
14	1.13	19.53	4.68	0.0	0.0	4.66	13.29	15.44	8.70	28.71	21.27	22.05	139.46
15	0.0	23.23	0.0	0.0	0.0	16.60	7.21	19.55	16.55	28.49	23.26	23.79	158.67
16	0.18	22.11	0.0	0.0	0.0	18.10	9.76	8.88	9.39	12.57	10.59	16.02	107.60
17	0.0	17.96	2.25	0.0	0.0	11.28	10.02	19.93	13.08	27.11	20.89	22.75	145.28
18	0.0	22.52	2.65	0.65	0.0	16.95	9.83	4.29	13.24	24.52	21.08	13.77	129.50
19	0.0	21.01	0.0	0.0	0.0	20.26	12.67	0.0	8.77	27.22	21.78	16.09	127.79
20	0.0	23.82	2.54	0.0	0.0	18.52	11.19	16.04	16.98	28.71	21.08	23.79	162.67
21	5.03	20.15	4.57	0.0	0.0	14.50	6.96	0.0	8.03	16.98	17.08	10.01	103.30
Tot	10.40	457.97	43.48	23.02	7.49	330.29	179.75	234.01	260.00	483.63	401.02	391.42	2,822.50
Avg	0.50	21.81	2.07	1.10	0.36	15.73	8.56	11.14	12.38	23.03	19.10	18.64	134.40

TABLE D-15

DOLCK SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	6.19	0.85	1.70	1.84	2.81	2.66	3.53	3.49	6.04	6.21	[illegible]	41.76
2	1.13	5.20	0.28	0.0	0.0	3.21	1.63	1.10	2.22	5.12	3.40	3.71	27.00
3	0.0	3.52	2.22	1.83	0.0	4.15	0.97	2.90	2.04	3.78	3.47	3.78	29.67
4	0.0	4.77	1.47	0.0	0.14	4.48	2.95	4.69	2.29	6.44	3.74	4.88	35.86
5	0.0	8.26	0.94	0.36	0.63	3.57	1.16	4.93	4.16	4.48	3.74	5.84	38.06
6	0.03	5.83	0.0	3.21	0.0	2.07	0.13	2.27	3.78	4.43	1.12	4.64	27.51
7	0.0	7.35	0.0	0.0	0.0	5.36	0.0	1.65	3.85	4.38	5.50	5.01	33.10
8	0.0	6.62	0.40	0.0	0.0	5.43	1.65	2.73	3.01	7.03	6.17	5.17	38.21
9	0.0	4.07	2.37	0.0	0.25	3.24	1.89	0.0	4.60	7.24	6.27	6.53	36.47
10	0.88	6.78	1.80	0.0	0.0	2.16	0.0	3.89	3.31	4.92	3.14	6.11	32.98
11	0.0	6.65	1.83	0.0	0.0	5.87	1.13	5.38	4.82	7.67	6.27	6.53	46.15
12	1.37	8.33	0.0	1.42	0.86	4.29	0.20	1.44	4.01	6.66	5.15	2.64	36.39
13	0.0	5.37	1.20	0.0	0.0	3.64	1.32	3.74	2.27	6.62	6.27	6.53	36.96
14	1.97	7.17	1.47	0.65	0.0	3.55	2.06	2.68	2.00	7.67	5.96	4.47	39.65
15	0.0	6.32	0.66	0.0	0.0	4.54	1.04	5.30	4.82	7.61	5.66	6.29	42.23
16	0.0	6.44	0.22	0.0	0.0	4.90	2.51	0.68	1.90	3.49	3.36	4.72	28.22
17	0.0	5.29	0.0	3.01	0.0	3.83	1.55	5.40	2.77	6.33	5.79	5.76	39.74
18	0.0	6.93	1.65	0.27	1.35	2.93	1.48	0.53	3.02	4.92	5.38	3.87	32.33
19	0.0	6.90	0.0	0.0	0.0	3.52	0.0	1.01	2.25	6.29	6.06	4.94	30.97
20	0.0	5.23	0.25	0.0	0.68	2.59	1.41	2.56	4.63	7.67	5.22	6.53	36.77
21	1.80	5.91	0.60	0.0	0.84	3.54	0.79	0.0	2.33	5.40	4.75	2.08	28.02
Tot	7.19	129.13	18.24	12.44	6.59	79.67	26.53	56.40	67.54	124.20	102.65	106.48	737.06
Avg	0.34	6.15	0.87	0.59	0.31	3.79	1.26	2.69	3.22	5.91	4.89	5.07	35.10

TABLE D-16

PENGGARON SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	16.19	1.92	0.0	2.96	10.93	6.58	8.06	9.31	15.87	14.47	14.43	100.72
2	2.14	15.06	2.85	0.0	0.0	10.19	5.36	2.86	5.28	11.56	8.09	6.17	69.56
3	0.0	6.67	4.56	4.80	0.0	7.95	3.19	7.64	5.53	9.83	6.92	8.40	65.50
4	0.0	12.11	0.93	0.0	0.0	12.10	6.70	8.02	5.83	14.22	8.01	9.40	77.33
5	0.0	15.13	4.07	0.0	0.0	9.80	4.07	9.24	9.95	9.79	9.49	14.16	85.70
6	0.0	15.58	3.00	7.36	0.0	5.81	2.36	5.05	6.62	11.61	3.04	11.65	72.07
7	0.0	15.21	0.0	0.0	0.0	12.96	0.0	8.40	10.01	11.82	12.42	11.65	82.46
8	0.83	16.38	0.79	0.0	0.0	13.36	3.92	7.68	8.11	15.17	13.05	12.97	92.27
9	1.64	8.77	4.29	0.0	0.0	9.65	2.97	0.81	10.54	16.78	14.47	15.07	85.00
10	2.82	17.77	4.44	0.0	0.0	8.48	0.47	9.94	7.40	10.23	7.89	14.51	83.93
11	0.0	14.57	4.98	0.0	0.0	11.31	1.44	12.29	10.92	17.70	14.47	15.07	102.76
12	3.45	19.40	1.18	4.07	1.44	7.71	4.67	4.22	7.21	16.34	11.05	4.83	85.56
13	0.0	15.09	4.79	0.0	0.0	10.82	5.82	8.58	8.41	16.59	14.47	15.07	99.65
14	4.47	15.96	5.21	0.75	0.0	11.99	7.06	6.50	3.34	17.70	13.83	11.31	98.12
15	0.0	14.39	0.0	0.0	0.0	11.83	4.86	12.05	10.61	17.56	13.23	14.59	99.13
16	0.0	17.57	0.24	0.0	0.0	9.90	3.92	0.47	4.87	5.07	8.55	11.31	61.89
17	0.0	14.03	0.0	3.66	0.0	10.05	4.33	12.11	6.05	15.76	14.[illegible]	13.02	93.15
18	0.0	18.51	5.52	1.67	2.37	9.76	2.39	5.78	7.58	10.79	13.76	9.02	87.16
19	0.07	18.30	2.85	0.0	0.0	6.79	1.16	3.74	5.66	14.03	14.47	12.04	79.10
20	0.0	14.32	0.0	0.0	1.41	3.77	4.41	7.27	10.40	17.70	11.14	14.94	85.35
21	4.31	13.24	2.56	0.0	0.0	7.09	4.29	0.0	5.79	13.38	10.76	5.68	67.11
Tot	19.73	314.22	54.18	195.15	8.17	202.24	79.94	140.69	159.43	289.50	237.77	245.31	1,773.51
Avg	0.94	14.96	2.58	9.29	0.39	9.63	3.81	6.70	7.59	13.79	11.32	11.68	84.45

TABLE D-17

UPPER SEDADI SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START - 19,800 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	56.36	3.19	2.08	0.0	44.06	11.95	28.23	37.02	65.40	54.42	57.55	360.24
2	0.0	58.55	11.43	0.0	0.0	55.81	15.30	11.16	26.80	64.08	33.09	39.52	315.74
3	0.0	34.98	4.26	0.0	0.0	50.40	10.84	20.54	31.52	54.42	30.98	43.25	281.20
4	0.0	44.70	0.0	0.0	0.0	51.57	35.28	38.91	15.23	70.33	33.27	57.79	347.08
5	0.0	61.88	5.80	19.25	0.0	19.45	23.06	48.25	35.92	48.71	54.91	63.51	380.73
6	0.0	63.97	0.91	3.16	0.0	26.88	27.18	34.91	32.33	56.14	30.29	48.55	324.32
7	0.0	81.43	0.0	0.0	0.0	44.86	5.86	31.97	33.79	50.52	55.15	54.52	358.09
8	5.74	63.00	5.18	0.0	0.0	50.57	30.89	29.46	37.02	71.35	54.19	52.53	399.92
9	0.0	49.18	6.57	0.0	0.0	60.18	10.53	11.95	42.46	73.84	63.69	65.74	384.11
10	10.09	81.24	29.90	0.0	0.0	49.41	0.0	51.52	35.06	68.61	34.88	55.20	415.91
11	0.0	60.44	0.0	0.0	0.0	51.07	18.39	46.91	40.47	77.29	63.10	65.30	422.97
12	5.53	85.54	4.41	15.26	5.03	45.02	28.58	20.88	33.79	67.21	47.98	24.01	383.21
13	0.0	48.27	2.88	0.0	0.0	47.77	48.47	41.27	28.54	77.88	63.10	66.33	424.52
14	13.15	62.84	0.0	21.30	0.0	37.76	30.35	30.53	23.79	77.88	62.26	56.12	415.99
15	0.0	55.28	0.0	0.0	0.0	36.99	17.09	52.76	40.96	77.88	62.66	65.74	409.35
16	2.66	54.20	2.12	0.0	0.0	42.94	13.70	4.94	14.54	41.90	38.54	40.07	255.61
17	0.0	32.14	0.0	0.0	0.0	36.22	21.71	56.62	37.91	75.06	63.10	45.18	367.94
18	0.0	60.44	5.33	5.17	0.0	39.16	12.58	19.05	38.37	64.52	57.69	38.79	341.11
19	0.0	47.82	0.0	0.0	0.0	35.00	33.06	20.38	18.37	71.35	63.10	48.15	337.23
20	0.0	52.20	5.80	0.0	0.94	20.60	37.17	45.19	48.07	77.88	57.16	57.79	402.81
21	14.41	54.97	7.35	0.0	0.0	18.59	15.30	0.0	30.71	55.18	43.12	17.90	257.53
Tot	51.58	1209.43	95.12	66.23	5.97	864.32	447.29	645.42	682.66	1387.43	1066.65	1063.50	7,585.58
Avg	2.46	57.59	4.53	3.15	0.28	41.16	21.30	30.73	32.51	66.07	50.79	50.64	361.22

TABLE D-18

LOWER SEDADI SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START - 17,400 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	2.52	44.67	0.0	0.0	0.0	26.76	4.07	34.36	38.70	62.03	55.06	56.10	324.28
2	13.35	45.61	19.69	0.0	0.0	38.58	24.96	26.05	28.78	54.08	41.43	38.01	330.52
3	0.0	11.02	0.0	0.0	0.0	28.35	24.50	32.67	27.70	51.23	39.99	50.78	266.24
4	0.0	46.95	0.0	0.0	0.0	28.88	38.60	37.88	28.42	57.86	38.93	46.35	323.88
5	0.0	65.76	0.0	0.0	0.0	30.62	33.51	51.20	36.43	44.08	48.25	58.29	368.13
6	14.05	71.08	12.86	0.0	0.0	16.72	26.20	41.81	30.62	53.54	35.57	49.94	352.33
7	0.0	67.45	0.0	0.0	0.0	20.66	12.32	39.15	26.46	51.40	53.49	50.36	321.30
8	13.81	60.83	0.0	0.0	0.0	52.42	24.19	27.15	38.46	64.38	54.71	50.78	386.74
9	9.47	44.01	5.09	0.0	0.0	60.19	18.64	30.19	41.02	66.86	55.97	58.29	389.73
10	14.05	75.34	19.10	0.0	0.0	54.94	5.96	51.87	35.99	58.26	45.19	55.00	415.70
11	0.0	65.46	0.0	0.0	0.0	32.92	22.21	51.87	40.21	65.96	55.97	57.38	391.98
12	11.56	71.24	4.55	10.68	0.0	45.47	15.16	32.50	35.36	65.41	51.66	25.18	368.76
13	0.0	58.07	1.33	0.0	0.0	34.69	42.20	38.24	35.15	67.92	55.45	58.29	391.34
14	15.82	60.83	0.0	6.20	0.0	33.46	34.88	32.83	31.76	67.92	55.45	56.10	395.25
15	0.0	62.46	12.15	0.0	13.60	39.28	17.61	47.28	41.31	68.44	50.47	54.74	407.33
16	9.67	62.75	0.0	0.0	0.0	45.32	21.91	12.88	14.91	39.24	41.61	42.67	290.96
17	4.67	48.44	0.0	0.0	0.0	27.29	15.44	47.74	32.33	67.18	52.68	50.15	345.93
18	3.05	49.39	10.05	0.0	0.0	29.82	7.05	21.61	31.56	55.00	53.49	49.73	310.75
19	8.67	61.57	0.0	0.0	0.0	8.28	26.99	26.20	31.56	67.53	55.97	52.56	339.32
20	0.0	43.74	5.23	0.0	0.0	0.0	36.27	38.24	40.74	[illegible].44	55.06	57.03	344.76
21	18.85	60.25	5.23	0.0	0.0	0.0	26.52	13.45	25.25	58.26	39.64	27.72	275.16
Tot	139.55	1,176.93	95.28	16.88	13.60	654.61	479.20	735.16	692.73	1,255.00	1,036.00	1,045.45	7,340.38
Avg	6.65	56.04	4.54	0.80	0.65	31.17	22.82	35.01	32.99	59.76	49.33	49.78	349.54

