CONTRATO

IICA / INDRHI / CSU

INSTITU
DE COO
AGR

INSTITUTO NACIONAL DE RECURSOS HIDRAULICOS (INDRHI)

UNIVERSIDAD DEL ESTADO DE COLORADO (CSU)

ESTUDIOS SOBRE LA OPERACION Y SEGURIDAD DEL SISTEMA DE EMBALSES DE VALDESIA

INFORME FINAL

VOLUMEN II

NORMAL OPERATION 1/

DOCUMENTO No. 37

31/08/86

Serie Publicaciones Misceláneas
A1/DO-86-003
ISSN-0534-5391

INFORME FINAL

VOLUMEN II

NORMAL OPERATION 1/

37

31/08/86

1/ This document was prepared by J.W. Labadie, V. Floris, N-F Chon, D.G. Fontane and W.W. Shaner

PRESENTACION

Los estudios de Operación y Seguridad del Sistema de Embalses de Valdesia fueron ejecutados conjuntamente por el Instituto Nacional de Recursos Hidráulicos (INDRHI) de la República Dominicana, la Universidad del Estado de Colorado (CSU) y el Instituto Interamericano de Cooperación para la Agricultura (IICA) a través del Contrato IICA/INDRHI/CSU firmado el 6 de abril de 1984. Los estudios se iniciaron el 6 de agosto de 1984 y finalizaron el 31 de agosto de 1986.

Los estudios fueron financiados por el INDRHI a través del préstamo 1655-DO del Banco Mundial.

La ejecución de los estudios se desarrolló en seis áreas:

a) Estudios Hidrológicos
b) Operación Normal
c) Operación de Emergencia
d) Inspección, Mantenimiento y Seguridad de Presas
e) Organización para la Operación del Sistema de Embalses
f) Entrenamiento y Transferencia de Tecnología

En este documento se incluye parte del material técnico del Informe Final, el cual consta de los siguientes volúmenes:

- Resumen
- Estudios Hidrológicos
- Operación Normal
- Estudios de Operación de Crecidas
- Estudios de Inspección, Mantenimiento y Seguridad de Presas
- Organización y Funciones para la Operación del Sistema de Embalses de Valdesia.

-Transferencia de Tecnología y Capacitación.

-Plan de Operación de Emergencia para el Sistema de Embalses de Valdesia.

-Plan de Operación Normal para el Sistema de Embalses de Valdesia: (1) Riego y Energía, (2) Control de Crecidas.

-Manuales de Operación de Modelos Computarizados para la Operación Normal del Sistema de Embalses.

-Manual de Usuario de Modelos de Sistemas Hidrológicos.

Santo Domingo, República Dominicana
31 de agosto de 1986

DR. JOSE D. SALAS
Coordinador por CSU

DR. AGUSTIN A. MILLAR
Coordinador General
Estudios Embalse Valdesia
(IICA)

ING. JULIO M. LLINAS
Coordinador por INDRHI

VOLUME II
NORMAL OPERATION

TABLE OF CONTENTS

APPENDICES:

2.1. INTRODUCTION

The Valdesia Reservoir system is a significant multipurpose project in the Dominican Republic that provides water for irrigation, hydropower, and possibly, in the future, municipal water supply. Its 60 MW power plant represents over 40% of the total rated hydropower capacity in the country and contributes 15% of total hydro energy production. It also supplies water for irrigating over 10,000 ha of important agricultural land. Unfortunately, since its completion in 1976, conflicts have arisen between energy and agricultural uses of the system, resulting in shortages to irrigation water supply. On the other hand, a stable and reliable energy supply from hydropower is critical if the country is to reduce reliance on expensive imported oil for thermal power plants.

A comprehensive reevaluation of the operation of the Valdesia system has been undertaken in order to maximize its capability in meeting energy and irrigation requirements during normal or nonemergency operating conditions. The need for such a reevaluation has become particularly evident since the destructive effects of Hurricane David in 1979, from which the country is still recovering. The key to substantial improvement in performance is operating the system in an integrated fashion that fully encompasses its multipurpose aspects. Such a fully integrated approach confronts system operators with a difficult task. Expanding the scope of the working system for more integrated analysis greatly multiplies the potential number of alternative operational strategies. This is further complicated by conflicting objectives, stochastic hydrology, and uncertain consumptive water use. Optimal coordination of the many facets of such a system

requires the assistance of computer modeling tools to provide information on which to base rational operational decisions. These tools can be employed both in operational planning of the Valdesia system, as well as actual real-time decision support.

2.1.1. Description of the study area.

a. Reservoir subsystem.

The storage subsystem includes two projects: Valdesia Reservoir and Las Barias Reservoir immediately downstream. Valdesia Reservoir is located on the Nizao River northwest of the City of Santo Domingo, capital of the Dominican Republic (Figure 2.1.1). The reservoir is impounded by a concrete dam designed for maximum storage of 153 $10^6 m^3$ at level 150 m.a.s.l. The spillway runs the entire length of the top of the dam and is controlled by five radial gates. A tunnel discharges water at a maximum rate of 90 m^3/s to a hydroelectric power plant with two Francis turbines rated at 30 MW each. Hourly energy generation data are compiled by CDE, as well as daily power discharge and water level measurements. This information can be used in mass balance calculations to estimate reservoir inflows. Valdesia Reservoir can provide some flood control benefits through maintenance of a flood reserve during months where flood danger is high.

Las Barias Reservoir, about 15 km downstream of Valdesia, is of much smaller size (3.0 $10^6 m^3$ maximum capacity at level 77 m.a.s.l.) with its primary purpose to reregulate daily peak period power releases from Valdesia Reservoir to provide stable discharges to the irrigation canals. Standardized operating criteria for these projects during both normal and flood emergency conditions have not been available in the

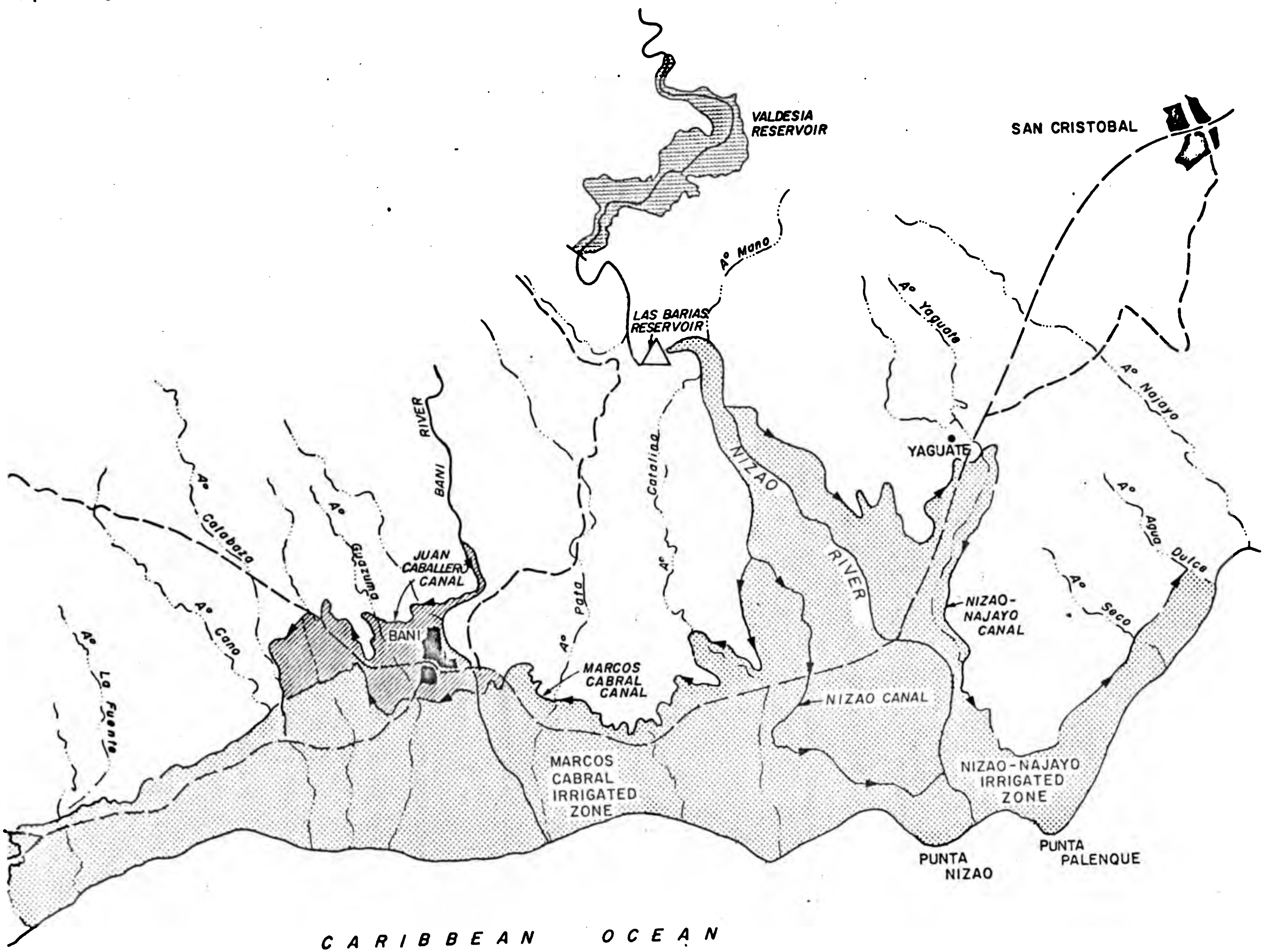


Figure 2.1.1 Valdesia Reservoir System

past, which has resulted in inconsistent energy production and untimely irrigation deficiencies.

The construction of other major reservoirs upstream of Las Barias (Jiguey and Aguacate) has been planned for enhanced regulation of the Nizao River, increased exploitation of hydropower potential in the river basin, and possible future domestic water supply for Santo Domingo. Although these projects are not directly included in this study, a generalized model has been developed which will easily allow their incorporation in future management and operational studies for the system.

b. Conveyance subsystem.

Irrigation water supply from Valdesia and Las Barias Reservoirs is distributed through two major irrigation canals:

1. Marcos A. Cabral: which diverts water from the Nizao River at Las Barias Reservoir, conveying it 47 km to the west of the River, with a total irrigated command area of 8707 ha. The canal has a maximum capacity of around 12 m^3/s (cms) and includes two major laterals. Daily measured flows, with some interruptions, are available over a nine year history of the system.
2. Nizao-Najayo: which diverts flow 34 km to the east of the river and irrigates 1636 ha. Maximum capacity is estimated at 2.8 m^3/s. Daily flow data for this canal are also available over a four year period, but contain many gaps and inconsistencies. An additional canal, Juan Caballero, is currently separate from the Valdesia system, but may be connected in the future.

c. Irrigation subsystem.

Tropical and subtropical crops such as rice, sugarcane, small vegetables, and fruit (particularly, large banana production) are grown in an average yearly temperature of 27°C with mean annual rainfall of 800 mm. Rainfall, however, is inadequate for meeting crop requirements and irrigation is needed year round mainly for the variety of crops grown rather than multiple plantings of the same crop over the year. Overall irrigation efficiencies in the system are quite low. Frederiksen, et al. (1985) assume the following efficiencies:

canals	85%
laterals	80%
application	75%
overall	51%

Based on interviews with operational personnel for the Valdesia system, this overall efficiency seems excessive. The following adjustments have been assumed for this study:

canals	85%
laterals	85%
application	50%*
overall ≃	35%

Future completion of lining of the main canals and possibly portions of the major laterals will of course improve the efficiencies, even though on-farm application efficiencies may continue to be a problem. Other problems include the fact that farmers at the end of the major canals tend to face consistent shortages, whereas those at the head of the canals are not using all of the water available to them (Frederiksen, et al., 1985). Future plans to install control structures and siphons in

* This figure should more than fulfill the salt leaching requirements.

the main canals should greatly improve equity in water distribution along the entire length of the canal.

The key to efficient water use is estimating as accurately as possible actual water needs and then minimizing both excesses and shortages. This requires extensive and accurate meteorological data, which were found to be severely deficient in this study. Meteorological data have been collected over limited time intervals at stations within or proximate to the irrigation zone. The most complete data are collected at a station in San Cristobal approximately 10 km from the study area. Though there are several years of daily climatological measurements available, processing is time consuming because the data are not in computer readable form.

2.1.2. Improved operations through computerized decision support.

Computer models of the Valdesia Reservoir system are needed for operational planning under normal conditions (i.e., excluding flood emergency conditions) as well as actual real-time operation of the system. Advances in computer technology, both hardware and software, have been dramatic in recent years and a wide array of tools are available and being applied to reservoir systems and other water resource projects. The first author of this volume, along with Charles Sullivan, Chief of the Reservoir Control Center, Southwestern Division of the U.S. Army Corps of Engineers, have edited a series of articles on "Computerized Decision Support Systems for Water Resource Managers" which highlight use of computer software and hardware technology for actual operation of a variety of large and small-scale water projects throughout the United States (Labadie and Sullivan, 1986). These articles appear in a dedicated issue of the Journal of Water Resources

Planning and Management, American Society of Civil Engineers, July 1986. The conclusions from these articles are that systems analysis and computer technology are essential to operating these systems at their maximum potential and efficiency.

Computer simulation models are currently being applied to operations within a number of river basin systems in the U.S. Many are customized for the particular system, but there is also substantial usage of generalized models such as HEC 5 (Hydrologic Engineering Center, 1979). Computer simulation models are particularly attractive for answering "what if" questions regarding the performance of alternative regulation strategies. However, they are not well suited for finding the best or optimum strategies when flexibility exists in coordinated reservoir system operation.

Optimizing models offer an expanded capability to systematically select optimum solutions or families of solutions, under agreed upon objectives and constraints. In addition, if properly constrained, an optimizing model can act as a simplified simulation model. However, simulation models are generally able to represent the operations of a system with a higher degree of accuracy and are useful for risk analysis in examining the long term reliability of proposed operating strategies.

The best approach is to combine simulation and optimization together so as to accentuate their respective strengths. Optimizing models should first be used for generating operational policies which can then be tested and refined with a more detailed simulation model. Therefore, two types of models are needed: one for simulation and one for optimization.

2.1.3. Objectives and overview of this study.

The objectives associated with this study include:

1. Develop optimal end-of-month storage guidecurves for the Valdesia Reservoir system that maximize expected energy production subject to meeting irrigation demands, with consideration of the stochastic hydrology and all possible initial storage conditions for each calendar month.
2. Perform a stochastic analysis to estimate the reliability of these optimal rules in meeting energy and irrigation requrirements, and assess the risks associated with possibly increasing energy production and irrigation targets.
3. Develop a generalized, easy to use river basin simulation model for the microcomputer which can serve as a weekly real-time operational tool for optimally synchronizing the hydropower and agricultural uses of the system, including allocation between the various irrigation sectors. This simulation model is envisioned to be run using the optimal reservoir guidecurves from the monthly analysis.
4. Provide an assessment of the expected economic benefits of applying the optimized operational guidelines to the system and compare the historical performance of the system with what would likely have occurred had the optimal operating rules been applied on a weekly basis over the historical period. Energy production, power capacity, and water deliveries for irrigation are the primary means of comparison.

5. Engage in technology transfer efforts to: (i) prepare Dominican engineers for application of this technology, (ii) provide all software developed for this study for microcomputer usage, and associated documentation, and train key Dominican engineers on the use of these models; and (iii) develop a practical operations manual for implementation of the optimal normal operation guidelines.

The basic scheme for meeting these objectives is shown in Figure 2.1.2. A temporal decomposition approach is selected which begins with development of optimal feedback decision policies for each calendar month for Valdesia Reservoir that maximize energy output subject to satisfying irrigation requirements. A fully dynamic optimization approach employing stochastic dynamic programming is utilized at the monthly level, requiring inputs of:

1. Month-to-month transition probabilities describing the stochastic characteristics of the Nizao River inflows to Valdesia Reservoir; since the flows are highly random, an explicit stochastic approach is necessary for developing operational policies that will maximize long-term beneficial use of the system.
2. Hours of hydropower production, which have been highly random in the past due to: variable daily peak load periods and use of the system for base load as necessitated by deficiencies or failure in various portions of the Dominican power network.

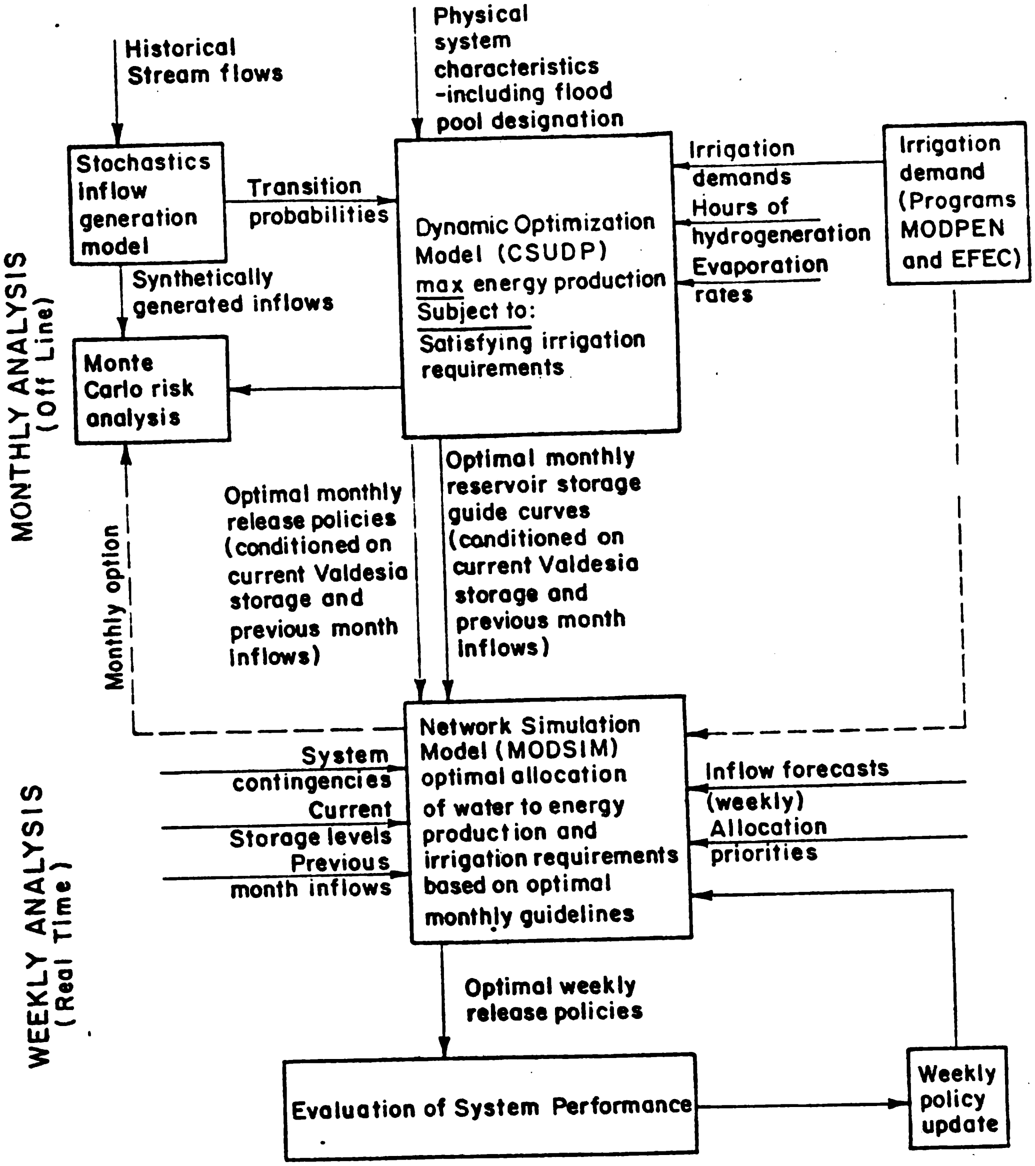


Figure 2.1.2 Hierarchical Approach for Developing Optimal Normal Operation Policies

3. Physical system features including power plant characteristics, reservoir capacities, surface area-head-capacity tables, etc.
4. Irrigation demands estimated using a modified Penman model.

It is expected that the dynamic programming optimization need only be rerun if it becomes evident that current values of one or more of the above inputs are no longer valid or need adjustment. The operating policies generated by the optimization specify optimal end-of-month storage levels, conditioned on initial storage levels and previous period inflows to consider the persistence of successive monthly inflows. These kind of "feedback" policies are essential in that they represent optimal guidelines for a large variety of storage and inflow conditions that may exist at any time, rather than just one inflexible optimal open loop policy.

Prior to actual real-time utilization of the optimal operating policies, they are tested through Monte Carlo analysis. These are performed using several hundred years of synthetically generated inflows to assess the probabilities of maintaining various acceptable levels of release for irrigation and power production, as well as determining the possibility of increasing target levels to improve beneficial use of the system. The same network simulation model to be utilized for weekly real-time operations is also employed for this task on a monthly basis.

Optimal guidecurves from the monthly analysis can now be utilized for weekly real-time operation of the system. A more detailed network simulation model is employed for determining the optimal allocation of water in the Valdesia system for hydropower and the various irrigation sectors in the system, while attempting to conform to the monthly guidelines. Opportunities are available at the weekly level

to include forecast information on inflows. These forecasts can be updated on a weekly basis and the model rerun to accommodate changing conditions as system performance is monitored. The goal is for the network simulation model to become a real-time operational tool that is tractable and easy to use by system operators. The guidecurves and computer models are intended as support mechanisms only for the system operators. Use of weekly and monthly targets allow flexibility in daily operations. They are regarded as targets only and operators are free to deviate from them as the need arises and their experience dictates.

In order to confirm the value of employing the guidecurves, policies, and computer models developed for normal operation of the Valdesia system, attempts have been made to assess the improvement in system performance that would have occurred historically had they been employed, versus the actual system performance. In addition, preliminary attempts have been made to assign an estimated economic value to these improvements.

A significant aspect of this project has been technology transfer activities including: (i) on-site training of personnel with INDRHI, CDE and other key agencies involved in operation of the Valdesia system on the general concepts of systems analysis and computer modeling for improving operational performance; (ii) more detailed, lengthy training at Colorado State University of certain key personnel with significant responsibility for operational planning, as well as incorporating their experience base for assuring the operational procedures are realistic; (iii) intensive instruction on understanding the computer models developed for this study and their implementation on microcomputer facilities, which will be the major computing environment

for operation of the system; and (iv) specific instruction on employing all the technology developed in this study for actual real-time operation of the system.

A comprehensive documentation and user manual for the computer models developed for this study has been prepared under separate cover. In addition, a separate Valdesia System Normal Operations Manual is provided which gives detailed, step by step instruction on implementation of the procedures for real-time operations. The purpose of this final report is to fully document all of the work leading to the normal operations procedures and computer models developed for the Valdesia Reservoir system. It is hoped that this effort can provide encouragement for applying similar technology to other projects in the Dominican Republic, and eventually developing a nationwide integrated decision support base for water resources.

2.2 COMPUTER MODELS FOR OPERATIONAL DECISION SUPPORT

Two computer models are utilized for this study: (i) a generalized river system simulation model called MODSIM, and (ii) a general purpose dynamic programming code called CSUDP for developing optimal stochastic operational guidelines to be tested and employed in MODSIM. These two programs work together in that CSUDP gives optimal operation rules which can be input to MODSIM for basic operational decisions and risk assessment. Again, the idea is that simulation and optimization should be used together. The former can more accurately depict the operation of the entire system, whereas the latter can be useful in helping find optimal operating guidelines for use in the simulation.

2.2.1. Optimization model for monthly operational targets: CSUDP.

There are a wide variety of optimization techniques available, including linear programming, nonlinear programming, dynamic programming, integer programming, network flow theory, optimal control theory, stochastic optimization, large-scale optimization methods, and multiobjective techniques. The Tennessee Valley authority (Shane and Gilbert, 1982) has implemented a linear programming model to schedule weekly releases for their 42 reservoir system. The optimization is performed on a week by week basis, rather than in a fully dynamic sense in anticipation of forecasted conditions. A nonlinear search technique is used to tradeoff current energy production with future potential energy. Prior to the intense drought of 1976-1977, dynamic programming was being used to operate a portion of the Central Valley Project in northern California (Sheer and Meredith, 1984). A 10% increase in hydropower production revenues during the period the algorithm was used was documented.

For this study, the optimization technique selected is dynamic programming. The reader is referred to Labadie (1980) and Yakowitz (1982) for applications of dynamic programming to water resources. The advantages of dynamic programming (DP) include:

a. particular suitability in solving sequential decision problems over many time periods or stages. As seen in Figure 2.2.1, reservoir operations can be naturally viewed as a sequential decision process with release decisions at each stage resulting in beneficial returns. Monthly storage volumes represent the "state" transitions between stages. With DP, computer time requirements increase linearly

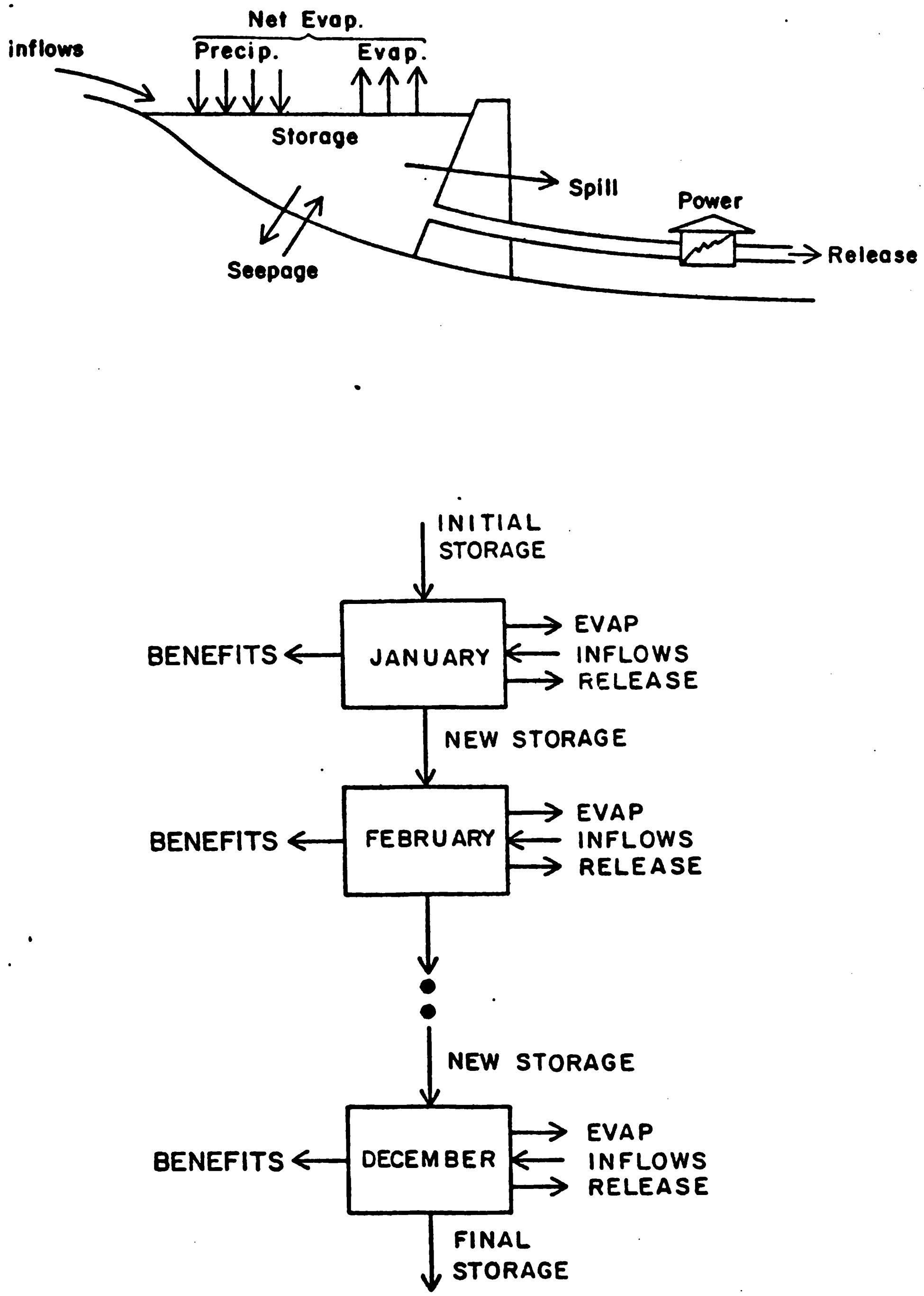


Figure 2.2.1 Illustration of Reservoir Operations as Sequential Decision Process

with the number of stages. With other methods, except for optimal control theory, computer time requirements increase geometrically.

b. Ease of considering nonlinear aspects of reservoir modeling including hydropower production functions and evaporation calculations. The former introduce a high degree of nonconvexity into the optimization problem which can cause severe difficulties with other methods.

c. Determination of "feedback" operating rules for a wide range of conditions or states of the system, rather than just one "open loop" optimal solution that would be obtained with other methods.

d. Solution efficiency actually increases when a large number of operational constraints are included, whereas the opposite occurs with other methods.

e. Particular attractiveness for solving stochastic optimization problems with inclusion of conditional risk constraints defining limits of probability of failure to meet certain operational criteria (Sneidovich, 1979).

The primary disadvantages are:

a. The so-called "curse of dimensionality," which asserts itself with a vengeance as the number of reservoirs considered surpasses three. Computer costs and rapid access storage requirements increase dramatically with each added reservoir.

b. Lack of available, generalized dynamic programming computer software. The usual approach is to write a specialized DP code for each new application. This requires both good programming skills and a thorough understanding of the theory and numerical aspects of DP.

The second disadvantage is overcome by the availability of Program CSUDP developed at Colorado State University (Labadie, 1980).

The first disadvantage is not a problem for this study since there are a limited number of reservoirs. Program CSUDP is used primarily for developing monthly optimal stochastic operating rules for Valdesia Reservoir. Program CSUDP is a flexible code that allows the user to include the specifics of a particular system objective function and constraints through user supplied subroutines linked to the main program. A microcomputer version of the program has been developed for this project for IBM PC or compatible machines.

2.2.2. Simulation model for weekly real-time operation: MODSIM.

For development of weekly operational guidelines under nonemergency conditions for the Valdesia Reservoir System, we propose use of Program MODSIM developed at Colorado State University. A version of this program for the IBM PC microcomputer has also been developed for this project.

The underlying principle of MODSIM is that most physical water resource systems can be represented as capacitated flow networks which can be solved efficiently and rapidly with modern network flow computational algorithms. The term "capacitated" refers to the existence of strict bounds on each link. The components of the system are represented in the network as nodes, both storage (i.e., reservoirs) and nonstorage (i.e., river confluences, diversion points, points of inflow, and demand locations) and links or arcs (i.e., canals, pipelines, and natural river reaches). In order to consider demands, inflow, and desired reservoir operating rules, several artificial nodes and links must be constructed such that mass balance is satisfied throughout the network, as illustrated in Figure 2.2.2. These

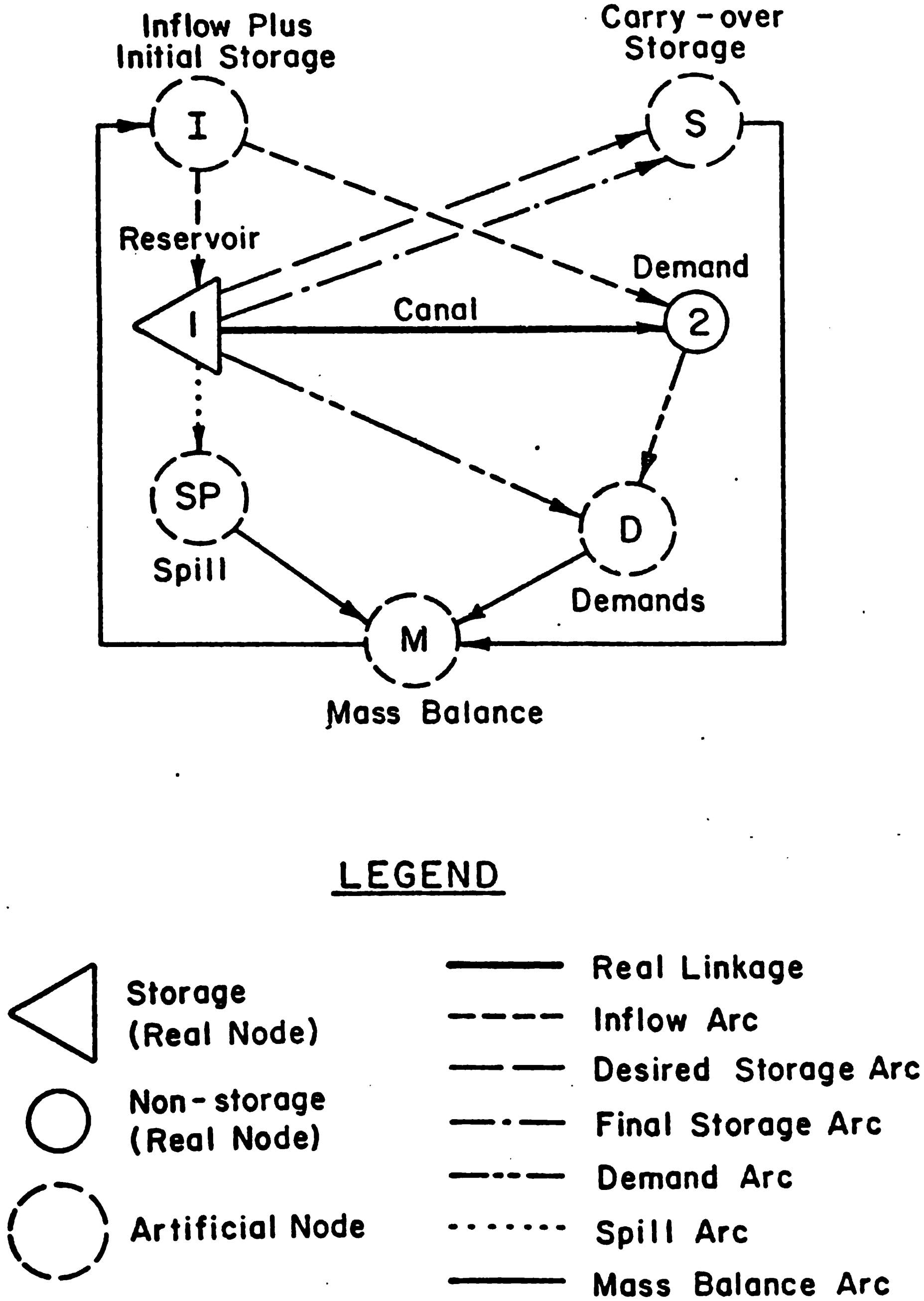


Figure 2.2.2 Illustration of Node-Arc Configuration of Network Simulation Model

artificial nodes and links are created automatically by MODSIM, so the user need only to be concerned with the actual system linkage.

MODSIM allows the use of "costs" that can be real costs or benefits (i.e., negative costs), or simply operational priorities assigned to certain nodes and links that serve to rank operational alternatives. Most other available general purpose river basin models do not have this capability, such as HEC 5 (Hydrologic Engineering Center, 1979), MITSIM (Lenton and Strzepek, 1977) and SSARR model (U.S. Army Corps of Engineers, (1972). With these models, various demands and operating priorities cannot be ranked by the user.

MODSIM employs the out-of-kilter (OKM) algorithm (Clausen, 1968) for optimally allocating flows and carryover storage throughout the system on the basis of these costs or priorities. The network flow problem is solved iteratively in a sequential fashion over time. Unlike other network programming-type algorithms, an initial feasible solution need not be provided when using the OKM. It is essentially a primal-dual linear programming algorithm specifically designed for efficient solution of minimum cost network flow problems.

The current version of Program MODSIM is primarily intended for obtaining weekly or monthly management guidelines over an entire river basin or selected subbasin. The model is not well suited to short term flood control operations requiring streamflow routing so its primary usage is in normal operations. The model is capable of generating operational plans that satisfy specified targets, priorities, and constraints. It also can be used to evaluate tradeoffs between conflicting uses during periods of deficient water availability. This

information can provide a rational, documentable basis for making difficult water allocation decisions.

One of the most important features of the model is its "user friendly" design. The model input has been structured in an interactive, conversational format which encourages use by water management personnel with little computer experience. The version used in this study was designed primarily for the IBM PC microcomputer and compatible machines operating under PC DOS 2.0 with a minimum of 320K memory. The source code is written in FORTRAN 77.

MODSIM is designed to be a tool only. The results are only as valid as the data input, but the model can be useful as a means of pinpointing data needs. Models can, and have been, abused, and model usage must always be tempered with sound judgment and experience. The user should have a good understanding of the assumptions and approximations associated with the model. Detailed documentation and user manuals for MODSIM and CSUDP can be found in the companion report "Manuales de Operacion de Modelos Computarizados para la Operacion Normal de Sistemas de Embalses," by J. Labadie, et al (1986).

2.2.3. . Simulation model for crop water requirements.

Efficient operation of the Valdesia system is closely linked to the accuracy of irrigation demand estimation and reliable delivery of those requirements over the entire length of the canal system. In order to calculate monthly and weekly net irrigation requirements, two additional computer programs were created:*

- MODPEN: estimates crop evapotranspiration using the modified Penman method.

---

* Note that in this study canal head requirements for water delivery are assumed to be satisfied through regulation of gates to be installed within the main canals.

- EFEC: calculates effective rainfall available to the crop root zone using a methodology recommended by Morel-Seytoux and Restrepo (1985).

a. <u>Modified Penman method</u>

The modified Penman method has received almost universal acceptance as the preferred method of obtaining daily and weekly potential evapotranspiration estimates. Detractors point to significant data requirements including daily temperature, humidity, wind speed, and solar radiation. Potential evapotranspiration is then multiplied by calibrated crop coefficients to determine water required by each type of crop for each period. Though there are definite gaps in the requisite data base for this project, it is still considered to be the appropriate method for weekly and daily demand estimation.

Guidelines for calculations by this method were taken from an FAO publication by Doorenbos and Pruit (1975) entitled "Crop Water Requirements". The Penman equation has two terms: an energy term which considers incoming radiation and an aerodynamic term based on wind and humidity. The modified Penman method involves a revised wind function and correction for day and night weather conditions not considered in the original wind term. The evapotranspiration calculation considers water vapor pressure as a function of humidity, as well as additional factors of wind speed, average temperature, and altitude. The radiation term is based on the amount of bright sunshine and the relative position of the sun and the station (month, latitude).

The crop coefficients modify the potential or referencial evapotranspiration assuming that crops are grown under optimum conditions producing optimum yields. Crops are categorized into ten

groups based on similar characteristics: time of planting or sowing, rate of crop development, length of growing season, climatic conditions, and frequency of rain or irrigation required. Similarities in plant structure were also used to group major crops. Since some plants resist transpiration well, size, roughness, reflectivity, and ground cover are also considered. Ideally, each crop should be studied using a lysimeter to determine water requirements more confidently.

b. Estimation of effective precipitation.