TABLE D-19

JUANA VALLEY SERVICE AREA IRRIGATION DEMANDS - MCM

RECOMMENDED CROPPING PATTERN WITH NOVEMBER START - 15,000 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	0.0	48.83	4.63	1.81	0.0	38.06	5.49	25.05	32.36	45.53	46.12	44.72	292.59
2	9.60	40.59	12.32	0.0	0.0	35.45	22.59	10.98	27.54	49.37	25.74	34.67	268.85
3	0.0	35.33	5.92	0.0	0.0	34.71	17.73	28.31	22.66	43.57	30.77	40.29	259.28
4	0.0	34.54	0.0	0.0	0.0	40.98	26.87	31.73	9.47	53.09	29.06	39.15	264.88
5	0.0	58.42	8.30	14.46	0.0	20.25	23.81	33.12	29.41	30.71	37.63	48.36	304.49
6	8.69	56.04	0.0	6.78	0.0	21.83	18.50	35.05	26.88	41.81	28.08	44.91	288.56
7	0.0	58.42	0.0	0.0	0.0	11.06	7.62	17.08	21.92	40.37	46.12	40.62	243.21
8	8.34	52.69	1.61	0.0	0.0	34.59	4.09	20.59	32.16	53.28	45.41	39.96	292.73
9	0.0	27.37	0.0	0.0	0.0	35.70	19.02	22.59	30.12	56.62	48.25	49.47	289.13
10	7.47	61.97	2.53	0.0	0.0	34.23	0.0	37.94	26.07	44.31	31.93	45.91	292.36
11	0.0	5.29	6.39	0.0	0.0	39.58	18.63	35.38	36.14	58.55	48.25	47.87	296.07
12	3.87	49.94	12.32	12.94	0.0	35.20	13.93	24.08	27.21	47.57	42.34	14.64	284.06
13	0.0	34.43	2.99	0.0	0.0	33.13	34.07	32.81	28.89	53.86	47.80	49.47	317.45
14	9.97	53.97	0.0	8.60	0.0	19.03	21.65	28.31	17.19	54.86	45.87	42.34	301.78
15	0.0	53.84	0.0	0.0	0.0	27.56	9.41	34.72	36.42	59.00	47.80	48.89	317.63
16	0.0	45.91	0.0	0.0	0.0	38.18	12.33	5.02	7.06	19.11	23.87	27.61	179.09
17	0.0	38.51	0.0	5.70	0.0	26.51	13.56	38.12	23.73	59.00	46.12	38.98	290.23
18	0.0	46.39	9.63	0.0	0.0	17.48	6.79	10.98	22.66	48.06	45.41	36.78	244.18
19	1.87	40.24	0.0	0.0	0.0	11.28	16.58	12.33	22.36	52.72	48.25	2.68	208.30
20	0.0	41.41	0.57	0.0	0.0	5.25	23.54	30.81	37.05	59.00	47.80	50.25	295.68
21	15.47	57.09	3.57	0.0	0.0	17.37	14.31	1.10	22.66	46.78	36.50	23.90	238.74
Tot	65.27	941.20	70.78	50.29	0.0	577.43	330.51	516.09	539.98	1,017.18	849.11	811.47	5,769.29
Avg	3.11	44.82	3.37	2.39	0.0	27.50	15.74	24.58	25.71	48.44	40.43	38.64	274.73

TABLE D-20

LUSI LEFT BANK SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START - 4,000 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	15.98	0.49	3.49	0.0	7.12	5.98	2.81	2.82	0.0	8.74	11.77	6.57	65.77
2	20.50	3.21	1.60	0.0	5.86	4.62	4.79	3.22	0.0	8.78	7.04	3.84	63.47
3	16.72	2.55	4.86	0.0	3.22	4.82	3.33	2.08	0.0	5.17	9.20	5.30	57.23
4	15.19	1.61	0.67	0.0	8.29	5.70	8.62	4.94	0.0	10.41	7.12	3.47	66.02
5	16.97	7.33	3.88	3.08	8.84	0.0	4.89	5.89	0.0	3.98	10.23	6.98	72.07
6	18.78	5.46	0.0	0.0	1.92	0.0	4.52	5.42	0.0	5.03	6.93	3.19	51.25
7	14.12	4.42	0.0	0.0	4.64	3.11	6.82	0.0	0.0	7.90	10.38	3.68	55.07
8	18.54	5.66	0.27	0.0	6.02	5.05	4.82	4.19	0.0	11.29	10.73	4.52	71.10
9	19.84	0.79	2.04	0.0	5.93	4.45	5.75	1.22	0.0	11.46	12.20	6.63	70.31
10	19.18	5.94	2.96	0.0	3.82	5.02	1.68	7.31	0.0	8.22	8.08	4.22	66.43
11	14.78	3.96	3.00	0.0	5.55	4.78	6.90	6.19	0.0	12.21	12.20	6.57	76.14
12	18.62	6.61	0.76	0.79	7.58	4.68	4.96	1.94	0.0	10.61	8.28	0.0	64.83
13	13.44	5.39	3.58	0.0	7.45	3.18	8.66	6.02	0.0	11.40	11.99	7.15	78.25
14	19.22	4.78	1.41	0.0	8.25	0.56	9.15	4.50	0.0	12.04	10.67	5.25	75.85
15	16.33	5.42	3.13	0.0	9.86	3.56	4.45	7.67	0.43	12.33	10.93	6.45	80.56
16	19.06	5.80	0.0	0.0	5.08	4.22	4.22	0.0	0.0	1.60	5.07	2.64	47.68
17	15.70	0.70	1.57	0.0	4.67	1.20	6.86	6.92	0.0	10.96	11.15	1.27	61.00
18	16.15	4.32	2.32	0.0	7.48	0.0	4.32	1.19	0.0	10.51	11.63	1.30	59.22
19	16.50	2.86	3.68	0.0	5.96	4.38	6.32	0.0	0.0	11.29	11.04	4.01	66.04
20	11.64	4.19	0.79	0.0	8.49	2.63	7.01	2.50	0.0	12.33	10.14	7.15	66.87
21	21.26	3.57	1.60	0.0	6.34	0.41	4.42	0.0	0.0	7.14	8.04	0.20	52.98
Tot	358.50	85.06	41.62	3.87	132.37	68.37	115.25	74.02	0.43	193.41	204.84	90.39	1,368.13
Avg	17.07	4.05	1.98	0.18	6.30	3.26	5.49	3.52	0.02	9.21	10.42	4.30	65.15

TABLE D-21

LUSI RIGHT BANK SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START - 5,000 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	19.97	0.61	4.36	0.0	8.90	7.48	3.52	3.53	0.0	10.93	14.71	8.21	82.21
2	25.63	4.02	2.00	0.0	7.33	5.77	5.98	4.03	0.0	10.98	8.81	4.80	79.33
3	20.90	3.18	6.08	0.0	4.02	6.02	4.16	2.60	0.0	6.46	11.49	6.62	71.53
4	18.98	2.02	0.84	0.0	10.36	7.13	10.77	6.17	0.0	13.02	8.90	4.34	82.52
5	21.21	9.17	4.85	3.85	11.05	0.0	6.11	7.36	0.0	4.98	12.79	8.72	90.08
6	23.47	6.82	0.0	0.0	2.40	0.0	5.65	6.78	0.0	6.29	3.67	3.99	64.06
7	17.65	5.52	0.0	0.0	5.80	3.89	8.53	0.0	0.0	9.88	12.97	4.59	68.84
8	23.18	7.08	0.34	0.0	7.53	6.32	6.03	5.24	0.0	14.11	13.41	5.65	88.88
9	24.80	0.99	2.55	0.0	7.41	5.56	7.19	1.53	0.0	14.32	15.25	8.29	87.88
10	23.97	7.43	3.71	0.0	4.77	6.27	2.10	9.13	0.0	10.27	10.11	5.27	83.04
11	18.48	4.95	3.75	0.0	6.93	5.98	8.62	7.74	0.0	15.27	15.25	8.21	35.17
12	23.28	8.26	0.95	0.98	9.48	5.85	6.19	2.43	0.0	13.26	10.35	0.0	81.04
13	16.80	6.74	4.48	0.0	9.31	3.97	10.82	7.52	0.0	14.25	14.99	8.93	97.81
14	24.02	5.98	1.76	0.0	10.32	0.71	11.44	5.63	0.0	15.06	13.34	6.56	94.82
15	20.41	6.78	3.91	0.0	12.32	4.45	5.56	9.59	0.54	15.42	13.67	8.06	100.71
16	23.82	7.25	0.0	0.0	6.35	5.27	5.27	0.0	0.0	2.0	6.34	3.30	59.60
17	19.62	0.87	1.96	0.0	5.84	1.50	8.57	8.65	0.0	13.70	13.94	1.58	76.25
18	20.19	5.40	2.90	0.0	9.35	0.0	5.39	1.48	0.0	13.14	14.54	1.63	74.02
19	20.63	3.58	4.60	0.0	7.45	5.48	7.90	0.0	0.0	14.11	13.80	5.01	82.55
20	14.55	5.23	0.99	0.0	10.62	3.29	8.76	3.13	0.0	15.42	12.67	8.93	83.59
21	26.57	4.46	2.00	0.0	7.93	0.52	5.52	0.0	0.0	8.93	10.06	0.26	66.23
Tot	448.13	106.32	52.02	4.83	165.47	85.46	144.07	92.52	0.54	241.77	256.05	112.98	1,710.16
Avg	21.34	5.06	2.48	0.23	7.88	4.07	6.86	4.41	0.03	11.51	13.03	5.38	81.44

TABLE D-22

SOUTH GROBOGAN SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START - 7,300 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	27.28	1.16	4.82	0.0	12.82	5.56	3.29	0.04	0.0	11.10	22.26	11.77	100.11
2	38.00	6.39	2.57	0.0	2.75	5.39	5.66	0.10	0.0	15.14	13.69	1.85	91.55
3	26.43	0.0	3.14	0.0	4.30	9.97	7.39	3.61	0.0	12.96	16.47	3.78	88.06
4	29.79	0.34	0.0	0.0	13.17	10.28	13.19	8.01	0.0	19.27	12.72	6.48	113.26
5	26.01	9.03	0.0	3.64	11.93	0.0	10.49	11.78	0.0	9.75	20.05	12.60	115.29
6	32.58	6.69	0.0	0.0	1.23	0.0	4.96	8.15	0.0	9.18	11.98	4.89	79.65
7	25.23	11.74	0.0	0.0	10.64	9.28	8.67	0.0	0.0	14.85	18.33	5.82	104.57
8	33.63	8.00	0.44	0.0	9.95	0.92	8.80	5.88	0.0	18.66	19.39	7.31	112.98
9	32.93	1.05	1.56	0.0	13.60	17.96	7.94	0.0	0.0	20.91	22.05	12.11	130.09
10	33.49	11.35	9.18	0.0	2.33	9.53	3.86	12.63	0.0	16.48	12.79	10.29	121.93
11	25.47	8.00	4.65	0.0	13.29	9.22	6.02	12.03	0.0	22.51	22.26	10.11	133.57
12	33.00	8.36	0.0	2.75	14.26	6.68	10.81	4.50	0.0	17.82	14.47	0.0	112.66
13	25.29	8.55	5.12	0.0	14.08	1.53	17.23	11.30	0.0	20.01	21.74	12.60	137.44
14	35.08	3.23	5.29	0.0	11.34	0.0	14.02	9.60	0.0	22.51	20.05	10.86	131.97
15	26.13	6.92	0.0	0.0	10.64	6.62	7.94	13.71	0.0	22.29	22.05	12.60	128.89
16	34.13	5.81	0.0	0.0	10.24	8.12	10.49	3.04	0.0	6.36	9.38	4.82	92.38
17	27.78	1.66	2.86	0.0	6.14	1.31	10.75	14.09	0.0	20.91	19.67	11.56	116.72
18	28.97	6.22	3.26	0.0	11.69	6.98	10.56	0.0	0.0	18.32	19.86	2.57	108.42
19	21.87	4.71	0.0	0.0	6.86	10.28	13.40	0.0	0.0	21.02	20.56	4.89	103.59
20	28.90	7.52	3.14	0.0	12.04	8.55	11.92	10.20	0.43	22.51	19.86	12.60	137.68
21	38.98	3.85	5.18	0.0	5.87	4.52	7.69	0.0	0.0	10.77	15.86	0.0	92.72
Tot	630.95	120.57	51.22	6.39	199.19	132.69	195.08	128.65	0.43	353.33	375.48	159.52	2,353.52
Avg	30.05	5.74	2.44	0.30	9.49	6.32	9.29	6.13	0.02	16.83	19.10	7.60	112.07

TABLE D-23

DOLOK SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	8.31	1.83	1.01	0.30	5.13	0.14	2.85	1.97	0.0	4.38	5.89	3.44	35.26
2	10.20	0.85	0.45	0.0	2.35	0.54	1.83	0.0	0.0	3.46	3.07	0.72	23.48
3	6.85	0.0	2.39	0.43	1.66	1.49	1.17	1.34	0.0	2.12	3.15	0.79	21.38
4	7.72	0.41	1.64	0.0	3.42	1.82	3.15	3.13	0.0	4.78	3.42	1.89	31.38
5	6.32	3.90	1.10	0.0	3.91	0.90	1.36	3.37	0.0	2.83	3.42	2.85	29.95
6	9.10	1.47	0.07	1.81	0.0	0.0	0.32	0.71	0.0	2.77	0.79	1.65	18.71
7	7.69	3.00	0.0	0.0	2.77	2.70	0.0	0.09	0.0	2.72	5.18	2.02	26.15
8	8.93	2.27	0.57	0.0	1.58	2.76	1.85	1.17	0.0	5.37	5.85	2.18	32.52
9	9.06	0.0	2.54	0.0	3.54	0.57	2.09	0.0	0.18	5.59	5.95	3.54	33.04
10	9.95	2.43	1.96	0.0	0.85	0.0	0.09	2.33	0.0	3.26	2.81	3.12	26.79
11	8.08	2.30	1.99	0.0	2.87	3.21	1.32	3.82	0.40	6.01	5.95	3.54	39.49
12	10.44	3.98	0.0	0.02	4.14	1.63	0.40	0.0	0.0	5.01	4.83	0.0	30.44
13	5.22	1.01	1.37	0.0	2.10	0.98	1.51	2.18	0.0	4.96	5.95	3.54	28.81
14	11.04	2.81	1.64	0.0	1.32	0.89	2.25	1.12	0.0	6.01	5.64	1.48	34.19
15	6.06	1.96	0.82	0.0	1.25	1.88	1.23	3.74	0.40	5.95	5.33	3.30	31.92
16	8.25	2.09	0.39	0.0	0.92	2.23	2.70	0.0	0.0	1.83	3.04	1.73	23.18
17	8.40	0.94	0.0	1.61	1.26	1.16	1.75	3.84	0.0	4.67	5.46	2.77	31.88
18	8.80	2.58	1.81	0.0	4.63	0.26	1.67	0.0	0.0	3.26	5.06	0.88	28.95
19	8.96	2.54	0.02	0.0	0.0	0.86	0.0	0.0	0.0	4.63	5.74	1.95	24.70
20	8.01	0.88	0.42	0.0	3.96	0.0	1.61	1.00	0.21	6.01	4.90	3.54	30.53
21	10.87	1.55	0.76	0.0	4.12	0.87	0.99	0.0	0.0	3.74	4.42	0.0	27.33
Tot	178.23	38.80	20.93	4.18	51.78	24.89	30.13	29.80	1.18	89.39	95.83	44.96	610.08
Avg	8.49	1.85	1.00	0.20	2.47	1.19	1.43	1.42	0.06	4.26	4.56	2.14	29.05

TABLE D-24

PENGGARON SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	17.20	6.14	2.29	0.0	10.53	4.78	7.03	4.46	0.0	12.05	13.72	7.53	85.74
2	23.06	5.01	3.23	0.0	5.54	4.04	5.81	0.0	0.0	7.74	7.34	0.0	61.77
3	16.97	0.0	4.93	1.58	1.15	1.80	3.64	4.04	0.0	6.01	6.17	1.50	47.79
4	17.16	2.06	1.31	0.0	5.99	5.95	7.15	4.42	0.0	10.40	7.26	2.50	64.20
5	16.78	5.08	4.44	0.0	7.53	3.65	4.52	5.64	0.0	5.97	8.74	7.26	69.61
6	20.43	5.53	3.37	4.14	0.0	0.0	2.81	1.45	0.0	7.78	2.29	4.75	52.54
7	18.57	5.16	0.0	0.0	7.32	6.81	0.0	4.80	0.0	7.99	11.67	4.75	67.06
8	21.76	6.33	1.17	0.0	6.06	7.21	4.37	4.08	0.0	11.34	12.30	6.07	80.70
9	22.57	0.0	4.67	0.0	6.03	3.50	3.42	0.0	0.34	12.96	13.72	8.17	75.37
10	23.75	7.72	4.82	0.0	1.28	2.33	0.92	6.34	0.0	6.40	7.14	7.61	68.29
11	19.83	4.52	5.35	0.0	2.02	5.16	1.89	8.69	0.72	13.87	13.72	8.17	83.96
12	24.38	9.35	1.55	0.85	9.02	1.56	5.12	0.62	0.0	12.51	10.30	0.0	75.25
13	12.34	5.04	5.16	0.0	5.64	4.67	6.27	4.98	0.0	12.76	13.72	8.17	78.77
14	25.39	5.91	5.58	0.0	2.09	5.84	7.51	2.90	0.0	13.87	13.08	4.41	86.59
15	13.90	4.34	0.0	0.0	2.12	5.68	5.31	8.45	0.41	13.74	12.48	7.69	74.13
16	18.21	7.52	0.62	0.0	3.02	3.75	4.37	0.0	0.0	1.24	7.80	4.41	50.94
17	19.54	3.98	0.0	0.43	7.13	3.90	4.78	8.51	0.0	11.93	13.40	6.12	79.73
18	20.69	8.46	5.89	0.0	9.94	3.61	2.84	2.18	0.0	6.96	13.01	2.12	75.71
19	20.99	8.25	3.23	0.0	0.0	0.64	1.61	0.14	0.0	10.21	13.72	5.14	63.92
20	18.53	4.27	0.0	0.0	8.98	0.0	4.86	3.67	0.20	13.87	10.39	8.04	72.80
21	25.23	3.19	2.94	0.0	6.74	0.94	4.74	0.0	0.0	9.56	10.01	0.0	63.35
Tot	417.27	107.84	60.55	6.99	108.14	75.82	88.94	75.36	1.67	298.57	222.02	104.43	1,478.20
Avg	19.87	5.14	2.88	0.33	5.15	3.61	4.24	3.59	0.08	14.22	10.57	4.97	70.39

TABLE D-25

UPPER SEDADI SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START - 19,800 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	84.35	12.14	4.84	0.0	25.29	17.00	13.93	12.39	0.0	48.57	51.12	27.19	296.80
2	89.87	14.33	13.08	0.0	12.83	28.75	17.28	0.0	0.0	47.25	29.79	9.16	262.34
3	57.79	0.0	5.91	0.0	0.0	23.34	12.82	4.70	0.0	37.59	27.58	12.89	182.73
4	88.93	0.48	0.0	0.0	25.13	24.51	37.26	23.07	0.0	53.50	29.97	27.43	310.28
5	66.52	17.66	7.45	5.07	26.84	0.0	25.04	32.41	0.0	31.88	51.61	33.15	297.61
6	87.26	19.75	2.56	0.0	0.0	0.0	29.16	19.07	0.0	39.31	26.99	18.19	242.29
7	80.99	37.21	0.0	0.0	29.49	17.80	7.84	16.13	0.0	33.69	51.85	24.16	299.15
8	97.81	18.78	6.83	0.0	12.98	23.51	32.87	13.62	0.0	54.52	50.89	22.17	333.98
9	81.34	4.96	8.22	0.0	21.62	33.12	12.51	0.0	0.0	57.01	60.39	35.38	314.52
10	102.16	37.02	31.55	0.0	0.0	22.35	0.0	35.68	0.0	51.78	31.58	24.84	336.96
11	71.85	16.22	0.0	0.0	0.0	24.01	20.37	31.07	0.0	60.46	59.80	34.94	318.72
12	97.60	41.32	6.06	1.07	38.36	17.96	30.56	5.04	0.0	50.38	44.68	0.0	333.01
13	54.46	4.05	4.53	0.0	13.27	20.71	50.45	25.43	0.0	61.05	59.80	35.97	329.73
14	105.22	18.62	0.0	7.11	16.81	10.70	32.33	14.69	0.0	61.05	58.96	25.76	351.26
15	54.76	11.06	0.0	0.0	13.13	9.93	19.07	36.92	0.0	61.05	59.36	35.38	300.64
16	94.73	9.98	3.77	0.0	26.52	15.88	15.68	0.0	0.0	25.07	35.24	9.71	236.58
17	65.56	0.0	0.0	0.0	9.05	9.16	23.69	40.78	0.0	58.23	59.80	14.82	281.09
18	88.93	16.22	6.98	0.0	23.45	12.10	14.56	3.21	0.0	47.69	54.39	8.43	275.96
19	90.82	3.60	0.0	0.0	7.90	7.94	35.04	4.54	0.0	54.52	59.80	17.79	281.95
20	66.68	7.98	7.45	0.0	34.27	0.0	39.15	29.35	3.19	61.05	53.86	27.43	330.42
21	106.48	10.75	9.00	0.0	21.01	0.0	17.28	0.0	0.0	38.35	39.82	0.0	242.69
Tot	1,734.10	302.13	118.22	13.25	357.96	318.77	486.89	348.09	3.19	1,034.60	997.35	444.76	6,158.70
Avg	82.58	14.39	5.63	0.63	17.05	15.18	23.19	16.58	0.15	49.24	50.79	21.18	293.27

TABLE D-26

LOWER SEDADI SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START - 17,400 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	83.43	5.81	0.0	0.0	13.21	2.98	5.81	20.44	0.0	47.24	52.16	29.42	260.51
2	94.26	6.75	21.14	0.0	0.0	14.80	26.70	12.13	0.0	39.29	38.53	11.33	264.92
3	72.40	0.0	0.0	0.0	0.0	4.57	26.24	18.75	0.0	36.44	37.09	24.10	219.59
4	77.33	8.09	0.0	0.0	0.0	5.10	40.34	23.96	0.0	43.07	36.03	19.67	253.00
5	68.89	26.90	0.0	0.0	16.22	6.84	35.25	37.28	0.0	23.29	45.35	31.61	297.62
6	94.96	32.22	14.31	0.0	0.0	0.0	27.94	27.89	0.0	38.75	32.62	23.26	291.95
7	75.72	28.59	0.0	0.0	21.41	0.0	14.06	25.23	0.0	36.61	50.59	23.68	275.90
8	94.72	21.97	0.0	0.0	0.0	28.64	25.93	13.23	0.0	49.59	51.81	24.10	309.99
9	90.38	5.15	6.54	0.0	12.44	36.41	20.38	16.27	1.58	52.07	53.07	31.61	325.90
10	94.96	36.48	20.55	0.0	0.0	31.16	7.70	37.95	0.0	43.47	42.29	28.32	342.88
11	80.32	26.60	1.19	0.0	0.0	9.14	23.95	37.95	0.77	51.17	53.07	30.70	314.86
12	92.47	32.38	6.00	0.0	18.86	21.69	16.90	18.58	0.0	50.62	48.76	0.0	306.25
13	53.35	19.21	2.78	0.0	22.63	10.91	43.94	24.32	0.0	53.13	52.55	31.61	314.43
14	96.73	21.97	0.0	0.0	11.92	9.68	36.62	18.91	0.0	53.13	52.55	29.42	330.93
15	71.02	23.60	13.60	0.0	42.89	15.50	19.35	33.36	1.87	53.65	47.57	28.06	350.46
16	90.58	23.89	0.0	0.0	12.95	21.54	23.65	0.0	0.0	24.45	38.71	15.99	251.76
17	85.58	9.58	0.0	0.0	10.51	3.51	17.18	33.82	0.0	52.39	49.78	23.47	285.82
18	83.96	10.53	11.50	0.0	0.0	6.04	8.79	7.69	0.0	40.21	50.59	23.05	242.36
19	89.58	22.71	0.0	0.0	0.0	0.0	28.73	12.28	0.0	52.74	53.07	25.88	284.98
20	65.33	4.88	6.68	0.0	17.67	0.0	38.01	24.32	1.30	53.65	52.16	30.35	294.36
21	99.76	21.39	6.68	0.0	1.07	0.0	28.26	0.0	0.0	43.47	36.74	1.04	238.40
Tot	1,755.73	388.71	110.97	0.0	201.79	228.48	515.74	444.35	5.53	944.41	975.10	486.67	6,057.47
Avg	83.61	18.51	5.28	0.0	9.61	10.88	24.56	21.16	0.26	44.97	49.33	23.17	288.45

TABLE D-27

JUANA VALLEY SERVICE AREA IRRIGATION DEMANDS - MCM

TWO PLUS ONE CROPPING PATTERN WITH OCTOBER START - 15,000 HA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	62.69	15.33	5.88	0.0	22.46	17.56	6.99	13.05	0.0	32.78	43.62	21.72	242.07
2	79.35	7.09	13.57	0.0	9.61	14.95	24.09	0.0	0.0	36.62	23.24	11.67	220.19
3	54.93	1.83	7.17	0.0	0.0	14.21	19.23	16.31	0.0	30.82	28.27	17.29	190.05
4	61.75	1.04	0.34	0.0	20.57	20.48	28.37	19.73	0.0	40.34	26.56	16.15	235.32
5	62.69	24.92	9.55	3.71	12.29	0.0	25.31	21.12	0.0	17.96	35.13	25.36	238.04
6	78.44	22.54	0.46	0.0	1.03	1.33	20.00	23.05	0.0	29.06	25.58	21.91	223.39
7	57.71	24.92	0.0	0.0	17.88	0.0	9.12	5.08	0.0	27.62	43.62	17.62	203.57
8	78.09	19.19	2.86	0.0	0.0	14.09	5.59	8.59	0.0	40.53	42.91	16.96	228.81
9	68.66	0.0	0.0	0.0	8.40	15.20	20.52	10.59	0.0	43.87	45.75	26.47	239.45
10	77.22	28.47	3.78	0.0	0.0	13.73	0.0	25.94	0.0	31.56	29.43	22.91	233.04
11	59.65	0.0	7.64	0.0	0.0	19.08	20.13	23.38	2.14	45.80	45.75	24.87	248.43
12	73.62	16.44	13.57	2.19	16.95	14.70	15.43	12.08	0.0	34.82	39.84	0.0	239.65
13	38.99	0.93	4.24	0.0	10.94	12.63	35.57	20.81	0.0	41.11	45.30	26.47	236.99
14	79.71	20.47	1.25	0.0	11.39	0.0	23.15	16.31	0.0	42.11	43.37	19.34	257.11
15	58.10	20.34	0.0	0.0	9.72	7.06	10.91	22.72	2.42	46.25	45.30	25.89	248.70
16	68.81	12.41	0.0	0.0	14.55	17.68	13.83	0.0	0.0	6.36	21.37	4.61	159.61
17	66.67	5.01	0.0	0.0	5.66	6.01	15.06	26.12	0.0	46.25	43.62	15.98	230.38
18	65.13	12.89	10.88	0.0	17.18	0.0	8.29	0.0	0.0	35.31	42.91	13.78	206.37
19	71.62	6.74	0.0	0.0	0.0	0.0	18.08	0.33	0.0	39.97	45.75	0.0	182.48
20	47.05	7.91	1.82	0.0	20.68	0.0	25.04	18.81	3.05	46.25	45.30	27.25	243.17
21	85.22	23.59	4.82	0.0	10.61	0.0	15.81	0.0	0.0	34.03	34.00	0.90	208.98
Tot	1,396.08	272.05	87.83	5.90	209.93	188.72	360.51	284.01	7.60	749.43	796.61	357.15	4,715.82
Avg	66.48	12.95	4.18	0.28	10.00	8.99	17.17	13.52	0.36	35.69	40.43	17.01	224.56

D.6. MODEL OPERATION

The model operation begins with placing all input data in arrays for reference during the run. Operations at each site are considered separately; should operation of a site have an effect on one previously considered, necessary changes in operation are made.

Model operation starts at Bandungharjo which is responsible only for that portion of the South Grobogan Service Area which cannot be served by gravity from the proposed South Grobogan Weir.

The model next considers operation at Ngemplak, an Upper Lusi tributary designated to serve the Lusi left bank service area and, in the case Bandungharjo Dam does not appear in the model, approximately 23 percent of the designated South Grobogan service area. If Bandungharjo is considered, shortages at the Upper South Grobogan area are made up from Ngemplak. Available water consisting of any one months' inflow plus the storage at the beginning of the month, is weighed against that months' demands in the service area or areas mentioned above. The releases, spills and shortages for that particular month are computed. The model then considers the combined operation of Banjarejo and Kedungwaru damsites. The demands on those two sites are the balance of Lusi Left not served from Ngemplak plus Lusi Right demands minus the river flow at the Mid Lusi Diversion site. Monthly spills, shortages, releases, ending storage and water surface elevations at the two reservoirs are then computed. Releases are not called for from Kedungwaru unless a shortage exists at Banjarejo. Banjarejo releases are called for only if river flow at the diversion does not meet the demand.

Operations at the Mid Lusi Diversion are considered next with the total demand being that of Lusi Left and Lusi Right less Ngemplak discharges. Monthly releases, spills and shortages are computed. The monthly values for every site are added to obtain the cumulative annual totals.

Operations are then considered at Kedungombo where the irrigation demand is that of the Upper Sedadi, South Grobogan, Lower Sedadi and Juana Valley service areas less incremental river flows at the respective diversion sites and the South Grobogan supply from Ngemplak and/or Bandungharjo. Power generated as a result of the irrigation release and water that otherwise would have been spilled is computed.

Operations at the three downstream diversions, namely, South Grobogan, Sedadi and Wilalung on the Serang River are then considered. At each point diverted volumes, spills, and irrigation shortages are computed.

Model operations then switch to the western portion of the basin considering first operation of Dolok reservoir and secondly Penggaron reservoir. Shortages at Penggaron are made up from Dolok if possible as previously described.

Operations at Rawa Pening are considered based on requirements at Glapan and Jragung (transbasin diversion) as well as any remaining Penggaron shortage. Operations at Jragung are considered next with provision of diversion to Penggaron in the case shortage still exists at Penggaron. Finally operations at Glapan and Gunung Wulan are considered. Provision of water from Glapan and/or Gunung Wulan is made if possible to make up shortages in the Jragung service area, a limit of 20 percent of the remaining storage at the two sites is imposed on diversion to Jragung.

The model then assesses Tuntang and/or Jragung shortages and, if they occur, calls for diversion of water from the Serang to the extent it is available, and re-evaluates shortages in the Tuntang/Jragung service areas. Power is computed in the UTS, Gunung Wulan and Jragung.

During basin operation the model makes full use of anticipated irrigation return flows, where applicable as previously discussed.

D.7. EVALUATION OF INDIVIDUAL PROJECTS

Carrying out all works necessary for full development of the water resources constitutes a project of considerable magnitude. One step utilized in the planning process was to isolate individual projects and analyze them on their own merit. Later, compatibility of that project with other planned projects was established.

D.7.1. Dolok Reservoir

The Dolok damsite was identified by NEDECO [2] in their 1973 study [1]. The site was also considered as a municipal and industrial water storage site by Burns and McDonnell/Trans-Asia in their 1976 study, "Water Supply Master Plan for the city of Semarang".

As discussed in Appendix C - Part II, Dolok is a technically attractive site with the basic constraint to the development being the small drainage area of only 34 km^2 above the damsite. Examination of existing topographic maps has shown that transbasin diversion of water to the Dolok above the damsite does not appear possible.