Effective precipitation is that portion of rainfall that contributes to the evapotranspiration requirement of a crop. The computer program begins with daily rainfall and removes the amount that is intercepted and returned to the atmosphere. Surface drainage depth is subtracted from the remaining amount by defining infiltration depth as the minimum of the precipitation rate and hydraulic conductivity at natural saturation, assuming a steady infiltration rate.

The infiltrated fraction of precipitation is either consumed by crops, stored in the soil, evaporated and/or serves as recharge to the aquifer by deep percolation. Unless the soil is initially saturated, some of the infiltrating water gradually fills available storage. Considering the average soil water field capacity, water content prevailing at the beginnng of the day, the thickness of the root zone and the recharge parameter for the precipitation process, a daily effective infiltration depth due to precipation can be calculated (Morel-Seytoux and Restrepo, 1985).

2.2.4 Microcomputer implementation of models.

The two major models, CSUDP and MODSIM, are written in FORTRAN 77 and implemented on an IBM PC. Both models are compiled by Microsoft

MS-FORTRAN Compiler V3.20 and linked by MS-FORTRAN Linker V2.41 under PC DOS 2.00. Size of required memory to run these two packages in shown in Table 2.2.1.

A general instruction and remark file named READ.ME! is enclosed in each package to describe the origin, characteristics and implementation of each model. Two example problems with data and output files are also enclosed for debugging purposes. For CSUDP, another documentation file CSUDPIBM.DOC is included to explain program usage in detail.

Since integer variable calculation is primarily used in the out-of-kilter method, MODSIM is linked with standard math library MATH.LIB of MS-FORTRAN V3.20. With this option, system units installed with or without an 8087 math coprocessor can run MODSIM successfully. In addition, MODSIM uses many integer variables with 32-bit precision. If the user needs to modify the program, the INTEGER*2 data type or $STORAGE metacommand should be used with caution. To increase the execution speed of CSUDP, an 8087 math coprocessor is utilized. The option of metacommand $NOFLOATCALLS in compiling and real math library 8087.LIB for linking are both used to obtain an executable file with increased execution speed.

The PC version of MODSIM is a user-friendly package. It is designed for interactive use and ease of implementation by beginners. A batch command file MODSIMX.BAT is provided to connect various aspects of the MODSIM package together. Entering "MODSIMX" after the DOS prompt initiates the package. The user can then follow instructions on the screen and answer various questions to create data files or to execute MODSIM for operational analysis. Once the user is familiar with all

Table 2.2.1. Minimum Required Memory for Executing CSUDP and MODSIM on the IBM PC with Executable Files Compiled by MS-FORTRAN V3.20

	CSUDP	MODSIM
Source Code	36,110	72,378
Code of Libraries Real Math Library	32,306 (8087.LIB)	40,214 (MATH.LIB)
Constants, Static Variables, and Stack Segment	11,824	17,472
Common Blocks	46,736	113,873
Total	126,976	243,937
Suggested System Memory	192K bytes	320K bytes

Note: 1. Memory is in Bytes and counted by decimal numbers.
2. 512 bytes of stack segment is temporarily assumed.

procedures of this package, it is possible to selectively access various parts directly.

CSUDP is a general dynamic programming package. The user needs to prepare user subroutines STATE, OBJECT, and READIN for describing a particular problem. After these three subroutines are successfully compiled, they should be linked with the other two main program object files CSUDP087.OBJ and DPSUB087.OBJ to obtain the executable file. Here the 8087.LIB and MS Linker V2.40 or V2.41 should be used for linking. If a PC system unit is installed without an 8087 coprocessor, the user can employ the other two object files CSUDP086.OBJ and DPSUB086.OBJ provided for linking with the real math library ALTMATH.LIB. A batch file DPLINK.BAT used for linking is enclosed in the package. The user may also study this file to determine which object files should be linked to obtain an executable file.

Hints about implementing the program with a floppy disk driver are given in file READ.ME!. Both models can be executed with floppy diskette, but only for small problems since up to five direct access files in MODSIM and up to three in CSUDP are created during execution. Some intermediate data are stored in a disk file to save main memory. For problems which have many stages and finer discretizations in CSUDP or many nodes and links in MODSIM, the corresponding direct access file will be extremely large. The only way to use the models in these cases is with a fixed disk. For details on the size of the direct access files, the user can also refer to the READ.ME! file.

The total number of files that can be opened concurrently by DOS varies from four to eight. For users running MODSIM on an IBM PC AT or compatible machine with DOS V3.00 or higher, FILE=15 is suggested to be

specified in the system configuration file CONFIG.SYS for allowing more files to be accessed at the same time.

The programs MODPEN and EFEC have not as yet been implemented on microcomputers because of the large data base necessary to run them. This includes a daily meteorological input data file, monthly cropping patterns for each sector and each type of crop, and monthly crop coefficients. Future work will attempt to adapt MODPEN and EFEC for real-time use on microcomputers, or directly incorporate them into Program MODSIM.

2.3. DATA ORGANIZATION AND PROCESSING

By far, the great majority of time and labor allocated to this project has been devoted to collection, processing, analysis, correction, and checking of a wide variety historical data associated with the Valdesia system. Without this intensive effort, there could be little confidence placed on the results and recommendations of this study. It is hoped that focus on use of computer models and their associated data requirements will provide impetus on improving the quality and density of water-related data collection networks throughout the Dominican Republic. Several limitations and gaps have been found in data quality and quantity in time and at specific locations. This has necessitated the filling of missing data by statistical procedures and mass balance calculations. None of the data obtained from the Dominican Republic were available in computer readable form (i.e., diskette or magnetic type), so all data had to be laboriously entered into disk files for use in this study. Table 2.3.1 summarizes the computerized data base developed for this study.

Table 2.3.1
Summary of Data Available for Normal Operation Study of the Valdesia Reservoir System

File Name	Description	Time Duration	Variables
POWER	Hourly energy releases, Valdesia Res.	1976-84	Releases (m^3/s)
NIZAO	Daily irrigation releases, Nizao-Najayo canal	1976-84	Releases (m^3/s)
CABRAL	Daily irrigation releases, M. Cabral canal	1976-84	Releases (m^3/s)
BASE2	Daily general data base	1976-84	Day number Precipitation at Sta. Valdesia (mm) Evaporation at Sta. Valdesia (mm) Discharge Sta. La Peñita (10^6m^3) Discharge Sta. Palo de Caja (10^6m^3) Water level at Valdesia Res. at 18:00 hrs(masl) Minimum water level at Valdesia Res. (masl) Maximum water level at Valdesia Res. (masl) Calculated inflows to Valdesia Reservoir (10^6m^3) Turbine operating hours Energy at Valdesia Plant (MW-hr) Water levels at Las Barias (masl) Irrigation releases through M. Cabral canal (10^6m^3) Irrigaton releases through Nizao-Najayo canal (10^6m^3)
DAEVAP	Monthly evaporation at Sta. Quija-Quieta and San Cristobal	1976-84	Evaporation in mm
DIFE	Daily level changes at Valdesia (18:00 hrs)	1976-84	Water levels (cm)

Table 2.3.1 (continued)
Summary of Data Available for Normal Operation Study of the Valdesia Reservoir System

File Name	Description	Time Duration	Variables
BANI	Daily temperatures at Sta. Bani	1976-84	Temperatures (°C)
LLUVIA	Rainfall data for Sta. Bani	1976-84	Rainfall (mm)
WBAS7	Weekly data base	1976-84	Day of starting week Water volume at Valdesia 18:00 hrs ($10^6 m^3$) Evaporation *.8 -precipitation (mm) Discharges Sta. La Peñita ($10^6 m^3$) Discharges Sta. Palo De Caja ($10^6 m^3$) Water levels at Valdesia, 18:00 hrs (masl) Minimum water levels at Valdesia (masl) Maximum water levels at Valdesia (masl) Calculated inflows to Valdesia Res. ($10^6 m^3$) Releases from Valdesia Res. ($10^6 m^3$) Power at Valdesia Plant (KW) Las Barias water levels (masl) M. Cabral irrigation releases ($10^6 m^3$) Nizao-Nijayo irrigation releases ($10^6 m^3$) Week number
AREA4	Monthly cropping areas for Sectors 1-8 for Nizao irrigation area	1984	Cropping area (ha)
AREA3	Monthly cropping areas for Sectors 1-8 for Nizao irrigation area	1983	Cropping area (ha)
MG3	Generated monthly inflows for 1100 years	-	Inflows (m^3/s)
TAPE6	Generated number of turbine operating hours for 1100 years	-	Number of Hours

Table 2.3.1 (continued)
Summary of Data Available for Normal Operation Study of the Valdesia Reservoir System

File Name	Description	Time Duration	Variables
SCRI4	Daily metereological data at Sta. San Cristobal	1984	Day number Temperature (°C) Wind Velocity (m/s) Cloud cover (OKTAS) Evaporation (mm) Relative humidity (%)
SCRI3	Daily metereological data at Sta. San Cristobal	1983	Day number Temperature (°C) Wind velocity (m/s) Cloud cover (OKTAS) Evaporation (mm) Relative humidity (%)

2.3.1. Irrigation system data.

a. Irrigation sectors and cropping patterns.

The total irrigation cropping area has been divided into eight sectors as aggregated from 30 previous zone designations that are being abandoned by INDRHI. The old sectors are listed in Table 2.3.2 and their aggregation into the new sectors is given in Table 2.3.3. The locations of the new sectors can be seen in Figure 2.3.1. This information was taken from the report "Organizacion de Operacion y Mantenimiento Informe Preliminar de Diagnostico," Fredericksen, et al. (1985). The 35 or so crop types are combined into 10 groups according to simularities in growing season (Table 2.3.4). Monthly crop coefficients for the Valdesia irrigation zone are shown in Figure 2.3.2. The crop coefficient data were obtained from a table prepared by the Operations Department of INDRHI. Discussions with Eng. Jose R. Duval (July 1985) concerning certain crops not included in the table resulted in agreement that the FAO Manual (Doorenbos and Pruit, 1975) should be consulted to complete this information.

b. Crop water requirements.

Program MODPEN is used to estimate crop evapotranspiration requirements on a daily, weekly and monthly basis by the modified Penman method, as described by Doorenbos and Pruit (1975). The primary formulas used in this method are:

$$ETO = \underbrace{W2 \cdot RN}_{\text{radiation term}} + \underbrace{W1 \cdot FU \cdot (EA-ED)}_{\text{aerodynamic term}} \qquad (2.3.1)$$

where

ETO = reference crop evapotranspiration

Table 2.3.2 Old Sectors in the Valdesia Irrigation Subsystem

Marcos A. Cabral Canal

Number	Name	Number	Name
1	Maximo Gomez	13	Sector Escondido
2	Matanzas	14	Paya Sar
3	Los Jobos	15	Paya Norte
4	Canafistol	16	Salto de Agua
5	Sombrero Norte	17	Carreton
6	Sombrero Sor	18	Catalina
7	El Llano Norte	19	Nizao 1
8	El Llano	20	Nizao 2
9	Boca Canasta Norte	21	Santana
10	Boca Canasta Sor	22	Pizarrete
11	Corbanal	23	Robledal
12	Mata Gorda	24	Las Barias

Nizao-Najayo Canal

Number	Name	Number	Name
1	Semana Santa	4	Sabana Palenque
2	La Cabria	5	Sabana Grande de Palenque
3	Juan Baron	6	La Reforma

Table 2.3.3 New Sectors in the Valdesia Irrigation Subsystem

Number	Numbers of Old Sectors
1	1,2,3
2	4,5,6,7
3	8,9,10
4	11,12,13,14,15
5	16,17
6	18,19,20,21,22,23,24
7	1,2(*)
8	3,4,5,6(*)

(*) Sectors of the Nizao-Najayo Canal.

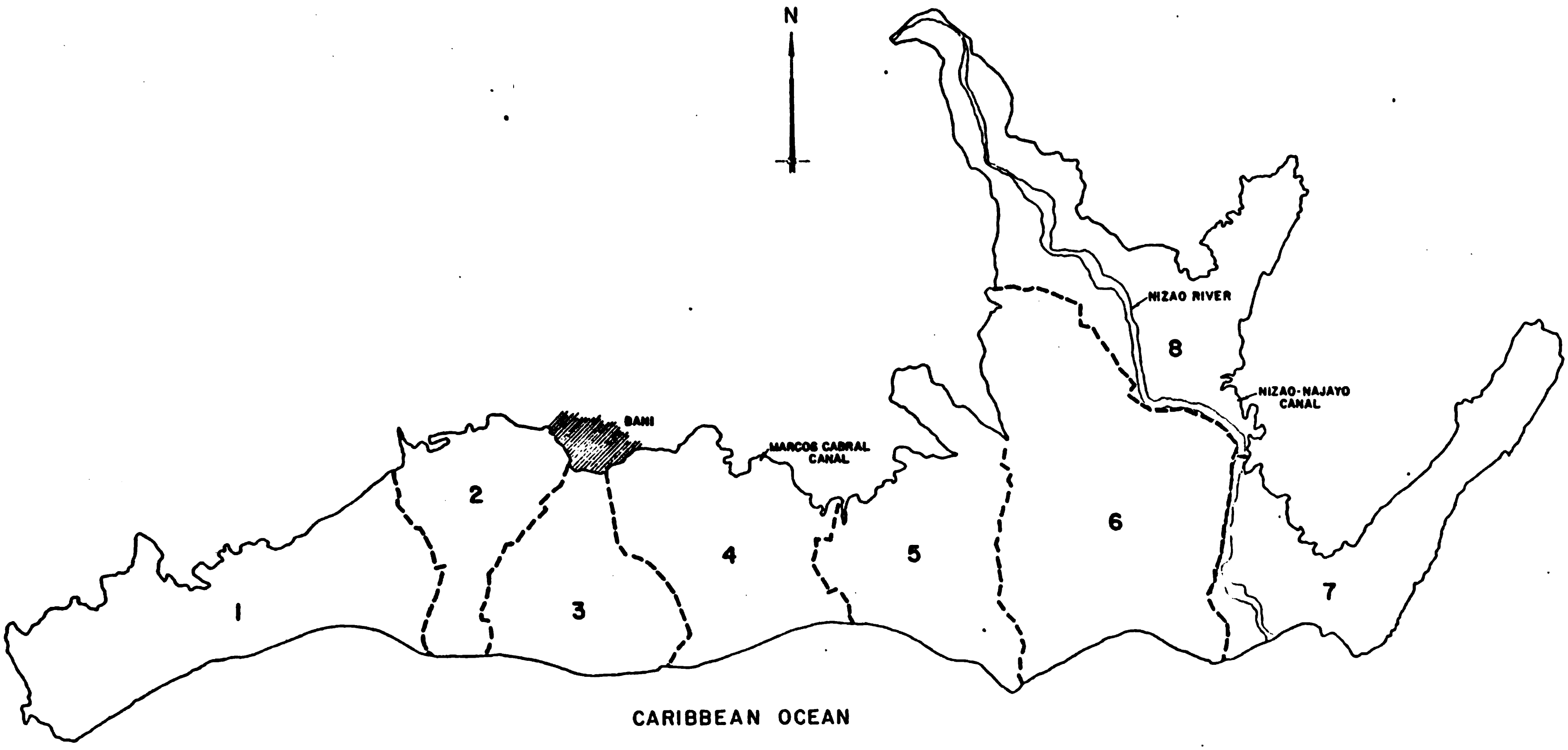


Figure 2.3.1 Distribution of the New Sectors for the Valdesia Irrigation Zone

Table 2.3.4
Crop groupings

No.	Name of the group	Crops in their respective group
1	rice	rice
2	corn	corn, sorghum, sunflower, peanuts, red beans, molondron
3	bananas	bananas, guineo, rulo
4	papaya	papaya (lechoza)
5	yuca	yuca
6	onions	onions
7	sugarcane	sugarcane
8	small vegetables (hortalizas)	tomatoes, pepinos, green beans (vainita), sugarbeets, berenjena, green pepper, cebollin, cabbage, name, melon, auyama, sweet potatoes, potatoes, cucumbers, watermelon
9	pastures	natural pastures, pangola, guinea
10	perennial	citrus, coconuts, mango, avocados, figs, mispero

Figure 2.3.2 Crop Coefficients for Various Crop Groupings.

(a)

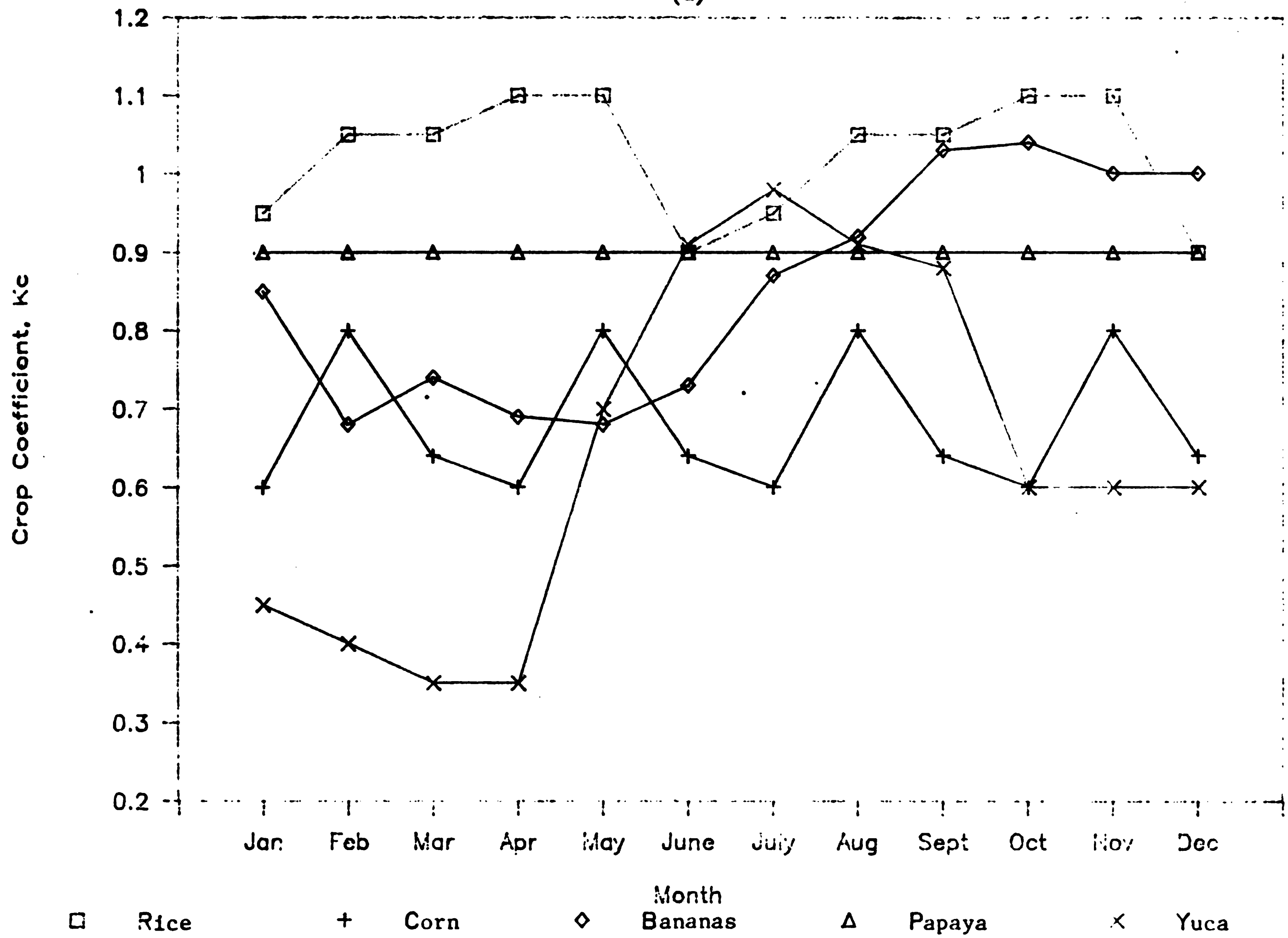


Figure 2.3.2 Crop Coefficients for Various Crop Groupings. (continued)

(b)

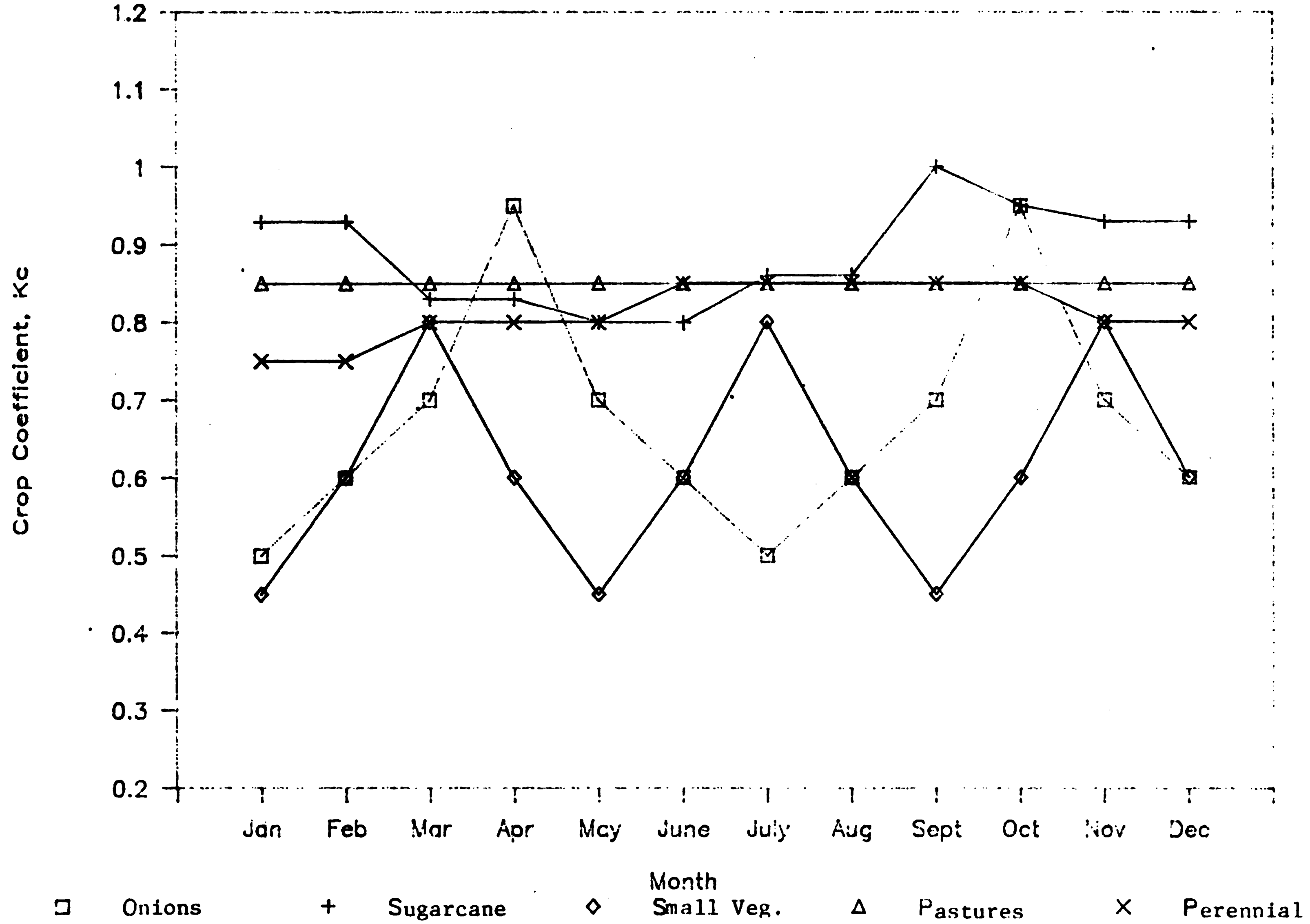
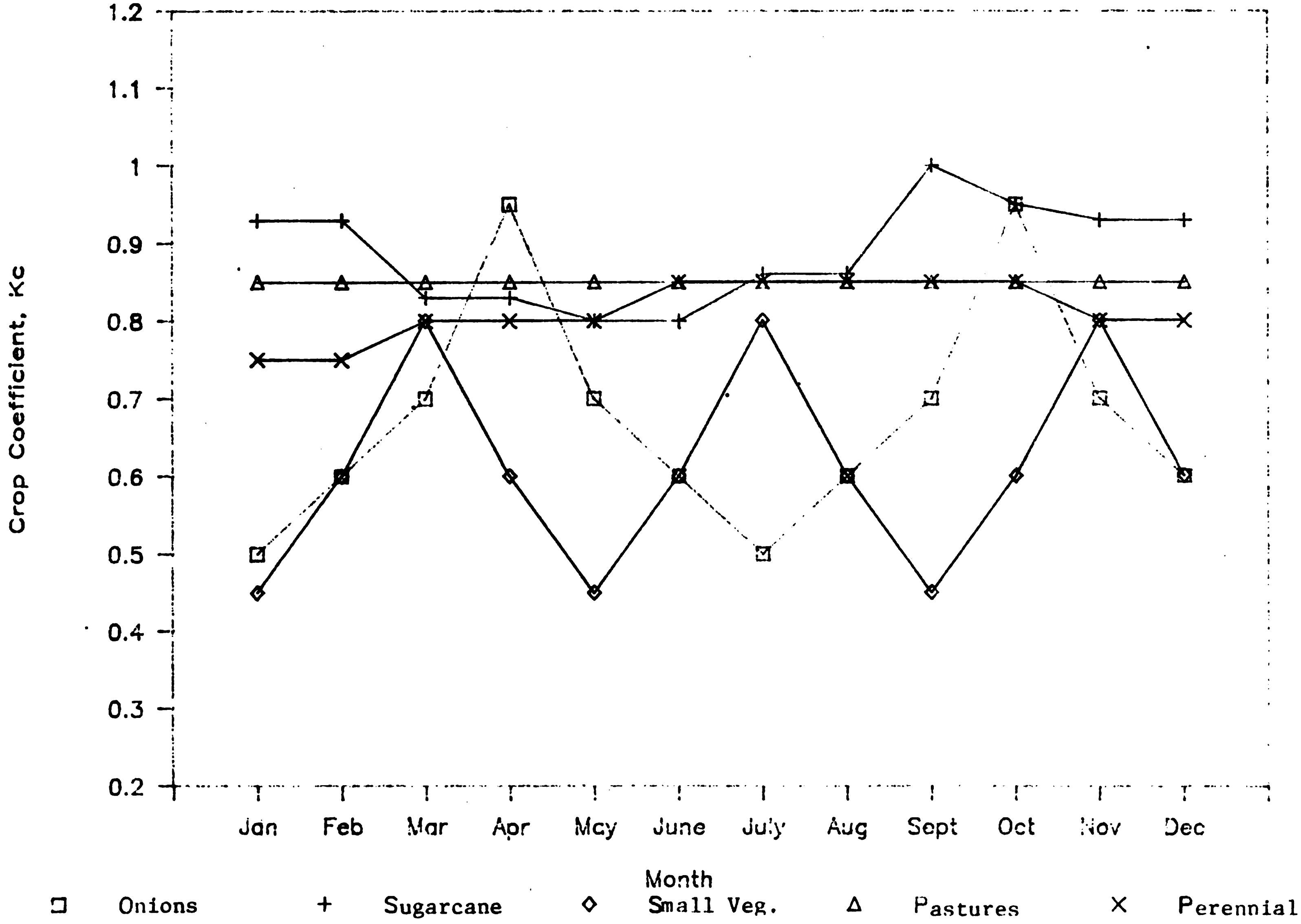


Figure 2.3.2 Crop Coefficients for Various Crop Groupings. (continued)

(b)



W2 - weighting factor for radiation term

RN - net radiation

W1 - weighting factor for aerodynamic term

FU - wind related function

EA - saturation vapor pressure at mean air temperature

ED - mean actual vapor pressure.

Values of W1 are considered related to temperature and elevation, as given in a table in Doorenbos and Pruit (1975). Considering the elevation of the zone of study the following equation was developed from this table mentioned above:

$$W1 = 0.571 - 0.013523 \cdot TEMP + 1.82988 \times 10^{-6} \cdot (TEMP)^3 \quad (2.3.2)$$

$$W2 = 1-W1 \quad (2.3.3)$$

ETO needs to be adjusted for daytime and nighttime weather conditions. For this project the correction factor is equal to one because of combined effects of daytime average wind speed, day-night ratio of wind speed and maximum relative humidity.

EA and ED are functions of average temperature and relative humidity, respectively, and can be estimated by formulas (as used in Program MODPEN) or by tables (see Doorenbos and Pruit, 1975).

The term FU is a wind related function calculated as:

$$FU = 0.27 \left(1 + \frac{U2}{100}\right) \quad (2.3.4)$$

where U2 is wind run in km/day at 2 m height.

Knowing the monthly average values of extra terrestrial radiation (RA) and the ratio of actual to maximum possible bright sunshine hours (CLOUD) the solar radiation (RS) is estimated as:

$$RS = (0.31+0.49 \cdot CLOUD) \cdot RA \qquad (2.3.5)$$

The coefficients of this equation were obtained from Smith (1959) using data from Jamaica at 18°N of latitude.

Considering a reflectivity of the crop surface (α) equal to 0.25, the net shortwave radiation (RNS) is:

$$RNS = (1-\alpha)RS = 0.75\ RS \qquad (2.3.6)$$

The term RN is a function of RNS and other correction factors including: vapor pressure (FED), bright sunshine (FNN) and temperature in long wave radiation (FT). All these coefficients are shown in tables in Doorenbos and Pruit (1975), Program MODPEN uses curves fitted to these data.

Actual evapotranspiration is now calculated as:

$$ET = ETO \cdot XKC \qquad (2.3.7)$$

where

ET = crop evapotranspiration

XKC = crop coefficient that varies according to crop stage during the season.

A listing of Program MODPEN is given in Appendix A.

c. <u>Effective precipitation</u>

Effective precipitation represents the portion of rainfall available to satisfy crop water requirements. A computer program called EFEC has been developed for estimating effective precipitation based on a procedure developed by Morel-Seytoux and Restrepo (1985).

Daily effective infiltration depth due to precipation is defined as:

$$DELPWP = PT - ESP - DDP \tag{2.3.8}$$

where

PT = total daily precipitation depth, cm

DDP = daily surface drainage depth, cm

and ESP is calculated by a Horton-type equation as:

$$ESP = PT \quad \text{for} \quad PT \leq PC + EP \cdot TP \tag{2.3.9}$$

$$= (PC + EP \cdot TP)[1 - e^{-[PT/(PC+EP \cdot TP)]}] \quad \text{for} \quad PT > PC + EP \cdot TP \tag{2.3.10}$$

where

EP = daily potential evaporation depth from a free water surface, cm

TP = precipation duration, days

PC = interception storage capacity

The DDP term in (2.3.8) is computed as:

$$DDP = \max(0, P - XK \cdot TP) \tag{2.3.11}$$

where XK is hydraulic conductivity at saturation (cm/d) and

$$P = 0 \quad \text{for} \quad PT \leq PC + EP \cdot TP \tag{2.3.12}$$

$$= PT-ESP \quad \text{for} \quad PT > PC + EP \cdot TP \qquad (2.3.13)$$

with P defined as unevaporated precipitation depth reaching the ground.

Daily effective infiltration depth DELWEP is defined as infiltrating water leaving the root zone and therefore not available for crop use, as calculated by:

$$DELWEP = \frac{DELPWP^{NP+1}}{(NP+1)[(THEFC-THEO)DELZR]^{NP}}$$

$$\text{for } DELPWP < (THEFC-THEO)DELZR \qquad (2.3.14)$$

$$= \left(\frac{NP}{NP+1}\right)(THEFC-THEO)DELZR$$

$$\text{for } DELPWP \geq (THEFC-THEO)DELZR \qquad (2.3.15)$$

where

THEFC = water content at field capacity

THEO = initial soil water content

DELZR = root zone thickness on current day, cm

NP = positive dimensionless recharge factor

The final effective precipitation depth available for crop water use is:

$$DELPE = \max(0, DELPWP-DELWEP) \qquad (2.3.16)$$

The listing for Program EFEC can also be found in Appendix A of this report. Application of programs MODPEN and EFEC to the Valdesia System has resulted in the monthly demand estimates given in Table 2.3.5 and the weekly estimates for each irrigation sector in Table 2.3.6.

2.3.2 Stochastic inflow characteristics.

Figure 2.3.3 gives the frequency distributions of Valdesia Reservoir inflows for the month of March, for illustration purposes. A

Table 2.3.5 Monthly Calculated Irrigation Demands for Year 1983 and 1984

	1984						1983						Total Average m^3/s (1983-84)
	ETP(mm)	Efect Precip (mm)	Consumptive Use Total (mm)	Consumptive Use Cabral (m^3/s)	Consumptive Use Nizao (m^3/s)	Consumptive Use Total (m^3/s)	ETP(mm)	Efect Precip (mm)	Consumptive Use Total (mm)	Consumptive Use Cabral (m^3/s)	Consumptive Use Nizao (m^3/s)	Consumptive Use Total (m^3/s)	(m^3/s)*
Jan	130.79	38.61	263.37	6.86	.80	7.66	113.09	12.72	286.77	7.68	.87	8.55	8.11
Feb	123.72	41.09	236.09	6.35	.72	7.07	129.91	0.00	371.17	10.05	1.14	11.19	9.13
Mar	169.39	20.00	426.83	11.33	)1.29	12.62	145.68	25.07	344.60	9.27	1.10	10.38	11.50
Apr	168.23	41.18	363.00	9.75	1.09	10.84	153.31	32.93	343.94	9.91	1.14	10.05	10.44
May	178.22	49.40	368.06	9.99	1.12	11.11	141.84	88.69	151.86	3.81	.49	4.30	7.71
Jun	138.91	33.38	301.51	8.14	.94	9.08	144.14	62.92	232.06	5.89	.76	6.65	7.87
Jul	170.11	85.05	243.03	6.49	.82	7.31	174.62	24.12	430.00	11.06	1.38	12.44	9.88
Aug	181.28	60.33	345.57	8.74	1.15	9.89	157.41	95.61	176.57	4.50	.57	5.07	7.48
Sep	164.36	78.81	244.43	6.01	.80	6.81	168.69	40.26	366.94	9.33	1.19	10.52	8.67
Oct	160.45	75.61	242.40	5.81	.79	6.60	151.56	39.80	319.31	8.13	1.02	9.15	7.88
Nov	158.71	20.00	396.31	10.21	1.26	11.47	156.23	28.89	363.83	9.41	1.10	10.51	10.99
Dec	149.12	32.99	331.80	8.31	1.04	9.35	141.61	30.26	318.14	7.92	.99	8.91	9.13

* considered a total efficiency of 35%.

Table 2.3.6 Calculated mean weekly consumptive use for the Valdesia irrigation subsystem (m^3/s).