D.7.1.a. Operations

A number of operation studies were conducted on this element alone using the "JRAT" model. Utilization of Dolok for irrigation only and in combination with varying municipal and industrial water demands was considered. Results of pertinent operation studies are summarized in Table D-28. In simulations the live storage provided at the site was initially set at 43 million cubic meters which was later reduced to 35 million cubic meters.

Straight line interpolation was utilized to determine the area irrigated at 95 percent firmness except in cases where the computed firmness was between 94.8 and 95.2 percent. In those cases computed service area figures were not changed. Results are summarized in Table D-29.

Without the need to supply municipal and industrial water to Semarang, and with diversion to the Penggaron service area limited to Dolok spill volume, the full 1,950 hectares Dolok service area could be served perennially at an irrigation firmness of 95 percent. Should 250 l/s of municipal and industrial water be supplied to the city of Semarang, 1,560 hectares of the Dolok service area could be served at 95 percent firmness.

For a municipal and industrial diversion rates of 500 and 750 l/s from Dolok, irrigated areas at 95 percent firmness are 996 hectares, and 725 hectares respectively. If 1,000 l/s of municipal and industrial water was to be supplied from Dolok, no dependable perennial irrigation in the Dolok system would be possible.

D.7.1.b. Economics

(i) Costs

Construction cost of Dolok Dam and appurtenances are estimated in Appendix C as $ 14.8 million (excluding land) for 35 million cubic meters live storage, and $ 17.2 million for 43 million cubic meters live storage. The entire reservoir area is covered by teak forest. Land aquisition costs for 350 ha is estimated at $ .56 million . System rehabilitation costs to allow for perennial irrigation are believed similar to those established for Tuntang/Jragung or $ 328/ha. If 35 million cubic meters of live storage and 500 l/s of M & I water are provided (Alternative A) service area costs are set at $ .34 million. In the case of 35 million cubic meters of live storage and irrigation only (Alternative B) and a service area of 1,950 hectares rehabilitation costs total $ .64 million. The project costs for the two alternatives considered are, therefore, $ 15.7 million and $ 16.0 million, respectively.

The operation and maintenance costs for the dam are taken as a fraction of the total cost, and the annual operation and maintenance costs for the irrigation system are set at $ 10.00/ha. Total costs for Alternative A are summarized in Table D-30 and total costs for Alternative B are summarized in Table D-31.

(ii) Benefits

Irrigation benefits are assumed similar to those derived for the Jragung service area and are set at $ 1,406/hectare annually at full development. M & I benefits are based on the raw water value established in Appendix E with an annual benefit of $ 2,481 /l/s. For Alternative A annual benefits are $ 1.40 million for irrigation and $ 1.24 million for M & I. The flood control benefits are estimated at $ .29 million. The total annual benefits at full development are estimated at $ 2.93 million.

(iii) Internal Rate of Return

A four year construction period is assumed for Dolok with a fifteen, thirty, thirty, and twenty-five percent distribution annual capital outlay through the construction period. Full irrigation development is assumed to occur five years after project completion. Summaries of cash flow utilized in computing the Internal Rate of Return are shown in Table D-32 and D-33 for Alternative A and B, and a summary of the economic analyses is presented in Table D-34. A fifty year project life is assumed. The internal rate of return for Alternative A is 11.3 and the resulting internal rate of return for Alternative B is 9.5 . Average annual benefits are $ 2.9 million and $ 3.1 million respectively.

D.7.1.c. Project Viability

It is recognized that the computed IRR of only 11.3 percent for Alternative A (500 l/s of M & I) marks Dolok as a marginal project. Detailed and complete M & I supply economics could raise the IRR considerable. For example, if water supply from Dolok Reservoir is increased to 750 l/s by reducing perennial irrigation area to 650 ha (a third alternative), the economics of the project improves and the IRR increases to 14.6 percent. Dolok Dam project is technically attractive and affords the best opportunity for increasing development in the western subbasins, and thus warrants detailed study. It was therefore retained in a number of development alternatives studied later in the project period.

D.7.2. Penggaron Reservoir

Because of limitations posed by the catchment size, sediment yield, and reservoir size the Penggaron Reservoir must be so operated to bypass wet season flows and sediment during three months out of a year.

D.7.2.a. Operations

A number of operation studies were conducted on this element using the "JRAT" model. Utilization of water for irrigation only, and in conjunction with varying municipal and industrial demands from Semarang were considered. Results of pertinent operation studies are summarized in Table D-35. Straight line interpolation was used to determine the area irrigated at 95 percent firmness. Results are summarized in Table D-36. No diversion to the Penggaron Reservoir from either Dolok or Jragung is allowed in these particular simulations. Without diversion from either Dolok or Jragung and a live storage capacity of 57 million cubic meters at the Penggaron Reservoir with sediment and flow bypassed in December, January and

February, only 1,584 hectares of land could be irrigated perennially. For municipal and industrial diversions of 250 and 500 l/s, the irrigated area drops to 1,285 and 1,056 hectares, respectively.

D.7.2.b. Project Viability

No economic analyses were conducted of this project. Based on the results of the above mentioned operation studies, it was determined early in the project period that further consideration should not be given to the development of the Penggaron damsite. The following reasons precluded further consideration.

1. The site geological conditions are marginal.
2. Sediment yield of the watershed is high. If sediment bypass is provided, it will greatly reduce reservoir storage capacity and its effectiveness to store water for dry season irrigation.
3. More than half (342 hectares) of the reservoir area is presently used for irrigated rice production. The negative benefits of building this project will be substantial on account of permanently losing the irrigated area to the reservoir.
4. Reservoir area is highly populated. The villages which occupy about 125 hectares of the area would require relocation and high cost compensation.
5. Anticipated costs of the project, due to the above given reasons, are very high while the anticipated benefits are low.

D.7.3. Bandungharjo Reservoir

The Serang River plan calls for irrigation of 7,300 hectares in the designated South Grobogan service area. Out of these, 1,680 hectares in the eastern portion of the area would require construction and operation of a low-lift pump station. The Bandungharjo Reservoir as conceived and analyzed by NEDECO was not particularly attractive. However, because of its ability to serve by gravity flow the above mentioned 1,680 hectares, without pumping, it was considered a potential element in the present study.

D.7.3.a. Operations

A number of operation studies were conducted on this element alone using the "JRAT" model. Results of pertinent operation studies are summarized in Table D-37. In all cases the live storage simulated at the site was 22 million cubic meters. As can be seen from the data presented in the table, Bandungharjo cannot meet the irrigation demands of the 1,680 hectares at 95 percent firmness; the irrigation demands of only 1,333 hectares at 95 percent firmness can be met.

D.7.3.b. Project Viability

No economic analysis was performed on the construction of Bandungharjo Dam alone. Results of the operation studies show that Bandungharjo should not be considered alone because of its inability to serve by gravity at 95 percent irrigation firmness the full 1,680 hectares in the South Grobogan service area. The reservoir should be considered in parallel with the Ngemplak Reservoir to determine combined capacity for serving the 1,680 hectares in question plus the 4,200 hectares of area on Lusi Left without diversion from the main stream of the Lusi River.

D.7.4. Ngemplak Reservoir

This proposed reservoir is located on the Peganjing River which is a tributary of the Lusi River and drains the watershed adjoining the Bandungharjo watershed. Storage provided at this location also affords the possibility of irrigation of the eastern portion of the South Grobogan area by gravity for which diversion from Bandungharjo was considered in the preceding section. Because of the larger catchment and larger annual yield coupled with a significantly higher live storage capacity of 68 million cubic meters, possibilities existed that the entire 1,680 hectares of the South Grobogan area could be served from this source. Additionally, a portion of the Lusi left bank area could also be developed for perennial irrigation by this project.

D.7.4.a. Operations

A number of operation studies were conducted on this element alone using the "JRAT" model. Areas irrigated were determined both for Ngemplak alone and in conjunction with the Mid Lusi Diversion with no storage provided upstream from the diversion. Results of pertinent simulations are summarized in Table D-38.

Without supplemental water from the Mid Lusi Diversion, storage at Ngemplak could serve a total service area of 2,880 hectares, (1,680 hectares in the South Grobogan area plus 1,200 hectares of the Lusi left bank area), with perennial irrigation water at 95 percent firmness. Also, with this storage available in the system, an additional 3,000 hectares on the Lusi Left could be irrigated perennially if Mid Lusi run-of-river diversions were made only on the left even without providing any storage on the Lusi River or its upper tributaries.

D.7.4.b. Economics

As may be noted from Table D-38, two approaches of Ngemplak operation were considered. In these cases where releases from Ngemplak and Lusi Diversions to the left compliment each other, the 1,680 hectares portion of South Grobogan and the entire 4,200 hectares of potential on the Lusi left bank can be irrigated. Construction of the Mid Lusi Diversion will however also benefit some area (to be established later in this appendix) on the right bank of the Lusi River. Costs associated with this development would be prorated. No economic analysis was conducted on this combination as it is considered later in the analyses of different project element combinations. Ngemplak alone with an associated irrigation area of 2,880 hectares was subjected to economic analysis.

(i) Costs

Construction cost of Ngemplak Dam and appurtenances including a diversion structure on the Peganjing River is estimated at $ 11.3 million. Land aquisition costs are derived in Table D-39 and total $ 3.95 million. All land to be irrigated is presently unirrigated. Escalated from SMEC estimates [5] service area costs including primary and secondary delivery as well as tertiary development should approximate $ 1,230.00/hectare or $ 3.54 million for the 2,880 hectares service area. O & M costs are derived in the same manner as was done for the Dolok Dam project. Total project costs are summarized in Table D-39.

(ii) Benefits

Benefits as established in Appendix E are $ 1,589/hectare/annum for irrigation of new lands in the proposed service area. Total annual benefits at full development would then be $ 4.58 million.

(iii) Internal Rate of Return

A four - year construction period is assumed for the Ngemplak Dam with a fifteen, thirty, thirty, and twenty-five percent cost distribution through the construction period. Full irrigation development is assumed to occur five years after project completion. Summaries of cash flow utilized in computing the internal rate of return are shown in Table D-40. Total project costs are $ 18.79 million. Average annual benefits over the fifty year period are $ 4.58 million, and the internal rate of return is 14.0. A fifty year project life was assumed in the analysis.

D.7.4.c. Project Viability

The Ngemplak Dam is one of the most attractive small projects identified in the Jratunseluna Basin. Based on its low initial investment of $ 18.79 million and a favorable IRR of 14.0 it was retained in the development plan. Its effectiveness when utilized with the Mid Lusi Diversion makes it an important element and warrants its consideration for early implementation. Elimination of the necessity for pump lift irrigation to the upper portion of the South Grobogan service area is an important benefit which adds to the attractiveness of this project.

D.7.5. Banjarejo Reservoir

The development of the Lusi Subbasin is most severely limited by lack of adequate storage sites in the main system. The Banjarejo damsite has a catchment area of 506 km^2 which calls for a large storage at this location. But unfortunately the maximum live storage capacity at the damsite, which is the only storage site, is only 77 million cubic meters. This is insufficient, even with sediment bypass to reduce need for the dead storage. Water stored at Banjarejo could be beneficially used by diversion at the Mid Lusi Diversion site. However, if the incremental river flows generated between Banjarejo and the Mid Lusi Diversion were not used in conjunction with the Banjarejo storage, the effectiveness of that storage would be seriously limited. Hence Banjarejo storage is considered only in conjunction with the Mid Lusi Diversion.

D.7.5.a. Operations

A number of operation studies simulating this configuration were conducted using the "JRAT" model. Results of the pertinent runs are summarized in Table D-41.

Straight line interpolation of the results shows that an area of 4,642 hectares on the right bank and 3,714 hectares on the left bank of the Lusi River could be perennially irrigated at 95 percent firmness with water from Banjarejo Reservoir.

D.7.5.b. Economics

As explained above Banjarejo is considered only in conjunction with a Mid Lusi Diversion. Therefore, the analysis of the project economy includes the costs and benefits of the Mid Lusi Diversion.

(i) Costs

Construction cost of the Mid Lusi Diversion and Banjarejo Dam and appurtenances is estimated at $ 31.2 million in Appendix C - Part II. Land aquisition costs based on a required 1,300 hectares aquisition are derived in Table D-42 and total $ 6.81 million. All land to be irrigated is presently unirrigated. Escalated from SMEC estimates [5], service area costs including primary and secondary delivery as well as teritary development should approximate $ 1,230.00/hectare or $ 10.3 million for the 8,356 hectares service area. The total project cost is estimated at $ 48.29. O & M costs are derived on the same basis as for the Dolok Dam project. Construction costs are summarized in Table D-43.

(ii) Benefits

Benefits as established in Appendix E - Part II are $ 1,589/hectare/annum for irrigation of new land in the proposed service area. Total annual benefits at full development would be $ 13.28 million.

(iii) Internal Rate of Return

A four-year construction period is assumed for Banjarejo with a fifteen, thirty, thirty, and twenty-five persent cost distribution through the construction period. Full irrigation development is assumed to occur five years after project completion. Summaries of cash flow utilized in computing the internal rate of return are shown in Table D-44. Total project costs are $ 48.29 million. Average annual benefits over the thirty year period assumed for the economic analysis are $ 13.28 million and the internal rate of return is 16.1.

D.7.5.c. Project Viability

This project, in conjunction with Mid Lusi Diversion would supply irrigation water to a total of 8,356 hectares of service area. The project is feasible as analyzed with the available information; however, detailed foundations and material investigations for the dam must be done to substantiate the assumtions made in this study.

The project service area is presently rainfed and will all be new to the proposed perennial irrigation. Therefore, it is advisable to first develop that area for technical irrigation and supplement wet-season irrigation and then at a later stage arrange to supply dry season irrigation. Keeping this consideration in view, the construction of Banjarejo Dam is proposed in the second stage of development; however Mid Lusi Diversion is proposed to be studied in detail and considered for implementation as a high priority project.

D.7.6. Kedungwaru Reservoir

As in the case of Banjarejo, storage at Kedungwaru could be most beneficially exploited, if used only to overcome shortages in the river flows at the Mid Lusi Diversion point. The storage at

Kedungwaru was considered for two reasons: 1) it produces the laregest water yield of all downstream Lusi tributaries and 2) its confluence with the Lusi River is upstream of the Mid Lusi Diversion site. It was felt that even a small live storage of 19 million cubic meters could be beneficial in overcoming shortages at Banjarejo if the two reservoirs were used in conjunction with one another.

D.7.6.a. Operations

A number of operation studies simulating this scheme were conducted. Results of the pertinent runs are summarized in Table D-45.

Straight line interpolation of the results shows that an area of 1,328 hectares on the Lusi left bank and 1,660 hectares on the Lusi right bank could be perennially irrigated at 95 percent firmness. (in coordination with Lusi River flows).

D.7.6.b. Economics

As explained above, Kedungwaru, like Banjarejo is considered only in conjunction with a Mid Lusi Diversion. Therefore diversion cost is assumed a part of project cost.

(i) Costs

Construction cost of the Kedungwaru Dam and appurtenances is estimated at $ 14.7 million in Appendix C - Part II. Construction cost of the diversion is estimated at $ 1.5 million. Land aquisition costs based on a required 400 hectares lost to the reservoir are derived in Table D-46 and total $ 1.61 million. All of the 2,988 hectares of land to be irrigated is presently unirrigated. Escalated from SMEC estimates [5] service area costs including primary and secondary delivery as well as tertiary development should approximate $ 1,230.00/hectare or $ 3.68 million for the 2,988 hectares service area. O & M costs are derived on the same basis as done for the Dolok Dam project. Construction costs are summarized in Table D-47.