WEEK	S. 1	S. 2	S. 3	S. 4	S. 5	S. 6	S. 7	S. 8	TOTAL
1	1.41429	0.94286	1.50000	0.94286	3.01429	1.01429	0.92857	0.171429	9.890
2	0.95714	0.64286	1.04286	0.62857	2.18571	0.65714	0.67143	0.100000	6.880
3	0.95714	0.67143	1.08571	0.64286	2.25714	0.68571	0.70000	0.114286	7.090
4	1.10000	0.74286	1.20000	0.72857	2.48571	0.75714	0.75714	0.114286	7.895
5	1.34286	0.85714	1.28571	1.04286	3.10000	1.17143	0.94286	0.185714	9.930
6	0.88571	0.58571	0.85714	0.64286	2.32857	0.84286	0.71429	0.114286	6.965
7	1.02857	0.67143	0.98571	0.74286	2.58571	0.94286	0.78571	0.142857	7.885
8	1.51429	0.97143	1.47143	1.17143	3.48571	1.32857	1.05714	0.214286	11.225
9	1.62857	1.02857	1.60000	1.20000	3.18571	1.35714	0.95714	0.257143	11.210
10	1.47143	0.92857	1.45714	1.11429	2.94286	1.24286	0.88571	0.228571	10.270
11	1.45714	0.92857	1.44286	1.10000	2.94286	1.24286	0.88571	0.228571	10.205
12	1.61429	1.01429	1.58571	1.18571	3.20000	1.35714	0.95714	0.257143	11.190
13	1.97143	1.25714	1.98571	1.42857	4.05714	1.70000	1.21429	0.328571	13.940
14	1.31429	0.85714	1.37143	1.00000	2.98571	1.30000	0.91429	0.257143	9.995
15	1.58571	1.00000	1.62857	1.24286	3.45714	1.54286	1.05714	0.271429	11.785
16	1.47143	0.92857	1.50000	1.14286	3.24286	1.44286	0.98571	0.257143	10.995
17	1.01429	0.67143	1.05714	0.80000	2.42857	1.05714	0.74286	0.185714	7.945
18	1.97143	1.22857	1.98571	1.52857	4.01429	1.85714	1.24286	0.328571	14.145
19	1.47143	0.90000	1.48571	1.21429	3.05714	1.45714	0.95714	0.228571	10.820
20	1.07143	0.65714	1.08571	0.94286	2.32857	1.12857	0.72857	0.171429	8.125
21	0.30000	0.20000	0.31429	0.27143	0.81429	0.38571	0.25714	0.057143	2.610
22	0.55714	0.35714	0.58571	0.38571	1.07143	0.45714	0.34286	0.100000	3.850
23	1.28571	0.80000	1.31429	0.94286	2.48571	1.11429	0.77143	0.214286	8.925
24	0.67143	0.40000	0.68571	0.54286	1.30000	0.62857	0.40000	0.100000	4.715
25	1.48571	0.90000	1.50000	1.11429	2.84286	1.30000	0.88571	0.242857	10.265
26	2.10000	1.21429	2.05714	1.45714	3.80000	1.72857	1.17143	0.314286	13.865
27	1.07143	0.61429	1.07143	0.70000	1.91429	0.88571	0.60000	0.171429	7.020
28	2.05714	1.20000	2.02857	1.37143	3.64286	1.67143	1.14286	0.342857	13.465
29	1.90000	1.10000	1.87143	1.24286	3.35714	1.52857	1.04286	0.314286	12.375
30	0.80000	0.47143	0.80000	0.48571	1.41429	0.61429	0.44286	0.114286	5.160
31	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000
32	1.57143	0.91429	1.61429	0.90000	2.71429	1.22857	0.84286	0.285714	10.065
33	2.11429	1.22857	2.15714	1.21429	3.68571	1.64286	1.15714	0.371429	13.575
34	1.60000	0.92857	1.65714	0.91429	2.75714	1.24286	0.87143	0.285714	10.225
35	1.07143	0.67143	1.21429	0.52857	2.15714	0.80000	0.70000	0.142857	7.280
36	1.84286	1.11429	1.95714	0.97143	3.52857	1.38571	1.11429	0.271429	12.190
37	1.81429	1.08571	1.92857	0.95714	3.47143	1.35714	1.10000	0.271429	12.000
38	0.48571	0.28571	0.51429	0.24286	0.94286	0.37143	0.30000	0.057143	3.195
39	1.02857	0.61429	1.21429	0.54286	2.15714	0.80000	0.67143	0.171429	7.215
40	1.42857	0.84286	1.60000	0.87143	2.70000	1.00000	0.85714	0.214286	9.515
41	1.38571	0.81429	1.54286	0.82857	2.58571	0.95714	0.82857	0.214286	9.140
42	0.85714	0.52857	0.94286	0.52857	1.55714	0.58571	0.48571	0.128571	5.595
43	1.18571	0.72857	1.31429	0.71429	2.20000	0.81429	0.70000	0.171429	7.815
44	1.45714	0.91429	1.87143	0.97143	2.78571	0.95714	0.85714	0.228571	10.045
45	1.58571	0.98571	1.85714	1.02857	2.90000	0.98571	0.90000	0.214286	10.465
46	1.90000	1.18571	2.30000	1.28571	3.55714	1.22857	1.10000	0.285714	12.845
47	1.54286	0.94286	1.75714	1.00000	2.78571	0.97143	0.87143	0.214286	10.085
48	1.38571	1.05714	2.01429	1.05714	3.10000	1.07143	0.98571	0.214286	10.890
49	0.77143	0.64286	1.28571	0.58571	1.91429	0.57143	0.58571	0.114286	6.480
50	1.57143	1.12857	2.12857	1.14286	3.31429	1.15714	1.05714	0.228571	11.725
51	1.18571	0.82857	1.54286	0.81429	2.40000	0.82857	0.75714	0.171429	8.530
52	1.25714	0.95714	1.80000	0.95714	2.80000	0.94286	0.87143	0.200000	9.795

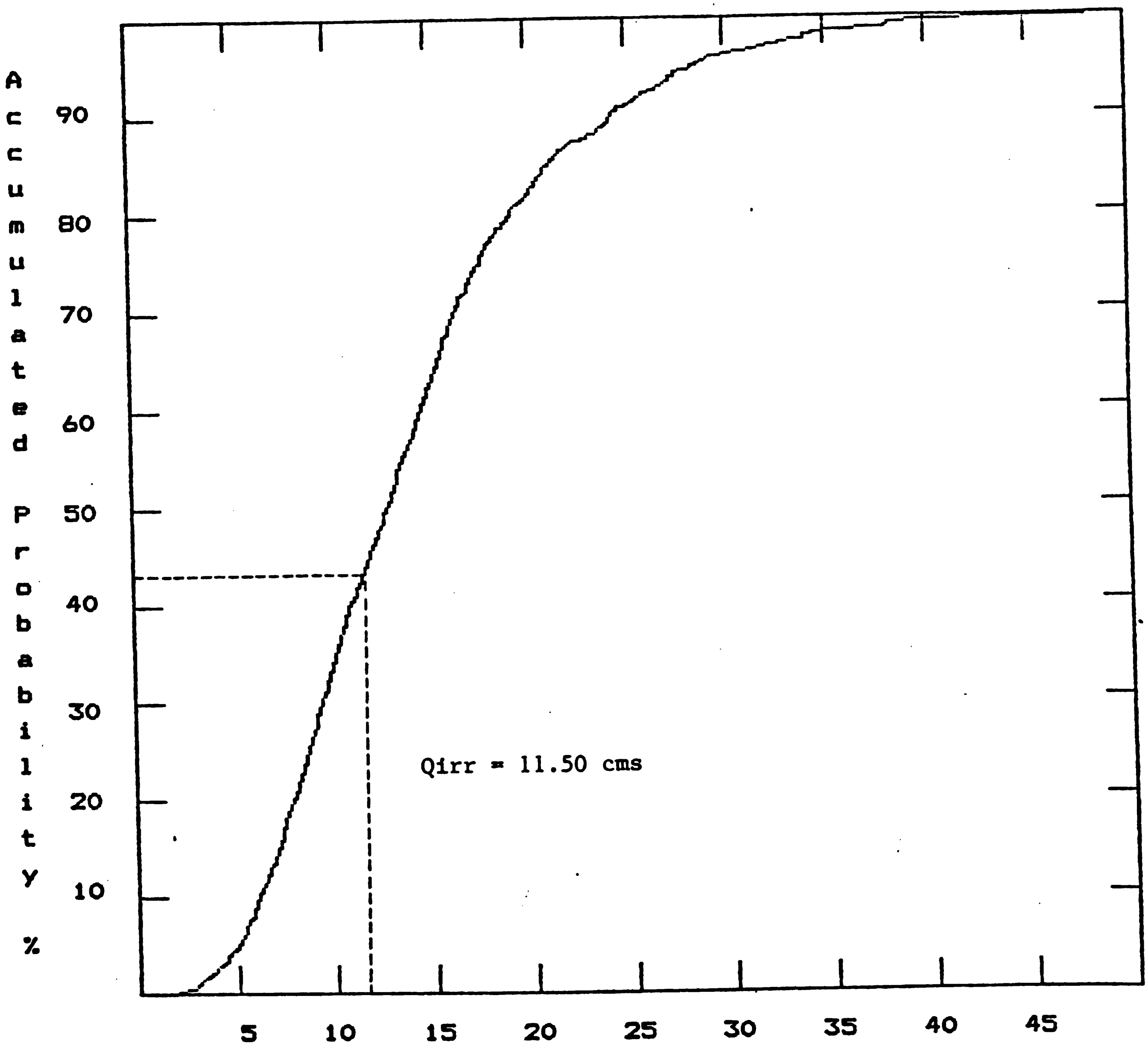


Figure 2.3.3 Generated Monthly Inflow , CMS

March

set of frequency distributions for all remaining months can be found in Appendix B, as generated by the Emergency Operations Group. All other local inflows to the system are considered negligible in comparison to these inflows. Also superimposed on these figures are average irrigation demands estimated from Table 2.3.5. These show the high risk of not meeting demands for certain months if Valdesia Reservoir were not available and supplies were run-of-the-river only. Data used for this analysis are based on 50 sets of synthetically generated flows upstream of Valdesia reservoir in 22 year lengths, giving a total of 1100 data sets.

Due to the existence of strong monthly serial correlation among inflows, the probabilities of inflow in a given month should be conditioned on what inflow actually occurred in the previous month. A set of discrete conditional probability distributions were developed for each month in the form of discrete transition probability matrices $P(I_i|I_{i-1})$ to preserve these characteristics, where I_i is the inflow in month i and I_{i-1} is the inflow in the previous month. Several transition matrices of varying order have been calculated, including 3x3, 3x9, 6x6 and 12x12. After analysis of the corresponding stationary operational policies from the stochastic dynamic programming analysis described in a subsequent section, the 12x12 order was ultimately selected for developing final operating rules. For the 12x12 transition matrix, inflows for both the current and previous month are divided into twelve classes. There are eleven limits for these twelve classes chosen as 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 95 percentiles of the empirical accumulated probability distribution of generated inflow for each month, as given in Table 2.3.7. The class mark of each class is

Table. 2.3.7 Class limits in transition matrix of each month and its corresponding percentile in probability distribution

Percentile	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Minimum	2.656	1.547	1.821	2.058	1.000	1.491	2.651	4.471	5.867	6.256	6.224	3.304
5	6.935	5.293	5.149	5.347	5.366	5.567	7.188	9.330	8.695	9.316	10.583	6.598
10	8.420	6.793	6.174	6.504	6.895	7.174	8.527	11.663	10.170	10.584	11.960	8.308
20	10.654	8.860	8.005	8.251	9.966	10.138	10.839	14.840	12.308	12.476	13.877	11.245
30	12.370	10.771	9.512	9.686	13.533	12.898	13.034	18.018	14.603	13.880	15.537	13.809
40	13.890	12.600	11.034	11.035	16.773	16.113	15.505	20.707	16.851	15.333	17.015	16.002
50	15.300	14.516	12.925	12.284	20.087	19.859	18.246	24.803	19.401	16.743	18.908	18.742
60	17.510	16.617	14.606	13.846	24.552	24.962	20.569	28.122	22.768	18.661	20.906	22.079
70	19.441	19.089	16.387	15.650	29.811	31.513	24.613	33.263	27.162	21.423	23.011	26.356
80	22.240	21.967	19.218	18.196	38.052	39.128	29.083	40.871	32.440	24.700	26.161	32.026
90	27.220	27.168	24.387	22.292	50.282	53.552	36.335	52.939	44.292	30.468	32.444	42.556
95	31.829	31.841	28.491	26.061	63.229	67.877	43.221	70.433	58.197	36.716	36.521	50.928
Next to Max	52.530	52.551	48.354	41.821	136.869	210.144	108.817	273.411	153.707	69.865	67.980	136.722
Maximum	59.104	53.239	51.971	50.333	197.840	225.957	109.485	430.546	163.226	77.526	69.895	142.059

Unit: CMS

taken as the mean value of all flow events in that class. The resulting transition probability matrices for all months can be found in Appendix C of this volume. Table 2.3.8 includes the probabilities for March inflows, conditioned on February flow classes.

2.3.3. Reservoir system and powerplant.

Elevation-area-volume relationships for Valdesia and Las Barias Reservoirs are provided in Tables 2.3.9 and 2.3.10. The elevation-capacity curve for Valdesia Reservoir is shown in Figure 2.3.4. These tables reflect conditions after Hurricane David. Maximum discharge capacity through the powerplant is 90 m^3/s. The two turbines located in the Valdesia hydropower plant are the Francis type and generate different levels of power as a function of the head, discharge and turbine efficiency (Table 2.3.11). Turbine elevation is at 70 m.a.s.l.

A typical daily load curve for power demand is given in Figure 2.3.5. It can be seen that there are two or three peak periods totalling eight to ten hours in duration. As described in Section 1.9 of Volume I, a bivariate stochastic modeling of inflows and hours of generation was carried out because of the variability of generation hours and strong correlation with inflows. Figure 2.3.6 gives the resulting accumulated probability distribution for March. A complete set of curves for all months can be found in Appendix D.

Figure 2.3.7 shows the flood pool allocation for Valdesia Reservoir which has been supplied to the Normal Operations study by the Emergency Operations group. Though there is no indication of any historical provision for flood control space in the reservoir, especially during periods of maximum flood danger, it was felt that some provision should be made to improve the flood protection capability of

Table 2.3.8 Transition Probability Matrix

From February to March , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	3.9725	5.7109	7.1656	8.8120	10.275	12.016	13.763	15.501	17.678	21.527	26.341	34.457
01	4.0087	0.4364 24	0.2000 11	0.2545 14	0.0182 1	0.0182 1	0.0545 3	0.0000 0	0.0182 1	0.0000 0	0.0000 0	0.0000 0	0.0000 0
02	6.1114	0.2037 11	0.2037 11	0.2037 11	0.1667 9	0.1111 6	0.0556 3	0.0370 2	0.0000 0	0.0000 0	0.0185 1	0.0000 0	0.0000 0
03	7.8893	0.1171 13	0.1261 14	0.2252 25	0.1892 21	0.0991 11	0.0811 9	0.0541 6	0.0901 10	0.0180 2	0.0000 0	0.0000 0	0.0000 0
04	9.8973	0.0273 3	0.0455 5	0.1636 18	0.1909 21	0.2364 26	0.1545 17	0.0545 6	0.0909 10	0.0182 2	0.0182 2	0.0000 0	0.0000 0
05	11.740	0.0182 2	0.0727 8	0.1455 16	0.1182 13	0.2091 23	0.1091 12	0.1364 15	0.0909 10	0.0545 6	0.0455 5	0.0000 0	0.0000 0
06	13.528	0.0091 1	0.0545 6	0.1000 11	0.1455 16	0.1273 14	0.1455 16	0.1273 14	0.1364 15	0.0727 8	0.0636 7	0.0182 2	0.0000 0
07	15.542	0.0091 1	0.0000 0	0.0818 9	0.1182 13	0.1091 12	0.1545 17	0.1818 20	0.1182 13	0.1364 15	0.0909 10	0.0000 0	0.0000 0
08	17.757	0.0000 0	0.0000 0	0.0273 3	0.0818 9	0.1091 12	0.1273 14	0.1545 17	0.1545 17	0.1545 17	0.1364 15	0.0545 6	0.0000 0
09	20.398	0.0000 0	0.0000 0	0.0273 3	0.0455 5	0.0455 5	0.1091 12	0.1091 12	0.1545 17	0.2273 25	0.2091 23	0.0727 8	0.0000 0
10	24.194	0.0000 0	0.0000 0	0.0000 0	0.0182 2	0.0000 0	0.0545 6	0.1000 11	0.1273 14	0.1818 20	0.2273 25	0.1636 18	0.1273 14
11	29.196	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0182 1	0.0909 5	0.0545 3	0.1636 9	0.2364 13	0.1636 9	0.2727 15
12	38.625	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0364 2	0.0000 0	0.1091 6	0.1636 9	0.2182 12	0.4727 26

Table 2.3.9 Elevation-Area-Volume Relation for Valdesia Reservoir. (Source: CDE)

ELEVATION (m.a.s.l.)	AREA ($10^3 m^2$)	Volume ($10^3 m^3$) ORIGINAL	SINCE MAY 1981
95	38	38	0
100	150	508	0
105	324	1693	0
110	871	4680	600
115	1572	10788	1173
120	2310	20493	6182
125	3406	34808	16214
130	4537	54669	32163
135	5664	80168	53736
140	6677	111021	80145
145	7492	146443	113465
150	8357	186066	153688

Table 2.3.10 Elevation-Area-Volume Relation for Las Barias Reservoir. (Source: CDE)

ELEVATION (m.a.s.l.)	AREA $10^3 m^2$)	VOLUME ($10^3 m^3$)
69	0	0
70	52	50
72	190	240
73	310	450
74	460	800
75	640	1400
76	805	2100
77*	910	3000
78	1000	4000
80	1140	6050

* maximum elevation without spill

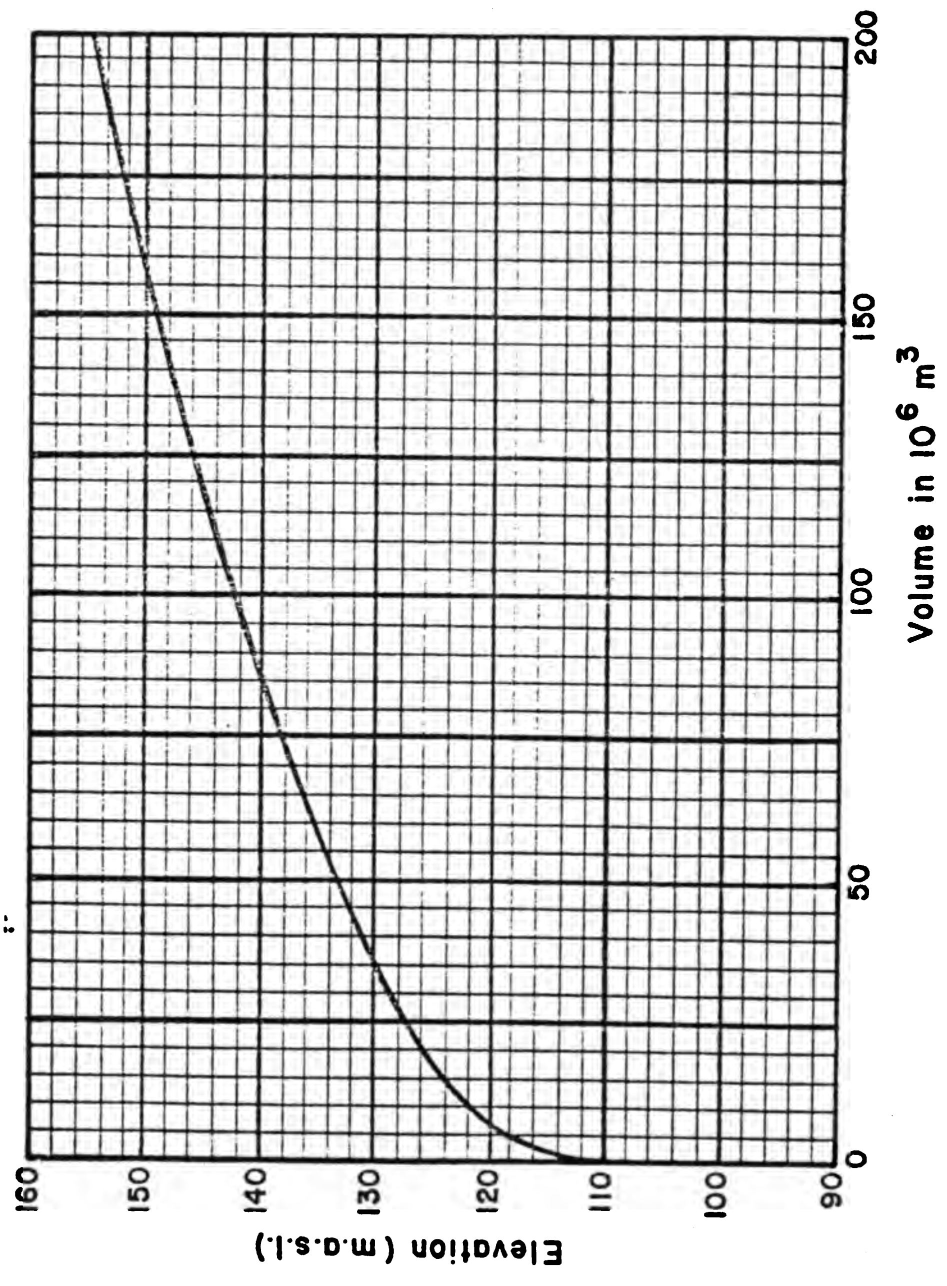


Figure 2.3.4 Elevation (m.a.s.l) vs. Head for Valdesia Reservoir (post-Hurricane David, 1979)

Table 2.3.11 Turbine Efficiencies

Head (m)	Discharge (m^3/s)								
	0	40	50	60	65	70	75	80	90
60	.0	.6442	.6893	.7085	.7190	.7131	.7133	.7046	.6797
64	.0	.6346	.6854	.7190	.7344	.7334	.7296	.7219	.6970
67	.0	.6346	.6893	.7258	.7373	.7430	.7440	.7411	.7430
71	.0	.6202	.6893	.7354	.7507	.7565	.7498	.7478	.7248
74	.0	.6144	.6874	.7402	.7526	.7632	.7613	.7574	.7315
77	.0	.6288	.6912	.7373	.7507	.7584	.7594	.7565	.7373
80	.0	.6422	.7037	.7421	.7526	.7622	.7670	.7613	.7334

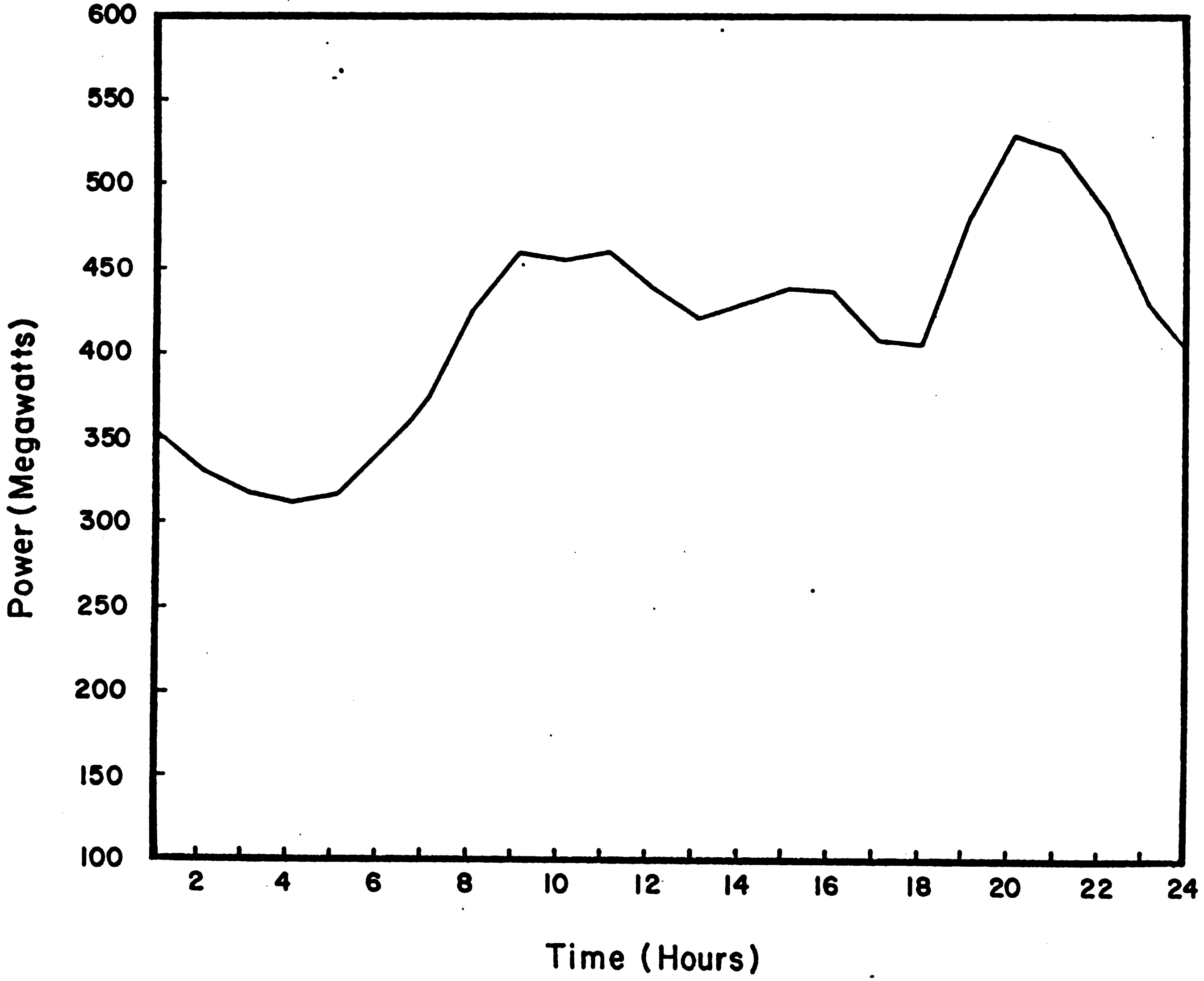


Figure 2.3.5 Typical Daily Power Load Curve (Feb. 22, 1985)

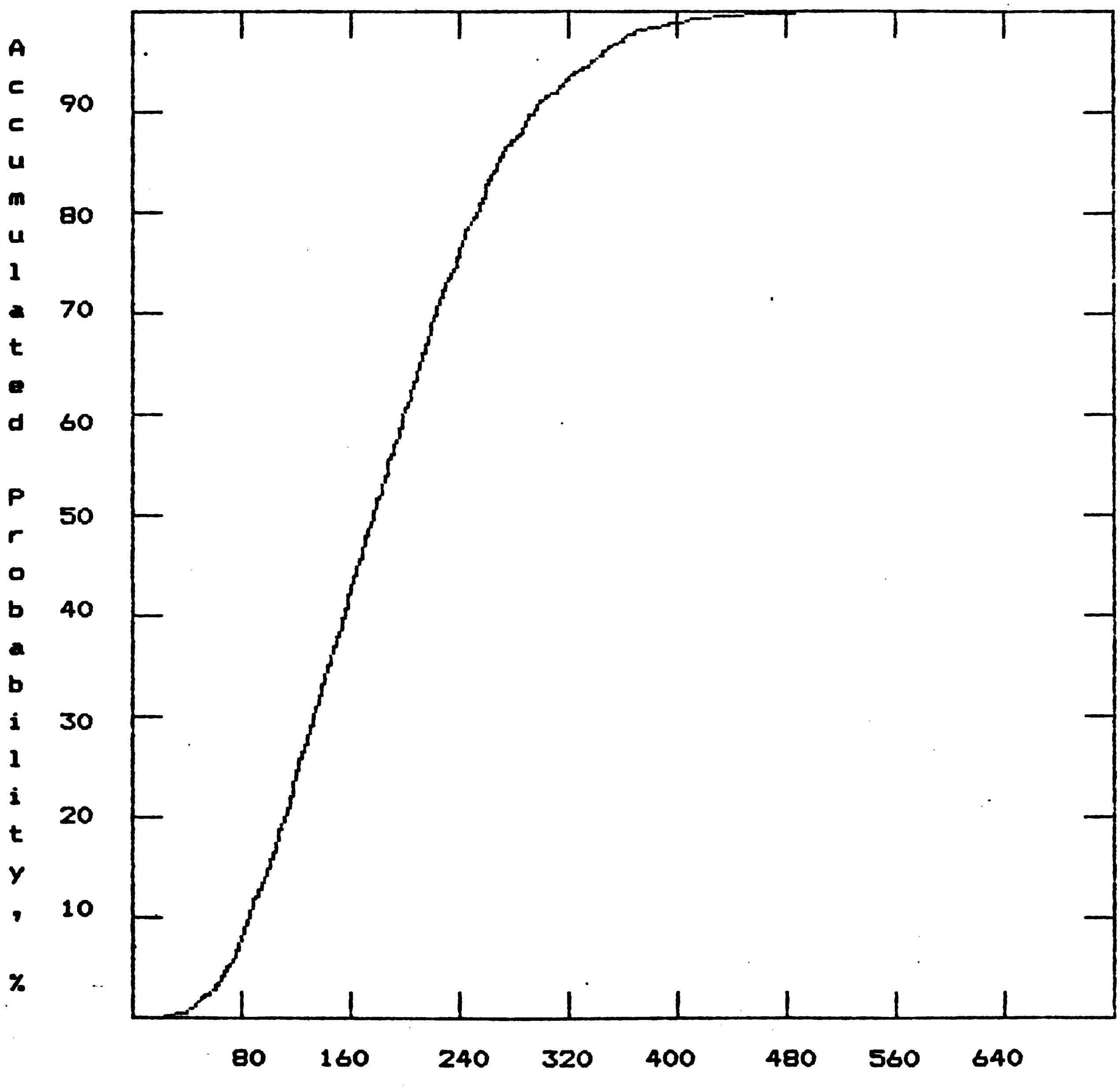


Figure 2.3.6

March

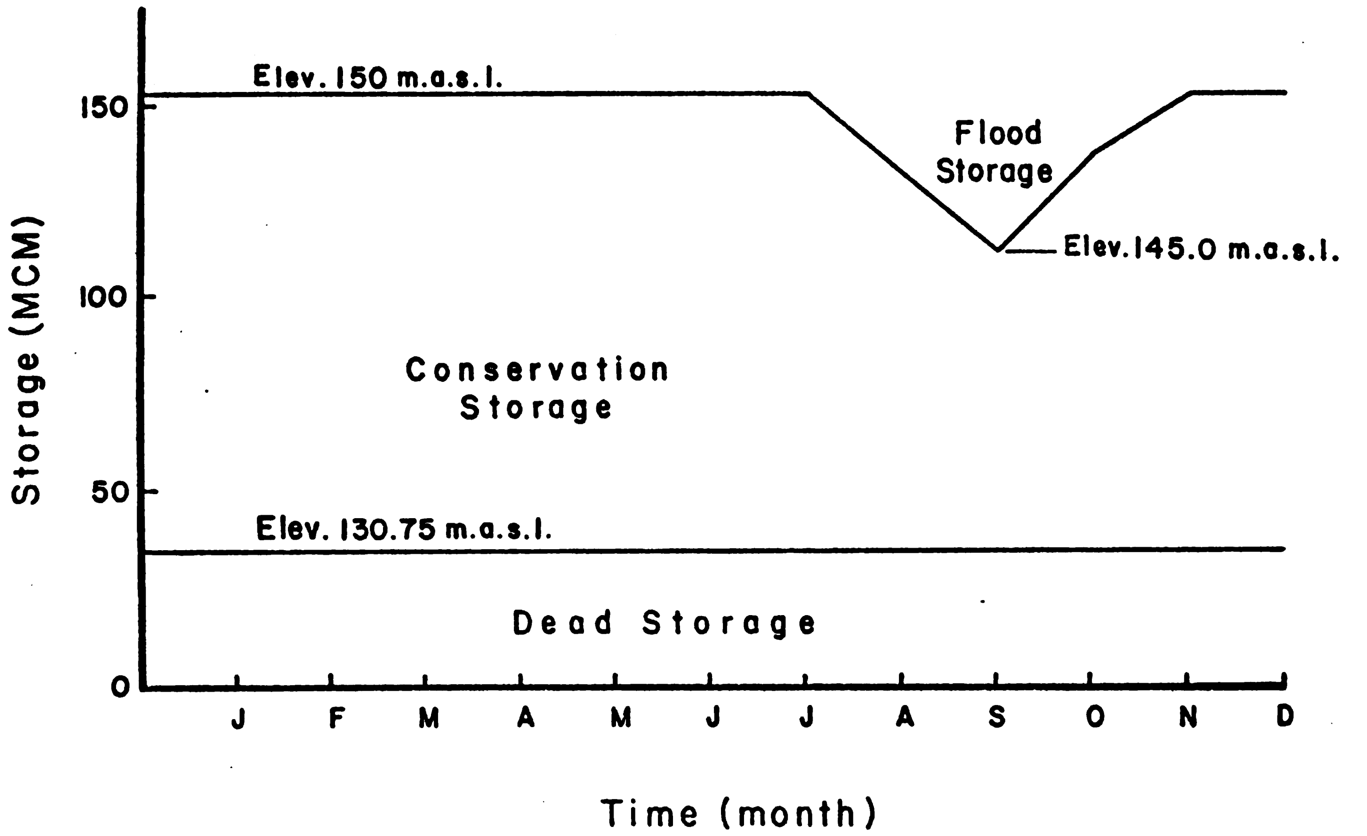


Figure 2.3.7 Designation of Storage Zones for Valdesia Reservoir

the Reservoir. As discussed in a subsequent section of this report, an analysis was performed to determine the possible loss in hydropower and water supply benefits as a result of imposition of this flood curve on normal operations.

For reservoir mass balance calculations, seepage was neglected and net evaporation (i.e., evaporation less precipitation) was obtained from data at meteorological Station Valdesia. Monthly data for 1976 to 1984, along with mean values are listed in Table 2.3.12.

2.3.4. Historical system operation.

The historical system behavior is reflected in Figures 2.3.8, 2.3.9, and 2.3.10, giving daily historical Valdesia water levels, releases, and power output, respectively. The interruption in service due to Hurricane David in September 1979 is clearly visible in these plots. Figure 2.3.10 reveals an attempt by system operators to maintain relatively stable and consistent power output at around 30 MW. However, storage levels and releases vary greatly which indicate that well defined operating rules were not followed historically. This has resulted in conflicts between power and agricultural users of the System over the years. Stabilized power output under highly variable releases and reservoir levels indicates that turbine generation hours and energy output should also be quite variable, which is confirmed in historical data provided by CDE.

Interviews with operations personnel have indicated that although meetings between power and agricultural interests have occurred at times to discuss operating objectives, the guidelines resulting from these discussions have not always been followed. It appears that energy production from Valdesia has been dictated, to a large extent, by

Table 2.3.12 Net Evaporation (Evaporation - Precipitation) at Sta. Valdesia

	1976	1977	1978	1979	1980	1981	1982	1983	1984	mean
	45	31	38	7	51	53	76	21	88	
Jan	151	151	143	156	114	127	124	116	133	
	106	120	105	149	63	74	48	95	45	89
	62	17	35	36	38	62	79	8	82	
Feb	136	155	139	150	129	133	121	128	122	
	74	138	104	114	91	71	42	120	40	88
	60	12	65	80	35	39	24	149	38	
Mar	153	193	149	157	155	156	152	134	162	
	93	181	84*	77	120	117	128	-15	124	103
	59	49	140	71	264	34	35	180	40	
Apr	188	188	124	153	107	210	130	140	153	
	129	139	-16	82	-157	176	95	-40	113	57
	87	480	252	260	100	796	309	1209	129	
May	165	161	133	121	135	82	105	112	180	
	28	-319	-119	-139	35	-714	-204	-1097	51	-269
	348	87	154	553	57	420	370	439	329	
Jun	148	165	132	89	173	129	106	134	143	
	-200	78	-22	-464	116	-291	-264	-305	-186	-170
	53	96	45	245	143	180	206	109		
Jul	192	153	175	113	151	157	163	182		
	139	57	130	-132	8	-23	-43	73		26
	155	254	255	21	253	203	88	307		
Aug	173	147	158	178	135	144	167	171		
	18	-107	-97	157	-118	-59	79	-136		-32
	108	144	110	513	180	95	199	196		
Sep	159	148	151	140	123	137	140	170		
	51	4	41	-373*	-57	42	-59	-26		-0
	213	185	261	271	102	155	138	142		
Oct	146	148	126	129	124	133	138	146		
	-67	-37	-135	-142	22	-22	0	4		-47
	72	191	127	131	103	110	112	53		
Nov	156	133	128	121	136	127	140	141		
	84	-58	1	-10	33	-17	28	88		22
	71	127	32	13	62	82	50	47		
Dec	153	135	137	156	137	125	150	129		
	82	8	105	143	75	43	100	82		79

* estimated
(all units in mm) e.g.
45 Precip (mm)
151 Evap (mm)
106 Net Evap (mm) = EVAP - PRECIP

** Evap = 0.8 * Pan Evap

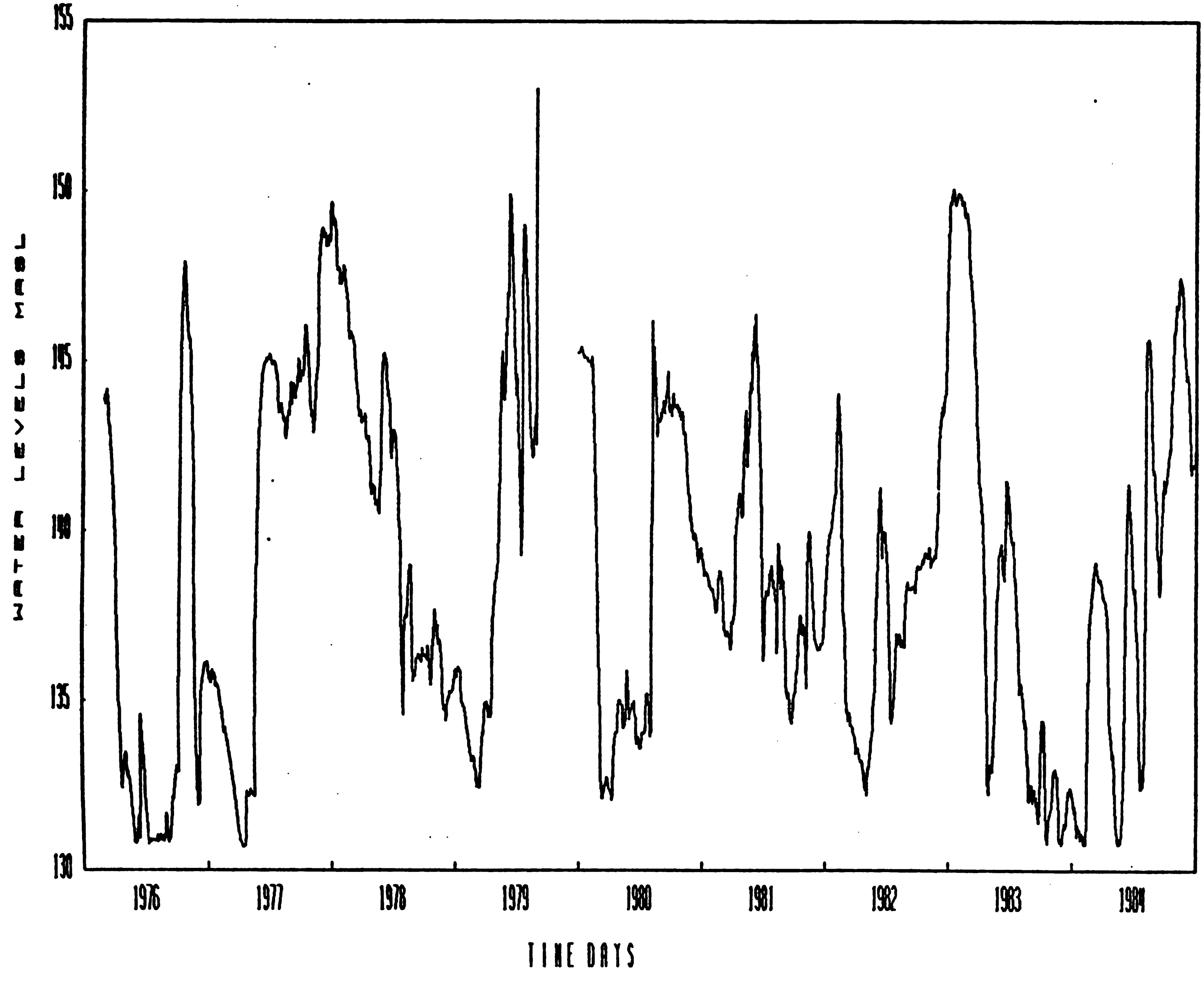


Figure 2.3.8 Daily Historical Water Levels in Valdesia Reservoir (m.a.s.l.)