(ii) Benefits

Benefits as established in Appendix E - Part II are $ 1,589.00/hectare/annum for irrigation of these new lands. Total annual benefits at full development would be $ 3.68 million.

(iii) Internal Rate of Return

A four-year construction period is assumed for Banjarejo with a fifteen, thirty, thirty, and twenty-five percent cost distribution through the construction period. Full irrigation development is assumed to occur five years after project completion. Summaries of cash flow utilized in computing the internal rate of return are shown in Table D-48. Total project costs are $ 21.49 million. Average annual benefits over the fifty-year period assumed for the economic analysis are $ 4.75 million and the internal rate of return is 11.9 percent. (For Kedungwaru Dam alone, without the Mid Lusi Diversion, the internal rate of return is 8.0 percent).

D.7.6.c. Project Viability

If considered in an individual capacity, the project does not show a favorable economic rate of return. However, in conjunction with the Banjarejo Dam and the Mid Lusi Diversion, the storage at Kedungwaru would increase the perennial irrigation service area along Lusi by about 1,660 hectares. Therefore, due to the same reasons given for the Banjarejo Dam, this project may be considered for implementation at a later stage after the rainfed service area along the Lusi has been converted into technically irrigated area.

TABLE D-28

OPERATION STUDIES ON THE DOLOK RESERVOIR

Run No.	Irrigated Area (ha)	Irrigation Firmness (%)	M & I Supplied (l/s)
1	1,950	95.2	0
2	2,145	91.7	0
3	2,340	86.5	0
9	1,755	90.1	250
10	1,560	94.8	250
11	1,365	96.8	250
14	1,560	84.5	500
15	1,170	92.9	500
16	780	97.6	500
19	975	91.1	750
20	585	96.8	750
23	780	79.4	1,000
24	390	90.9	1,000

TABLE D-29

POSSIBLE MULTIPLE USE OF DOLOK WATERS

M & I Diversion (l/s)	Irrigated Area (ha)	Irrigation Firmness (%)
0	1,950	95.2
250	1,560	94.8
500	996	95.0
750	725	95.0

TABLE D-30

PROJECT COSTS - DOLOK RESERVOIR (35×10^6 m^3) - IRRIGATION OF 996 ha WITH 500 L/S M & I SUPPLY

ALTERNATIVE A

No.	Item	Cost ($\$ \times 10^6$)
1.	Land Aquistion	.56
2.	Dam and Appurtences	14.80
3.	Service Area Rehabilitation	.34
	Total:	15.70

TABLE D-31

PROJECT COSTS - DOLOK RESERVOIR (35×10^6 m^3) - IRRIGATION OF 1,950 ha NO M & I SUPPLY

ALTERNATIVE B

No.	Item	Cost ($\$ \times 10^6$)
1.	Land Aquisition	.56
2.	Dam and Appurtences	14.80
3.	Service Area Rehabilitation	.64
	Total:	16.00

TABLE D-32

DOLOK - IRRIGATION PLUS 500 l/s M & I (ALTERNATIVE A)

CASH FLOW

Year	Costs		Benefits					Cash Flow	Number of Years
	Construction	Total	Irrigation	Power	M & I	Flood Control	Total		
1	2.4	2.4	-	-	-	-	-	-2.4	1
2	4.7	4.7	-	-	-	-	-	-4.7	1
3	4.7	4.7	-	-	-	-	-	-4.7	1
4	3.9	3.9	-	-	-	-	-	-3.9	1
5	-	0.5	.28	-	1.24	.29	1.81	1.76	1
6	-	0.5	.56	-	1.24	.29	2.09	2.04	1
7	-	0.5	.84	-	1.24	.29	2.27	2.32	1
8	-	0.5	1.12	-	1.24	.29	2.65	2.6	1
9 - 30	-	0.5	1.4	-	1.24	.29	2.93	2.88	23

IRR = 11.3 %

TABLE D-33

DOLOK - IRRIGATION ONLY - (ALTERNATIVE B)

CASH FLOW

Year	Costs		Benefits				Cash Flow	Number of Years
	Construction	Total	Irrigation	Power	Flood Control	Total		
1	2.4	2.4	-	-	-	-	-2.4	1
2	4.8	4.8	-	-	-	-	-4.8	1
3	4.8	4.8	-	-	-	-	-4.8	1
4	4.0	4.0	-	-	-	-	-4.0	1
5	-	0.6	.55	-	.29	.84	+ .78	1
6	-	0.6	1.10	-	.29	1.39	+1.33	1
7	-	0.6	1.64	-	.29	1.93	1.87	1
8	-	0.6	2.19	-	.29	2.48	2.42	1
9 - 30	-	0.6	2.74	-	.29	3.03	2.97	42

IRR = 9.53%

TABLE D-34

ECONOMIC ANALYSES - DOLOK ALONE

ALTERNATIVES A & B

Alternative	Live Storage (10^6 m^3)	Project Cost ($\$ \times 10^6$)	Annual Benefits ($\$ \times 10^6$)	M & I (l/s)	Irrigated Area (ha)	IRR (%)
A	35	15.8	2.9	500.0	996	11.3
B	43	16.0	3.0	0.0	1,950	9.5

TABLE D-35

OPERATION STUDIES ON THE PENGGARON RESERVOIR

Run No.	Irrigated Area (ha)	Irrigation Firmness (%)	M & I Supplied (l/s)
51	3,960	75.0	0
52	2,970	83.7	0
53	1,980	91.3	0
54	990	98.8	0
55	2,970	79.4	250
56	1,980	87.3	250
57	990	98.4	250
58	1,980	85.7	500
59	990	95.6	500
60	445	98.8	500

TABLE D-36

POSSIBLE MULTIPLE USE OF PENGGARON WATERS

M & I Diversion (l/s)	Irrigated Area (ha)	Irrigation Firmness (%)
0	1,584	95.0
250	1,285	95.0
500	1,056	95.0

TABLE D-37

OPERATION STUDIES ON BANDUNGHARJO RESERVOIR

Run No.	Irrigated Area (ha)	Irrigation Firmness (%)
40	1,333	95.2
41	1,007	100.0

TABLE D-38

OPERATION STUDIES ON NGEMPLAK RESERVOIR WITH AND WITHOUT MID LUSI DIVERSION

Run No.	Ngemplak Alone			Ngemplak with Mid Lusi Diversion *		
	Irrigated Area		Irrigation	Irrigated Area		Irrigation
	South Grobogan (ha)	Lusi Left (ha)	Firmness (%)	South Grobogan (ha)	Lusi Left (ha)	Firmness (%)
50	1,680	4,000	67.5	1,680	4,000	100.0
82-B	1,680	3,600	69.8	1,680	3,600	100.0
83	1,680	3,200	72.2	1,680	3,200	100.0
84	1,680	2,800	75.8	1,680	2,800	100.0
91	1,680	2,000	83.7	1,680	2,000	100.0
93	1,680	1,200	95.2	1,680	1,200	100.0

* No storage upstream of Mid Lusi Diversion

TABLE D-39

TOTAL COSTS NGEMPLAK DAM PROJECT

1. LAND AQUISITION COSTS - NGEMPLAK - 1,000 hectares

Land Use	Unit Price ($Rp \times 10^6$/ha)	Area (ha)	Cost ($Rp \times 10^6$)
Irrigation Riceland	5	200	1,000
Dry Fields	2	200	400
Villages	3	200	600
Forest	1	450	450
		Total:	2,450
			$ 3.95 x 10^6

2. PROJECT COSTS (IRRIGATION AREA 2,880 hectares)

No.	Item	Cost ($ x 10^6)
1	Land Aquisiton	3.95
2	Dam & Appurtenances	11.3
3	Delivery & Dist. System	3.54
	Total:	18.79

TABLE D-40

NGEMPLAK ALONE

CALCULATION OF INTERNAL RATE OF RETURN (IRR)

Year	Costs		Benefits				Cash Flow	Number of Years
	Construction	Total	Irrigation	Power	M & I	Total		
1	2.82	2.82	-	-	-	-	-2.82	1
2	5.64	5.64	-	-	-	-	-5.64	1
3	5.64	5.64	-	-	-	-	-5.64	1
4	4.69	4.69	-	-	-	-	-4.69	1
5	-	.06	.92	-	-	.92	.86	1
6	-	.06	1.83	-	-	1.83	1.77	1
7	-	.06	2.75	-	-	2.75	2.69	1
8	-	.06	3.66	-	-	3.66	3.60	1
9 - 50	-	.0	4.58	-	-	4.58	4.52	42

IRR = 14.0

TABLE D-41

OPERATION STUDIES ON BANJAREJO RESERVOIR
WITH MID LUSI DIVERSION

Run No.	Irrigated Area		Irrigation Firmness	
	Lusi Left (ha)	Lusi Right (ha)	Lusi Left (%)	Lusi Right (%)
29	7,200	9,000	79.8	79.8
28	6,400	8,000	86.1	86.1
25	4,000	5,000	94.0	94.0
30	3,200	4,000	96.8	96.8
31	2,400	3,000	99.6	99.6

TABLE D-42

LAND AQUISITION COSTS - BANJAREJO - 1,300 ha

Land Use	Percent of Area	Unit Price ($Rp \times 10^6$/ha)	Area (ha)	Cost ($Rp \times 10^6$)
Villages	20	3	260	780
Irrigated Rice	40	5	520	2,600
Dry Fields	25	2	325	650
Forest	15	1	195	195

Total: Rp $4,225 \times 10^6$
$\$ 6.81 \times 10^6$

TABLE D-43

PROJECT COSTS - BANJAREJO DAM PROJECT
INCLUDING MID LUSI DIVERSION

No.	Item	Cost ($ x 10^6)
1	Land Aquisition	6.81
2	Dam and Appurtenances	31.20
3	Diversion Dam	
4	Service Area Irrigation System	10.28
	Total:	48.29

TABLE D-44

BANJAREJO DAM PROJECT

INTERNAL RATE OF RETURN

Year	Costs		Benefits				Cash Flow	Number of Years
	Construction	Total	Irrigation	Power	M & I	Total		
1	7.24	7.24	-	-	-	-	-7.24	1
2	14.49	14.49	-	-	-	-	-14.49	1
3	14.49	14.49	-	-	-	-	-14.49	1
4	12.07	12.07	-	-	-	-	-12.07	1
5	-	.16	2.66	-	-	2.66	+2.46	1
6	-	.16	5.31	-	-	5.31	+5.15	1
7	-	.16	7.97	-	-	7.97	+7.81	1
8	-	.16	10.62	-	-	10.62	+10.46	1
9 - 50	-	.16	13.28	-	-	13.28	+13.12	42

IRR = 16.1%

TABLE D-45

OPERATION STUDIES ON KEDUNGWARU RESERVOIR
WITH MID LUSI DIVERSION

Run No.	Irrigated Area		Irrigation Firmness	
	Lusi Left (ha)	Lusi Right (ha)	Lusi Left (%)	Lusi Right (%)
34	2,400	3,000	89.3	89.3
35	1,600	2,000	93.3	93.3
36	800	1,000	98.8	98.8
37	400	500	100.0	100.0

TABLE D-46

LAND AQUISITION COSTS AT KEDUNGWARU

Land Use	Percent of Area	Unit Price (Rp x 10^6/ha)	Area (ha)	Cost (Rp x 10^6)
Villages	10	3	40	120
Irrigated Rice	30	5	120	600
Dry Fields	10	2	40	80
Forest	50	1	200	200
			Total:	Rp 1,000 x 10^6
				$ 1.61 x 10^6

TABLE D-47

PROJECT COSTS KEDUNGWARU DAM PROJECT

No.	Item	Cost ($ x 10^6)
1	Land Aquisition	1.61
2	Dam and Appurtenances	14.7
3	Diversion Dam	1.5
4	Service Area Irrigation System	3.68
	Total:	21.49

TABLE D-48

KEDUNGWARU DAM & MID LUSI DIVERSION

INTERNAL RATE OF RETURN

Year	Cost		Benefits		Cash Flow	Years
	Construction	Total	Irrigation	Total		
1	3.22	3.22	-	-	-3.22	1
2	6.45	6.45	-	-	-6.45	1
3	6.45	6.45	-	-	-6.45	1
4	5.37	5.37	-	-	-5.37	1
5	-	.07	.95	.95	+ .88	1
6	-	.07	1.9	1.9	+ .83	1
7	-	.07	2.85	2.85	+2.78	1
8	-	.07	3.8	3.8	+3.73	1
9 - 50	-	.07	4.75	4.75	+4.68	42

IRR = 11.9%

D.8. EFFECTS OF SERANG - TUNTANG DIVERSION ON PLANS DEVELOPED IN THE TUNTANG/JRAGUNG INTEGRATED DEVELOPMENT PLAN

In the Tuntang/Jragung Integrated Development Plan in Part I of this appendix, it was determined that if Rawa Pening were raised to afford 125 million cubic meters of live storage and Glapan Barrage constructed so as to provide 87 million cubic meters of live storage, 20,907 hectares of the Tuntang/Jragung service areas could receive perennial irrigation water at 95 percent firmness.

D.8.1. Operations

Runs number 61, 62 and 63 simulated this condition but allowed for the possibility of diversion from the Serang to the Tuntang/Jragung system to make up shortages in that system. The Serang River Development Plan as proposed by SMEC [3] was imposed on the eastern side of the basin. Runs number 65, 66, 67 and 68 simulated similar conditions but considered only 10,000 hectares rather than 15,000 hectares in the Juana Valley served from the Serang system. Results are summarized in Table D-48.

In the case where 15,000 hectares are irrigated in the Juana Valley, straight line interpolation of results of runs shows that 14,874 hectares on the Tuntang and 7,649 hectares on the Jragung could be irrigated at 95 percent firmness with annual average diversion of only around 1 million cubic meters from the Serang River. In many years shortages do not occur, thus, actual volume diverted during any shortage period would be greater than the average annual. The total area on the Tuntang/Jragung system of 22,523 hectares represents an increase of only 1,616 hectares or 7 percent as a result of Serang-Tuntang Diversion.

Note: This result has to be compared to something to come up with the finding that there is a distinct advantage of not diverting to Tuntang/Jragung.

Runs 65 through 68 summarized in Table D-49 show that with the present operational rules applied in the model for diversion, any reduction in demand at Wilalung simply firms up supplies at Serang Diversion points does not increase firmness at Jragung or Tuntang.

The differences in firmness at South Grobogan, Upper Sedadi and Wilalung is noticeable. This is due to the operational rules governing Kedungombo releases and selection of service area diversion points. Since the firmness averages ± 95 percent, these differences would not affect insignificantly the result of this study.

D.8.2. Findings

The findings presented above indicate a distinct increase of benefits in the use of excess Lusi/Serang waters, which would spill at Wilalung, for an expanded Lusi development as compared to a Serang to Tuntang Diversion.