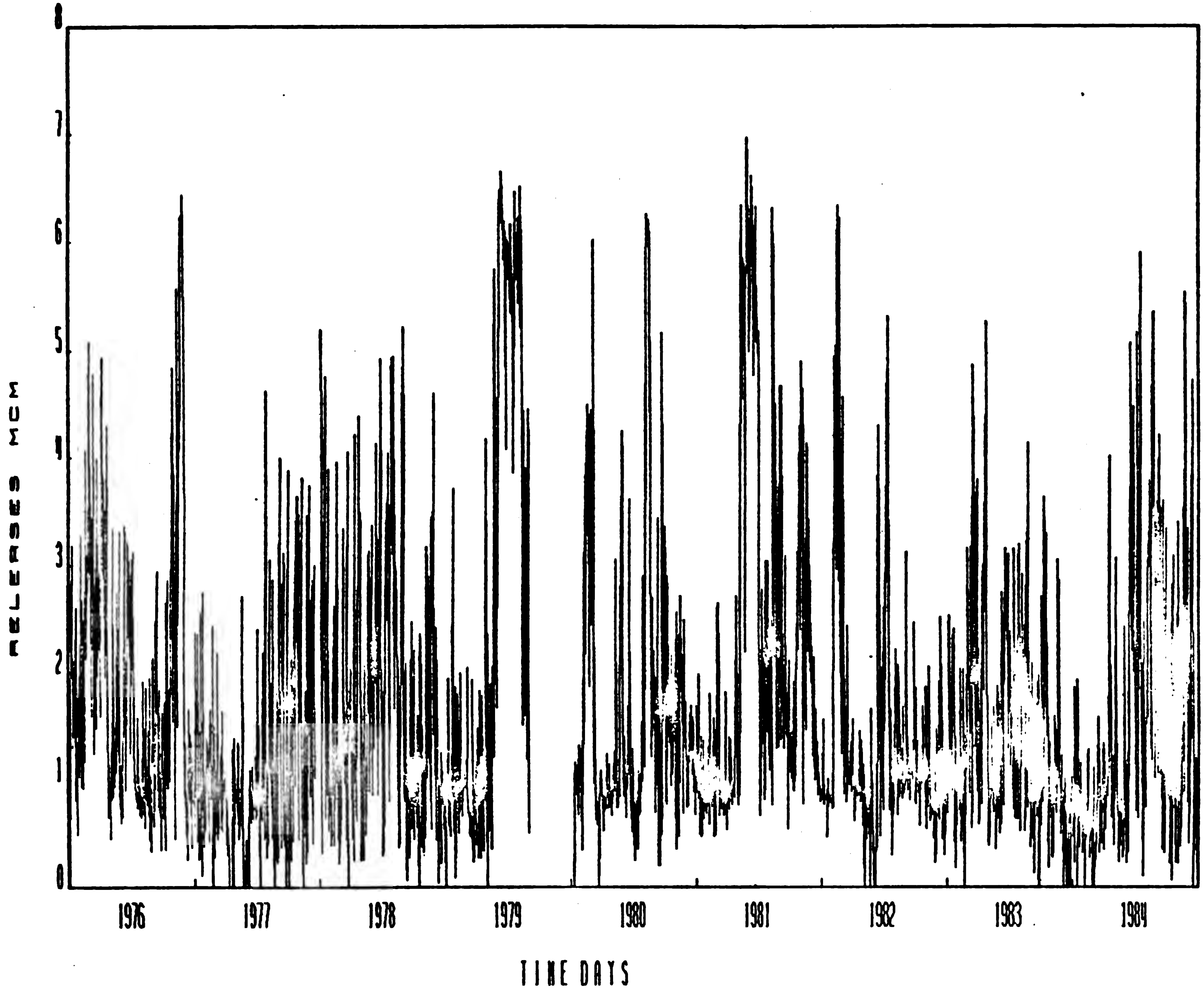


Figure 2.3.9 Daily Historical Releases from Valdesia Reservoir (MCM/day)

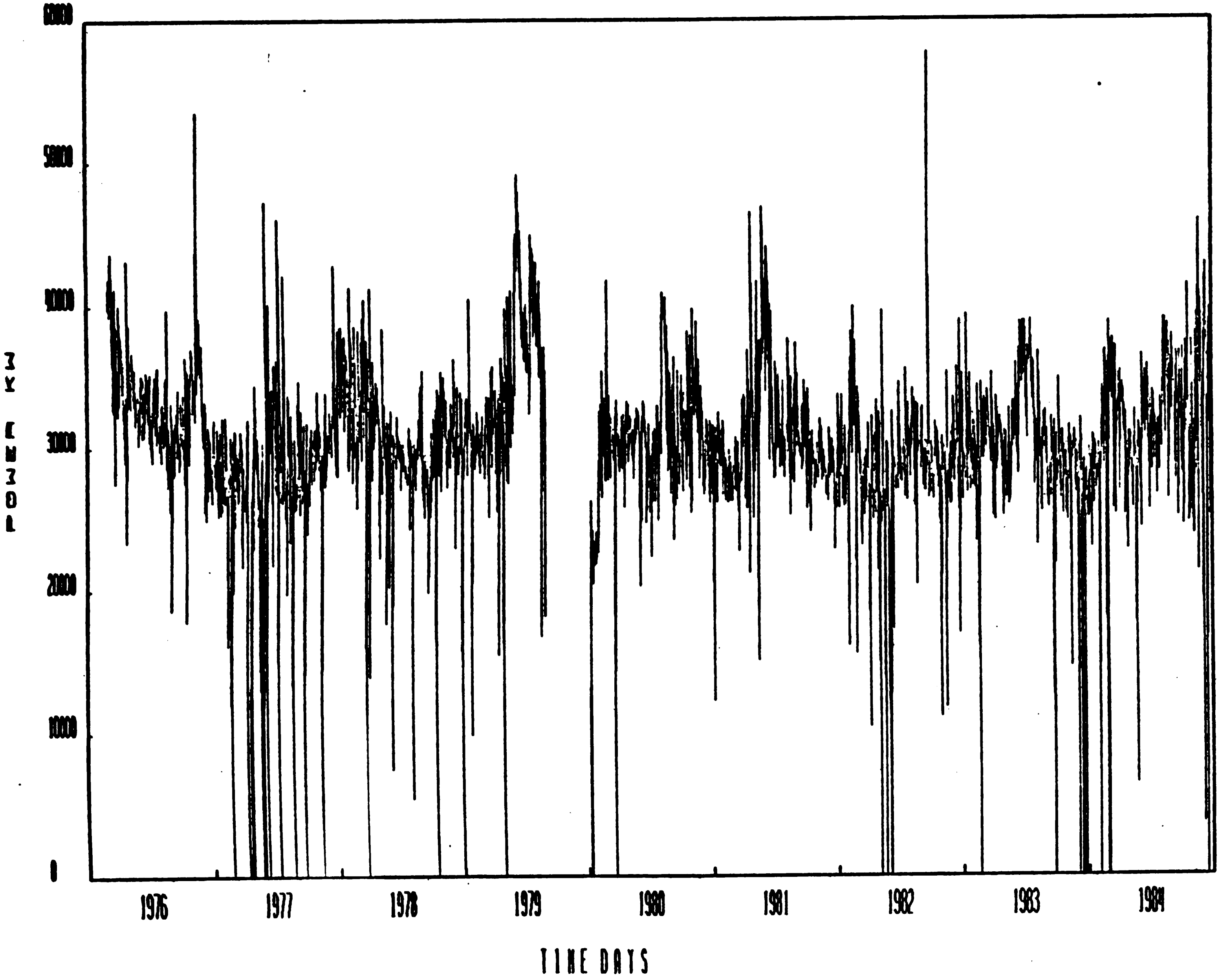


Figure 2.3.10 Daily Historical Power Output from Valdesia Reservoir and Powerplant (KW).

failure or deficiencies in various parts of the Dominican Republic power distribution network which operators attempt to make up with Valdesia power. Ideally, releases from Valdesia Reservoir should be for power only, with Las Barias reregulating these flows for consistent irrigation supply. With a usable capacity of 3 MCM (Table 2.3.10), Las Barias could only store around 9 hours of power flows at peak capacity (i.e., 90 m^3/s). With less usable capacity due to carryover storage, there is great danger of spill at Las Barias and loss of irrigation water during longer periods of generation.

2.3.5 Economic data and analysis.

A preliminary economic analysis of the Valdesia system has been undertaken in order to evaluate the benefits of improving operations through application of the optimal guidecurves and policies developed in this study. A discount rate of 15 percent is assumed for this analysis, which represents capital scarcity without taking into account inflation, risk to the private sector, income taxes, or national concern over economic stability. This rate is lower than the 20 percent figure proposed by the Central Bank of the Dominican Republic since it is designed to reflect long term conditions.

For this analysis, flood control benefits are excluded not because they are unimportant, but because insufficient information was available at the time of this report for relating operational improvements developed by the Emergency Operations portion of this study with reduction in downstream damage from flooding. Future work should focus on estimation of these benefits.

a. Hydropower benefits.

A characteristic of hydropower production is that the initial investment is large, considering the entire dam and reservoir project, while the cost of operation is relatively small. The situation is reversed for thermal plants; i.e., lower investment costs but higher operation costs due to the expense of imported oil for steam and diesel plants, primarily. According to the Payne-Gamei report (1984), the country will encounter severe economic difficulties should it continue to import petroleum at current levels.

Using 1982 data, Tables 2.3.13 and 2.3.14 compare capacity and production data by major plant type, including data on Valdesia. Costs by plant type for 1983 and 1984 are presented in Table 2.3.15, also including values for Valdesia. It is clear that additions to basic generation capacity are needed.

From the viewpoint of replacement benefits, Shaner (1986) has estimated a real difference between the average costs of diesel fired plants and the Valdesia powerplant of DR$0.53/KWH.* This is a valid comparison since from these tables, diesel plants are primarily employed for intermediate and peaking purposes, which is comparable to hydropower usage. This replacement value should be valid up to about 8 GWH/yr, which is the average energy output of diesel plants over 1982, 1983 and 1984.

b. Irrigation benefits.

Benefits from additional water for irrigation purposes include:

1. security against dry years
2. availability of water when needed
3. growing more than one crop per year

---

* Though valid for historical analysis, this figure may be currently too high.

Table 2.3.13. Rated Capacity for 1982 (megawatts)

Plant Type	Base	Intermediate	Peaking	Total
Steam	478.8	0	0	478.8
Hydro*	13.5	23.1	97.7	134.3
Gas	0	70.0	134.9	204.9
Diesel	0	1.0	9.0	10.0
Totals	492.3	94.1	241.6	828.0

*Valdesia: 60 MW - maximum rated capacity
22.4% of total peaking
40.2% of total hydro-rated
6.5% of total

Table 2.3.14. Generation for 1982 (gigawatt-hours)

Plant Type	Base	Intermediate	Peaking	Total
Steam	1777	0	0	1777
Hydro*	81	196	177	454
Gas	0	59	84	143
Diesel	0	.2	5	7
Totals	1858	257	266	2381

*Valdesia: 68 GWH
25.6% of total peaking
15.0% of total hydro
2.9% of total

Table 2.3.15. Operating and Maintenance Costs for January and April (DR$/KWH)

Plant Type	1983	1984
Steam	5.54	6.04
Hydro*	1.17	2.73
Gas	13.84	12.16
Diesel	18.51	20.30
Overall	5.31	7.09

*Valdesia:	DR$/KWH	1.87	5.79
	% of hydro	160	212
	% of overall	35	82

4. increasing the area under cultivation
5. shifting to more profitable crops
6. greater water security resulting in farmers willing to apply cash inputs.

Despite these benefits from additional water, other factors influence farmer's decisions, e.g., crop rotation requirements, pests, marketing, credit, etc. Frederiksen et al. (1985) have noted that more than water is important to the farmer. This is indicated by the fact that farmers located at the heads of the major canals are only irrigating on the average of 10 hours per day, and not at all on the weekends, even though water is actually available 24 hours per day. At the same time, farmers at the end of the system suffer water shortages and receive whatever water reaches them during turns of 8 and 12 days. To learn if those at the head of the system would gain from increased water from Valdesia, it is important to know how they irrigate and why they act as they do. With more water they could:

1. irrigate the same amount of land in less time, which reduces their effort (manhours of work), or
2. irrigate more land in the same amount of time.

On the other hand, those at the tail end of the system would certainly benefit from an increase in water made available to them, assuming there is sufficient additional capacity in the canals to accommodate increased flows. A comparison of total weekly irrigation requirements computed by the modified Penman method and displayed in Table 2.3.6 reveals that with a total estimated canal capacity of 14.8 m^3/s, there is sufficient unused capacity available for a 10 percent increase in deliveries, except for perhaps two weeks out of the year.

Even for those two weeks, there is likely no problem since adjacent weeks have lower demands, which would allow requirements in the critical weeks to be spread over a longer time.

Shaner (1986) has divided head and tail end users by assuming 57 percent of total irrigated lands and 46 percent of total users are at the head end. Farmers benefiting from increased water supply vary according to whether they are among the head end or tail end groups.

Table 2.3.16 indicates the typical cropping patterns for the "headenders" and tailenders" as presented in Frederiksen, et al. (1985). This table indicates that the intensity of land use approximates 80 percent, so that opening of additional irrigation land is possible.

Table 2.3.17 provides estimates of average yield, price, and variable costs associated with major crops grown in the area, as compiled by Shaner 1986. Obtaining yield estimates for rice, sugarcane, bananas and papayas was extremely difficult, due to high variation in published data and uncertainty about units of measure. Factors influencing yields include year, location, irrigated or rainfed, plant variety, input use, etc., which makes correlating published data to the study area difficult.

Estimation of prices is also difficult because of the range in values for various years expressed in both DR and US dollars. For this study, an exchange rate of DR$3.25 to US$1.00 has been assumed, which is based on the shadow price of foreign exchange rather than the official rate. Production costs are considered to be relatively more accurate than the other estimates and have been compiled from a number of sources by Shaner (1986). These costs included agrochemicals,

Table 2.3.16. Typical Crops Grown in Head and Tail Sections (Frederiksen et al., 1985)

Crops	Head Sections		Tail Sections	
	Hectares	Percent of Total	Hectares	Percent of Total
Rice	274	5.9	16	0.6
Sugarcane	2,864	61.5	5	0.2
Vegetables	585	12.6	158	4.8
Papaya	43	0.9	246	7.5
Corn	174	3.7	73	2.2
Peanuts	63	1.4	63	1.9
Pastures	169	3.6	207	6.3
Bananas	189	4.1	1,835	56.3
Cassava	41	0.9	75	2.3
Other	253	5.4	586	17.9
Total Cropped	4,655	100.0	3,264	100.0
Total Area	5,772		4,174	
% of Cropped Area	80.7%		78.2%	

Notes:

1. Using the old sector definition (Table 2.3.2), Head Sections include 13 to 24 for M.A. Cabral and 1 to 4 for Nizao-Najayo; Tail Sections include 1 to 11 for M.A. Cabral and 5 for Nizao-Najayo; information was not available for Section 12 for M.A. Cabral and Section 6 for Nizao-Najayo.

2. Major vegetables are onions, chili peppers, tomatoes, eggplant, and molondorones; major other crops are beans and guandules.

3. Areas devoted to each crop are sometimes approximated as that most representative during the crops principal growing season, since areas devoted to a crop might vary considerably during the year. Total areas devoted to all crops were checked against total areas to judge whether results appeared realistic.

Table 2.3.17. Average Net Variable Profits for Major Crops Grown in Project Area

Crops	Yield (tons/ha)	Price (DR$/ton)	Gross Revenues (DR$/ha)	Variable Costs (DRS/ha)	Net Revenue (DR$/ha)
Rice	5.0	860	4,300	1,150	3,150
Sugarcane	90	80	7,200	800	6,400
Vegetables*	20	400	8,000	1,540	6,460
Papaya	15	400	6,000	1,280	4,720
Corn	3	290	870	420	450
Peanuts	2.2	800	1,760	380	1,380
Pastures	1.0	200	200	70	130
Bananas	33	100	3,300	1,860	1,440
Cassava	12	280	3,360	1,000	2,360
Other**	2.5	1,000	2,500	640	1,860

* Based on values, in equal proportions, for tomatoes, chili peppers, eggplant, onions, and molondron.
**Based on values, in equal proportions, for beans and guandules.

Notes: Yields and prices are projected to 1990, based in part on the World Bank's "The Outlook for Primary Commodities, 1984 to 1995," by Ronald C. Duncan, ed., 1984. Values covered by this report are rice, peanuts, corn, and bananas.

unskilled labor, and other (seeds, land preparation, etc.). For unskilled labor, a shadow price of 40 percent of the market rate was applied. It was assumed that all agrochemicals were imported and the shadow price of foreign exchange was applied in this estimation.

Table 2.3.18 presents a summary of all results. The yield factor in percent is based on an analysis by Shaner (1986) which, using a curve relating percent of maximum yield to percent of ideal water quantity available, relates yield values to average worldwide farmers that would be reflected in World Bank figures.

Shaner (1986) assumes that average farmers receive 70 percent of the ideal amount; farmers at the head receive 80 percent; and those at the tailend receive 53 percent. Shaner (1986) explains that the latter figure should be lower, but reflects the fact that tailenders tend to use water with more care because of its scarcity to them. From a relation developed by Hargreaves (1977), these estimates indicate that headenders produce 11 percent more yield then average, and tailenders 20 percent less yield than average.

Of the various ways of increasing benefits from increases in available irrigation water, we are primarily assuming that increases in cultivated areawill occur because there is extra land available and this option would probably result in less cost and effort to farmers in this study area, and that an increase in available irrigation water can be directly correlated to an increase in cultivated area. These assumptions will then be employed in the final economic analysis of optimal normal operation strategies.

Table 2.3.18. Profitability of Farming in Head and Tail Sections

Crops	Net Profit per Crop (DR$/ha)	Head Sections Yield Factor, %	Crops per Year	Percent of Area	DR$/ha	Tail Sections Yield Factor, %	Crops per Year	Percent of Area	DR$/ha
Rice	3150	111	1.8	5.9	371	80	1.2	0.6	18
Sugarcane	6400	111	1.0	61.5	4369	80	1.0	0.2	10
Vegetables*	6450	111	1.8	12.6	1624	80	1.2	4.8	297
Papaya	4700	111	1.0	0.9	47	80	1.0	7.5	282
Corn	450	111	1.8	3.7	33	80	1.2	2.2	10
Peanuts	1400	111	1.8	1.4	39	80	1.2	1.9	26
Pasture	150	111	1.0	3.6	6	80	1.0	6.3	8
Bananas	1450	111	1.0	4.1	66	80	1.0	56.3	653
Cassava	2350	111	1.0	0.9	23	80	1.0	2.3	43
Other**	1850	111	1.8	5.4	200	80	1.2	17.9	318
Totals					6778				1665

* Tomatoes, chili peppers, eggplant, onions, molondron

**Beans and guandules

2.4 MODEL CALIBRATION FROM HISTORICAL DATA

As mentioned previously, normal operation studies require the two computer programs CSUDP and MODSIM. These two programs work together: CSUDP gives optimal monthly operation rules which can be input to MODSIM to further analyze system performance and provide weekly operational guidance. The objective of the calibration phase is to develop computer models that, based on successful reproduction of historical values, can accurately predict system behavior for future optimal operation of the integrated system.

2.4.1. Calibration runs of CSUDP Program.

a. Program setup and data input.

The calibration of CSUDP is based on monthly data as shown in Table 2.4.1. The elevation-area-volume relations for Valdesia and Las Barias Reservoirs were given previously in Tables 2.3.9 and 2.3.10. Table 2.4.2 lists the power that can be generated for various discrete levels of discharge and elevation based on the efficiencies in Table 2.3.11.

CSUDP requires three user-supplied subroutines and one input data file. Subroutine STATE, for this particular case, includes data for the elevation-area-volume curve (CEAV), net precipitation over the reservoir (PME) and Nizao river inflows (AP). It calculates the releases (U) based on given beginning-of-month (X) and end-of-month (X1) levels of the reservoir over the current period. The model actually optimizes target end-of-period storage levels (X1) directly, rather than releases. This kind of inverted optimal operating policy is considered more reasonable since most reservoirs are operated by level guidelines rather than discharge guidelines.

TABLE 2.4.1 Monthly Data for Valdesia Reservoir (Source CDE)

Year	Month	Precipitation - Evaporation (mm) PME	Inflows (10^6m^3) AP	Reservoir Levels (m.a.s.l) (beginning of month)	Hour of Gen. (hrs) XNH	Water Power Release	Energy Generated (GWH) EG
1982	January	- 75.80	48.31	137.72	257.15	26.14	3.65
	February	- 69.30	75.17	141.19	837.75	98.14	14.57
	March	-160.10	27.42	137.12	398.05	47.78	6.33
	April	- 45.40	23.20	133.59	267.70	28.93	3.73
	May	193.30	45.49	132.42	208.17	22.37	2.90
	June	243.20	57.08	137.30	441.32	44.53	6.36
	July	- 96.60	48.31	139.45	579.90	61.89	8.53
	August	-106.70	45.91	136.85	341.27	37.62	5.18
	September	40.10	39.24	138.77	350.12	37.38	5.23
	October	- 23.60	34.19	138.70	302.10	31.02	4.34
	November	- 49.00	35.23	139.25	265.50	26.76	3.75
	December	-125.70	82.67	140.85	301.95	30.09	4.54
							69.11
1983	January	-124.50	56.53	148.11	384.12	41.59	6.61
	February	- 65.20	22.30	149.84	342.95	32.10	5.15
	March	- 18.70	22.52	148.61	725.70	74.11	11.47
	April	17.70	17.84	141.18	566.97	62.64	8.64
	May	246.70	68.25	132.57	299.58	32.65	4.40
	June	97.50	65.43	139.28	512.02	60.43	8.87
	July	- 83.00	34.07	140.34	461.73	57.87	8.27
	August	116.90	36.33	135.48	433.87	50.13	6.60
	September	15.00	34.68	132.49	265.13	29.98	3.82
	October	- 28.70	39.14	133.60	410.22	47.14	6.05
	November	-116.20	28.48	131.79	281.95	32.64	4.15
	December	-111.50	21.82	130.59	140.45	15.66	1.97
							76.00
					TOTAL		145.11

TABLE 2.4.2 Power (MW) for Discrete Values of Elevation and Discharge for a Single Turbine (Valdesia Powerplant)

Discharge (m^3/s)	Elevation (m.a.s.l.)						
0	130.75	134	137	141	144	147	150
20	8.0	8.3	8.7	9.0	9.3	9.9	10.5
25	10.7	11.2	11.8	12.5	13.0	13.6	14.4
30	13.2	14.1	14.9	16.0	16.8	17.4	18.2
32.5	14.5	15.6	16.4	17.7	18.5	19.2	20.0
35	15.6	16.8	17.8	19.2	20.2	20.9	21.8
37.5	16.6	17.9	19.1	20.4	21.6	22.4	23.5
40	17.5	18.9	20.3	21.7	22.9	23.8	24.9
42.5	18.4	19.8	21.3	22.7	24.0	25.1	26.0
45	19.0	20.5	22.0	23.5	24.9	26.1	27.0

Subroutine OBJECT includes data for the number of hours of energy generation per month (XNH), the power table based on reservoir level and discharge (CEPQ), historical energy generated (EQ), and water released for power (AGT). Based on interpolations of power for different levels of releases and reservoir heads, OBJECT calculates the theoretical generated energy. It then calculates the squared deviation error between the calculated and historical releases (run #1) and the squared deviation between the calculated and historical power (run #2). Program CSUDP then employs dynamic programing to find the optimal storage guidelines that minimize the total squared-error deviation for calibration purposes.

Typical samples of Subroutines STATE, OBJECT, and input data file, are shown in Figures 2.4.1, 2.4.2, and 2.4.3. All runs were made with the current version microcomputer of Program CSUDP.

b. Results.

Figure 2.4.4 gives the results of the calibration for minimizing the difference between the observed and calculated releases (run #1). A sample CSUDP output for this run is given in Figure 2.4.5. In all these runs, a splicing option was used where initial coarse increments on storage were successively spliced to more accurate levels. Figure 2.4.6 presents results of minimizing the deviation between the historical and calculated power releases (run #2). Figure 2.4.7 shows the water levels resulting from run #1, and Figure 2.4.8 displays the water levels from run #2. Observing the results of runs 1 and 2, we can conclude that the calibration using either the power releases or the energy generated gives an excellent fit.

Figure 2.4.1 Subroutine STATE for CSUDP Run #1

```
      SUBROUTINE STATE
C
C     THIS SUBROUTINE CALCULATES THE MONTHLY WATER POWER RELEASES
C
C     CEAV : DATA FOR THE CURVES ELEVATION-AREA-VOLUME
C     PME  : NET PRECIPITATION (PRECIP-EVAPOR) IN MM
C     AP   : INFLOW IN MCM
C     X    : WATER LEVEL AT THE INITIAL OF THE MONTH IN M.O.S.L.
C     X1   : WATER LEVEL AT THE END OF THE MONTH IN M.O.S.L.
C     U    : WATER POWER RELEASES (MCM)
C
      COMMON/ONEDM/X,X1,U,F,I,J,K,L,R,PNALTY
      DIMENSION CEAV(14,3),PME(24),AP(24)
      DATA CEAV/95.,100.,105.,110.,115.,120.,125.,130.,135.,140.,145.,
     *150.,155.,160.,38.,150.,324.,871.,1572.,2310.,3406.,4537.,5664.,
     *6677.,7492.,8357.,9000.,9776.,0.,0.,0.,600.,1173.,6182.,16214.,
     *32163.,53736.,80145.,113465.,153088.,196481.,243421./
      DATA PME/-75.80,-69.30,-160.1,-45.4,193.3,243.2,-96.6,-106.7,40.1,
     *-23.6,-40.9,-125.7,-124.5,-65.2,-18.7,17.7,246.7,97.5,-83.0,116.9,
     *15.0,-28.7,-116.2,-111.5/
      DATA AP/48.31,75.17,27.42,23.2,45.49,57.08,48.31,45.91,
     *39.24,34.19,35.23,82.67,56.53,22.30,22.52,17.84,68.25,65.43,
     *34.07,36.33,34.68,39.14,28.48,21.82/
      DO 1 I10=1,14
      IF(X.GT.CEAV(I10,1))GO TO 1
      K10=I10
      GO TO 2
    1 CONTINUE
      K10=14
    2 DO 3 I10=1,14
      IF(X1.GT.CEAV(I10,1))GO TO 3
      K11=I10
      GO TO 4
    3 CONTINUE
      K11=14
    4 A0=CEAV(K10-1,2)+(CEAV(K10,2)-CEAV(K10-1,2))*(X-CEAV(K10-1,1))/
     *(CEAV(K10,1)-CEAV(K10-1,1))
      S0=CEAV(K10-1,3)+(CEAV(K10,3)-CEAV(K10-1,3))*(X-CEAV(K10-1,1))/
     * (CEAV(K10,1)-CEAV(K10-1,1))
      A1=CEAV(K11-1,2)+(CEAV(K11,2)-CEAV(K11-1,2))*(X1-CEAV(K11-1,1))/
     *( CEAV(K11,1)-CEAV(K11-1,1))
      S1=CEAV(K11-1,3)+(CEAV(K11,3)-CEAV(K11-1,3))*(X1-CEAV(K11-1,1))/
     *(CEAV(K10,1)-CEAV(K10-1,1))
      U=(S0-S1)/1000.+AP(I)+PME(I)*(A0+A1)*.5E-6
C     WRITE(IN,101)X,X1,A0,S0,S1,U
C 101 FORMAT('X=',F8.1,'X1=',F8.1,'A0=',F8.1,'S0=',F8.1,
C    * 'S1=',F8.1,'U=',F8.1)
      RETURN
      END
```

Figure 2.4.2 Subroutine OBJECT for CSUDP Run #1

```
      SUBROUTINE OBJECT
C
C     THIS SUBROUTINE CALCULATES THE SQUARE DIFFERENCE BETWEEN THE
C     HISTORICAL AND CALCULATED VALUES OF RELEASES AND POWER
C
C     XNH  : POWER GENERATION HOURS PER MONTH
C     CEPQ : DATA FROM THE ELEVATION-AREA-VOLUME TABLE
C     EG   : HISTORICAL POWER GENERATED PER MONTH (GWH)
C     EG1  : CALCULATED POWER PER MONTH (GWH)
C     AQT  : HISTORICAL WATER POWER RELEASE PER MONTH (MCM)
C     U    : CALCULATED WATER POWER RELEASE PER MONTH (MCM)
C
      COMMON/ONEDM/X,X1,U,F,I,J,K,L,R,PNALTY
      DIMENSION XNH(24),CEPQ(10,8),EG(24),AGT(24)
      DATA XNH,CEPQ,EG/257.15,873.75,398.05,267.70,208.17,441.32,
     1579.90,341.27,350.12,302.10,265.50,301.95,384.12,342.95,725.70,
     2566.97,299.58,512.02,461.73,433.87,265.13,410.22,281.95,140.45,
     30.0,20.0,25.0,30.0,32.5,35.0,37.5,40.0,42.5,45.0,
     4130.75,8.0,10.7,13.2,14.5,15.6,16.6,17.5,17.7,19.0,
     5134.0,8.3,11.2,14.1,15.6,16.8,17.9,18.9,19.8,20.5,
     6137.0,8.7,11.8,14.9,16.4,17.8,19.1,20.3,21.3,22.0,
     7141.0,9.0,12.5,16.0,17.7,19.2,20.4,21.7,22.7,23.5,
     8144.0,9.3,13.0,16.8,18.5,20.2,21.6,22.9,24.0,24.9,
     9147.0,9.9,13.6,17.4,19.2,20.9,22.4,23.8,25.1,26.1,
     1150.0,10.5,14.4,18.2,20.0,21.8,23.5,24.9,26.0,27.0,
     23.65,14.57,6.33,3.73,2.90,6.36,8.53,5.18,5.23,4.34,3.75,4.54,
     36.61,5.15,11.47,8.64,4.4,8.87,8.27,6.6,3.82,6.05,4.15,1.97/
      DATA AGT/26.14,98.14,47.78,28.93,22.37,44.53,61.89,37.62,
     *37.38,31.02,26.76,30.09,41.59,32.10,74.11,62.64,32.65,
     *60.43,57.87,50.13,29.98,47.14,32.64,15.66/
      XPROM=(X+X1)/2.
      Q=U/XNH(I)*1E6/3600
      IF(Q.GT.CEPQ(2,1))GO TO 5
      IQ=3
      GO TO 21
    5 DO 1 I10=2,10
      IF(Q.GT.CEPQ(I10,1))GO TO 1
      IQ=I10
      GO TO 21
    1 CONTINUE
      IQ=10
   21 IF(XPROM.GT.CEPQ(1,2))GO TO 2
      IX=3
    2 DO 3 I10=2,8
      IF(XPROM.GT.CEPQ(1,I10))GO TO 3
      IX=I10
      GO TO 4
    3 CONTINUE
      IX=8
    4 PP=CEPQ(IQ-1,IX-1)+(CEPQ(IQ-1,IX)-CEPQ(IQ-1,IX-1))*(XPROM-CEPQ(1,
     *IX-1))/(CEPQ(1,IX)-CEPQ(1,IX-1))
```

```
      PP1=CEPQ(IQ,IX-1)+(CEPQ(IQ,IX)-CEPQ(IQ,IX-1))*(XPROM-CEPQ(1,
     *IX-1))/(CEPQ(1,IX)-CEPQ(1,IX-1))
      POT=(PP1-PP)*(Q-CEPQ(IQ-1,1))/(CEPQ(IQ,1)-CEPQ(IQ-1,1))+PP
      EG1=POT*XNH(I)*1E-3
      EDIFF=EG1-EG(I)
C     F=(EG1-EG(I))**2
      F=(U-AGT(I))**2
C     F=EG1
      RETURN
      END
```

Figure 2.4.3 CSUDP INPUT DATA FILE (FILE5)

```
CSUDP CALIBRATION FOR VALDESIA RESERVOIR. RUN #1
  1    1   24    1    1    1
  1    0    0    1    0    1
     2.7       .05       .1       .0      3.0      3.0
  3
  1     137.7     137.7
  2     130.0     150.0
 25     132.1     132.1
  1
  1        0.      100.
```

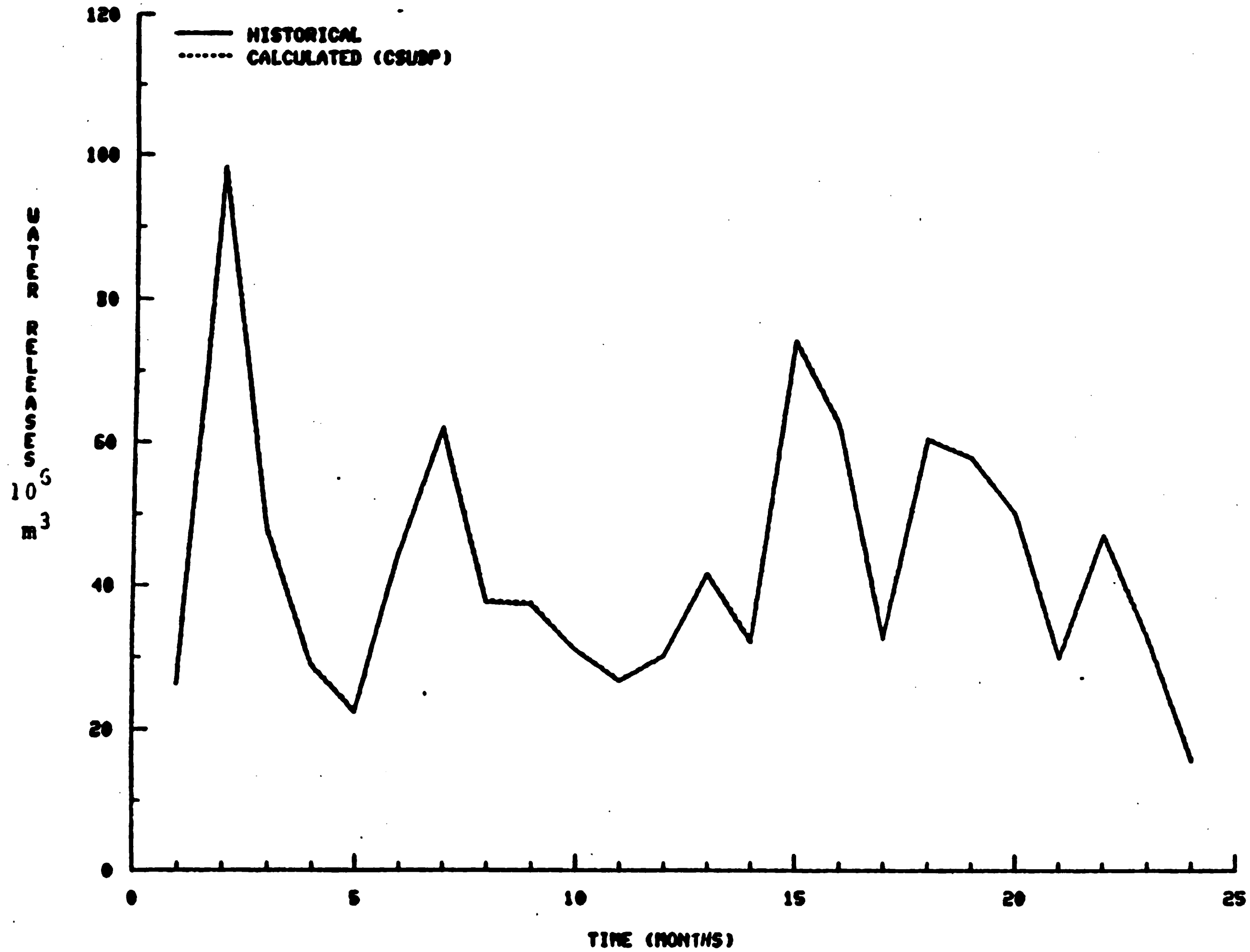


FIG. 2.4.4 MONTHLY POWER RELEASES FOR VALDESIA RES. (1982-83). RUN 1

FIGURE 2.4.5

```
TITLE     CSUDP CALIBRATION FOR VALDESIA RESERVOIR. RUN #1
-----
***************************************
*                                     *
*        1 DIMENSIONAL PROBLEM        *
*                                     *
*         MINIMIZATION PROBLEM        *
*                                     *
*     OBJECTIVE IS SUMMATION TYPE     *
*                                     *
*      DETERMINISTIC OPTIMIZATION     *
*                                     *
*      PROBLEM ASSUMED INVERTIBLE     *
*                                     *
*         LAST TIE VALUE TAKEN        *
*                                     *
*       SPLICING WILL OCCUR ON X      *
*         SPLICE =  3.000             *
*         XMULT =   3.000             *
*                                     *
*        NUMBER OF STAGES = 24        *
*                                     *
*                                     *
***************************************

INTERVAL FOR X =  2.700
INTERVAL FOR U =  .1000
TOLERANCE =  .0000
```

UPPER AND LOWER BOUNDS ON X(I+1) AND U(I)

I	XMIN(I)	XMAX(I)	UMIN(I)	UMAX(I)
1	137.7	137.7	.0000	100.0
2	130.0	150.0	.0000	100.0
3	130.0	150.0	.0000	100.0
4	130.0	150.0	.0000	100.0
5	130.0	150.0	.0000	100.0
6	130.0	150.0	.0000	100.0
7	130.0	150.0	.0000	100.0
8	130.0	150.0	.0000	100.0
9	130.0	150.0	.0000	100.0
10	130.0	150.0	.0000	100.0
11	130.0	150.0	.0000	100.0
12	130.0	150.0	.0000	100.0
13	130.0	150.0	.0000	100.0
14	130.0	150.0	.0000	100.0
15	130.0	150.0	.0000	100.0
16	130.0	150.0	.0000	100.0
17	130.0	150.0	.0000	100.0
18	130.0	150.0	.0000	100.0

19	130.0	150.0	.0000	100.0
20	130.0	150.0	.0000	100.0
21	130.0	150.0	.0000	100.0
22	130.0	150.0	.0000	100.0
23	130.0	150.0	.0000	100.0
24	130.0	150.0	.0000	100.0
25	132.1	132.1		

OPTIMAL SOLUTION FOR X(1) = 137.700

I	X*	U*
1	137.7000	30.30000
2	140.8000	90.10000
3	138.1000	52.80000
4	132.7000	34.60000
5	130.0000	22.80000
6	135.4000	44.30000
7	138.1000	62.00000
8	135.4000	45.30000
9	135.4000	39.50000
10	135.4000	34.10000
11	135.4000	20.70000
12	138.1000	28.90000
13	146.2000	34.10000
14	148.9000	43.20000
15	146.2000	75.30000
16	138.1000	55.90000
17	130.0000	31.60000
18	138.1000	66.00000
19	138.1000	59.90000
20	132.7000	48.50000
21	130.0000	23.10000
22	132.7000	50.70000
23	130.0000	28.00000
24	130.0000	12.20000
25	132.1000	

MINIMUM OBJECTIVE VALUE = 609.2175

.
.
.

CONTINUE THE ITERATIONS UNTIL FINAL RESULTS ARE OBTAINED

.
.
.

I	X*	U*
1	137.7000	26.30000
2	141.4000	98.30000
3	137.3000	47.90000
4	132.8500	29.00000
5	131.4500	22.50000
6	136.6500	44.60000
7	139.3000	62.20000
8	136.5500	37.90000
9	137.9500	37.60000
10	138.3000	31.10000
11	138.8500	26.90000
12	140.3000	30.20000
13	147.5500	41.70000
14	149.3000	32.50000
15	147.9500	74.40000
16	140.7000	62.80000
17	131.8000	32.90000
18	139.3500	60.60000
19	140.3000	58.00000
20	135.7500	50.20000
21	132.8500	30.20000
22	133.9000	47.20000
23	132.0000	32.90000
24	130.8500	15.90000
25	132.1000	

MINIMUM OBJECTIVE VALUE = .9255104

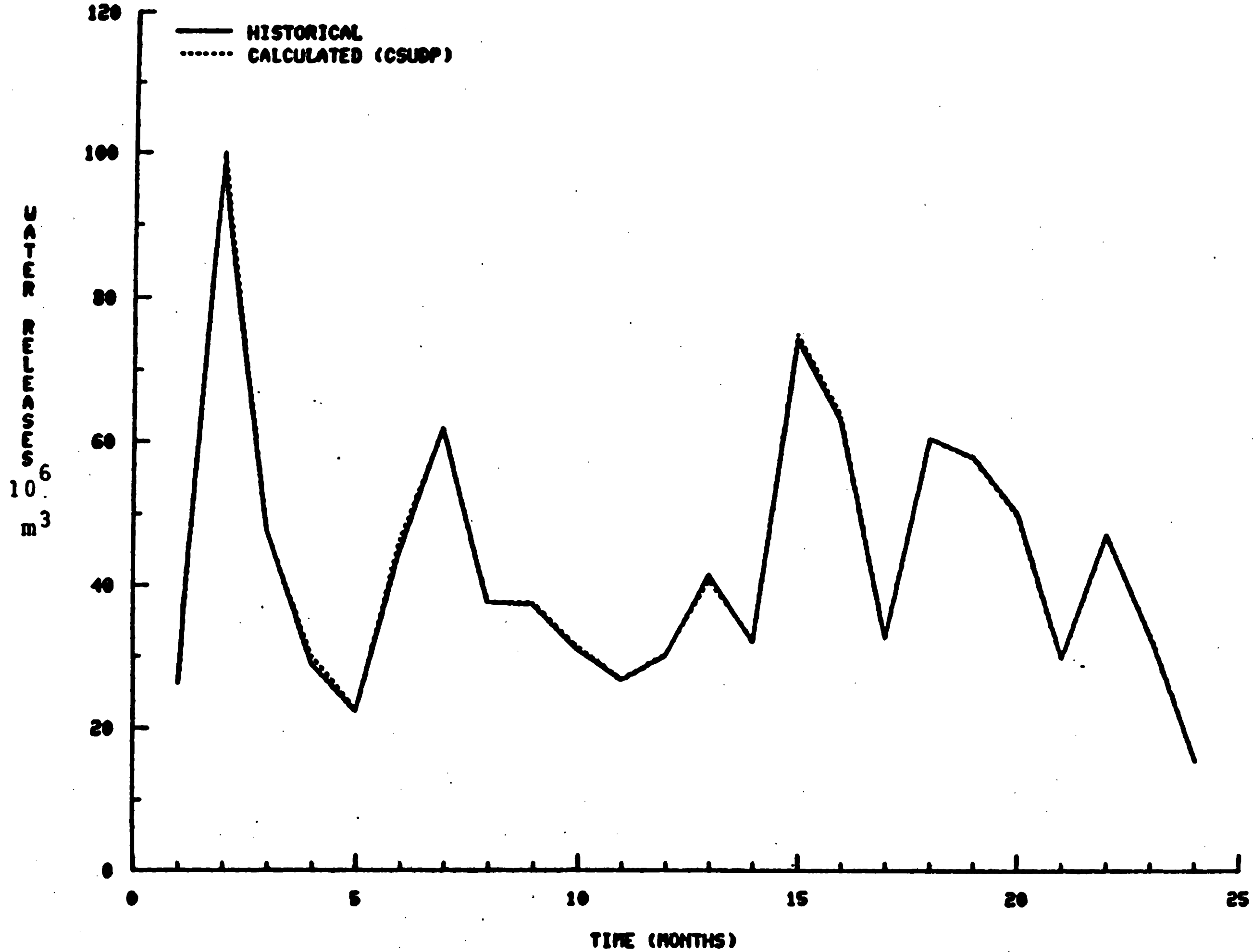


FIG. 2.4.6 MONTHLY POWER RELEASES FOR VALDESIA RES.(1982-83). RUN 2

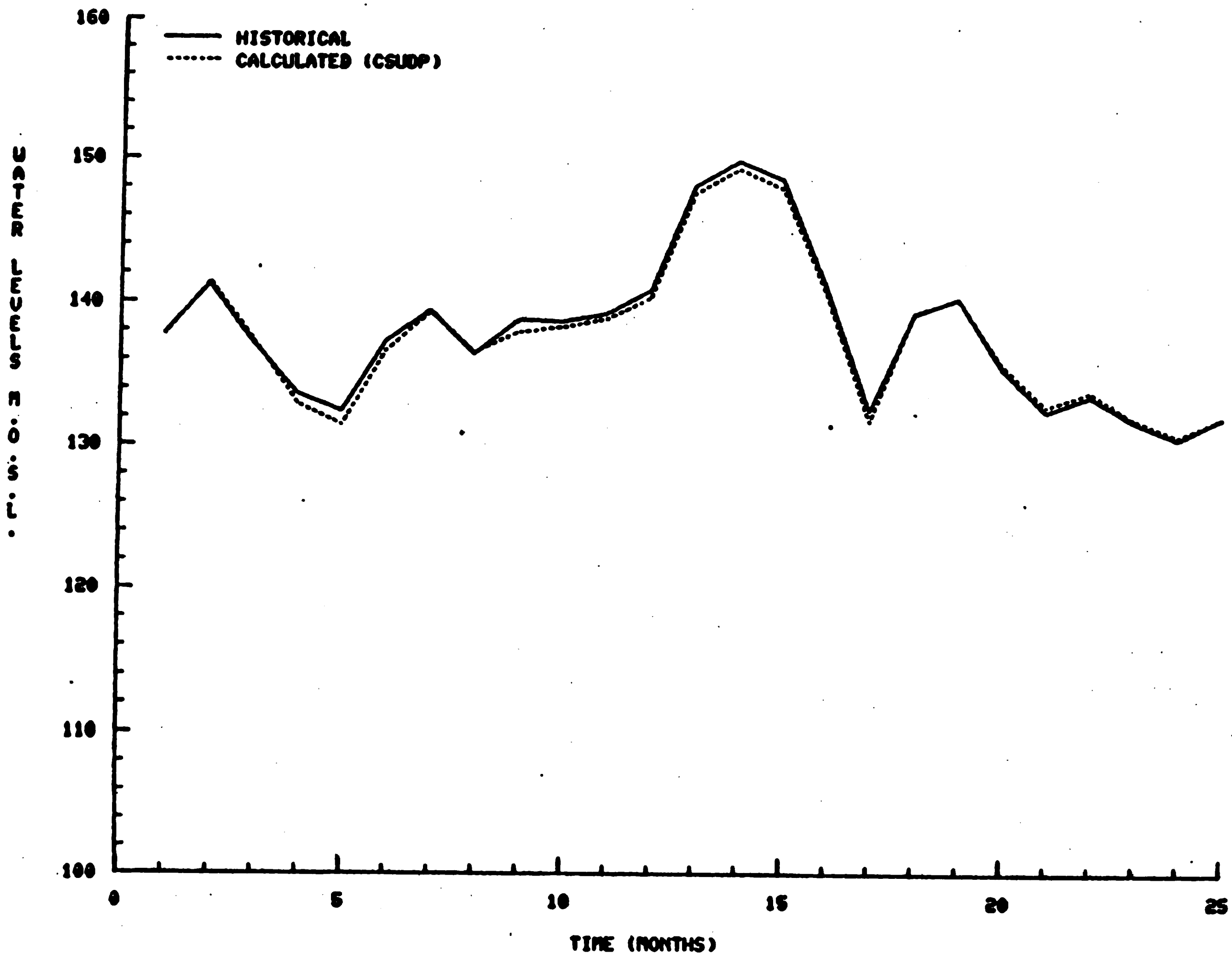


FIG. 2.4.7 MONTHLY RESERVOIR LEVELS FOR VALDESIA (1982-83). RUN 1

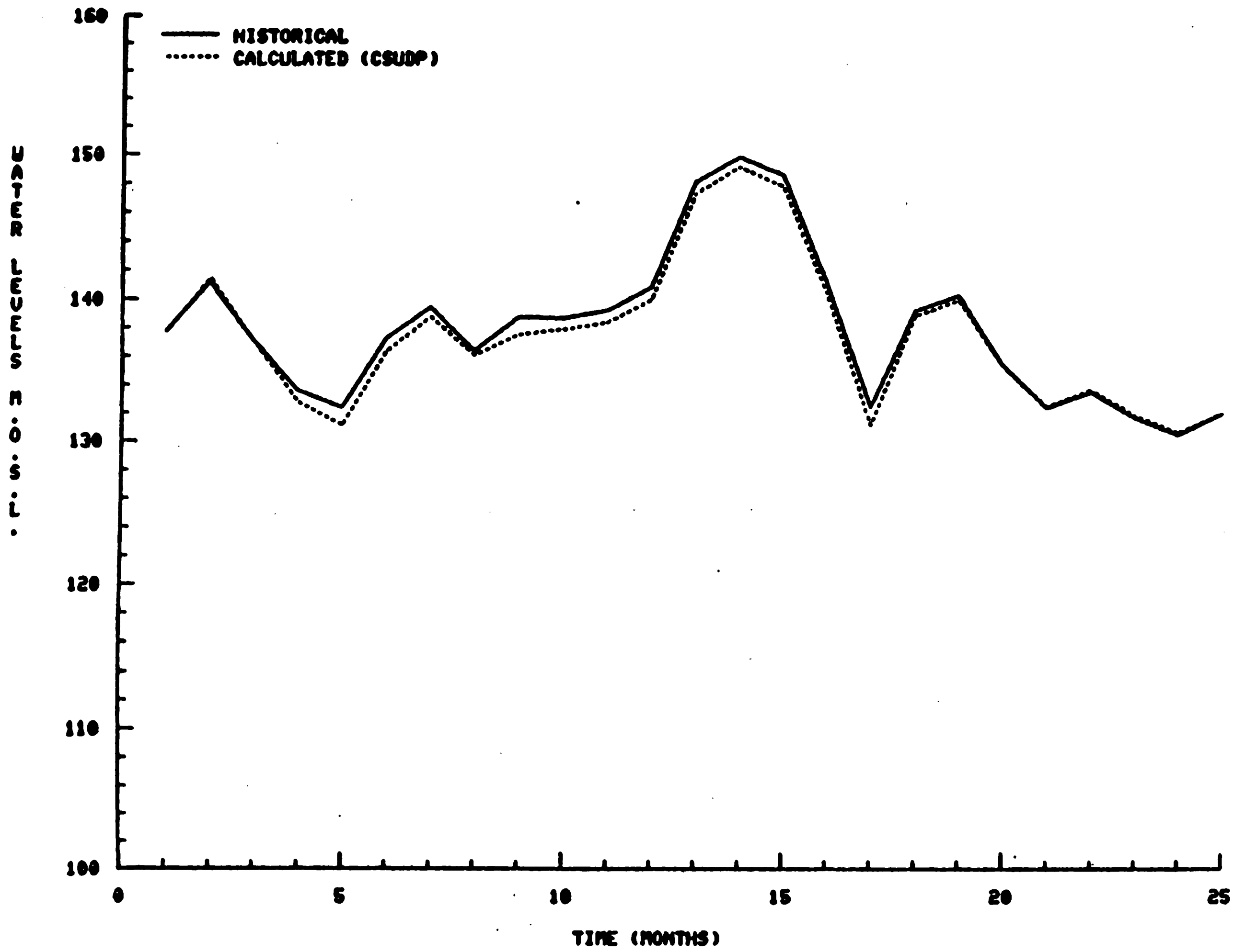


FIG. 2.4.8 MONTHLY RESERVOIR LEVELS FOR VALDESIA (1982-83). RUN 2

2.4.2 Calibration of Program MODSIM

Since MODSIM is to be used for weekly operational analysis, it must also be calibrated to weekly historical data. The approach taken here was to force MODSIM to maintain the historical weekly storage levels over the nine year period, and then see if the canal releases and hydropower production produced by the model reasonably match observed data. Several modifications were made in MODSIM to adapt it to the data available and conditions existing in the Valdesia Reservoir system. In particular, the model previously allowed only average turbine efficiencies to be entered. Now, turbine efficiencies can vary with head and discharge, which is much more realistic for the Valdesia system. Another improvement is that actual number of hours or synthetically generated hours the turbines are operating per period (i.e., week or month) can be considered instead of assuming constant hours for the entire period.

a. Program setup and data input.

As was shown in Figure 2.1.1, the Valdesia Reservoir system has two reservoirs: the larger one being Valdesia Reservoir and the smaller Las Barias Reservoir for regulating the power releases for irrigation. There are two irrigation zones: one irrigated by the Marcos A. Cabral canal and the other by the Nizao-Najayo canal. Water spilled in Las Barias Reservoir passes directly to the Nizao river. In Figure 2.4.9 the same system is shown, but in a network configuration compatible with MODSIM. MODSIM solves the following optimization problem:

$$\min \sum_{i=1}^{N} \sum_{j=1}^{N} c_{ij} \, q_{ij} \qquad (2.4.1)$$

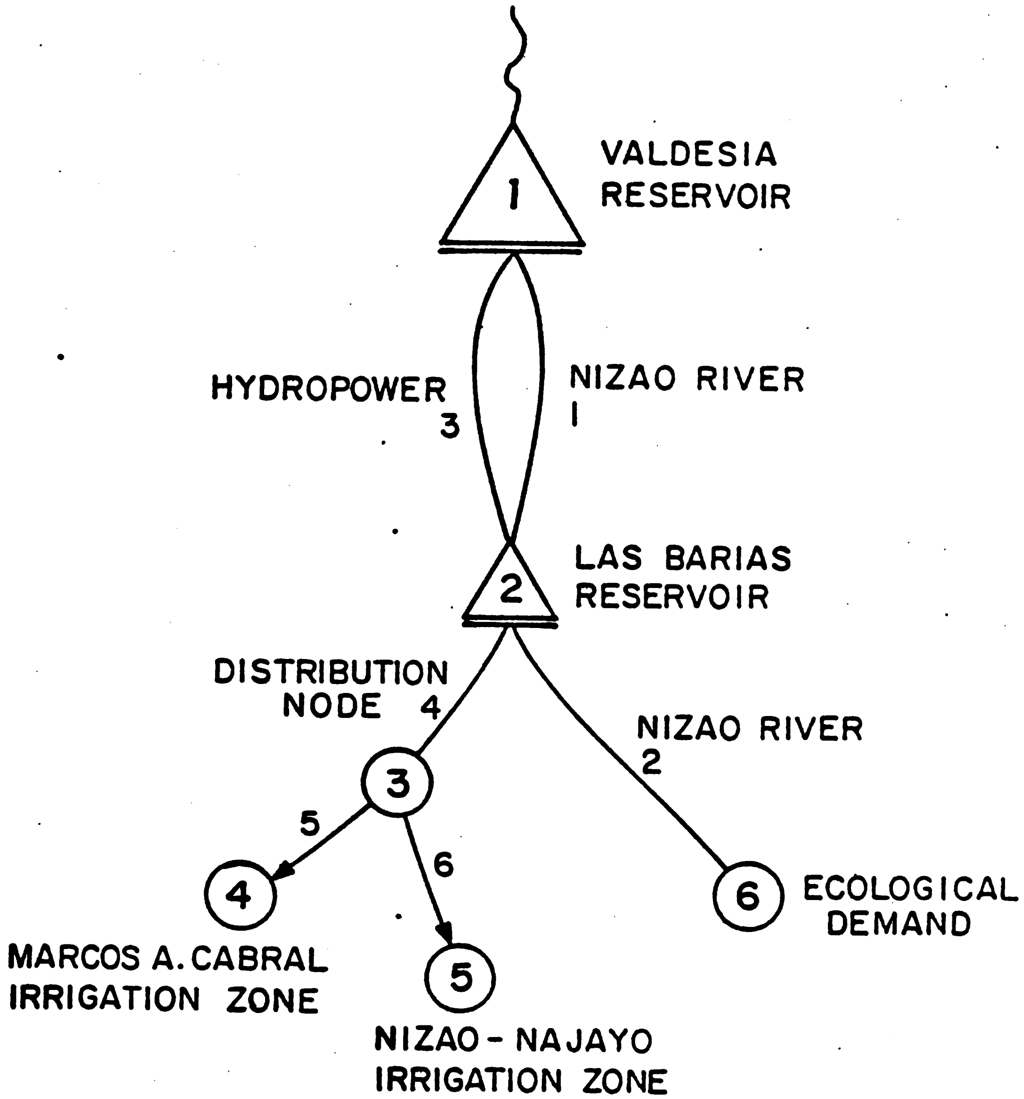


FIG. 2.4.9 MODSIM Network Configuration for the Valdesia Reservoir System

subject to:

$$\sum_{i=1}^{N} q_{ij} - \sum_{k=1}^{N} q_{jk} = 0 \quad \text{for } j = 1,\ldots,N \qquad (2.4.2)$$

$$\ell_{ij} \leq q_{ij} \leq u_{ij} \quad \text{for } i,j = 1,\ldots,N \qquad (2.4.3)$$

where q_{ij} is the flow in link (i,j) defined by initial node i and terminal node j; c_{ij} is a unit cost or priority factor (negative cost represents a benefit) on flows in link (i,j); ℓ_{ij} is the lower limit on flow in link (i,j); u_{ij} is the upper limit; and N is the total number of nodes. Constraint (2.4.2) guarantees that mass balance is satisfied at every node.

As explained in more detail in the report "Manuales de Operacion de Modelos Computarizados para la Operacion Normal de Sistemas de Embalses," Labadie, et al. (1986), several artifical nodes are added to the network automatically by MODSIM to represent reservoir carryover capacity and demand satisfaction. A priority number between 1 and 99 is designated by the user to each reservoir, with a lower number then being assigned a larger negative cost by MODSIM for carryover storage, and therefore a larger benefit. Priority numbers are likewise assigned to demand nodes in the same way. Ideal target storage levels and target demands are specified by the user, which are translated into upper limits u_{ij} on the artificial carryover storage and demand links. For calibration purposes, the target storage levels correspond to actual historical reservoir levels. Node and link designation for calibration purposes is shown in Table 2.4.3, along with priorities, costs, and minimum and maximum bounds. Notice from Table 2.4.3 that Valdesia

Table 2.4.3 Nodes and Links in the MODSIM Network Configuration for Calibration Purposes

NODES

no.	name	priority	CAPACITY ($10^3 m^3$) lower bound	upper bound	Initial Level
1	Valdesia Res.	1	348	186066*	140482
2	Las Barias Res.	40	240	6050**	1400
3	Distribution node	-	-	-	
4	M. Cabral demand node	10	demands input in ADATA file		
5	Nizao-Najayo demand node	30	demands input in ADATA file		
6	Ecological demand	99	demands input in ADATA file		

LINKS

no.	name	cost	RELEASES ($10^3 m^3$/month) lower bound	upper bound
1	Nizao River (from Valdesia Res. to Las Barias Res.)	0	0	4233600
2	Nizao River (downstream of Las Barias)	-1	0	4233600
3	Hydropower (water releases through the hydropower plant at Valdesia)	-1	0	54432
4	Distribution link	0	0	8951
5	M. Cabral canal	0	0	7258
6	Nizao-Najayo canal	0	0	1693

* Based on the head-volume curve before the hurricane
**Based on the head-volume curve after the hurricane

Reservoir is given a priority number of 1, which is assigned the highest possible benefit for carryover storage by MODSIM. Since all other priority numbers are greater, then MODSIM, as a result of the network optimization, attempts to exactly satisfy the historical target storage levels. The model does not assign any benefit to exceeding these levels. The model will then calculate reservoir mass balance, hydropower and releases as a consequence of following the target historical levels, and these can be compared with the historical data. Notice from Table 2.4.3 that there are small negative costs (i.e., benefits) assigned to links 2 and 3. This simply encourages extra water to be released for irrigation and hydropower, rather than storing it in Valdesia above the historical target levels.

For model calibration, data input consists of net evaporation (evaporation-precipitation), inflows, turbine operation time, reservoir releases, and historical water levels at Valdesia and Las Barias Reservoirs. Water surface areas and reservoir storages used in the model are calculated from elevation-area-capacity curves provided by CDE, both before and after Hurricane David. Also included are efficiency tables for the turbines at Valdesia Reservoir. Daily data were analyzed and completed before being summed into weekly values for use in the model. These weekly data were then divided into three groups: 180 weeks before Hurricane David in 1979, and two 132 week sets afterward. Simultaneously, records of the historical energy produced by the turbines, the actual releases of water from Valdesia and Las Barias Reservoirs, and the measured surface levels were organized for comparison with calculations made by MODSIM.

Since direct measurement of Valdesia Reservoir inflow is not available, daily historical records of reservoir storage, releases, precipitation, and evaporation were utilized in mass balance calculations to estimate the inflows. Average net evaporation per month from Valdesia Reservoir was determined as follows:

$$E_{net} = 0.8 \text{ (Pan Evap.)} - \text{(Precipitation) [m.]} \qquad (2.4.4)$$

where precipitation and pan evaporation were measured at station Valdesia. Net evaporation is then multiplied by the reservoir surface area to obtain the net volume. Available records of reservoir releases include measurements of discharge for successive hourly intervals over 24 hour periods. The first measurement of a period corresponds to the time when the storage level in the reservoir is measured; i.e., at 18:00 hours each day. These hourly discharges are summed to obtain the volume of release per day. Using the following mass balance equation, inflows to Valdesia Reservoir were calculated as:

$$I_t = V_{t+1} - V_t + R_t + E_{net,t} \qquad (2.4.5)$$

where

I_t = daily inflow, $10^6 m^3/d$

V_t = storage volume on day t, $10^6 m^3$

R_t = reservoir releases per day, $10^6 m^3/d$

$E_{net,t}$ = net evaporation per day (an average value for the entire month is used), $10^6 m^3/d$

Operational duration for the power turbines as recorded by CDE were also input to MODSIM to complete the initial data base needed for calibration.

All incomplete data were filled on a daily basis either by using an average value taken from neighboring data, or by matching hydrologic

conditions of another year and using the data for the needed period of that year. After completing all daily values, the data in each seven day interval were summed to obtain a weekly data base. These data were then input to MODSIM along with reservoir storage capacity, discharge capacity through the turbines, canal capacities, and efficiency tables for the turbines.

b. Results.

The reference data for calibration contained the historical power produced per week, water surface levels for Valdesia and Las Barias Reservoirs, and water releases to the Marcos A. Cabral and Nizao-Najayo canals. The calibration procedure was to compare the historical with the calculated power generation, assuming historical irrigation demands and reservoir levels were matched.

Historical power values were plotted against the corresponding results of MODSIM so that problems could be identified and corrected to obtain the most realistic results possible. (See Figures 2.4.10, 2.4.11 and 2.4.12)

As is shown in the figures mentioned above, model MODSIM appeared to match the historical values reasonably well. A consistent overestimation was corrected by a slight modification in turbine efficiencies (all values multiplied by 0.96). With these new values, more precise results were obtained. This is justified since the turbine efficiency table is based on newly installed units which can suffer some loss in efficiency due to aging, cavitation, etc.

It should be noted that historical data were not available for water delivered through the Nizao-Najayo Canal after August 1979 because the gaging station was destroyed by Hurricane David. The values

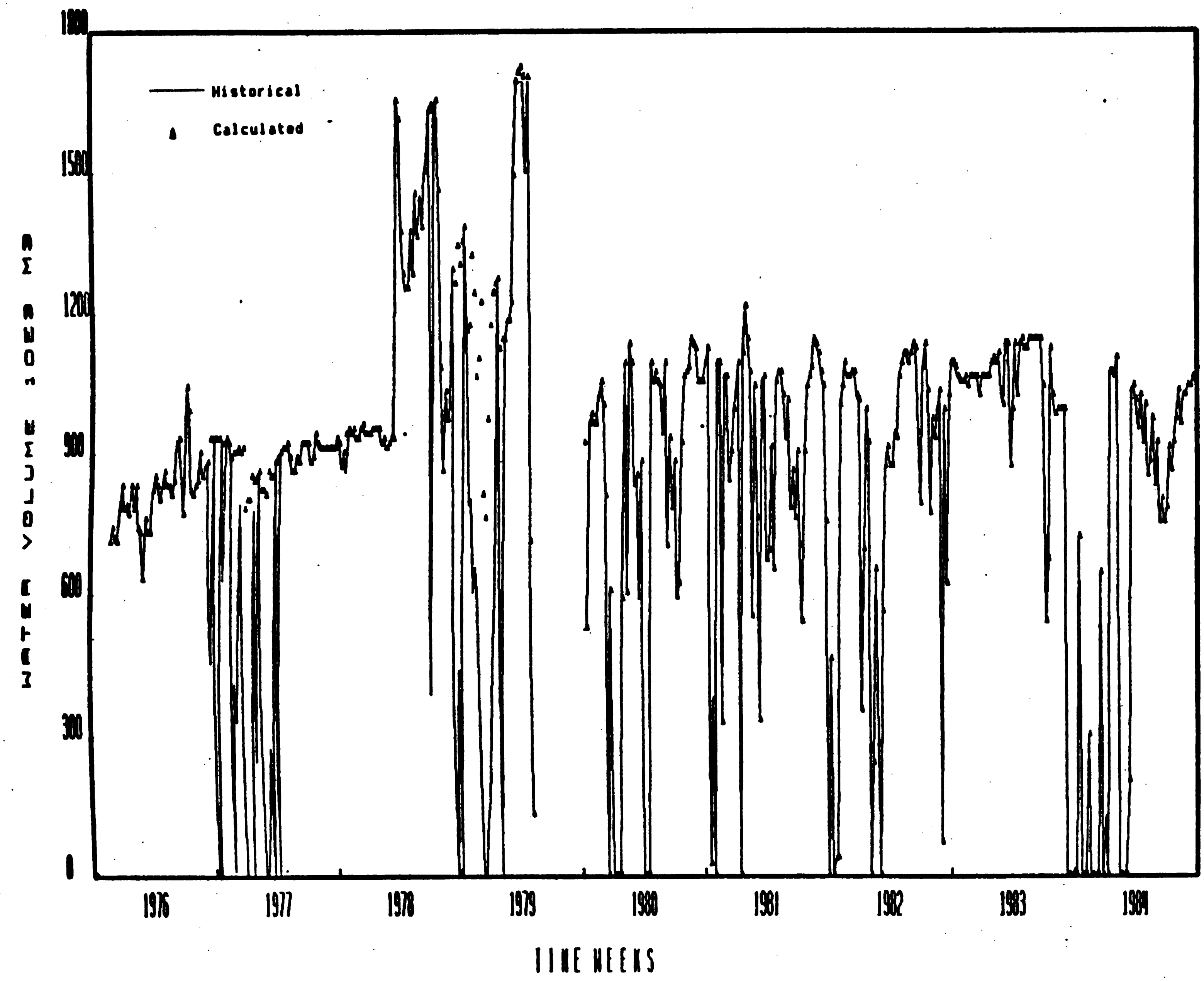


Figure 2.4.10 Comparison of Historical and Calculated Valdesia Power Output (KW).

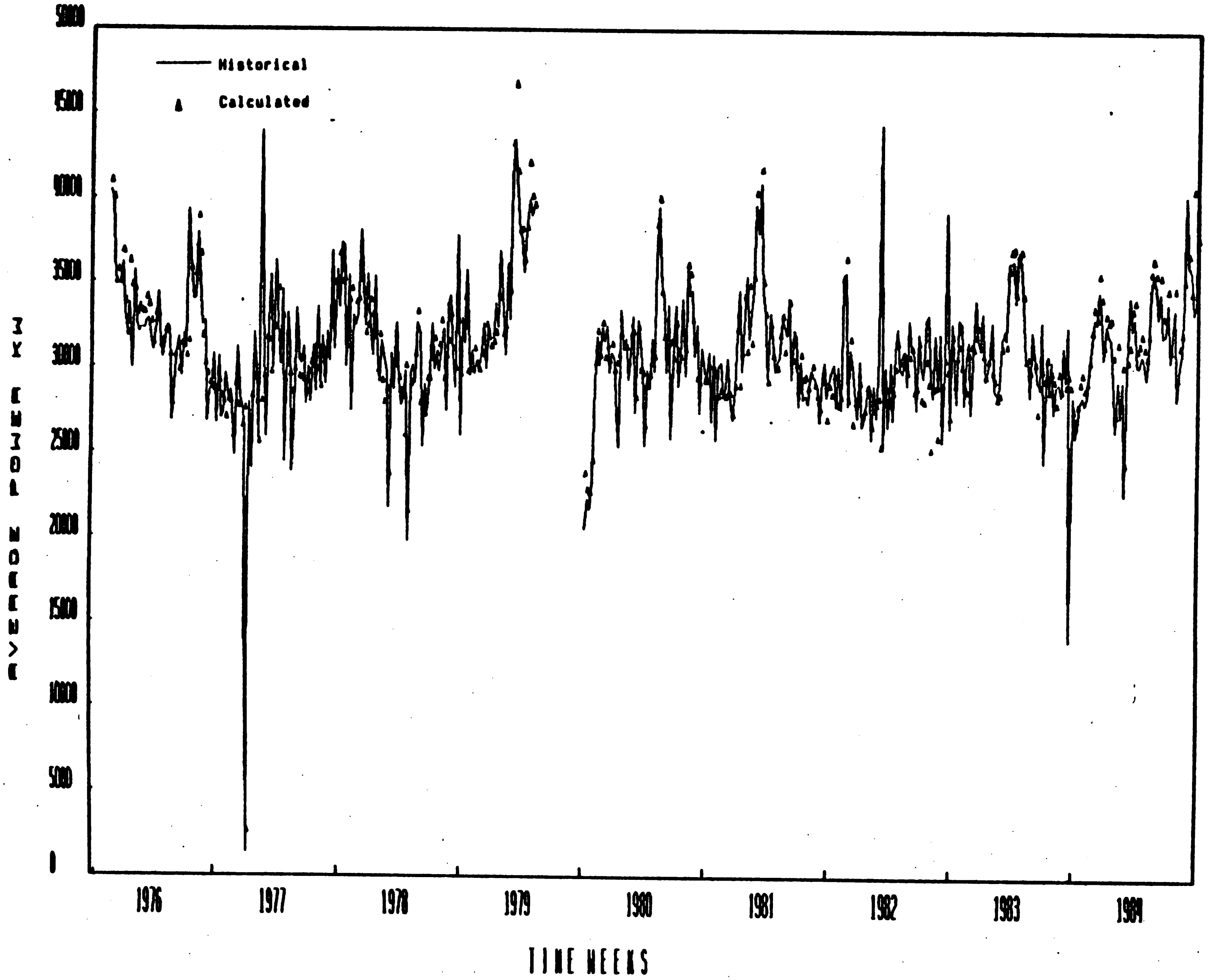


Figure 2.4.11 Comparison of Historical and Calculated Flows in M. Cabral Canal.

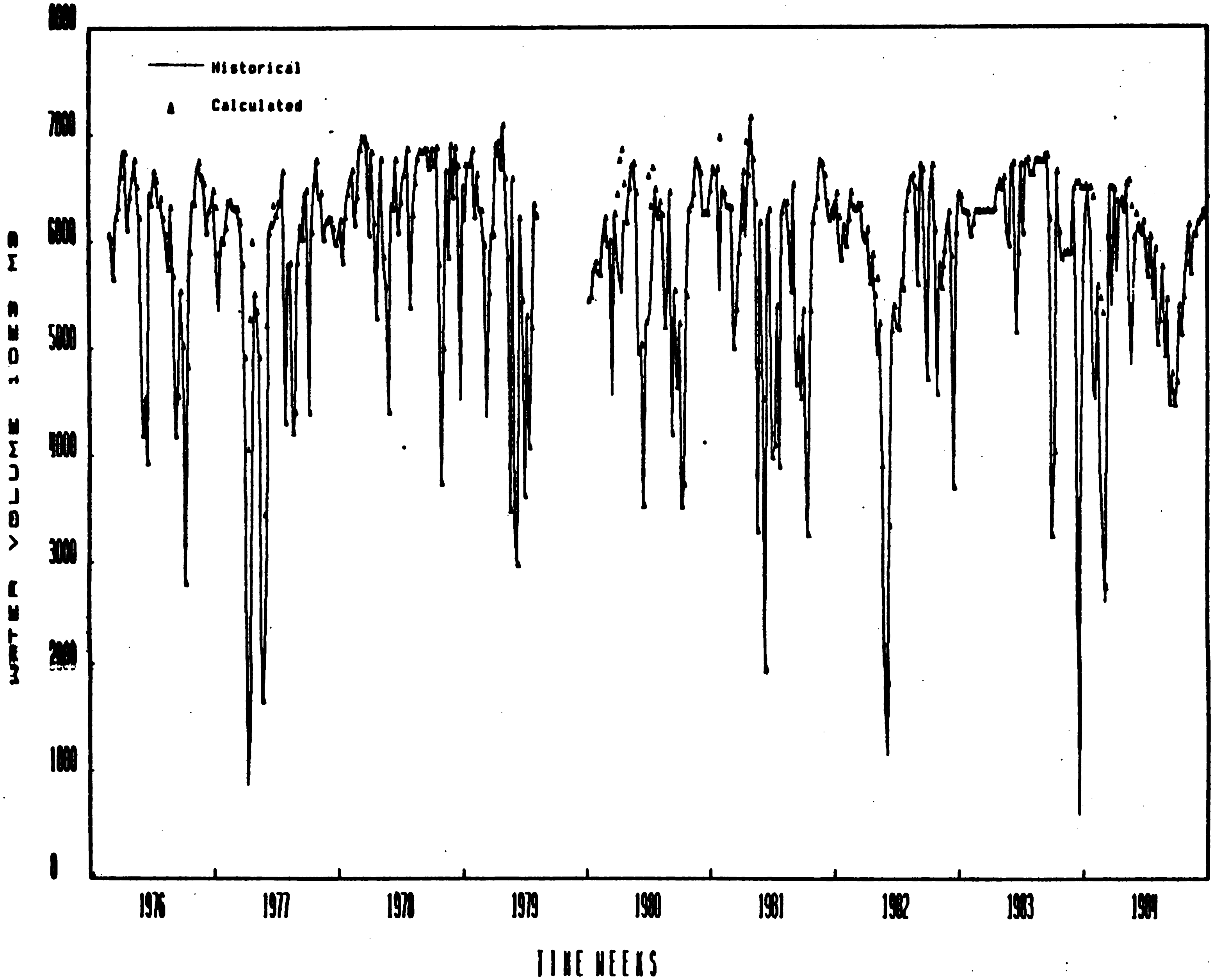


Figure 2.4.12 Comparison of Historical and Calculated Flows - N. Najayo Canal.

shown as historical data on Figure 2.4.12 after August 1979 are actually predicted values from MODSIM.

2.5 DEVELOPMENT OF OPTIMAL MONTHLY GUIDECURVES

2.5.1 Application of stochastic dynamic programming.

As described in Section 2.4, the CSUDP dynamic programming model can be used in a deterministic sense to analyze optimal reservoir operations for any given period of input data. Since results of the analysis are based upon that specific period of input data, then generalized operational policies can be obtained only by analyzing a lengthy period covering a variety of hydrologic conditions. Though this may be adequate for calibration purposes, it can be computationally expensive for developing general operating guidelines under a wide variety of hydrologic conditions. In addition, it may be difficult to obtain a unique operating rule in this case.

Since inflows to a reservoir are a stochastic process, operational policies that consider this stochasticity directly can be obtained by using explicit stochastic optimization procedures which directly incorporate inflow probability distributions rather than deterministic inflow levels. Stochastic dynamic programming, which was selected for this analysis, can find feedback policies that optimize the long-term expected value of the operational objective. Transition probability matrices are used to describe the discrete probability of a certain inflow conditioned on the previous period inflow. Optimal policies are determined in stochastic dynamic programming by searching over discrete inflow levels for a current month conditioned on a specific inflow class of the previous month. The general form of the

recursion equation used in stochastic dynamic programming can be written as:

$$F_i(V_i, I_{i-1}) = \max_{V_{i+1}(\text{or } R_i)} \sum_{k=1}^{K} p(I_{ik}|I_{i-1})[E_i(V_i, R_i, V_{i+1}) + F_{i+1}(V_{i+1}, I_{ik})] \quad (2.5.1)$$

where $E_i(\cdot)$ = energy generated during period i, as function of releases and average head over the period

$i = 1, \ldots, N$ is index of months, with transition probabilities repeated every 12 months

$k = 1, \ldots, K$ is index of discrete values of random inflow

V_i = Reservoir initial storage for month i

R_i = Reservoir release during month i

I_{i-1} = value of a specific inflow class for month i-1

I_{ik} = discrete random inflow at month i, discrete level k

$p(I_{ik}|I_{i-1})$ = probability of occurence of I_{ik} conditioned on previous I_{i-1}.

$$\therefore \sum_{k=1}^{K} p(I_{ik}|I_{i-1}) = 1 \quad (2.5.2)$$

There are two ways the reservoir mass balance can be considered:

noninverted form: $V_{i+1,k} = V_i - R_i - EVAP_i(V_i, V_{i+1,k}) + I_{ik}$

inverted form: $R_{ik} = V_i - V_{i+1} - EVAP(V_i, V_{i+1}) + I_{ik}$

Notice that in the noninverted form, the end-of-period volume is treated as a random variable, and releases R_i are directly optimized. This results in optimal release policies $R_i^*(V_i, I_{i-1})$. In the inverted form, optimization is performed directly over the end-of-period volume and releases are now regarded as random. This results in optimal storage guidecurves $V_{i+1}^*(V_i, I_{i-1})$. The latter are considered to be more flexible for reservoir operations.

An important aspect of the optimization is the calculation of energy $E_i(V_i, R_i, V_{i+1})$. Since there are actually two turbines, it is necessary to perform a preoptimization in order to determine the optimal loading of each turbine under a variety of discrete discharge and head conditions. Table 2.4.2 defines power output for a single turbine, and it is assumed that each turbine has the same characteristics. A simple combinatorial approach is performed where for various discrete increments of head and discharge, the optimal division of discharge between the two turbines is calculated such that total power output from both turbines is maximized, even though in some cases, it may turn out to be optimum to load just one of the turbines. It is believed that the computer program developed for this combinatorial analysis can be useful to system operators on a daily basis for deciding how to optimally allocate flows between the two turbines. A complete listing of the computer program can be found in Appendix G of this report, along with a set of optimal tables in increments of 0.5 m head and 2 cms discharge. These increments can be easily changed in the computer program if more precision is desired.

This preoptimization was performed prior to the running of Program CSUDP and an optimal combined table of maximum power output from both turbines as a function of head and discharge was directly input into CSUDP.

Since the transition probabilities repeat every 12 months, the undiscounted stochastic dynamic programming is run over several years to determine if optimal guidecurves for each month are becoming stationary. For this study, calculation for three or four years has been sufficient to guarantee convergence. The optimal seasonally stationary policies can be applied each year over the entire operation horizon with any sequence of inflows. To find a stationary policy, all other variables used in the reservoir analysis, such as average irrigation demand (Table 2.3.5), net evaporation (Table 2.3.12), average hours for power generation in each month (Figure 2.3.6 and Appendix C), storage flood rule (Figure 2.3.7), power table (Table 2.5.1) and elevation-area-volume data (Table 2.3.9). All of these values are summarized in Table 2.5.1.

2.5.2 Problem setup and execution with CSUDP.

Subroutines STATE, OBJECT, READIN and the input data file were developed for CSUDP. They are shown in Figure 2.5.1 and 2.5.2. The objective function defined in Subroutine OBJECT is simply to maximize total expected energy production. Other objectives such as maximizing firm or reliable energy were also run, but appeared to result in inferior policies. When it was attempted to include irrigation demands as explicit lower limits on reservoir releases, infeasibilities always occurred. This means that on rare occasions, it was impossible to meet the irrigation requirements based on Valdesia release alone. Subsequent Monte Carlo analysis which included Las Barias Reservoir revealed that releases from Las Barias storage could meet these small shortages.