TABLE D-49

OPERATION STUDIES TO DETERMINE BENEFITS FROM SERANG/TUNTANG/JRAGUNG DIVERSION

WITH SERANG PLAN AND PHASES 1 AND 2

OF THE TUNTANG/JRAGUNG PLAN IMPLEMENTED

Run No.	Storage Capacities Kedung-ombo (10^6 m^3)	Pawa Pening (10^6 m^3)	Glapan (10^6 m^3)	Irrigated Areas South Grobogan (ha)	Upper Sedadi (ha)	Lower Sedadi (ha)	Juana Valley (ha)	Tuntang (ha)	Jragung (ha)	Irrigation Firmness South Grobogan (%)	Uppor Sedadi (%)	Wilalung (%)	Tuntang (%)	Jragung (%)	Average Annual Ser-Tun Div. (10^6 m^3)	M... Mun... (1...
61	655	125	87	7,300	19,800	17,400	15,000	18,700	9,300	96.0	93.3	95.2	90.5	92.5	4.2	2,
62	655	125	87	7,300	19,800	17,400	15,000	14,025	6,975	96.0	93.3	95.2	96.0	96.0	.6	2,
63	655	125	87	7,300	19,800	17,400	15,000	11,688	5,813	96.0	93.3	95.2	99.2	96.8	.5	2,
65	655	125	87	7,300	19,800	17,400	10,000	23,375	11,625	97.2	94.8	96.8	84.5	87.7	14.2	2,
66	655	125	87	7,300	19,800	17,400	10,000	18,700	9,300	97.2	94.8	96.8	90.5	92.5	4.6	2,
67	655	125	87	7,300	19,800	17,400	10,000	14,205	6,975	96.0	94.6	96.8	96	96	.6	2,
68	655	125	87	7,300	19,800	17,400	10,000	11,688	5,813	97.2	94.8	96.8	99.2	96.8	.5	2,

D.9. MAXIMIZING DEVELOPMENT ON THE LUSI RIVER

Consideration was given to the possibility that maximization of development along the Lusi River might have adverse effects on the Serang River project in which the Lusi run-of-river flows at Wilalung are used. Therefore, the following planning steps were taken.

1. Look at different packages of projects on the Lusi River and its tributaries.

2. Select with reason an attractive package of projects and operate for optimization of sizes and capacities.

3. Impose the selected array and the Serang River project on the model and evaluate the effect of the Lusi Development on the Serang project.

4. Reduce the irrigated area in the Juana Valley (reduce or eliminate lift area if necessary) until desired firmness is obtained throughout the Serang system.

D.9.1. Ngemplak and Bandungharjo in Parallel to Serve the Lusi Left Bank

As previously established Bandungharjo Reservoir alone will not meet the irrigation demands of the upper 1,680 hectares of South Grobogan alone and it appears not necessary to give further attention to Bandungharjo. Likewise it was established that Ngemplak alone could serve the 1,680 hectares of South Grobogan plus 1,200 hectares of the Lusi left bank area without any diversion from the main stream of the Lusi River. It was further established in D.7.4.a. that Ngemplak complimented by Mid Lusi Diversion to the left bank could easily serve the full Mid Lusi area of 4,200 hectares plus the 1,680 hectares South Grobogan area. A check was made, then, to ascertain if Ngemplak in parallel with Bandungharjo could meet both Lusi left bank and Upper South Grobogan demands without diversion from the Lusi.

D.9.1.a. Operations

Runs 94, 95 and 96 were made for this determination. In each run live storages of 22 million cubic meters and 68 million cubic meters were provided at Bandungharjo and Ngemplak, respectively. The results of the runs are summarized in Table D-50.

Straight line interpolation shows that these two sites together could serve the 1,680 hectares of South Grobogan plus 2,954 hectares of the Lusi left service area with perennial irrigation water at 95 percent firmness.

To irrigate the total left bank area diversion from the Lusi would be required.

D.9.1.b. Project Viability

It is apparent that diversion from Mid Lusi is necessary even with the two reservoirs if the 4,200 hectares of potential irrigation area identified on the left bank of the Lusi River are to be adequately served.

As discussed in Appendix C, Bandungharjo is at best a marginal site. Considerable upstream blanketing of the abutment ridges is required to ensure safety of the dam. To protect Desa Klampit which is located very close to the only site available for the spillway, an elaborate spillway structure is necessary. Due to these reasons and the fact that diversion at Mid Lusi would still be required if the total area on the Lusi left bank is to be supplied with perennial irrigation, the Bandungharjo site was dropped from further consideration.

D.9.2. Ngemplak, Banjarejo and the Mid Lusi Diversion

Two storage sites, Ngemplak and Banjarejo and the Mid Lusi Diversion were considered in conjunction with each other with respect to serving the upper 1,680 hectares of South Grobogan, which require pumped irrigation if served from the Serang River, and both the Lusi left bank and Lusi right bank service areas.

D.9.2.a. Operations

A number of operation studies were run simulating the particular combination. These are summarized in Table D-51. This particular array of elements will effectively serve the upper 1,680 hectares of land in South Grobogan, the 4,200 hectares on the left bank and 5,700 hectares on the right bank of the Lusi River. Total area thus served is 11,580 hectares.

D.9.2.b. Economics

(i) Costs

The construction costs for all the elements of this combination are summarized in Table D-52. Total cost is estimated at $ 68.5 million.

(ii) Benefits

Benefits as established in Appendix E - Part I are $ 1,589 /hectare/annum for irrigation of these new lands. Total annual benefits at full development would then be $ 18.4 million.

(iii) Internal Rate of Return

A four-year construction period is assumed for Mid Lusi, and three and four years construction periods are assumed for the Ngemplak and the Banjarejo Dams respectively. The Mid Lusi Diversion is started first followed after two years by the Banjarejo Dam and the Ngemplak Dam.

Full irrigation development for each phase is assumed to occur five years after project completion. Summaries of cash flows used in computing the internal rate of return are shown in Table D-54. Phasing of the development is shown in Table D-53. Total costs are $ 68.5 million. Average annual benefits over the fifty year period are $ 18.4 million and the internal rate of return is 15.9.

D.9.2. Sub-Development Viability

The project shows an acceptable internal rate of return and is compatible with the overall development objectives of the Lusi Basin. After the Mid Lusi Diversion has been constructed and the irrigation service areas are adapted to technical irrigation, dry season flows from the Banjarejo and the Ngemplak Reservoirs would convert 11,580 hectares of wet season irrigation areas to perennial irrigation areas. The project, therefore, warrants consideration and should be phased in the earlier years of implementation of the overall development plan.

D.9.3. Ngemplak, Banjarejo, Kedungwaru and the Mid Lusi Diversion

In this study three storage sites and the Mid Lusi Diversion were considered in conjunction with one another with respect to serving the upper 1,680 hectares of South Grobogan and both the Lusi left bank and the Lusi right bank areas. The objective is to increase perennial irrigation area from the Mid Lusi Diversion.

D.9.3.a. Operations

A number of operations studies were performed simulating this particular combination of elements. These are summarized in Table D-55. These three storage sites together will irrigate 12,880 hectares comprising 1,680 hectares on the Upper South Grobogan, 4,200 hectares on the Lusi left bank and, 7,000 hectares on the Lusi right bank. This totals only 1,300 hectares more than the area served by the same combination of elements but without Kedungwaru which is disccused in the preceding Section D.9.2.

D.9.3.b. Economics

(i) Costs

Construction costs of $ 86.4 million for all applicable array items are summarized in Table D-56.

(ii) Benefits

Benefits as established in Appendix E - Part I are $ 1,589/hectare/annum for irrigation of these new lands. Total annual benefits at full development would then be $ 20.47 million.

(iii) Internal Rate of Return

The phasing of the projects and the period of construction of each project are shown in Table D-57. Full irrigation development for each phase of the sub-development is assumed to occur five years after project completion. The phasing of the development proposed is also shown in Table D-57. A summary of cash flow used in computing the internal rate of return is shown in Table D-58. Total costs are $ 86.41 million.

Average annual benefits over the fifty year period are $ 20.5 million and the internal rate of return is 14.8.

D.9.3.c. Sub-Development Viability

The Kedungwaru Dam, as an individual project, is not economically attractive. However, in conjunction with the Banjarejo and the Ngemplak Reservoirs, it can increase the irrigation service area off Mid Lusi Diversion by 1,300 hectares.

The implementation of this project should depend upon the success achieved in developing the areas around the Lusi River from rainfed to technical irrigation. If those areas show good development potential, Kedungwaru Dam may become a desirable project to increase perennial irrigation. The economic rate of return of this overall scheme is favorable.

D.9.4. Evaluation of the Effects of Maximum Mid Lusi Development on the Serang River Project as Planned

The maximum development considered on the Lusi was exemplified in the sub-development array analyzed in Section D.9.3. that consisted of provision of storage at Ngemplak, Banjarejo and Kedungwaru in combination with construction of the Mid Lusi Diversion. A total perennially irrigated area of 12,880 hectares can be served. As agreed early in these planning studies no basic changes in the existing Serang River Development Plan should be made. The Serang River plan basically provides 655 million cubic meters of live storage at Kedungombo and is projected to serve 7,300 hectares at South Grobogan, 19,800 hectares in the Upper Sedadi, 17,400 hectares in the Lower Sedadi and between 10,000 and 15,000 hectares in the Juana Valley. Approximately 1,680 hectares of the proposed South Grobogan service area and 5,000 hectares of the Juana Valley service area would require low lift pump stations to achieve command. The plan called for maximum beneficial use of run-of-river flows of the Lusi and Lower Serang at Wilalung by diverting at that point to both the Juana Valley and the Lower Sedadi area.

Either Lusi development scheme, discussed in Section D.9.2. and Section D.9.3. could have adverse effects on the plan in that flows at Wilalung below the Serang-Lusi confluence would be reduced thus increasing the demands on storage at Kedungombo. On the other hand demand on Kedungombo from South Grobogan is reduced with the introduction of Ngemplak which would serve approximately 23 percent of the designated South Grobogan area. Appropriate studies imposing maximum Lusi Development and the Serang River plan on the combined water resources of the Lusi-Serang Subbasins were conducted.

D.9.4.1. Operation Studies

Several operation studies were conducted to establish the compatibility of the Lusi Development with the planned Serang Development. These are summarized in Table D-59.

Run 98 simulates development on the Serang River as currently planned. The only changes introduced are 1) the same cropping pattern of 3 rice crops on 75 percent of the area at full development as on the Tuntang system is applied to the Serang areas and; 2) the reservoir operation at Kedungombo is based strictly on downstream irrigation demand, with no requirement for the generation of firm power.

As pointed out earlier, firmness at South Grobogan, Upper Sedadi, Lower Sedadi and the Juana Valley vary slightly due to operational rules established at the Kedungombo Reservoir and the South Grobogan, Sedadi and Wilalung Diversion structures. Average firmness obtained of perennial irrigation is near 95 percent.

Referring again to Table D-59, Run number 131, the maximum Lusi development established in Section D.9.3. is imposed on the Serang Plan simulated in Run number 98. Irrigation firmness at South Grobogan increases because of the additional water from Ngemplak. Approximately 20 percent of the water released from Kedungombo in Run number 98 specifically for South Grobogan is available at Wilalung.

In Run number 131, it is evident that if full development of projected areas in South Grobogan, along the Lusi River, Upper and Lower Sedadi and the Juana Valley is considered, the available storages cannot meet the irrigation requirements at or about 95 percent firmness.

A portion of the Juana Valley area will require pumped irrigation. Therefore, to make up shortages in the other irrigation service areas the logical choice would be to reduce the Juana Valley area. This was done in Runs number 148 and 149. All proposed irrigation areas can be served with perennial water at or about 95 percent firmenss if the Juana Valley area is reduced to 12,000 hectares. The boundary between the Upper and Lower Sedadi areas is adjustable; therefore irrigation firmness in both the areas will average 95 percent. Thus, the combination of storage, diversion and irrigation service areas shown in Run number 148 is the optimum solution for development of water resources of the aestern part of the Jratunseluna Basin, namely the Serang and Lusi River Subbasins.

TABLE D-50

OPERATION STUDIES - NGEMPLAK AND BANDUNGHARJO IN PARALLEL

WITHOUT LUSI DIVERSION

Run No.	Storage Provided		Area Irrigated		Irrigation Firmness
	Bandungharjo (10^6 m^3)	Ngemplak (10^6 m^3)	South Grobogan (ha)	Lusi Left (ha)	(%)
94	22	68	1,680	4,000	81.7
95	22	68	1,680	3,200	92.9
96	22	68	1,680	2,400	96.8

TABLE D-51

OPERATION STUDIES, BANJAREJO, NGEMPLAK AND MID LUSI DIVERSION

IN CONJUNCTION WITH ONE ANOTHER

Run	Area Irrigated			Irrigation Firmness		
No.	Lusi Left (ha)	Lusi Right (ha)	South Grobogan (ha)	Lusi Left (%)	Lusi Right (%)	South Grobogan (%)
108	4,000	5,000	1,680	96.4	96.4	100.0
109	3,600	4,500	1,680	98.8	98.8	100.0
110	* 4,400	5,500	1,680	95.2	95.2	100.0
111	4,800	6,000	1,680	94.0	94.0	100.0
112	5,600	7,000	1,680	90.9	90.9	100.0

* Any area over 4,200 ha on Left Bank may be transferred to right bank. i.e. Run 110 results would be applicable to 4,200 ha on the left bank and 5,700 ha on the right bank.

TABLE D-52

COSTS - BANJAREJO + NGEMPLAK + MID LUSI DIVERSION

Item No.	Description	Cost ($ x 10^6)
1.	Mid Lusi Diversion (land & structure)	4.30
2.	Land aquisition Ngemplak	3.95
3.	Land aquisiton Banjarejo	6.81
4.	Construction Ngemplak	11.30
5.	Construction Banjarejo	27.9
6	Distribution and Delivery	14.2
	Total:	68.5

TABLE D-53

PHASING - SUB-DEVELOPMENT INVOLVING

BANJAREJO, NGEMPLAK AND THE MID LUSI DIVERSION

Year	Construction		Irrigated Area		
	Start	Complete	South Grobogan (ha)	Lusi Left (ha)	Lusi Right (ha)
1	Banjarejo & Mid Lusi	↓	-	-	-
2	↓	↓	-	-	-
3	↓	Banjarejo & Mid Lusi	-	-	-
4	Ngemplak	↓	-	3,000	5,356
5	↓	Ngemplak	-	3,000	5,356
6			1,680	4,200	5,356
7			1,680	4,200	5,356
8			↓	↓	↓

TABLE D-54

NGEMPLAK, BANJAREJO & MID LUSI DIVERSION

CASH FLOW

Year	Costs		Benefits		Cash Flow	Years
	Construction*	Total	Irrigation	Total		
1	10.28	10.28	-	-	-10.28	1
2	20.55	20.55	-	-	-20.55	1
3	20.55	20.55	-	-	-20.55	1
4	17.30	17.30	-	-	-17.33	1
5	-	.23	3.68	3.68	+ 3.45	1
6	-	-	7.36	7.36	+ 7.13	1
7	-	-	11.04	11.04	+10.81	1
8	-	-	14.72	14.72	+14.49	1
9 - 50	-	-	18.4	18.4	+18.17	42

IRR = 15.9%

* Concurrent construction of the components is shown here for computing the IRR. The proposed phasing of the components is discussed in D.9.2.