Table 2.5.1. Averaged Represented Values used for Analyzing Optimal (Statioanary) Policy in CSUDP

Variables	Irrigation Demand (CMS)	Net Evaporation (mm)	Maximum Storage (MCM)	Time for Power Generation (fraction)	Number of Days	Convert 1 CMS to MCM
January	8.11	89.44	153	.230968	31	.373357
February	9.13	88.20	153	.313894	28.25	.409702
March	11.50	103.13	153	.250793	31	.373357
April	10.44	57.89	153	.243139	30	.385802
May	7.71	-269.78	153	.283427	31	.373357
June	7.87	-170.89	153	.461958	30	.385802
July	9.88	26.13	153	.403858	31	.373357
August	7.48	-32.88	133	.384355	31	.373357
September	8.67	-0.57	113	.278681	30	.385802
October	7.88	-47.13	137	.303253	31	.373357
November	10.99	22.88	153	.378194	30	.385802
December	9.13	79.75	153	.219758	31	.373357

Reservoir Geometric Data

Elevation	(masl)	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.	160.
Area	(1000 M*M)	324.	871.	1572.	2310.	3406.	4537.	5664.	6677.	7492.	8357.	9000.	9776.
Volume	(MCM)	0.	.600	1.173	6.182	16.21	32.16	53.74	80.14	113.5	153.1	196.5	243.4

Power Table (MW)

m^3/s \ head (m.a.s.1)	130.75	132.00	134.00	136.00	138.00	140.00	142.00	144.00	146.00	148.00	150.00
20.00	8.00	8.12	8.30	8.57	8.77	8.93	9.10	9.30	9.70	10.10	10.50
25.00	10.70	10.89	11.20	11.60	11.98	12.33	12.67	13.00	13.40	13.87	14.40
30.00	13.20	13.55	14.10	14.63	15.18	15.73	16.27	16.80	17.20	17.67	18.20
35.00	15.60	16.06	16.80	17.47	18.15	18.85	19.53	20.20	20.67	21.20	21.80
40.00	17.50	18.04	18.90	19.83	20.65	21.35	22.10	22.90	23.50	24.17	24.90
45.00	19.00	19.58	20.50	21.50	22.37	23.12	23.97	24.90	25.70	26.40	27.00
50.00	21.40	21.78	22.40	23.20	23.95	24.65	25.37	26.10	26.90	27.77	28.80
55.00	23.90	24.44	25.35	26.23	27.15	28.05	28.93	29.80	30.60	31.53	32.60
60.00	26.45	27.14	28.25	29.27	30.35	31.45	32.53	33.60	34.40	35.33	36.40
65.00	29.00	29.85	31.20	32.27	33.45	34.75	35.93	37.00	37.93	38.93	40.00
70.00	31.20	32.12	33.60	34.93	36.30	37.70	39.07	40.40	41.33	42.40	43.60
75.00	33.20	34.20	35.80	37.40	38.85	40.20	41.63	43.20	44.27	45.53	47.00
80.00	35.00	36.08	37.80	39.67	41.30	42.70	44.20	45.80	47.00	48.33	49.80
85.00	36.50	37.62	39.60	41.60	43.30	44.70	46.27	48.00	49.47	50.80	52.00
90.00	38.00	39.15	41.00	43.00	44.75	46.25	47.93	49.80	51.40	52.80	54.00

Figure 2.5.1. Subroutines used in the CSUDP runs.

```
C ######################################################################
C
C     STATIONARY OPERATION POLICY ANALYSIS: STOCHASTIC DYNAMIC PROG
C
C      VALDESIA RESERVOIR:  MAX ENERGY  ST  MEET IRRIGATION DEMAND
C                           RANDOM INFLOW (CONDITIONAL PROBABILITY)
C
C ####################################################################==
C
C
C *********************************************************************
C
      SUBROUTINE STATE
C
C     *****************************************************************
C
C        THIS SUBROUTINE CALCULATES THE MONTHLY WATER POWER RELEASES
C        INVERTIBLE FORM
C        A SMALL PENALTY IS ADDED TO THE CASE THAT
C        RESERVOIR RELEASE IS GREATER THAN TURBINE DISCHARGE CAPACITY
C
C        X     : STORAGE VOLUME AT THE INITIAL OF THE MONTH IN  MCM
C        X1    : STORAGE VOLUME AT THE END     OF THE MONTH IN  MCM
C        U     : RESERVOIR RELEASE, AVAILABLE FOR POWER  IN CMS
C        R     : RANDOM INFLOW IN  CMS
C        QIRR  : TYPICAL MONTHLY IRRIGATION DEMAND OF ZONE A1 (CMS)
C        EMP   : AVERAGED NET EVAPORATION (EVAPOR-PRECIP) IN  MM
C        TCF   : MONTHLY CONVERSION FACTOR,  1 MCM - TCF CMS
C        WS    : ENERGY PENALTY WEIGHTING FACTOR, FOR
C                NOT MEETING THE IRRIGATION DEMAND, IN GWH
C        WU    : NEGATIVE RELEASE PENALTY WEIGHTING FACTOR
C        SPILL : EXCESS WATER AFTER MEETING IRRIGATION DEMAND
C
C     *****************************************************************
C
C
      COMMON /ONEDM/ X, X1, U, F, I, J, K, L, R, PNALTY
C
      DIMENSION  QIRR(12), EMP(12), TCF(12)
C
      DATA  QIRR/  8.11,  9.13, 11.50, 10.44,  7.71,   7.87,
     2             9.88,  7.48,  8.67,  7.88, 10.99,   9.13/
      DATA  EMP/  89.44,  88.20, 103.13,  57.89, -269.78, -170.89,
     2            26.13, -32.88,  -0.57, -47.13,   22.88,   79.75/
      DATA  TCF/ .373357, .409702, .373357, .385802, .373357, .385802,
     2           .373357, .373357, .385802, .373357, .385802, .373357/
      DATA  WS/ 100./,  WUX/ 1./,  WUN/ 1000./
C
      CALL  VTABL ( X , EL, A , 2)
      CALL  VTABL ( X1, EL, A1, 2)
C
      IM - MOD(I,12)
```

```
      IF (IM.EQ.0)  IM = 12
      U = (X - X1 - EMP(IM)*(A+A1)*.5E-6) * TCF(IM) + R
C
C **  PENALTY WILL BE COUNTED IN GWH
C
      F = 0.
C
C **  IF  U > 300 ,  LET  U = 300  TO AVOID A LARGE PENALTY
C
      IF (U.GT.300.)  THEN
          F = F - WUX * ( U - 300. )
          U = 300.
      ENDIF
C
C **  IF  U < 0 ,  LET  U = 0  TO AVOID DOUBLE PENALTY ON NEGATIVE RELEASE
C
      IF (U.LT.0.)  THEN
          F = F + WUN * U
          U = 0.
      ENDIF
C
C **  FOR U THAT LIES BETWEEN 0 AND QIRR(IM) WILL BE PENALIZED HERE ...
C **  IF SPILL < 0 MEANS INSUFFICIENT WATER SUPPLY FOR IRRIGATION
C **  USE A LARGE PENALTY WEIGHTING FACTOR WS TO PENALIZE IT
C
      SPILL = U - QIRR(IM)
      IF (SPILL.LT.0.)  F = F + WS * SPILL
C
      RETURN
      END


C ******************************************************************
C
      SUBROUTINE VTABL ( VO, EL, AR, IC)
C
C     ******************************************************************
C
C        VOLUME-HEAD-AREA TABLE OF VALDESIA
C        FOR INTERPOLATION OF HEAD OR AREA FROM KNOWN VOLUME
C
C        V  :  VOLUME.  MCM
C        E  :  ELEVATION.  M  (A.S.L.)
C        A  :  SURFACE AREA.  (1000*M^2)
C        IC :  CHOICE OF INTERPOLATION.  1 FOR HEAD,  2 FOR AREA
C
C         INPUT:  VO, IC
C        OUTPUT:  EL  OR  AR
C
C     ******************************************************************
C
C
      DIMENSION  V(12), E(12), A(12)
C
```

```
      DATA  V/    0.,       .600,   1.173,   6.182,  16.214,  32.163,
     2            53.736, 80.145, 113.465, 153.088, 196.481, 243.421/
      DATA  E/  105.,    110.,     115.,     120.,     125.,     130.,
     2          135.,    140.,     145.,     150.,     155.,     160./
      DATA  A/  324.,    871.,    1572.,    2310.,    3406.,    4537.,
     2         5664.,   6677.,    7492.,    8357.,    9000.,    9776./
C
      DO 20 I = 2,12
      IF (VO.LT.V(I))  GOTO 30
   20 CONTINUE
   30 NV = I
      IF (IC.EQ.1) CALL TWOPLN (VO, V(NV), V(NV-1), E(NV), E(NV-1), EL)
      IF (IC.EQ.2) CALL TWOPLN (VO, V(NV), V(NV-1), A(NV), A(NV-1), AR)
C
      RETURN
      END


C *********************************************************************
C
       SUBROUTINE TWOPLN (X, X1, X2, Y1, Y2, Y)
C
C     ****************************************************************
C
C         LINEAR INTERPOLATION BETWEEN 2 POINTS
C
C         FOR VALUE X BETWEEN (X1,X2), LINEARLY INTERPOLATE THE
C         CORRESPONDING VALUE Y OF (X,Y) BETWEEN (X1,Y1) AND (X2,Y2)
C
C           - --------*--------------*--------------*-------- +
C                 (X2,Y2)          (X,Y)          (X1,Y1)
C
C          INPUT:  X, X1, X2, Y1, Y2
C         OUTPUT:  Y
C
C     ****************************************************************
C
C
      IF (X1.EQ.X2) THEN
         IF (Y1.NE.Y2) STOP 'CAN''T INTERPOLATE LINE Y=C FOR 2 X''S !'
         Y = Y1
         RETURN
      END IF
C
      Y = Y2+(Y2-Y1)*(X-X2)/(X2-X1)
C
      RETURN
      END


C *********************************************************************
C
      SUBROUTINE SRFLN2 (PW, HDI, QPI)                              041786
```

```
C
C     *****************************************************************
C
C       LINEAR INTERPOLATION OF TABLE DATA
C
C       POWR, NH, NQ
C       THE POWER DATA SET OF RESERVOIR, POWR (NH*NQ MATRIX),
C       WITH H-AXIS ARRAY H  AND  Q-AXIS ARRAY Q
C       BOTH H AND Q ARRAY SHOULD BE IN ASSCENDING ORDER.              041786
C
C       PW, HD, QP
C       FIND THE INTERPOLATED VALUE "PW" FOR A SPECIFIC
C       COORDINATE (HD,QP) ON THE TABLE (MATRIX)
C       POWR : POWER, IN MW
C         HT : ELEVATION, IN M (A.S.L.)
C         QT : POWER RELEASE, IN CMS
C
C       TAKE AVERAGE POWER COEFFICIENT OF 2 CORRESPONDING POINTS
C       FIRST, THE VALUE IS INTERPOLATED OVER H AXIS FIRST.
C       THEN INTERPOLATE THE FINAL POWER COEFFICIENT FROM THESE
C       2 NEW POINTS (E1 & E2) OVER Q AXIS.
C
C       FOR POINTS OUTSIDE THE TABLE IS ASSIGNED VALUED WITH
C       ALL DATA WITH EITHER HEAD OR DISCHARGE SMALLER THAN THE        041786
C       MINIMUM H OR Q VALUE IS RETURNED WITH ZERO COEFFICIENT.        041786
C       IF BOTH HEAD AND DISCHARGE OF THE POINT ARE GREATER THAN       041786
C       THE MAXIMUM H AND Q VALUE, THEN POWR(NH,NQ) IS RETURNED.       041786
C       IN CASE QP IS LARGER THAN THE MAXIMUM QT(NQ), THEN QP IS       041786
C       TRUNCATED TO QT(NQ), OR QP=QT(NQ).                             041786
C       FOR HD IS LARGER THAN THE MAXIMUM HT(NH), THEN IH=NH IS        041786
C       RETURNED.
C
C                  0      | POWR(NH,IQ) | POWR(NH,NQ)
C             ------------+------IQ.----+------------  HT(NH)
C                        IH2  X       X  |
C                         |   |       |  |                ^
C                  0     IH   E1--PW--E2 | POWR(IH,NQ)    | HDI
C                         |   |       |  |                |
C                        IH1  X       X  |
C             ------------+--IQ1----IQ2-+------------  HT(1)
C                  0      |      0      |      0
C                       QT(1)  ----->  QT(NQ)
C                                QPI
C
C
C         KNOWN :  POWR(NH,NQ), HT(NH), QT(NQ)
C         INPUT :  HDI=HD,  QPI=QP
C        OUTPUT :  PW
C
C     *****************************************************************
C
C
      DIMENSION  POWR(11,15), HT(11), QT(15)
C
C     TOTAL  165 (NH*NQ)  DATA POINTS ON THE TABLE
```

```
C **  THIS NEW POWER TABLE IS TAKEN FROM COMBINING THE TWO POWER TABLES
C **  OF TWO IDENTICAL TURBINES
C
      DATA  NH, NQ/ 11, 15/
      DATA  QT/  20.0,  25.0,  30.0,  35.0,  40.0,  45.0,  50.0,
     *           55.0,  60.0,  65.0,  70.0,  75.0,  80.0,  85.0,  90.0/
      DATA  HT/ 130.75,  132.00,  134.00,  136.00,  138.00,
     *          140.00,  142.00,  144.00,  146.00,  148.00,  150.00/
      DATA ((POWR(IH,IQ),IH=1,11),IQ= 1, 5)/  8.00,  8.12,  8.30,  8.57,
     *     8.77,  8.93,  9.10,  9.30,  9.70, 10.10, 10.50, 10.70, 10.89,
     *    11.20, 11.60, 11.98, 12.33, 12.67, 13.00, 13.40, 13.87, 14.40,
     *    13.20, 13.55, 14.10, 14.63, 15.18, 15.73, 16.27, 16.80, 17.20,
     *    17.67, 18.20, 15.60, 16.06, 16.80, 17.47, 18.15, 18.85, 19.53,
     *    20.20, 20.67, 21.20, 21.80, 17.50, 18.04, 18.90, 19.83, 20.65,
     *    21.35, 22.10, 22.90, 23.50, 24.17, 24.90/
      DATA ((POWR(IH,IQ),IH=1,11),IQ= 6,10)/ 19.00, 19.58, 20.50, 21.50,
     *    22.37, 23.12, 23.97, 24.90, 25.70, 26.40, 27.00, 21.40, 21.78,
     *    22.40, 23.20, 23.95, 24.65, 25.37, 26.10, 26.90, 27.77, 28.80,
     *    23.90, 24.44, 25.35, 26.23, 27.15, 28.05, 28.93, 29.80, 30.60,
     *    31.53, 32.60, 26.45, 27.14, 28.25, 29.27, 30.35, 31.45, 32.53,
     *    33.60, 34.40, 35.33, 36.40, 29.00, 29.85, 31.20, 32.27, 33.45,
     *    34.75, 35.93, 37.00, 37.93, 38.93, 40.00/
      DATA ((POWR(IH,IQ),IH=1,11),IQ=11,15)/ 31.20, 32.12, 33.60, 34.93,
     *    36.30, 37.70, 39.07, 40.40, 41.33, 42.40, 43.60, 33.20, 34.20,
     *    35.80, 37.40, 38.85, 40.20, 41.63, 43.20, 44.27, 45.53, 47.00,
     *    35.00, 36.08, 37.80, 39.67, 41.30, 42.70, 44.20, 45.80, 47.00,
     *    48.33, 49.80, 36.50, 37.62, 39.60, 41.60, 43.30, 44.70, 46.27,
     *    48.00, 49.47, 50.80, 52.00, 38.00, 39.15, 41.00, 43.00, 44.75,
     *    46.25, 47.93, 49.80, 51.40, 52.80, 54.00/
C
      HD = HDI
      QP = QPI
C
      IF (HD.LT.HT(1) .OR. QP.LT.QT(1))  THEN                          041786
                                         PW = 0.                        041786
                                         RETURN                         041786
                                         ENDIF                          041786
C
C
      IH=0
      IQ=0
      IF (HD.GE.HT(NH))  IH = NH                                        041786
      IF (QP.GE.QT(NQ))  IQ = NQ                                        041786
      IF (QP.GT.QT(NQ))  QP = QT(NQ)                                    041786
C
      DO 200 I=1,NH-1                                                   041786
      IF (HD.EQ.HT(I))  THEN
                        IH = I
                        GO TO 300
                        ENDIF
      IF (HD.GT.HT(I))  IH1 = I
  200 CONTINUE
      IH2=IH1+1
C
  300 DO 400 I=1,NQ-1                                                   041786
```

```
      IF (QP.EQ.QT(I))  THEN
                        IQ = I
                        GO TO 500
                        ENDIF
      IF (QP.GT.QT(I))  IQ1=I
  400 CONTINUE
      IQ2=IQ1+1
C
C **  FOR POINT CLASSIFIED TO CORNER OR GRID POINT, JUST RETURN THE VALUE
C
  500 IF (IH.NE.0 .AND. IQ.NE.0) THEN
                                 PW = POWR(IH,IQ)
                                 RETURN
                                 ENDIF
C
C **  PERFORM LINEAR INTERPOLATION ON A LINE
C **  FOR POINT SIT AT BOUNDARY OR GRID LINE
C
      IF (IH.NE.0)  THEN
         CALL TWOPLN
     1        (QP,QT(IQ1),QT(IQ2),POWR(IH,IQ1),POWR(IH,IQ2),PW)
         RETURN
         ENDIF
      IF (IQ.NE.0)  THEN
         CALL TWOPLN
     1        (HD,HT(IH1),HT(IH2),POWR(IH1,IQ),POWR(IH2,IQ),PW)
         RETURN
         ENDIF
C
C **  PERFORM LINEAR INTERPOLATION ON A THE TABLE
C
C **  FIRST, 2 LINEAR INTERPOLATIONS OVER H-AXIS FOR NEW PWI VALUE
C **   THEN, GET NEW VALUE OVER THE Q-AXIS DIRECTION
C
      CALL TWOPLN (HD,HT(IH1),HT(IH2),POWR(IH1,IQ1),POWR(IH2,IQ1),PW1)
      CALL TWOPLN (HD,HT(IH1),HT(IH2),POWR(IH1,IQ2),POWR(IH2,IQ2),PW2)
      CALL TWOPLN (QP,QT(IQ1),QT(IQ2),PW1,PW2,PW)
C
      RETURN
C
      END


C ***********************************************************************
C
      SUBROUTINE OBJECT
C
C     *******************************************************************
C
C       THIS SUBROUTINE CALCULATES THE ENERGY GENERATED IN EACH MONTH
C
C       FPG  : AVERAGED TOTAL POWER GENERATION TIME IN EACH MONTH
C       TCF  : MONTHLY CONVERSION FACTOR,  1 MCM = TCF CMS
C              (FRACTION)
```

```
C       DAYM : TOTAL DAYS IN A MONTH
C       U    : CALCULATED WATER POWER RELEASE PER MONTH     (CMS)
C       QP   : ACTUAL FLOW RELEASE RATE THRU TURBINE        (CMS)
C       QTBX : MAXIMUM FLOW CAPACITY THRU TWO TURBINES      (CMS)
C       XMAX : MAXIMUM ALLOWED STORAGE IN CURRENT MONTH IM  (MCM)
C       POW  : AVERAGE POWER GENERATED BY INTERPOLATION      (MW)
C       ENG  : ACTUAL ENERGY PRODUCED                       (GWH)
C       F    : CCLCULATED ENERGY INCLUDING PENALTY          (GWH)
C       WP   : ENERGY PENALTY WEIGHTING FACTOR, FOR
C              WATER RELEASE EXCESS THE MAXIMUM TURBINE DISCHARGE
C
C     ****************************************************************
C
      COMMON /ONEDM/ X, X1, U, F, I, J, K, L, R, PNALTY
C
      DIMENSION  FPG(12),  DAYM(12),  XMAX(12),  TCF(12)
C
      DATA   FPG/ .230968, .313894, .250793, .243139, .283427, .461958,
     2            .403858, .384355, .278681, .303253, .378194, .219758/
      DATA   TCF/ .373357, .409702, .373357, .385802, .373357, .385802,
     2            .373357, .373357, .385802, .373357, .385802, .373357/
      DATA  DAYM/ 31.,28.25,31.,30.,31.,30.,31.,31.,30.,31.,30.,31./
      DATA  XMAX/  153., 153., 153., 153., 153., 153.,
     2             153., 133., 113., 137., 153., 153./
      DATA  WP/ 0.1/,  QTBX/ 90.0/
C
      IM = MOD(I,12)
      IF (IM.EQ.0)  IM=12
C
      CALL  VTABL ( X , E , AR, 1)
      CALL  VTABL ( X1, E1, AR, 1)
      EM = (E+E1)/2.
C
      QP = U / FPG(IM)
      CALL SRFLN2 (POW, EM, QP)
C
      ENG = POW * .024 * DAYM(IM) * FPG(IM)
      F = F + ENG
C
C
C **  THE MAXIMUM EQUIVALENT AVERAGE RESERVOIR RELEASE FOR POWER GENERATION
C **  WILL BE UMAX=QTBX*FPG(IM) FOR TWO TURBINES.
C **  ONCE THERE IS (UNNECESSARY) EXCESS RELEASE AND X1 IS NOT FULL,
C **  A SMALL PENALTY WEIGHTING FACTOR WP IS APPLIED TO THE AVAILABLE STORAGE
C **  THUS, DRIVE THE STORAGE KEEP AS HIGH AS POSSIBLE !
C
      IF (X1.LT.XMAX(IM))  THEN
          UMAX = QTBX * FPG(IM)
          UEXCS = U - UMAX
          IF (UEXCS.GT.0.)  THEN
              XEXCS = ( XMAX(IM) - X1 ) * TCF(IM)
              IF (UEXCS.GT.XEXCS)  UEXCS = XEXCS
              F = F - WP * UEXCS
          ENDIF
      ENDIF
```

```
C
      RETURN
      END


C **********************************************************************
C
      SUBROUTINE READIN
C
C     ********************************************************************
C
      RETURN
      END
```

Figure 2.5.2. Input data file used in CSUDP runs (optimal operation rules)

```
STATIONARY OPERATION POLICY OF VALDESIA RESERVOIR.   RUN INV 12X12-#4
  -1    1   48    1    1    1
   1    1   12    0    0    2
      2.0      0.1      0.0      0.0      0.0
  17
   1       35.      153.
   9       35.      133.
  10       35.      113.
  11       35.      137.
  12       35.      153.
  21       35.      133.
  22       35.      113.
  23       35.      137.
  24       35.      153.
  33       35.      133.
  34       35.      113.
  35       35.      137.
  36       35.      153.
  45       35.      133.
  46       35.      113.
  47       35.      137.
  48       35.      153.
   1
   1        0.      300.
      12
   5.5102   7.6897   9.4707   11.486   13.111   14.608   16.288   18.488
   20.666   24.367   29.279   37.493                              01  01
      12
   4.0087   6.1114   7.8893   9.8973   11.740   13.528   15.542   17.757
   20.398   24.194   29.196   38.625                              02
      12
   3.9725   5.7109   7.1656   8.8120   10.275   12.016   13.763   15.501
   17.678   21.527   26.341   34.457                              03
      12
   4.3508   5.9561   7.4184   8.9743   10.322   11.737   13.075   14.619
   16.921   20.014   23.931   30.353                              04
      12
   4.0241   6.1822   8.4843   11.781   15.218   18.337   22.153   27.156
   33.337   43.358   55.936   83.589                              05
      12
   4.0005   6.3710   8.8024   11.431   14.444   17.989   22.483   28.019
   34.578   45.814   59.784   97.299                              06
      12
   5.7850   7.9154   9.6742   11.845   14.233   16.714   19.446   22.400
   26.659   32.556   39.482   55.894                              07
      12
   7.7630   10.646   13.213   16.576   19.307   22.898   26.456   30.446
   36.775   46.200   60.206   111.41                              08
      12
   7.4465   9.3810   11.259   13.565   15.606   18.174   21.029   24.876
   29.388   37.564   50.860   86.017                              09
      12
   8.4400   10.010   11.616   13.156   14.574   16.091   17.709   19.979
```

22.997	27.103	33.291	47.626				10
12							
9.4234	11.310	12.869	14.762	16.259	17.935	19.885	21.879
24.449	29.050	34.409	46.006				11
12							
5.1575	7.5630	9.7400	12.589	14.874	17.343	20.320	24.207
29.173	36.263	46.281	68.123				12
12							
5.5102	7.6897	9.4707	11.486	13.111	14.608	16.288	18.488
20.666	24.367	29.279	37.493				01 02
12							
4.0087	6.1114	7.8893	9.8973	11.740	13.528	15.542	17.757
20.398	24.194	29.196	38.625				02
12							
3.9725	5.7109	7.1656	8.8120	10.275	12.016	13.763	15.501
17.678	21.527	26.341	34.457				03
12							
4.3508	5.9561	7.4184	8.9743	10.322	11.737	13.075	14.619
16.921	20.014	23.931	30.353				04
12							
4.0241	6.1822	8.4843	11.781	15.218	18.337	22.153	27.156
33.337	43.358	55.936	83.589				05
12							
4.0005	6.3710	8.8024	11.431	14.444	17.989	22.483	28.019
34.578	45.814	59.784	97.299				06
12							
5.7850	7.9154	9.6742	11.845	14.233	16.714	19.446	22.400
26.659	32.556	39.482	55.894				07
12							
7.7630	10.646	13.213	16.576	19.307	22.898	26.456	30.446
36.775	46.200	60.206	111.41				08
12							
7.4465	9.3810	11.259	13.565	15.606	18.174	21.029	24.876
29.388	37.564	50.860	86.017				09
12							
8.4400	10.010	11.616	13.156	14.574	16.091	17.709	19.979
22.997	27.103	33.291	47.626				10
12							
9.4234	11.310	12.869	14.762	16.259	17.935	19.885	21.879
24.449	29.050	34.409	46.006				11
12							
5.1575	7.5630	9.7400	12.589	14.874	17.343	20.320	24.207
29.173	36.263	46.281	68.123				12
12							
5.5102	7.6897	9.4707	11.486	13.111	14.608	16.288	18.488
20.666	24.367	29.279	37.493				01 03
12							
4.0087	6.1114	7.8893	9.8973	11.740	13.528	15.542	17.757
20.398	24.194	29.196	38.625				02
12							
3.9725	5.7109	7.1656	8.8120	10.275	12.016	13.763	15.501
17.678	21.527	26.341	34.457				03
12							
4.3508	5.9561	7.4184	8.9743	10.322	11.737	13.075	14.619
16.921	20.014	23.931	30.353				04

12							
4.0241	6.1822	8.4843	11.781	15.218	18.337	22.153	27.156
33.337	43.358	55.936	83.589				05
12							
4.0005	6.3710	8.8024	11.431	14.444	17.989	22.483	28.019
34.578	45.814	59.784	97.299				06
12							
5.7850	7.9154	9.6742	11.845	14.233	16.714	19.446	22.400
26.659	32.556	39.482	55.894				07
12							
7.7630	10.646	13.213	16.576	19.307	22.898	26.456	30.446
36.775	46.200	60.206	111.41				08
12							
7.4465	9.3810	11.259	13.565	15.606	18.174	21.029	24.876
29.388	37.564	50.860	86.017				09
12							
8.4400	10.010	11.616	13.156	14.574	16.091	17.709	19.979
22.997	27.103	33.291	47.626				10
12							
9.4234	11.310	12.869	14.762	16.259	17.935	19.885	21.879
24.449	29.050	34.409	46.006				11
12							
5.1575	7.5630	9.7400	12.589	14.874	17.343	20.320	24.207
29.173	36.263	46.281	68.123				12
12							
5.5102	7.6897	9.4707	11.486	13.111	14.608	16.288	18.488
20.666	24.367	29.279	37.493				01 04
12							
4.0087	6.1114	7.8893	9.8973	11.740	13.528	15.542	17.757
20.398	24.194	29.196	38.625				02
12							
3.9725	5.7109	7.1656	8.8120	10.275	12.016	13.763	15.501
17.678	21.527	26.341	34.457				03
12							
4.3508	5.9561	7.4184	8.9743	10.322	11.737	13.075	14.619
16.921	20.014	23.931	30.353				04
12							
4.0241	6.1822	8.4843	11.781	15.218	18.337	22.153	27.156
33.337	43.358	55.936	83.589				05
12							
4.0005	6.3710	8.8024	11.431	14.444	17.989	22.483	28.019
34.578	45.814	59.784	97.299				06
12							
5.7850	7.9154	9.6742	11.845	14.233	16.714	19.446	22.400
26.659	32.556	39.482	55.894				07
12							
7.7630	10.646	13.213	16.576	19.307	22.898	26.456	30.446
36.775	46.200	60.206	111.41				08
12							
7.4465	9.3810	11.259	13.565	15.606	18.174	21.029	24.876
29.388	37.564	50.860	86.017				09
12							
8.4400	10.010	11.616	13.156	14.574	16.091	17.709	19.979
22.997	27.103	33.291	47.626				10
12							

```
    9.4234    11.310    12.869    14.762    16.259    17.935    19.885    21.879
    24.449    29.050    34.409    46.006                                  11
        12
    5.1575    7.5630    9.7400    12.589    14.874    17.343    20.320    24.207
    29.173    36.263    46.281    68.123                                  12
.5882.2157.1961.0000.0000.0000.0000.0000.0000.0000.0000.0000    01   01
.1667.3148.2778.1481.0741.0185.0000.0000.0000.0000.0000.0000
.0833.1481.3426.2130.1204.0741.0093.0093.0000.0000.0000.0000
.0392.0294.1667.2059.2059.1176.0882.0882.0392.0196.0000.0000
.0000.0097.1262.2621.1553.1650.1262.1068.0388.0097.0000.0000
.0000.0377.0755.0849.1698.2264.1792.1226.0377.0472.0189.0000
.0000.0000.0288.0962.1442.1346.2404.1923.1154.0481.0000.0000
.0000.0094.0000.0283.1415.1792.1321.1226.2358.1415.0094.0000
.0000.0000.0095.0381.0190.0571.1333.2000.2857.1524.1048.0000
.0000.0000.0000.0094.0000.0377.0849.1038.1792.3396.1604.0849
.0000.0000.0000.0185.0185.0000.0185.0926.0741.3704.2037.2037
.0000.0000.0000.0000.0000.0000.0000.0196.0196.1176.1961.6471
.6182.2182.1091.0182.0182.0000.0182.0000.0000.0000.0000.0000    02
.1636.2545.2909.2000.0545.0182.0182.0000.0000.0000.0000.0000
.0917.1284.2936.1927.1560.0734.0459.0183.0000.0000.0000.0000
.0180.0541.2703.2613.1441.1261.0631.0360.0180.0090.0000.0000
.0000.0273.1091.2000.2455.1455.1364.0909.0273.0182.0000.0000
.0000.0273.1000.1000.1636.1364.1909.1545.0909.0273.0091.0000
.0000.0091.0273.1000.1364.1727.1636.1727.1091.0818.0273.0000
.0000.0000.0091.0182.0273.2000.1727.1909.1909.1727.0182.0000
.0000.0091.0000.0182.0727.0818.1636.1636.2364.1455.0909.0182
.0000.0000.0000.0000.0182.0455.0455.1364.2182.3545.1455.0364
.0000.0000.0000.0000.0000.0182.0000.0364.1455.2727.2727.2545
.0000.0000.0000.0000.0000.0000.0000.0364.0727.1091.1455.6364
.4364.2000.2545.0182.0182.0545.0000.0182.0000.0000.0000.0000    03
.2037.2037.2037.1667.1111.0556.0370.0000.0000.0185.0000.0000
.1171.1261.2252.1892.0991.0811.0541.0901.0180.0000.0000.0000
.0273.0455.1636.1909.2364.1545.0545.0909.0182.0182.0000.0000
.0182.0727.1455.1182.2091.1091.1364.0909.0545.0455.0000.0000
.0091.0545.1000.1455.1273.1455.1273.1364.0727.0636.0182.0000
.0091.0000.0818.1182.1091.1545.1818.1182.1364.0909.0000.0000
.0000.0000.0273.0818.1091.1273.1545.1545.1545.1364.0545.0000
.0000.0000.0273.0455.0455.1091.1091.1545.2273.2091.0727.0000
.0000.0000.0000.0182.0000.0545.1000.1273.1818.2273.1636.1273
.0000.0000.0000.0000.0000.0182.0909.0545.1636.2364.1636.2727
.0000.0000.0000.0000.0000.0000.0364.0000.1091.1636.2182.4727
.4545.1273.1818.1091.0545.0364.0182.0000.0000.0182.0000.0000    04
.1455.2000.2727.1091.1455.0909.0182.0000.0182.0000.0000.0000
.1000.1182.2273.1545.1091.1273.0364.0455.0455.0273.0091.0000
.0182.0727.1818.2000.1364.0909.0909.1182.0727.0182.0000.0000
.0455.0727.1000.1818.1636.1636.0818.1273.0455.0182.0000.0000
.0273.0364.1364.0636.1545.1455.1636.0727.0909.0727.0273.0091
.0000.0273.0545.1182.1000.1273.1273.1545.1182.1273.0364.0091
.0000.0091.0364.0364.1364.1000.1818.1455.1636.1455.0182.0273
.0000.0000.0182.1000.0727.0818.1364.1455.1364.1818.0909.0364
.0091.0000.0182.0364.0273.1000.1091.1364.1545.1818.1182.1091
.0000.0000.0000.0000.0000.0000.1091.0727.2000.3091.1818.1273
.0000.0000.0000.0000.0000.0000.0000.0364.1273.1273.2182.4909
.4000.2000.2364.0545.0182.0000.0364.0364.0182.0000.0000.0000    05
.1818.1455.2727.1636.0727.0909.0182.0364.0182.0000.0000.0000
```

.0909.1636.1727.1727.1091.1636.0727.0182.0273.0091.0000.0000
.0545.0727.1727.1636.1636.1727.1182.0727.0091.0000.0000.0000
.0364.0273.1364.1455.1545.1364.0727.1091.1091.0545.0182.0000
.0182.0273.1091.1364.1636.0545.1182.1273.1364.1091.0000.0000
.0000.0182.1091.1273.0727.1182.1182.1727.1091.0818.0545.0182
.0000.0091.0364.0636.1818.1364.1455.1182.1182.1000.0545.0364
.0091.0091.0091.0273.0636.0727.1909.1364.2091.1091.1091.0545
.0000.0000.0000.0364.0364.0818.0909.1636.1636.2727.0727.0818
.0000.0000.0000.0364.0182.0364.0545.0545.0909.3273.1818.2000
.0000.0000.0000.0000.0000.0000.0364.0364.1091.2000.2000.4182
.3636.3091.2000.0727.0545.0000.0000.0000.0000.0000.0000.0000 06
.2364.0909.2364.2364.0727.1091.0182.0000.0000.0000.0000.0000
.1273.1091.2273.1545.1455.1000.0636.0545.0091.0091.0000.0000
.0364.1000.1818.1636.2182.1091.0455.0909.0455.0000.0000.0091
.0273.0273.1818.1364.1182.1273.1636.1000.0636.0455.0091.0000
.0091.0273.0545.1636.1636.1818.1455.0818.1182.0455.0091.0000
.0000.0182.0545.1091.1182.1182.1545.2000.0727.1182.0364.0000
.0000.0091.0636.0364.0727.1636.2091.1091.1818.1091.0364.0091
.0000.0091.0182.0455.0909.0727.1182.1273.1909.2273.0545.0455
.0000.0000.0000.0364.0091.0636.0636.1636.1818.2636.1455.0727
.0000.0000.0000.0000.0000.0000.0182.0909.1091.2727.2182.2909
.0000.0000.0000.0000.0000.0182.0364.0545.1636.0909.2000.4364
.5273.2182.1455.0727.0364.0000.0000.0000.0000.0000.0000.0000 07
.2000.2364.3636.1273.0727.0000.0000.0000.0000.0000.0000.0000
.1000.1091.2818.2455.1636.0636.0182.0000.0182.0000.0000.0000
.0182.0909.2455.2000.1909.1455.0727.0182.0182.0000.0000.0000
.0091.0455.1273.2000.1545.1364.1818.0818.0545.0091.0000.0000
.0091.0091.0636.1545.1364.2273.1818.1091.0727.0273.0091.0000
.0000.0091.0182.0545.1636.1273.2182.1909.0909.1273.0000.0000
.0000.0000.0091.0364.1000.1727.1364.2000.1727.1182.0455.0091
.0000.0000.0000.0091.0273.1000.0909.2000.2364.2091.0909.0364
.0000.0000.0091.0000.0091.0091.0818.1182.2182.3273.1182.1091
.0000.0000.0000.0000.0000.0182.0364.1091.1818.2545.1818.2182
.0000.0000.0000.0000.0000.0182.0000.0545.0545.1091.2909.4727
.4364.2545.1818.0727.0364.0182.0000.0000.0000.0000.0000.0000 08
.1667.2222.2963.1481.1111.0185.0370.0000.0000.0000.0000.0000
.0901.1802.2072.2342.1712.0721.0450.0000.0000.0000.0000.0000
.0636.0455.2636.1455.1273.1455.0909.0455.0545.0182.0000.0000
.0364.0091.1909.2091.1636.1273.1091.0909.0364.0273.0000.0000
.0091.0182.0364.1364.2091.1818.1091.1727.0727.0545.0000.0000
.0000.0000.0182.0727.1182.1000.1636.2273.1545.1182.0273.0000
.0000.0091.0455.0455.0545.1545.1818.0909.1818.1909.0364.0091
.0000.0000.0000.0273.0636.1091.1636.1545.2091.2091.0364.0273
.0000.0000.0000.0182.0182.0909.1000.1455.1818.1818.1727.0909
.0000.0000.0000.0000.0000.0000.0182.1091.1455.3091.2182.2000
.0000.0000.0000.0000.0000.0000.0182.0364.0727.0909.2364.5455
.3455.3091.1818.0909.0364.0364.0000.0000.0000.0000.0000.0000 09
.1091.1636.3636.1455.0727.0364.0364.0727.0000.0000.0000.0000
.1091.1182.1818.2636.1182.0818.0636.0364.0273.0000.0000.0000
.1000.0909.1455.1455.1455.1182.1182.0545.0545.0273.0000.0000
.0364.0364.1909.0909.1182.1818.1273.0727.0818.0364.0273.0000
.0091.0273.0727.1273.1636.1364.1091.1182.1455.0818.0091.0000
.0000.0000.0455.0818.1727.1091.1909.1727.1182.0818.0182.0091
.0091.0000.0545.0909.0818.1455.1182.1455.1000.1909.0364.0273
.0000.0000.0273.0545.0727.0727.1091.1727.1636.1636.1091.0545

.0000.0000.0091.0273.0636.1182.1091.1364.1636.1727.1273.0727
.0000.0000.0000.0000.0000.0000.0545.0909.2000.3091.1818.1636
.0000.0000.0000.0000.0182.0000.0182.0182.0909.1818.1636.5091
.3519.1111.2963.0741.0185.0741.0370.0000.0370.0000.0000.0000 10
.1964.1429.1250.2321.0714.0893.0536.0357.0536.0000.0000.0000
.0818.1636.2000.1909.0818.1000.1091.0545.0091.0000.0091.0000
.0545.1091.1364.1636.1455.1000.1000.0727.0636.0455.0091.0000
.0727.0364.1818.1000.1909.1182.0909.0545.0545.0727.0182.0091
.0091.0273.0727.1455.1091.1545.1727.1000.0818.1000.0273.0000
.0000.0273.0818.1000.1455.1455.1182.1909.1455.0273.0000.0182
.0000.0000.0545.0636.1364.1273.1182.0909.1545.1545.0909.0091
.0091.0091.0545.0545.0636.0455.1273.1727.1455.1636.0818.0727
.0000.0000.0000.0273.0636.1000.0909.1636.1636.2182.0818.0909
.0000.0000.0000.0182.0364.0364.0364.0909.2000.1818.2545.1455
.0000.0000.0000.0000.0000.0182.0182.0727.0727.2545.1091.4545
.4909.2364.1455.0364.0545.0364.0000.0000.0000.0000.0000.0000 11
.1273.1455.2909.1455.0909.1091.0182.0182.0364.0000.0000.0182
.0459.0826.2018.1927.2018.1009.0642.0642.0183.0275.0000.0000
.0450.0991.1712.1441.1532.1261.0901.0631.0360.0450.0270.0000
.0636.0455.1000.1091.1727.1182.0909.1273.1182.0364.0182.0000
.0273.0000.1273.1545.1273.1636.1818.0909.0818.0455.0000.0000
.0000.0545.0818.1182.1273.0818.1545.0818.1636.0909.0091.0364
.0000.0182.0545.1000.0545.1091.1364.1455.1455.1455.0364.0545
.0000.0091.0364.0364.0545.0545.0818.1636.1545.2182.1091.0818
.0000.0091.0091.0273.0182.1364.1455.1455.1545.1455.1364.0727
.0000.0000.0000.0364.0182.0545.0545.1091.1091.2909.1636.1636
.0000.0000.0000.0182.0182.0182.0364.1091.1091.2000.1636.3273
.4444.1667.1852.1111.0185.0556.0000.0000.0185.0000.0000.0000 12
.2321.2321.2500.1429.0357.0179.0536.0357.0000.0000.0000.0000
.1364.1273.2091.1818.1545.1182.0455.0091.0182.0000.0000.0000
.0091.1000.1909.2000.1364.1364.0909.1000.0273.0091.0000.0000
.0091.0455.1727.1273.1909.1636.0818.1364.0545.0091.0091.0000
.0000.0182.1182.1000.1636.1545.1455.0727.1091.0909.0273.0000
.0000.0091.0455.1000.1364.1273.2000.1182.1455.0909.0273.0000
.0000.0000.0273.0818.1000.1091.1636.1545.1273.1364.0909.0091
.0000.0000.0182.0636.0455.0818.1545.2000.1636.1636.0364.0727
.0091.0000.0000.0182.0273.0636.0818.1182.2182.2364.1455.0818
.0000.0000.0000.0000.0364.0182.0182.1091.2000.2727.1636.1818
.0000.0000.0000.0000.0000.0000.0000.0364.0545.2545.1636.4909

Therefore, to encourage the model to attempt to meet irrigation demands if possible, a penalty term is subtracted from energy production if shortages occur.

2.5.3 Optimal monthly operational guidecurves.

Normal operation rules for this system are designed to guide the operation of Valdesia Reservoir to meet its hydropower and water supply objectives. Without considering real-time feedback control, a set of rule curves is usually developed for operation over the project life of the reservoir. Instead of providing simple operation rule curves, this study takes a further step by incorporating current hydrologic conditions (previous month inflow) and the entire range of possible beginning storage levels in the reservoir into the normal operation guidelines.

For the purpose of flexibility in operation, a family of target storage operation curves corresponding to each level of conditioned previous random inflows was developed from the results of the stochastic, invertible form analysis with Program CSUDP. For the approach described in Section 2.5.1, the corresponding optimal (stationary) operation rules are shown in Figures 2.5.3 to 2.5.26. The corresponding tabular values of these operating rules can be found in Appendix E.

For illustrative purposes, CSUDP was also run for the moninverted form, which produces optimal release policies such as shown in Figure 2.5.27. Though these curves are of interest, it is believed that the optimal storage guidecurves are more valuable to system operators and more conducive to input to Program MODSIM for weekly analysis.

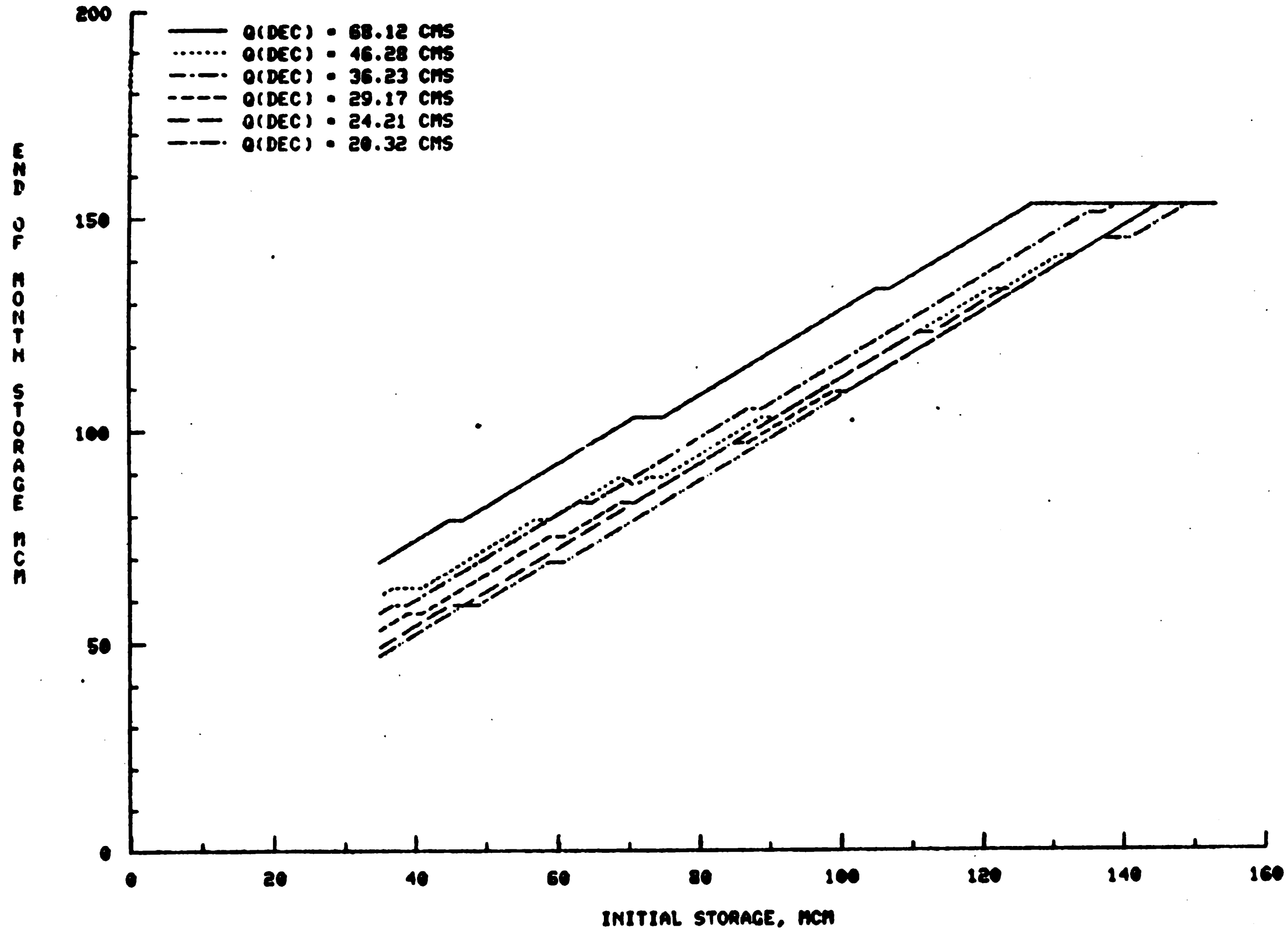


Figure 2.5.3 OPERATING POLICY OF JANUARY FOR Q(DEC) GREATER THAN 18.74 CMS

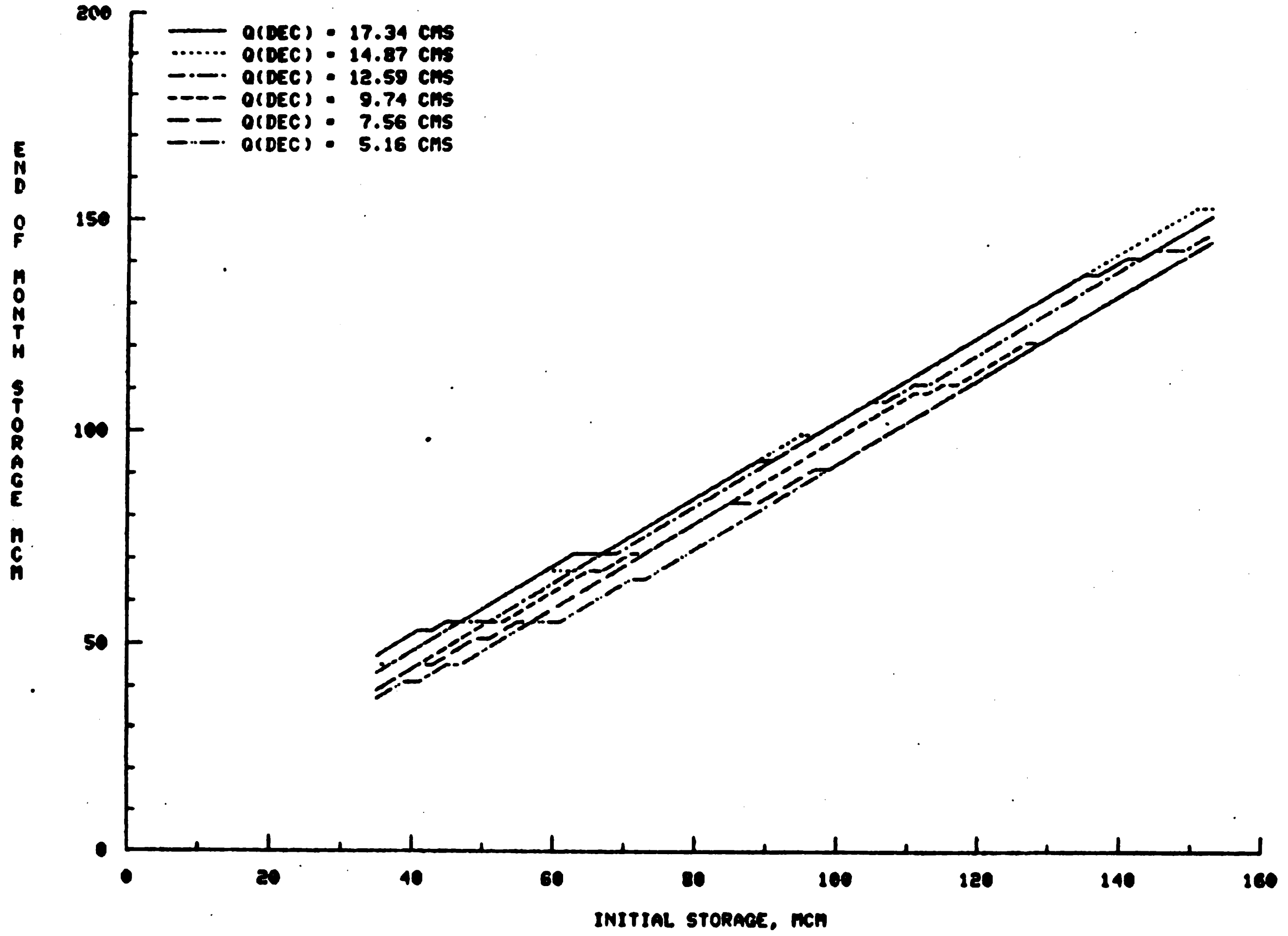


Figure 2.5.4 OPERATING POLICY OF JANUARY FOR Q(DEC) LESS THAN 18.74 CMS

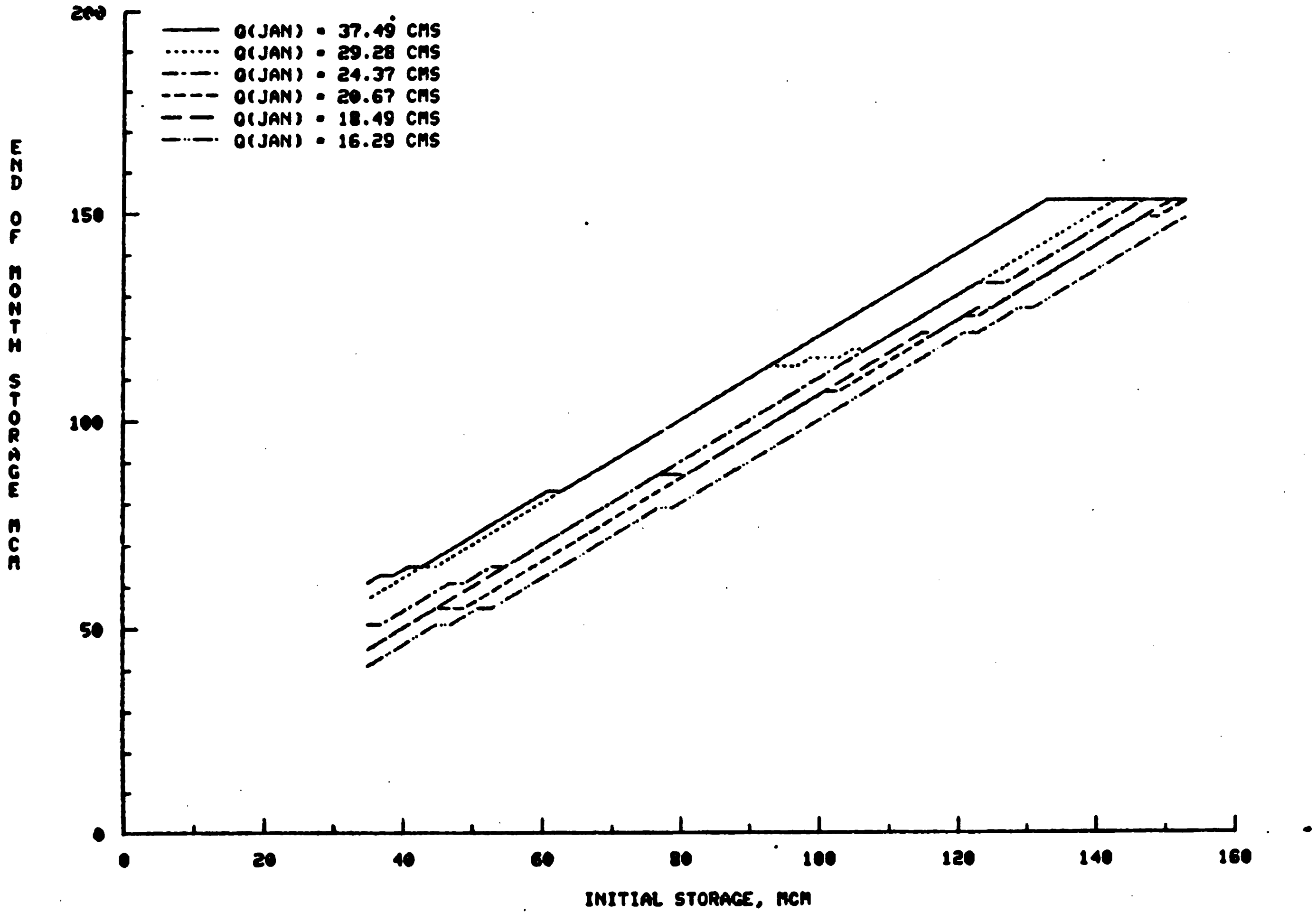


Figure 2.5.5 OPERATING POLICY OF FEBRUARY FOR Q(JAN) GREATER THAN 15.30 CMS

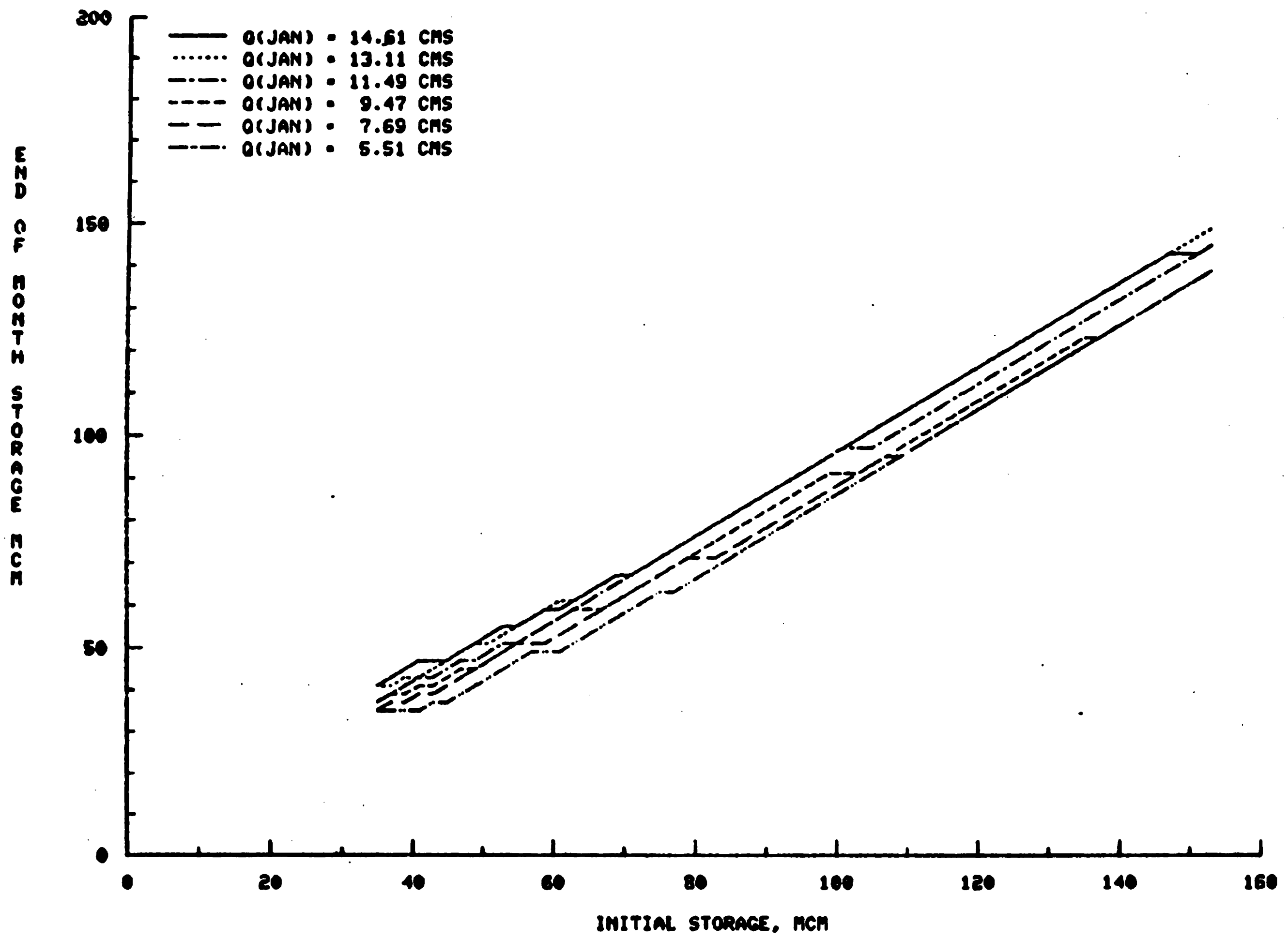