TABLE D-55

OPERATION STUDIES

BANJAREJO, NGEMPLAK, KEDUNGWARU AND THE MID LUSI DIVERSION

IN COMBINATION *

Run No.	Area Irrigated Lusi Left (ha)	Area Irrigated Lusi Right (ha)	Area Irrigated South Grobogan (ha)	Irrigation Firmness Lusi Left (%)	Irrigation Firmness Lusi Right (%)	Irrigation Firmness South Grobogan** (%)
125	4,200	6,000	1,680	96.0	96.0	95
126	4,200	7,000	1,680	94.8	94.8	95
123	4,200	9,000	1,680	93.7	93.7	95

* Live Storage: Banjarejo - 77 x 10^6 m^3
Kedungwaru - 19 x 10^6 m^3
Ngemplak - 68 x 10^6 m^3

** Estimated.

TABLE D-56

COSTS - BANJAREJO + NGEMPLAK + MID LUSI DIVERSION

Item No.	Description	Cost ($ x 10^6)
1.	Mid Lusi Diversion (land & structure)	4.30
2.	Land Aquisition Ngemplak	3.95
3.	Land Aquisition Banjarejo	6.81
4.	Land Aquisition Kedungwaru	1.6
5.	Construction Ngemplak	11.30
6.	Construction Banjarejo	27.9
7.	Construction Kedungwaru	17.91
8.	Distribution and Delivery	14.2
	Total:	86.41

TABLE D-57

PHASING - SUB-DEVELOPMENT INVOLVING

BANJAREJO, NGEMPLAK, KEDUNGWARU AND THE MID LUSI DIVERSION

Year	Construction		Irrigated Area		
	Start	Complete	South Grobogan (ha)	Lusi Left (ha)	Lusi Right (ha)
1	Banjarejo & Mid Lusi	↓	-	-	-
2	↓		-	-	-
3		↓	-	-	-
4		Banjarejo & Mid Lusi	-	3,000	5,356
5	Ngemplak & Kedungwaru		-	3,000	5,356
6	-	Ngemplak & Kedungwaru	1,680	4,200	7,000
7	-	-	1,680	4,200	7,000
8	-	-	↓	↓	↓

TABLE D-58

NGEMPLAK, BANJAREJO, KEDUNGWARU & MID LUSI DIVERSION

CASH FLOW

Year	Costs		Benefits		Cash Flow	Years
	Construction*	Total	Irrigation	Total		
1	12.97	12.97	-	-	-12.97	1
2	25.92	25.92	-	-	-25.92	1
3	25.92	25.92	-	-	-25.92	1
4	21.60	21.60	-	-	-21.60	1
5	-	.27	4.09	4.09	+ 3.82	1
6	-	.27	8.18	8.18	+ 7.91	1
7	-	.27	12.27	12.27	+12.0	1
8	-	.27	16.36	16.36	+16.09	1
9 - 50	-	.27	20.47	20.47	+20.20	42

IRR = 14.8%

* Concurrent construction of the components is shown here for computing the IRR, the proposed phasing is discussed in D.9.3.

TABLE D-59

SUMMARY OF MODEL RUNS CHECKING COMPATIBILITY OF SERANG AND LUSI DEVELOPMENT

Run	Storage				Irrigated Area						Irrigation Firmness						Po
No.	Kedung-ombo (10^6 m^3)	Ngem-plak (10^6 m^3)	Banja-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 (%)	Ke ((
98	655	0	0	0	7,300	0	0	19,800	17,400	15,000	96.0	-	-	93.3	95.2	95.2	[illegible]
131	655	68	77	19	7,300	4,200	7,000	19,800	17,400	15,000	96.8	94.8	94.8	92.9	94.0	94.0	[illegible]
148	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	[illegible]
149	655	68	77	19	7,300	4,200	7,000	19,800	17,400	10,050	98.0	94.8	94.8	94.8	96.0	96.0	[illegible]

D.10. MAXIMIZING DEVELOPMENT IN THE TUNTANG/JRAGUNG/DOLOK/PENGGARON SUBBASINS

Part I of the study dealt specifically with the integrated development of the Tuntang and Jragung Rivers. In this extended study little effort was expended on these two subbasins isolated from the remainder of basin as these possibilities were fully explored and are the exclusive subject of part I of this appendix. Findings reached and discussed in Section D.8. indicate a distinct advantage in total benefits which can be obtained from a maximum Lusi River development rather than from attempting to make excess Serang project water available to the Tuntang/Jragung/Penggaron/Dolok development. Therefore, the integrated development of Tuntang/Jragung with Penggaron and Dolok may for all practical purposes be considered separately from development of the Lusi/Serang.

D.10.1. Operation Studies - West Side Maximum Development

The following discussion deals with the Tuntang-Jragung Development Plan which is presented for three conditions; Case I, Case II and Case III.

Case I includes live storage capacity of 175 million cubic meters at Rawa Pening, 190 million cubic meters at Gunung Wulan and 87 million cubic meters at Glapan, and a transbasin diversion from the Tuntang River to the Jragung River. The storage provided at Dolok is 35 million cubic meters.

In this case, it is assumed that sociological and practical constraints to raising of Rawa Pening without levees can be overcome. As discussed in Section D.7.2. a decision was reached early in these planning studies that further consideration should not be given to the construction of Penggaron Dam and Reservoir. It also was established in Part I of these studies that further consideration should not be given to the construction of Jragung Dam and Reservoir if alternative storage sites at Rawa Pening, Glapan and ultimately at Gunung Wulan will be provided. Maximum development of the four subbasins then consists of raising of Rawa Pening and construction of Glapan Barrage, Gunung Wulan and Dolok.

In Case II, live storage capacities of 125 million cubic meters and 260 million cubic meters were provided at Rawa Pening and Gunung Wulan, respectively. The transbasin diversion from Tuntang to Jragung is also included in this case. Both schemes provided identical benefits, i.e. perennial irrigation at 95 percent firmness of 35,000 hectares and 2,000 l/s of M & I water from Muncul Springs. For the original study the development of the Dolok and Penggaron Subbasins was not considered.

In Case III Rawa Pening remains at its present storage capacity of 43 million cubic meters. Storage reservoirs are provided at Jragung and Gunung Wulan with capacities of 75 million and 260 million cubic meters, respectively. The Tuntang to Jragung Diversion is part of this case. Perennial irrigation is provided to 9,300 hectares in the Tuntang service area and 11,625 hectares at Jragung. Water to Semarang can be delivered from Jragung, Muncul Springs and Dolok at the required 4,000 l/s.

D.10.1.1. Operations

For updating the development plan for the Jratunseluna Basin, all the subbasins were included in the study. In the western part of the basin, the Dolok and Penggaron Subbasins were grouped with the Tuntang/Jragung Subbasins for which an integrated development plan had earlier been proposed and operation study carried out. A dam on the Penggaron River, due to reasons explained elsewhere in this report, was dropped from further consideration. The operation study was thus confirmed to the reservoirs on the Tuntang, Jragung and the Dolok Rivers. The results of the operation study show that if Dolok Dam is constructed for irrigation only with 43 million cubic meters of live storage and combined with the original development plan of the Tuntang/Jragung Rivers, an area of 36,950 hectares is perennially irrigated at 95 percent firmness. However, as shown in D.7.1. economics of constructing Dolok Dam for irrigation alone are not encouraging.

The Dolok Dam project was then called upon to provide M & I water supply to the city of Semarang in addition to providing perennial irrigation to areas to which water cannot be diverted from the adjoining subbasins.

D.10.2. Economics of "Maximum Development - West Subbasin Case I"

(i) Costs

Cost associated with this combination are as follows: For construction of Rawa Pening, $ 1.0 million; construction of Glapan Barrage, $ 23.9 million; construction of Dolok, $ 14.8 million; construction of Gunung Wulan, $ 103.5 million plus $ 13.2 million for the power house. (total construction costs of $ 156.4 million). In the 36th year after completion of Gunung Wulan Dam, power plant replacement would cost $ 4.62 million. For land acquisition at Rawa Pening, $ 39.0 million; land for Glapan Barrage, $ 6.4 million; land for Dolok $ 0.56 million; and land for Gunung Wulan, $ 7.98 million. (total land aquisition costs of $ 53.94). Rehabilitation of the irrigation system on 30,950 hectares at $ 328/hectare, $ 10.15 million. (total costs for land, construction excluding power house replacement, and irrigation system rehabilitation, $ 220.49 million). O & M costs as a percentage of construction costs are $ 0.39 million;

plus \$ 10/hectare for the irrigation system, \$ 0.31 million; and \$ 0.05 million for power plant O & M. (total O & M, \$ 0.75 million).

(ii) Benefits

Irrigation benefits accruing from an increase of \$ 1,406 in net farm income per hectare on 30,950 hectares amount to \$ 43.5 million. Full benefits should accrue after a development period of five years. M & I water benefits accruing from the project are estimated to be \$ 9.92 million. Flood control benefits are expected to be \$ 1.25 million. 50 GWh of firm power and 110 GWh of secondary power would be lost because of this development plan, but 184.5 GWh of secondary power would be generated, so the net effect would be an annual loss amounting to \$ 0.48 million.

(iii) Internal Rate of Return

The internal rate of return of the Case I development plan in the Western Subbasins is 16.4 percent.

D.10.3. Maximum Development - West Side Subbasins Case II

This case assumes that social and political problems associated with the raising of Rawa Pening without levees cannot be overcome but that levees to the limits established in Part I of this study can be constructed. 125 million cubic meters of storage is provided at Rawa Pening; 260 million cubic meters of live storage is provided at Gunung Wulan (260 million cubic meters storage at Gunung Wulan is in all cases interchangeable with 190 million cubic meters at Gunung Wulan and 87 million cubic meters live storage at Glapan). 35 million cubic meters of live storage is available from Dolok. Again no consideration is given to construction of Jragung Reservoir.

D.10.3.1. Operations

A number of runs were made to simulate this array, however irrigation firmness achieved at Gunung Wulan and Glapan resulted from Serang-Tuntang Diversion because no development on the Lusi-Serang was simulated in the operation. These firmness values were corrected to values without diversion from Serang as established in Part I of this study. The data are summarized in Table D-61. Full development under this array would allow perennial irrigation of the full Tuntang service area, 10,460 hectares in the Jragung service area (90%) and 996 hectares on Dolok while providing 4,000 l/s of M & I water to Semarang.

D.10.3.2. Economics

(i) Costs

Construction costs associated with this combination are: $ 24.0 million for raising Rawa Pening; $ 14.8 million for Dolok; and $ 116.5 million for Gunung Wulan Dam plus $ 13.2 million for the power house. (total construction costs of $ 168.5 million). Land aquisition costs for the three components would be $ 12.86 million ($ 4.88 million for Rawa Pening and Dolok, and $ 7.9 million for Gunung Wulan). Rehabilitation of the irrigation system on 28,833 hectares at $ 328/hectare, would cost $ 9.46 million. (total costs for land, construction, and irrigation system rehabilitation are $ 190.82 million). O & M costs as a percentage of construction are $ 0.36 million; plus power house O & M of $ 0.05 million, and O & M of the irrigation system at $ 10/hectare, amounting to $ 0.29 million. (total O & M, $ 0.70 million). After 35 years of use, power plant replacement at Gunung Wulan would cost $ 4.62 million.

(ii) Benefits

Irrigation benefits accruing from the "Case II" development in the Western Subbasins would be an increase of $ 1,406 in the net farm income per hectare on 28,833 hectares, amounting to $ 40.54 million. This level of benefits would be reached after 5 years of growth in equal annual increments. M & I water supply benefits are estimated to be $ 9.92 million; and flood control benefits $ 1.25 million. 50 GWh of firm power and 110 GWh of secondary power would be lost, but 204.2 GWh would be generated, so the net effect on power would be a gain amounting to $ 0.95 per year.

(iii) Internal Rate of Return

The internal rate of return of the Case II development plan in the Western Subbasins is 16.4 percent.

D.10.3.3. Sub-Development Viability

The internal rate of return for Case I Development, as described in Section D.10.2., was also 16.4 percent, the same rate as for Case II. Project costs for Case I were $ 220.5 million and for Case II they were $ 190.8 million. Evaluated solely on economic aspects, Case II with lower costs would be preferable, but non-economic aspects associated with raising Rawa Pening with or without levees cause the difference in costs. Benefits accruing from irrigation are greater for Case I than Case II, because of the additional number of hectares benefited. Both Case I and Case II are economically feasible.

D.10.4. Maximum Development - West Side Subbasins Case III

A knowlegeable and justifiable selection of Case I (D.10.3) or Case II (D.10.2) as the preferred development array cannot be made until the results of a full feasibility level study at Rawa Pening are available. The feasibility of overcoming social and political constraints associated with the implementation of Case I and of solving the foundation and drainage problems in the implementation of Case 2 need to be carefully analyzed and confirmed for decision making.

It is foreseen that a resolution of the sociological and political problems which are connected with the raising of Rawa Pening will be extremely difficult and time consuming. As the key element in the development plan for the western subbasins the status of Rawa Pening, however, has to be established before a sensible orderly and economically sound program for project implementation can be drawn up. Despite the economic benefits that could be realized from the development of Rawa Pening it may be advisable, in this case, to forego the goal of optimum utilization of the water resources for a scheme of development that produces somewhat fewer economic benefits, but eliminates emotional, cultural, environmental and political factors that are likely to delay and, possibly, block implementation. The critical water supply situation in Semarang demands a quick decision. Excellent water is available from Muncul Springs, without treatment and with plenty of hydraulic head for delivery to the highest locations in Semarang. As shown in Part I of the study, withdrawal of M & I water at Rawa Pening requires that storage is provided at the Tuntang and the Jragung Rivers. The storage requirements depend on the amount of water taken from Muncul Springs. For economic and practical reasons the water supply from Muncul Springs should be maximized, which is possible with the introduction of a storage dam at Jragung.

Case III investigates the existing conditions at Rawa Pening with a life storage of 43 million cubic meters.

D.10.4.1. Operations

Under these conditions to maintain an acceptable area of irrigation development Jragung II is introduced back into the system. Run number 163 with "JRAT" assumed storage of 43 million cubic meters at Rawa Pening, 75 million cubic meters at Jragung and 35 million cubic meters at Dolok. A full 4,000 l/s M & I water is provided to the city of Semarang. 500 l/s is provided by Dolok, 1,500 l/s is diverted from the Jragung and 2,000 l/s is diverted from Muncul Springs above Rawa Pening. The full Tuntang service area is served, 9,300 hectares of the 11,625 hectares Jragung area is served and 996 hectares of the Dolok area is served with perennial water.

D.10.4.2. Sub-Development Viability

This particular array of elements would be considered only if the proposed and forthcoming full feasibility investigation of Rawa Pening should result in a decision to not increase present capacity at Rawa Pening.

D.10.5. Maximum Development of Perennial Irrigation and M & I Water Supply in the Jratunseluna Basin

The plan of development in Section D.9. is presently considered to constitute maximum development in the Lusi-Serang Subbasins. The combination of projects consists of provision of storage at Ngemplak, Banjarejo and Kedungwaru to supplement river diversions at the Mid Lusi Diversion site. This array as shown in Section D.9. will serve a total 12,880 hectares of land with a perennial irrigation supply.

The Serang River Development Plan is to be implemented as proposed by SMEC with exception that the area of the South Grobogan service area to be served from Kedungombo and the South Grobogan Weir is reduced from 7,300 to 5,620 hectares and the area served in the Juana Valley is limited to 12,000 hectares total. Of these 12,000 hectares, 4,750 hectares will require pump irrigation based on results obtained by SMEC [4] in their latest studies of irrigation development potential in the Juana Valley.

In Section D.10., the maximum development to be considered for the western subbasins is explored. Three possibilities of development at Rawa Pening, and the subsequent effects on the integrated development of the subbasins, were explored.

In the selection of elements to maximize basin development to feasible limits, the optimum conditions at Rawa Pening were obtained with storage increased to 175 million cubic meters. Therefore, the conditions described in Section D.10.1. were assumed in the maximum development scheme for the Jratunseluna Basin. The west side elements imposed for the overall operation include the raising of Rawa Pening to 175 million cubic meters without levees, construction of Gunung Wulan to provide 260 million cubic meters live storage (or Glapan plus Gunung Wulan), construction of the Tuntang to Jragung transbasin diversion with a capacity of 18 cubic meters per second and construction of Dolok Reservoir to provide 35 million cubic meters of storage. All features of the development plan and physical benefits are summarized below:

Site	Area Storage Provided (10^6 m^3)	Service Area	Area Perennially Irrigated at 95% Firmness (ha)
Penggaron	0	Penggaron	0
Dolok	35	Dolok	1,950
Jragung	0	Jragung	11,625
Gunung Wulan	260	Tuntang	23,375
Kedungombo	655	South Grobogan	7,300
Ngemplak	68	Upper Sedadi	19,800
Banjarejo	77	Lower Sedadi	17,400
Kedungwaru	19	Juana Valley	12,000
Rawa Pening	175	Lusi Left	4,200
		Lusi Right	7,000
Total:	1,289	Total:	104,600

M & I Water

Supply Point	Rate (l/s)
Muncul	2,000
Jragung	1,500
Dolok	500
Total:	4,000

D.10.5.1. Development Economics

(i) Costs

As indicated in Section D.10.3.2., the total costs of maximum development in the Western Subbasins (Case II) would be $ 220.5 million. Maximum development in the Eastern Subbasins, as indicated in Section D.9.3.b., would be 86.4 million. The total cost for maximum development in the entire Jratunseluna Basin would thus be $ 306.9 million.

(ii) Benefits

The benefits in both basins of maximum development would be $ 73.2 million per year, consisting of $ 52.7 per year in the Western Subbasins and $ 20.5 million in the Eastern Subbasins.

(iii) Analyses

Since the maximum development plans for the two subbasins are separate plans which are not linked in any way for purposes of implementation, each plan should evaluated separately. As previously indicated the internal rate of return for development in the Western Subbasins is 16.4 percent; in the Eastern Subbasins the internal rate of return is 14.8 percent.

TABLE D-60

MAXIMUM DEVELOPMENT - WEST SIDE SUB-BASINS - RAWA PENING

LIMITED TO 125 x 10^6 m^3 AND NO STORAGE PROVIDED AT JRAGUNG

(In all cases M & I is provided as follows: Muncul - 2,000 l/s, Dolok - 500 l/s, Jragung - 1,500 l/s)

Run No.	Storage Provided			Area Irrigated			Irrigation Firmness			Energy	
	Rawa Pening (10^6 m^3)	* Gunung Wulan (10^6 m^3)	Dolok (10^6 m^3)	Tuntang (ha)	Jragung (ha)	Dolok (ha)	Tuntang (%)	Jragung (%)	Dolok (%)	U T S (GWh)	Gunung Wulan (GWh)
150	125	260	35	23,375	12,787	996	93.7	92.9	95.6	133.3	80.2
151	125	260	35	23,375	10,462	996	94.8	94.8	95.6	141.4	80.2
152	125	260	35	23,375	8,137	996	96.0	94.8	95.6	139.9	80.2

* Gunung Wulan @ 260 x 10^6 m^3 may be replaced by Gunung Wulan @ 260 x 10^6 m^3 and Glapan @ 87 x 10^6 m^3.

D.11. CONCLUSIONS

The conclusions derived from the planning study related to the Jratunseluna Basin Updated Development Plan are recorded hereunder.

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)	M & I Water Supply (l/s)	Annual Value (US $)	IRR (%)
1. Raising of Rawa Pening	125	31.01	14,204	1,500	12.98	21.5
	175	43.96	18,060	1,500	17.98	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. Raising of Rawa Pening

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 995 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 D-61, D-62, and D-63.

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. 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 (1/s)	Irrigated Area (ha)
Rawa Pening Storage		
Capacity 125 x 10^6 m^3	500	15,500
(F.S.L. El. 467.0 M.S.L.)	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.

11. 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 D-61, D-62, and D-63.

TABLE D-61

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) 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	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 → (1981–1986)						← 23,556 → (1987–1990)				← 33,139 → (1991–1996)						← 87,959 → (1997–2000)				100,649		
M & I Water Supply	l/s	← 0 → (1981–1986)						← 2,000 → (1987–1990)				← 2,500 → (1991–2000)										4,000		
Annual Benefits: Irrigation	US$ 10^6	← (1981–1986) →						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		
Annual Benefits: M & I Water Supply	US$ 10^6	← (1981–1986) →						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		
Annual Benefits: Flood Control	US$ 10^6	← (1981–1986) →						.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	1.25		
Annual Benefits: Hydropower	US$ 10^6	← (1981–1986) →						-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		
Annual Benefits: Total	US$ 10^6	← (1981–1986) →						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 D-62

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																						130.38	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		
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		
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		
Flood Control	US$ 10^6							.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	1.24		
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		
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

D-117

TABLE D-63

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)	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																						13.73	11.3
Jragung Dam	75																						71.39	13.8
Rawa Pening	43																							
Tuntang-Jragung Trans-basin Diversion	-																						2.4	-
Gunung Wulan Dam	190																						130.38	14.1
Glapan Barrage	87																						32.77	20.8
EASTERN SUBBASINS																								
Kedungombo Dam	655																						206.0	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 Benefits: 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 Benefits: 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	8.65	8.68	9.92		
Annual Benefits: 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 Benefits: 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 Benefits: 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	86.93	125.3		

LEGEND

═══ Mapping

▬ ▬ ▬ Investigation

━━━ Design/Construction

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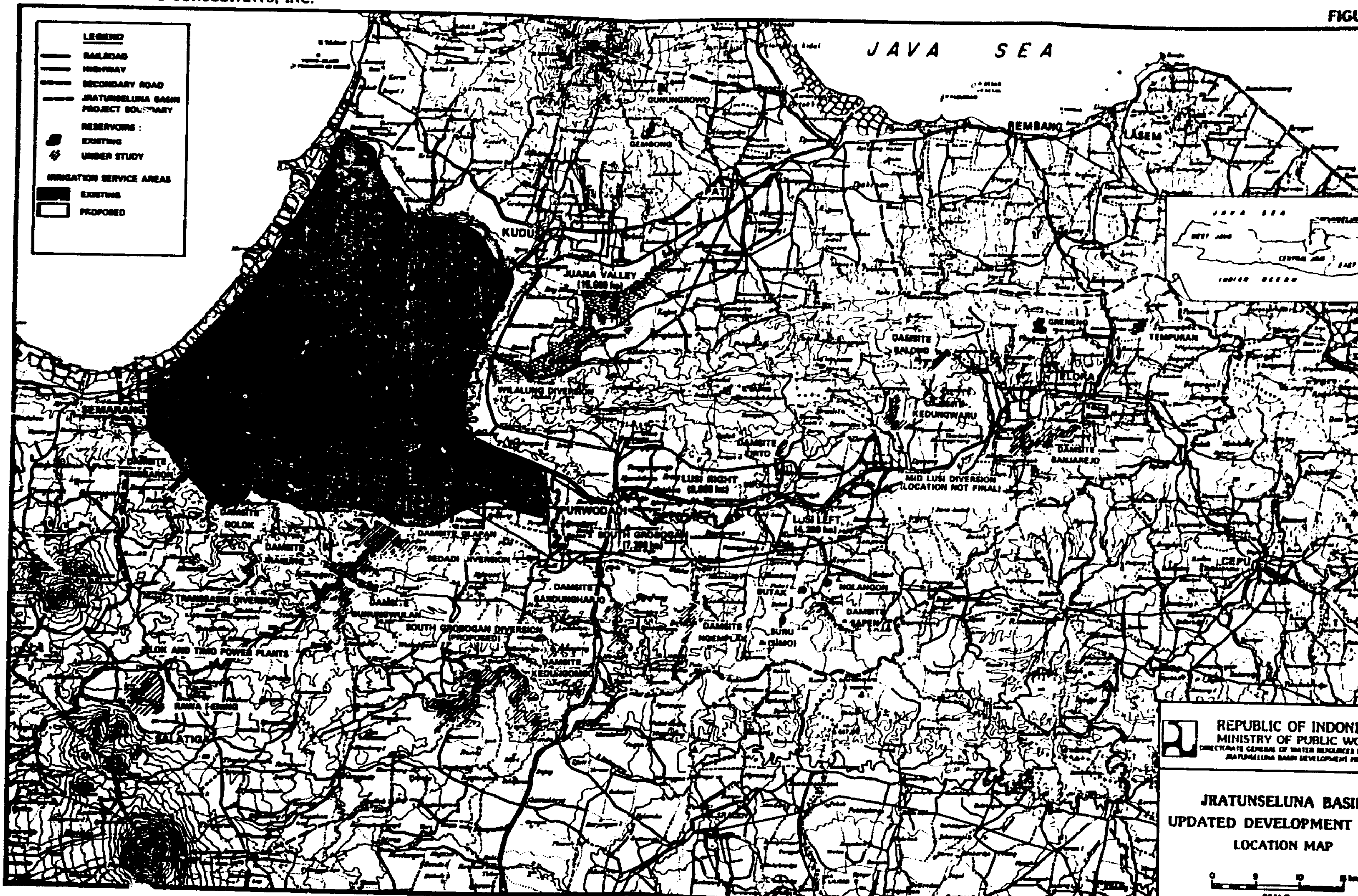
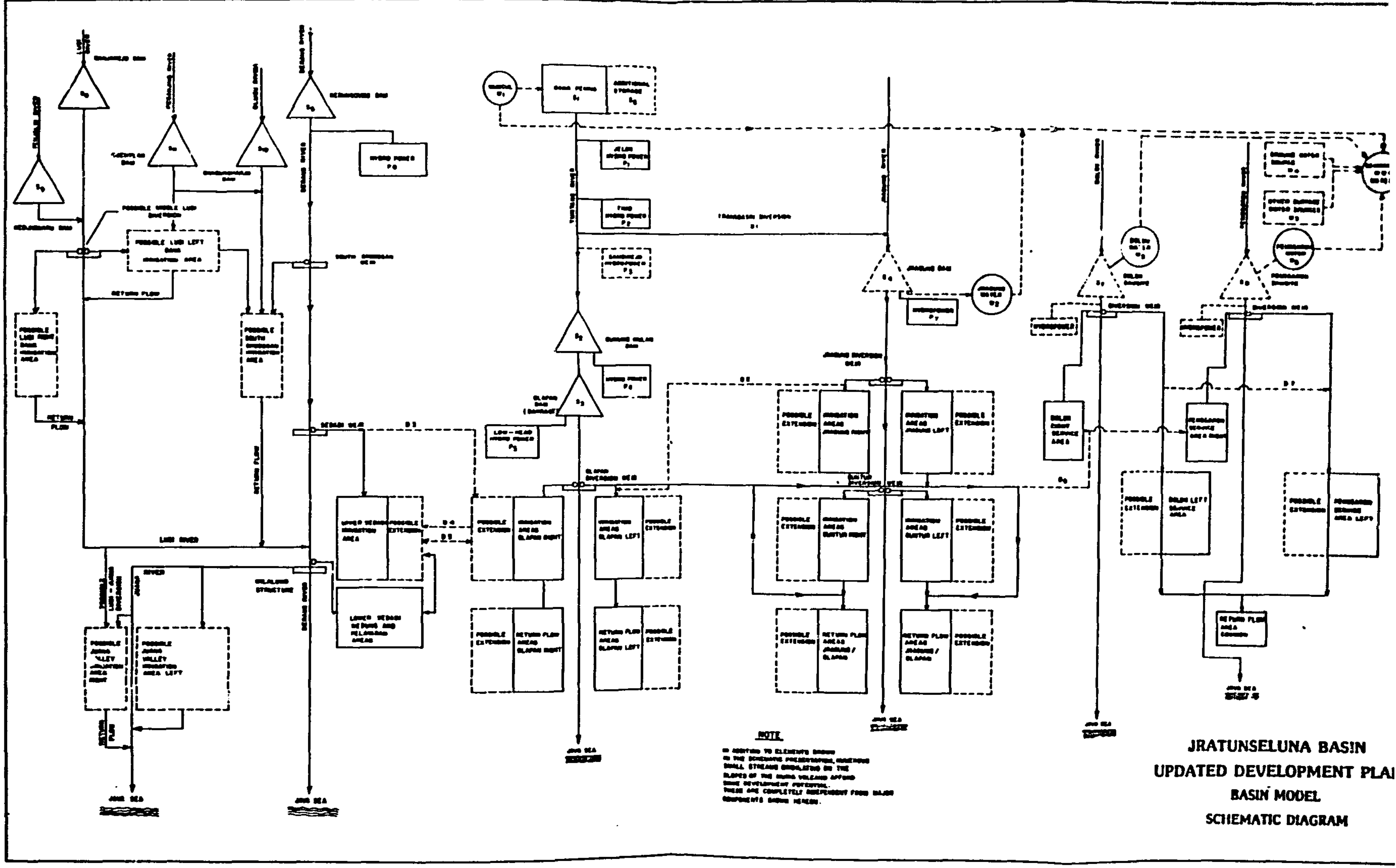

FIGU
LEGEND
RAILROAD
HIGHWAY
SECONDARY ROAD
JRATUNSELUNA BASIN PROJECT BOUNDARY
RESERVOIRS :
EXISTING
UNDER STUDY
IRRIGATION SERVICE AREAS
EXISTING
PROPOSED
JAVA SEA
GUNUNGROWO
GEMBONG
REMBANG
LASEM
PATI
KUDUS
JUANA VALLEY
SEMARANG
WILALUNG DIVERSION
GRENENG
TEMPURAN
DAMSITE
SALONG
KEDUNGWARU
BLORA
DAMSITE
BANJAREJO
LUSI RIGHT
MID LUSI DIVERSION (LOCATION NOT FINAL)
PURWODADI
LUSI LEFT
SOUTH GROBOGAN
DAMSITE
DOLOK
DAMSITE GLAPAN
SEDADI DIVERSION
TUNTANG DIVERSION
DAMSITE
SANDUNGHARJO
SOUTH GROBOGAN DIVERSION (PROPOSED)
DAMSITE
NGEMPLAK
SURU
NGLANGON
DAMSITE
SAPEN
CEPU
RAWA PENING
SALATIGA
DAMSITE
KEDUNGOMBO
REPUBLIC OF INDONE
MINISTRY OF PUBLIC WO
JRATUNSELUNA BASI
UPDATED DEVELOPMENT
LOCATION MAP
SCALE

PRC ENGINEERING CONSULTANTS, INC. FIGURE



JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
BASIN MODEL
SCHEMATIC DIAGRAM

P&C ENGINEERING CONSULTANTS, INC.

FIGURE D