Figure 2.5.6 OPERATING POLICY OF FEBRUARY FOR Q(JAN) LESS THAN 15.30 CMS

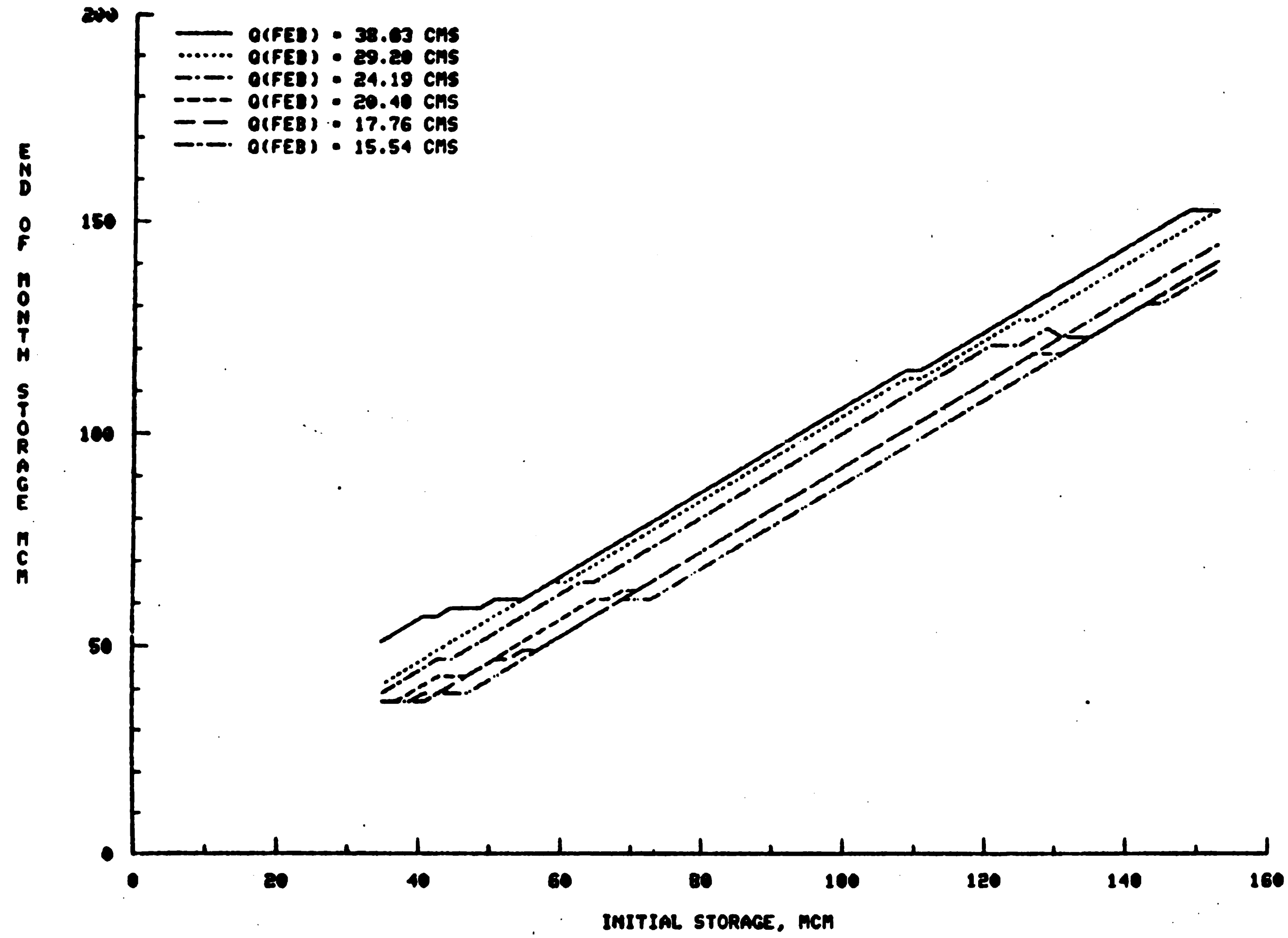


Figure 2.5.7 OPERATING POLICY OF MARCH FOR Q(FEB) GREATER THAN 14.52 CMS

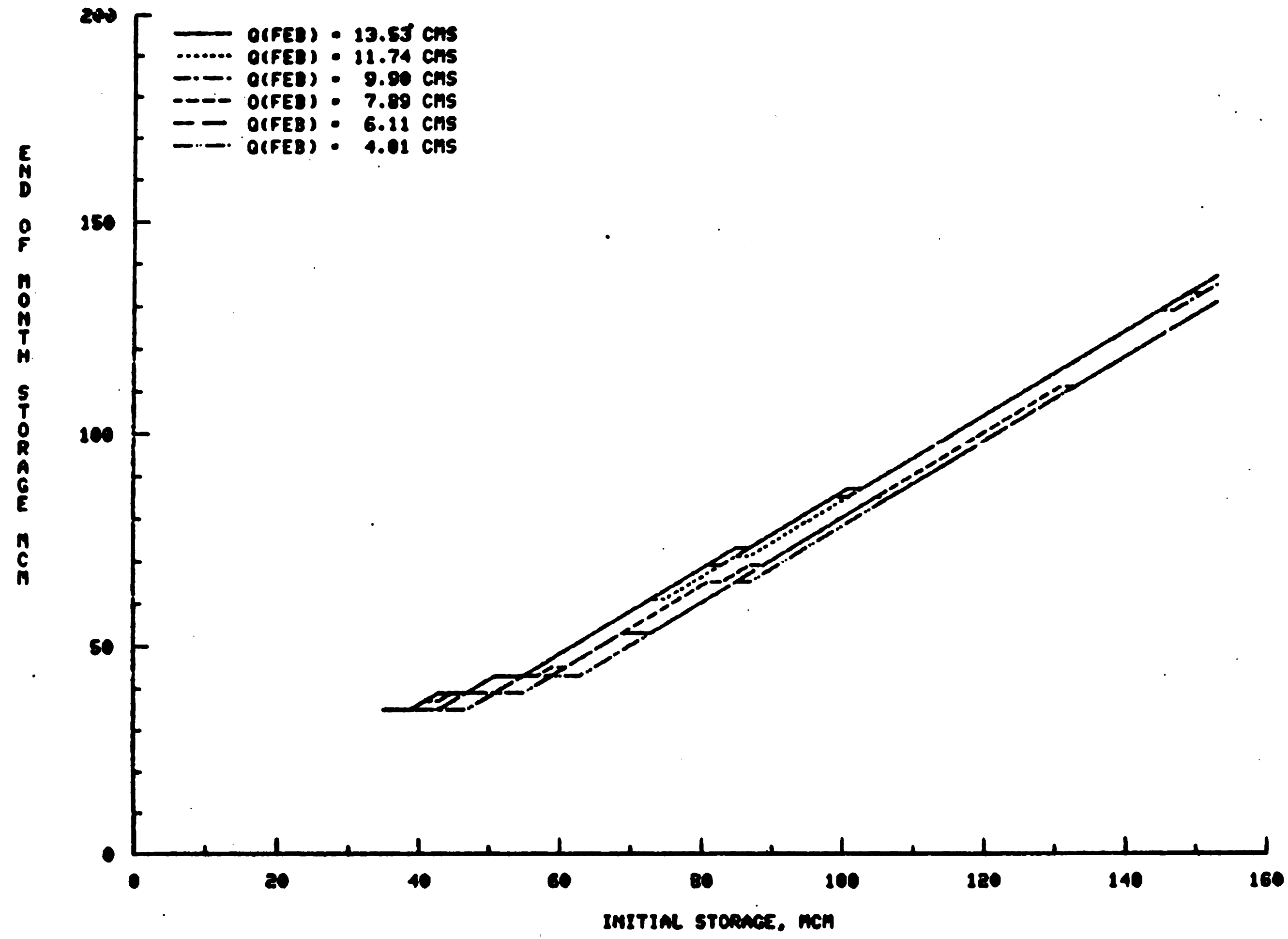


Figure 2.5.8 OPERATING POLICY OF MARCH FOR Q(FEB) LESS THAN 14.52 CMS

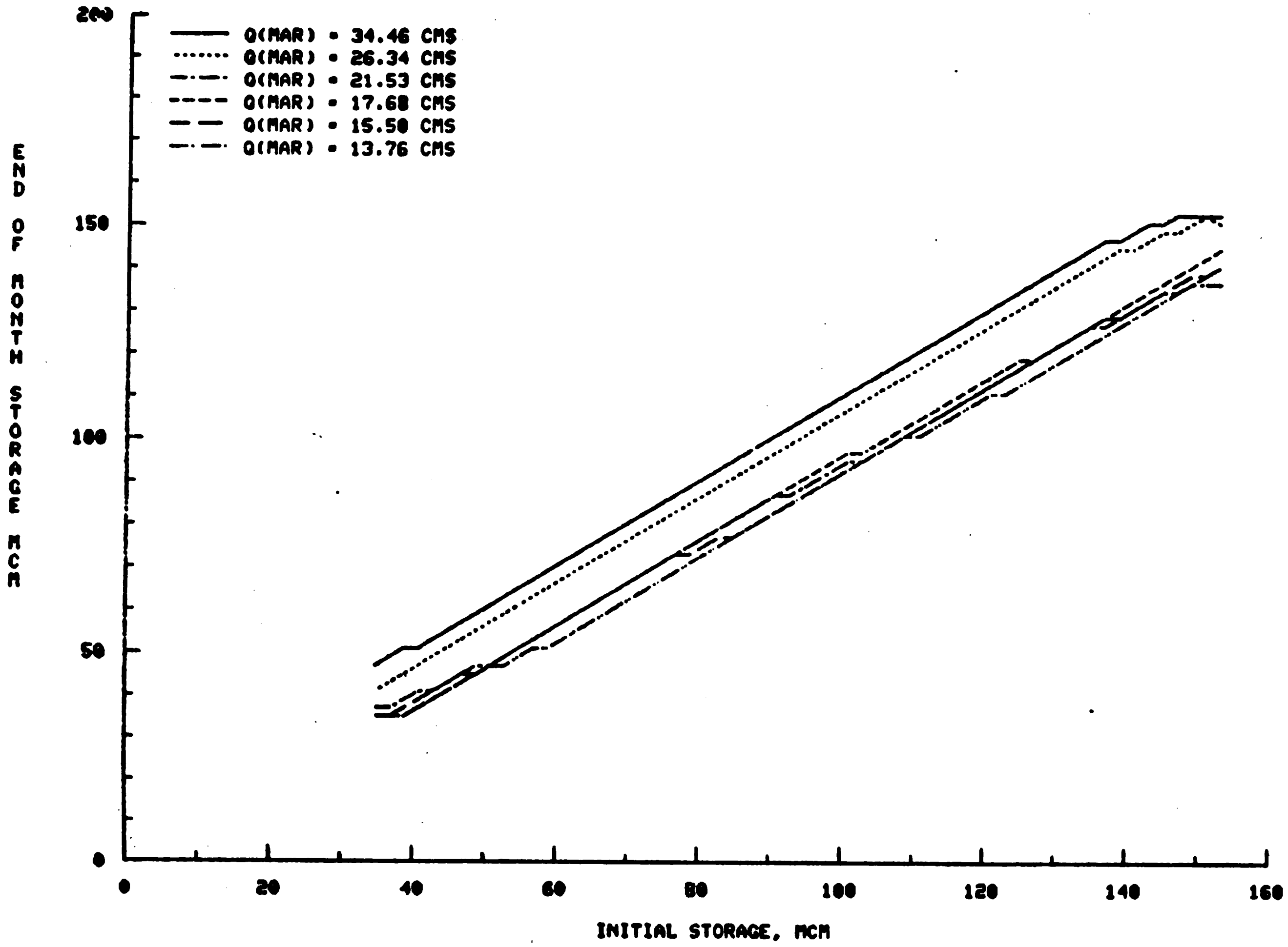


Figure 2.5.9 OPERATING POLICY OF APRIL FOR Q(MAR) GREATER THAN 12.93 CMS

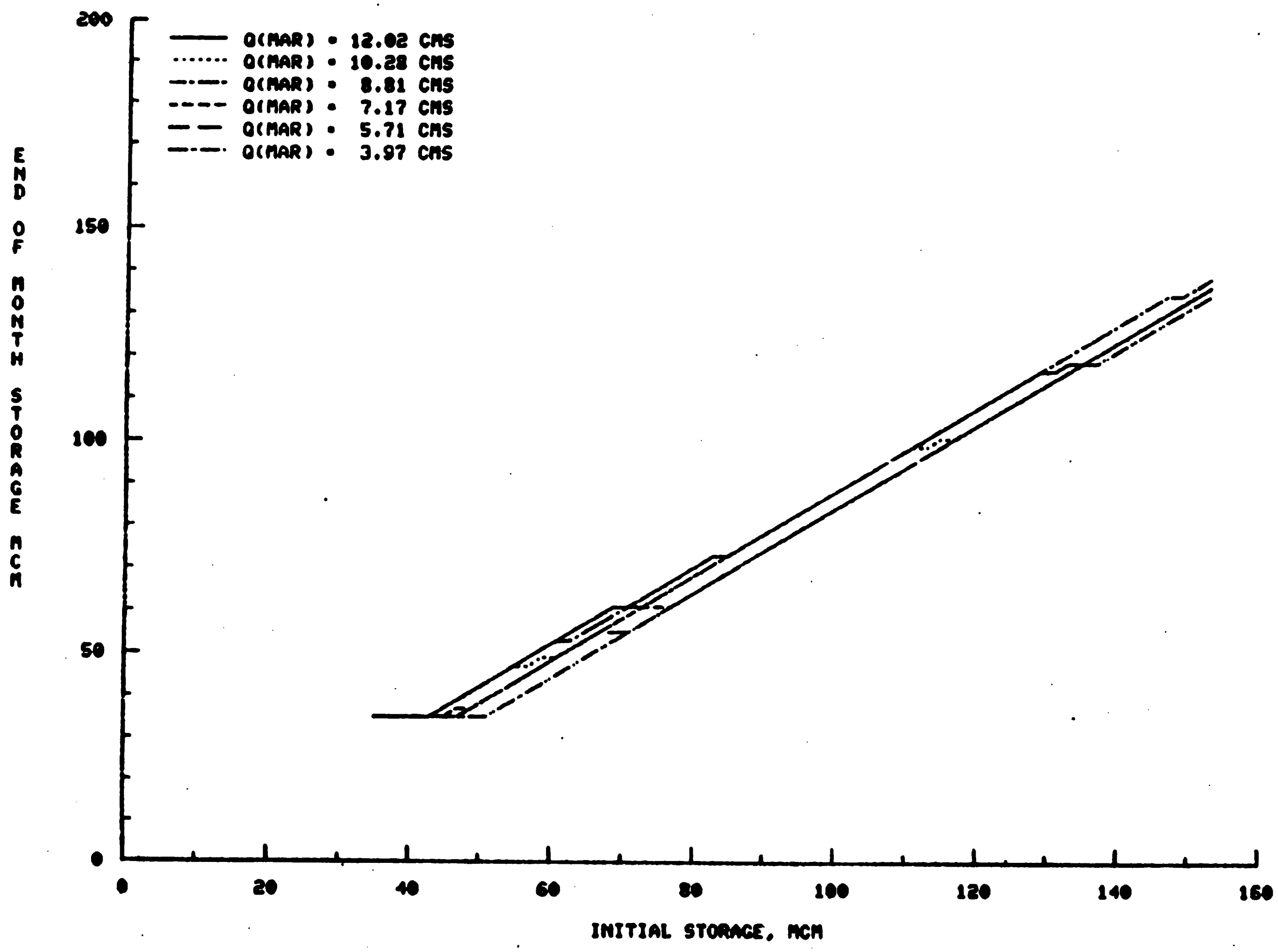


Figure 2.5.10 OPERATING POLICY OF APRIL FOR Q(MAR) LESS THAN 12.93 CMS

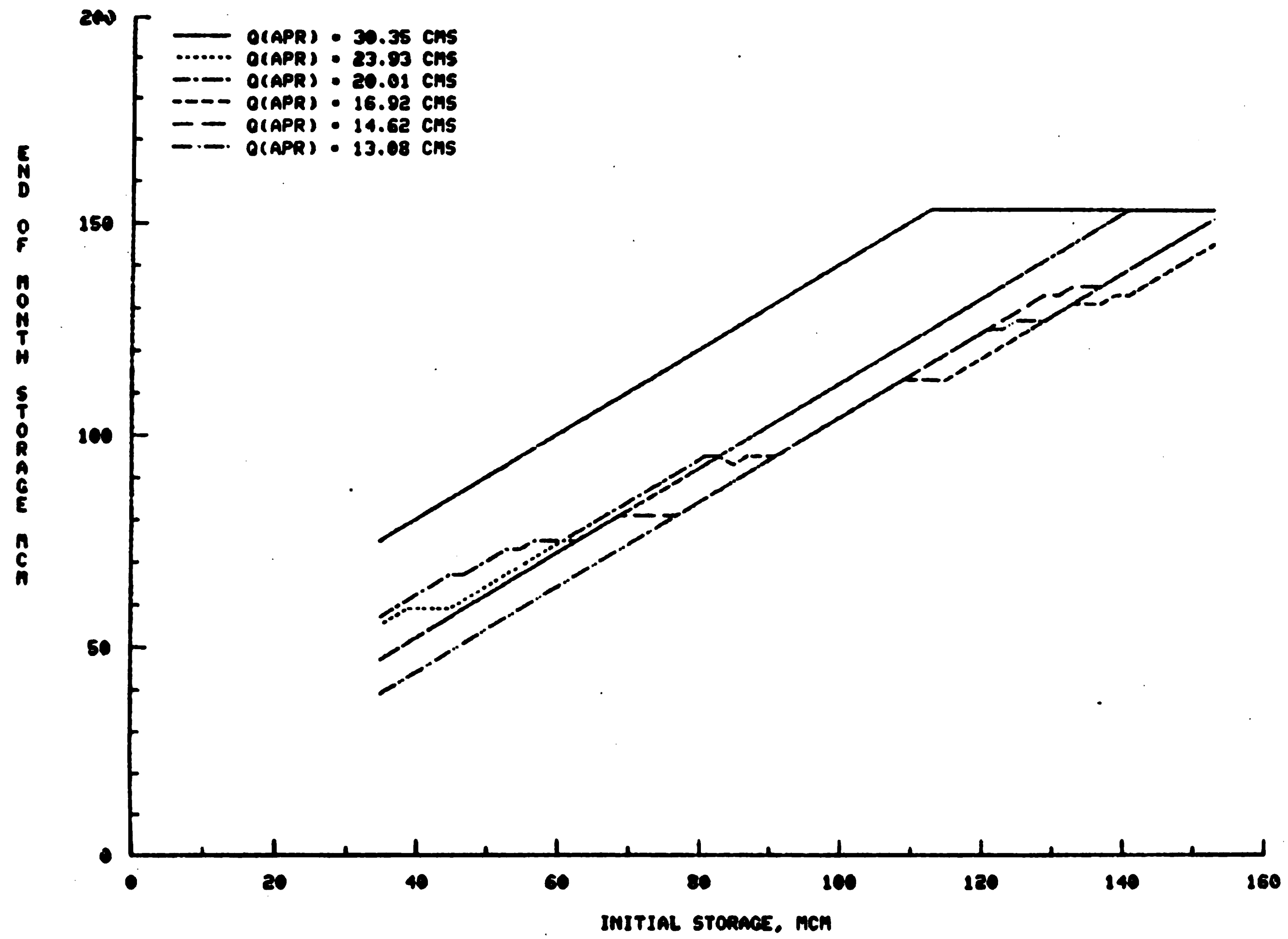


Figure 2.5.11 OPERATING POLICY OF MAY FOR Q(APR) GREATER THAN 12.28 CMS

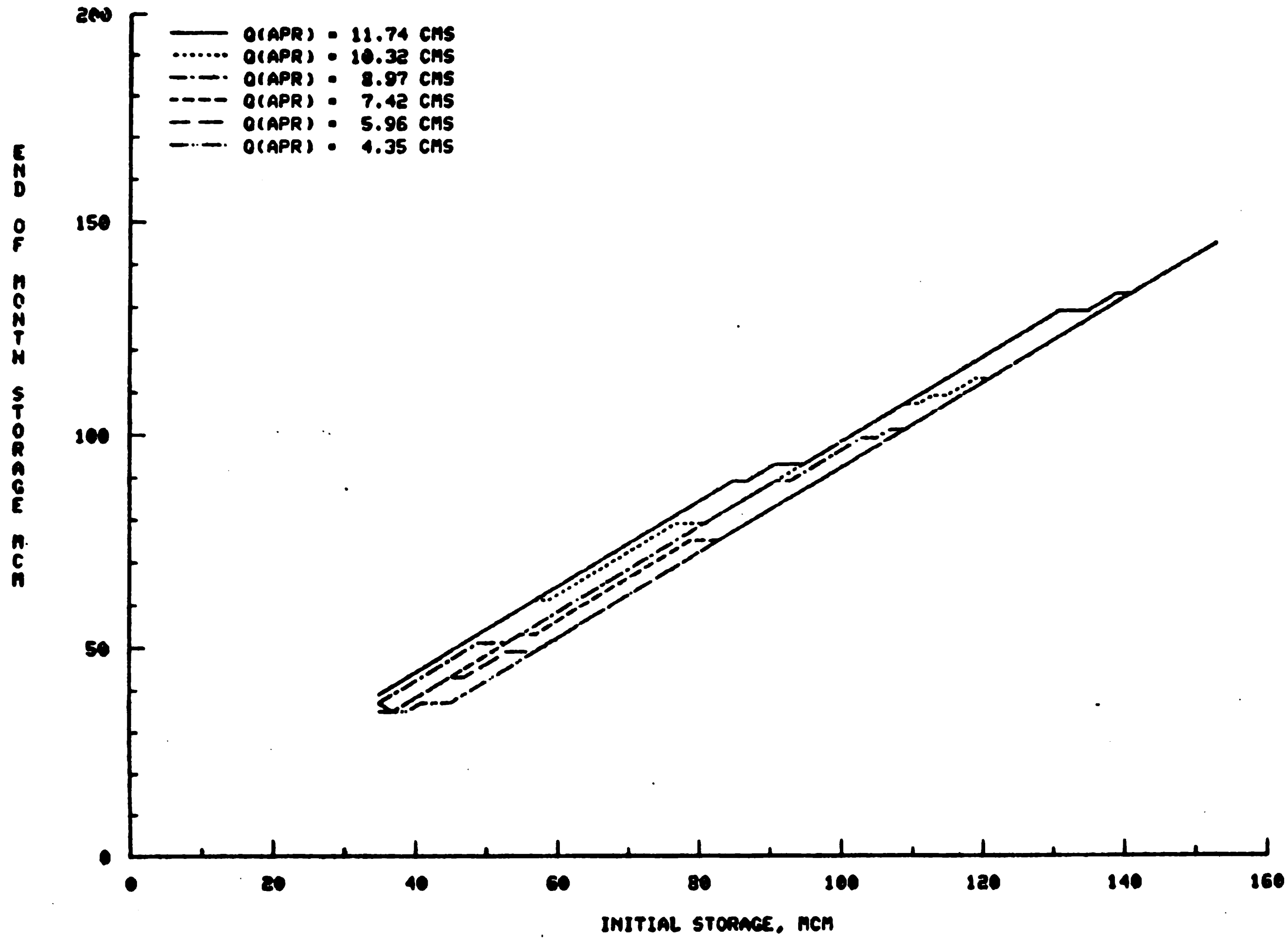


Figure 2.5.12 OPERATING POLICY OF MAY FOR Q(APR) LESS THAN 12.28 CMS

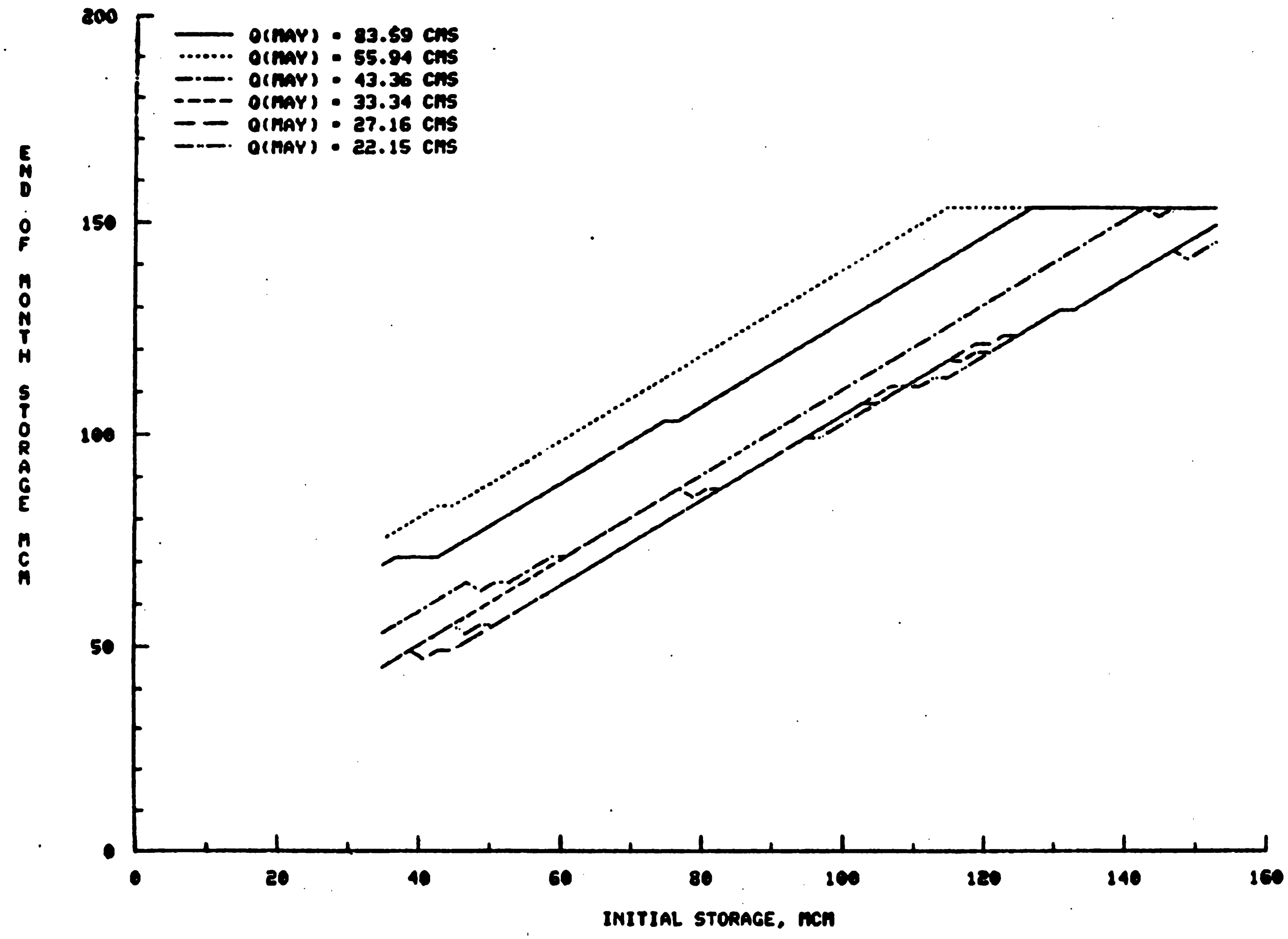


Figure 2.5.13 OPERATING POLICY OF JUNE FOR Q(MAY) GREATER THAN 20.09 CMS

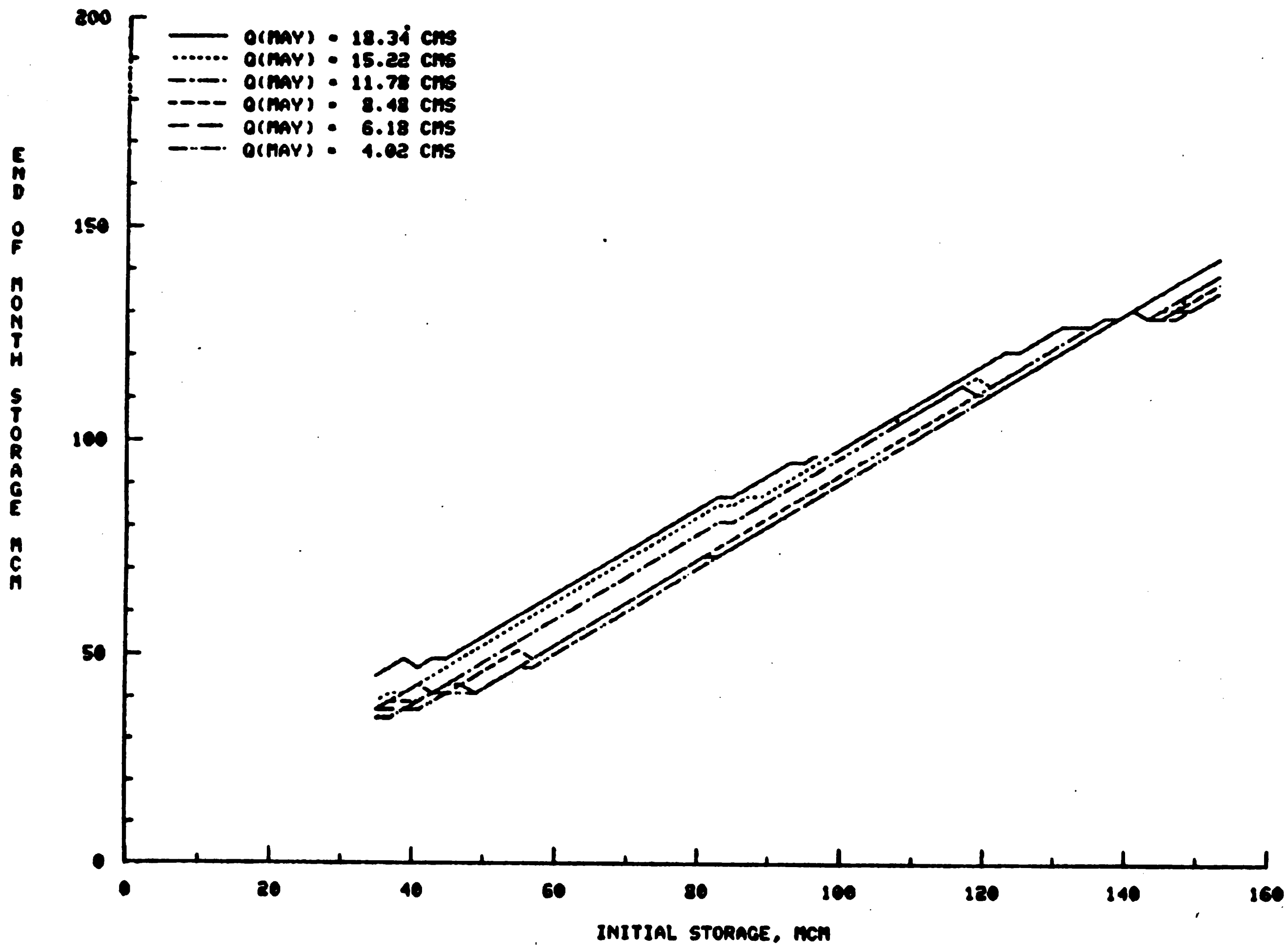


Figure 2.5.14 OPERATING POLICY OF JUNE FOR Q(MAY) LESS THAN 20.09 CMS

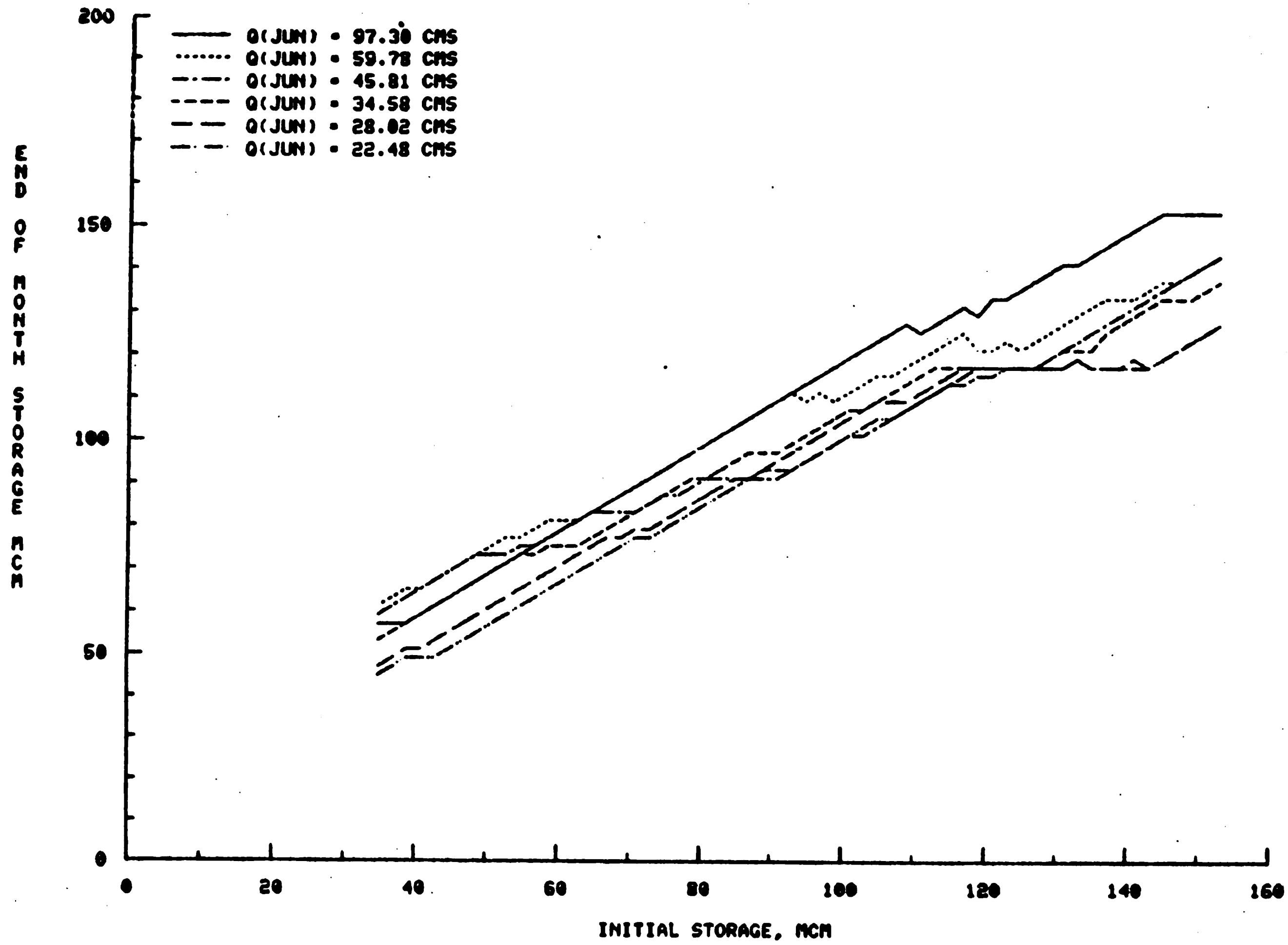


Figure 2.5.15 OPERATING POLICY OF JULY FOR Q(JUN) GREATER THAN 19.86 CMS

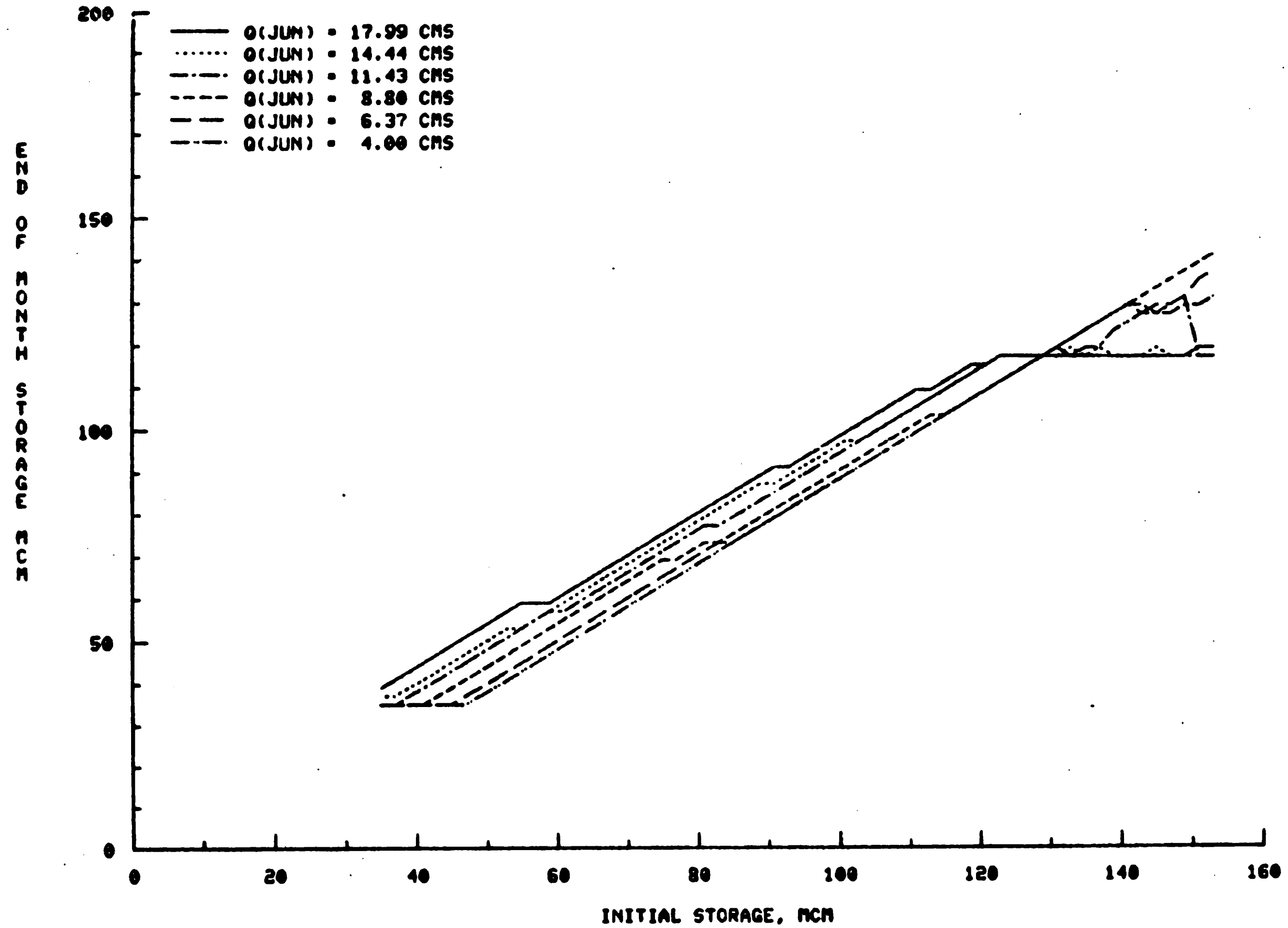


Figure 2.5.16 OPERATING POLICY OF JULY FOR Q(JUN) LESS THAN 19.86 CMS

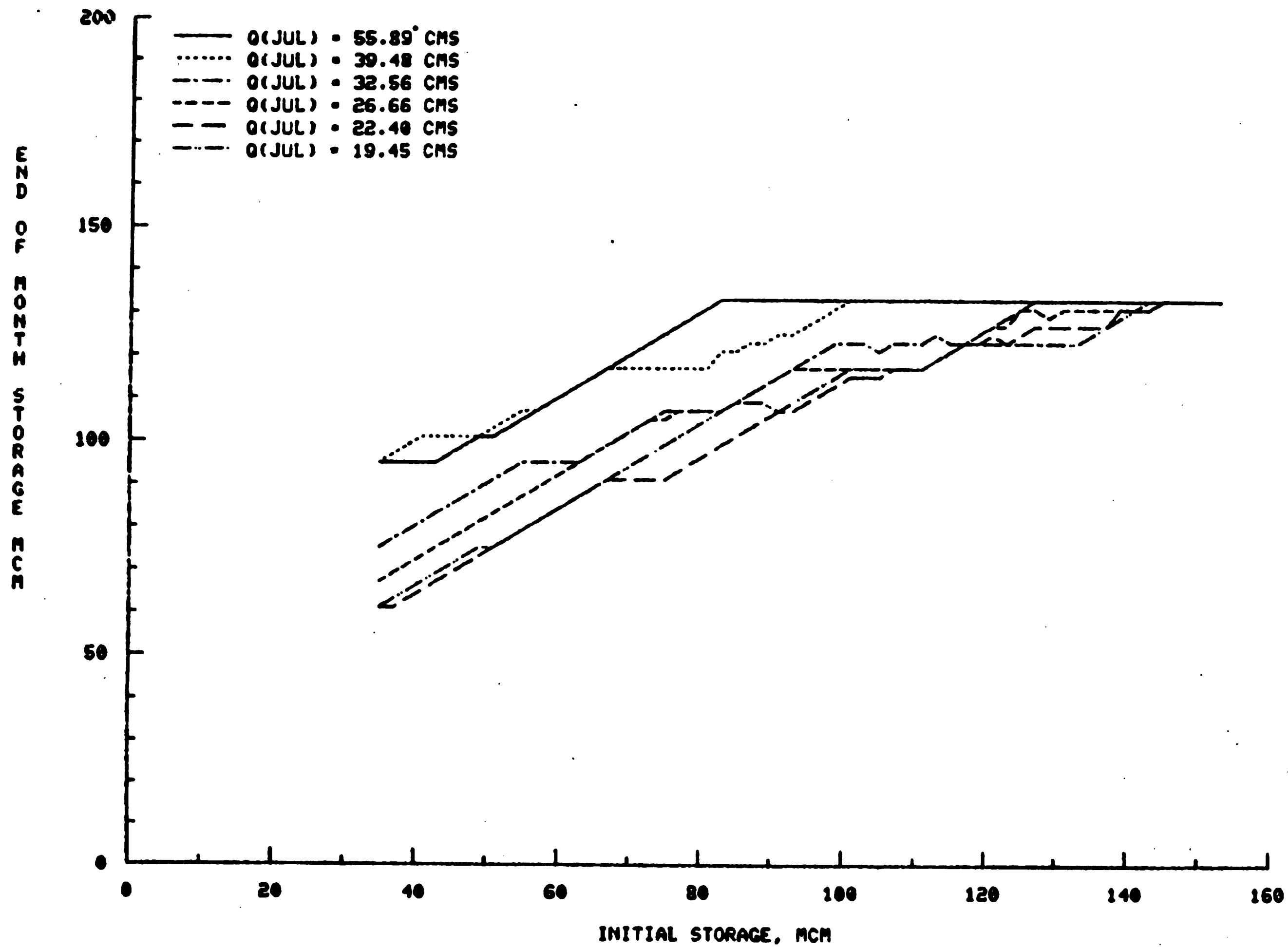


Figure 2.5.17 OPERATING POLICY OF AUGUST FOR Q(JUL) GREATER THAN 18.25 CMS

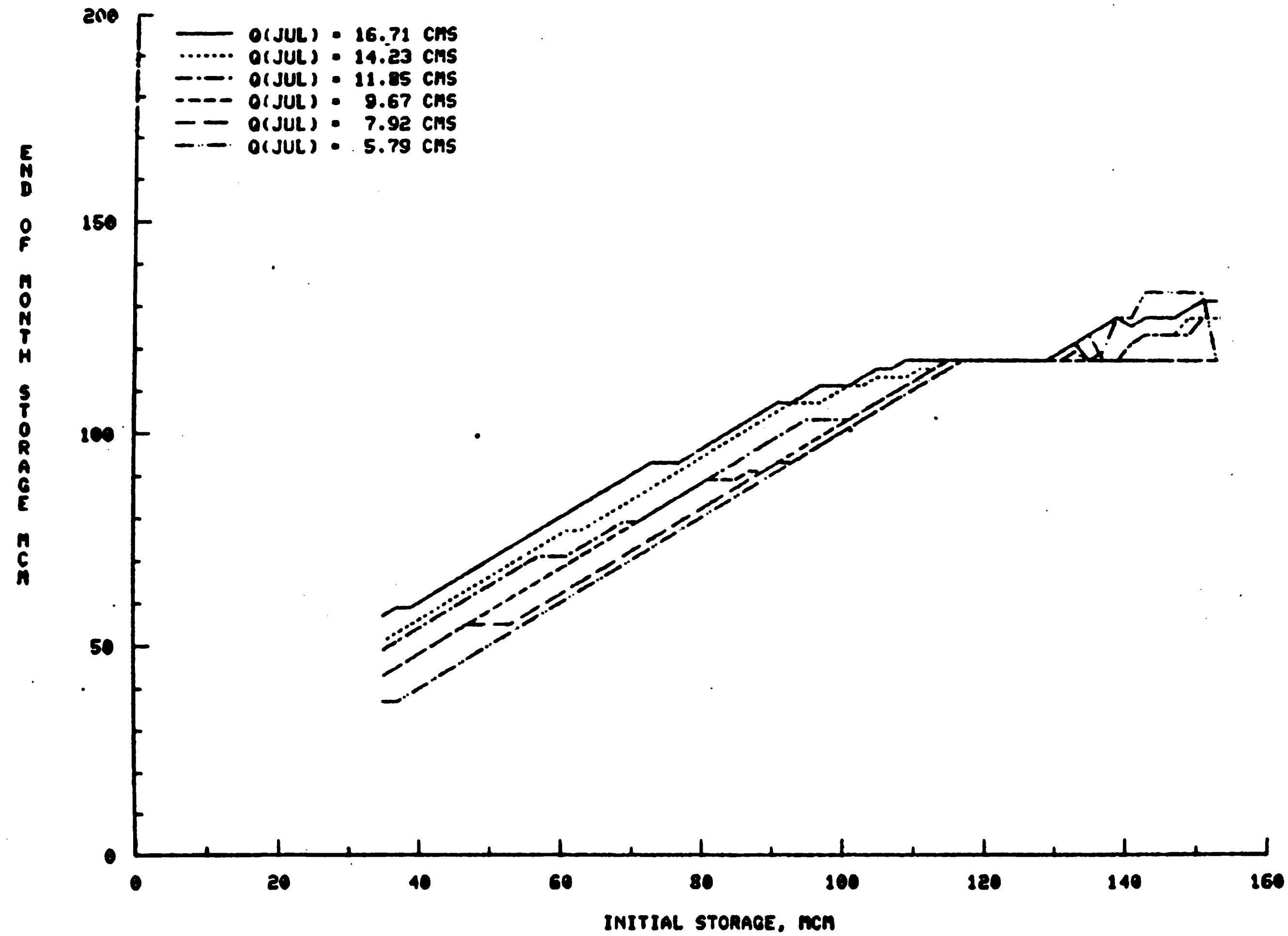


Figure 2.5.18 OPERATING POLICY OF AUGUST FOR Q(JUL) LESS THAN 18.25 CMS

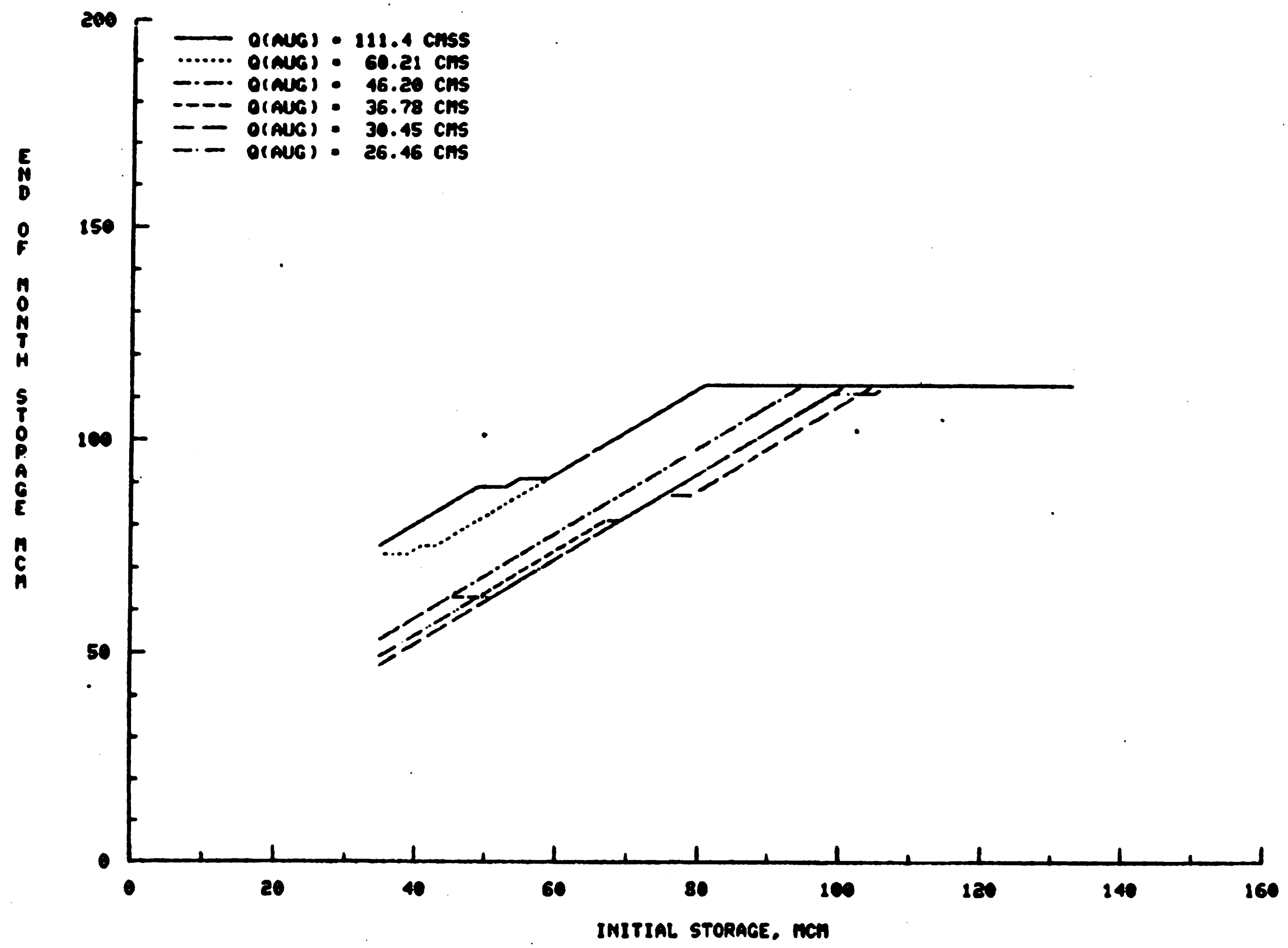


Figure 2.5.19 OPERATING POLICY OF SEPTEMBER FOR Q(AUG) GREATER THAN 24.80 CMS

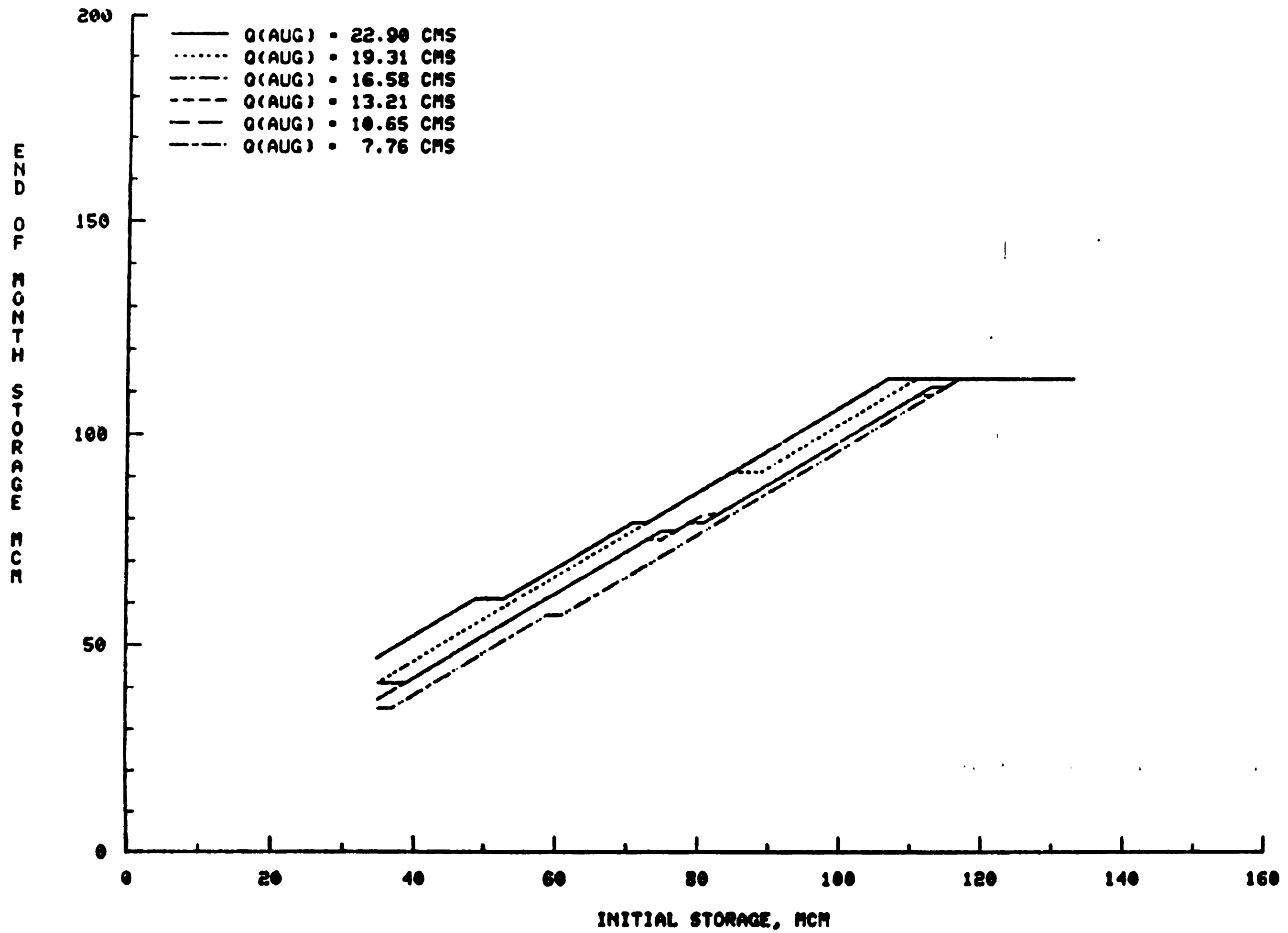


Figure 2.5.20 OPERATING POLICY OF SEPTEMBER FOR Q(AUG) LESS THAN 24.80 CMS

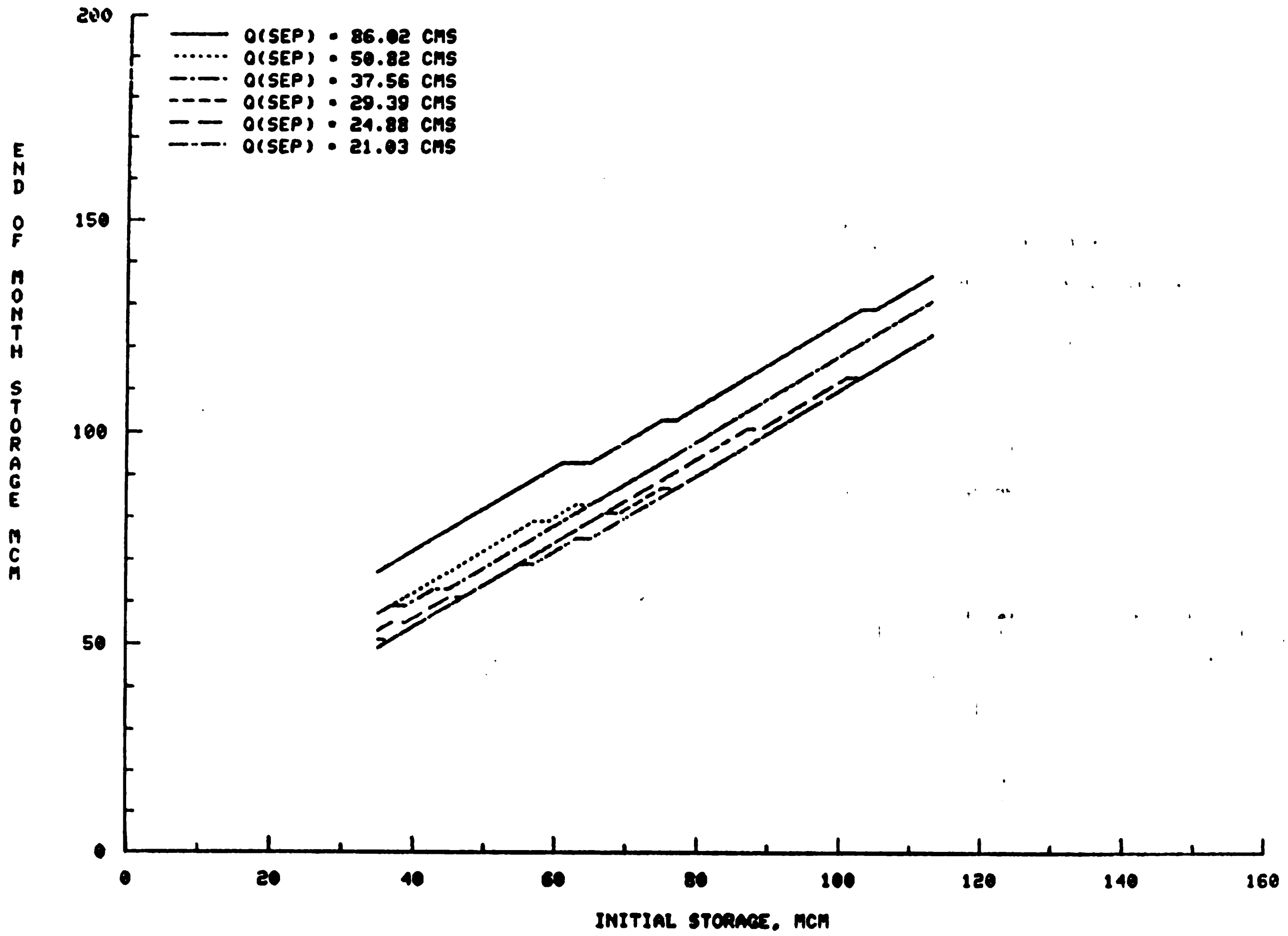


Figure 2.5.21 OPERATING POLICY OF OCTOBER FOR Q(SEP) GREATER THAN 19.04 CMS

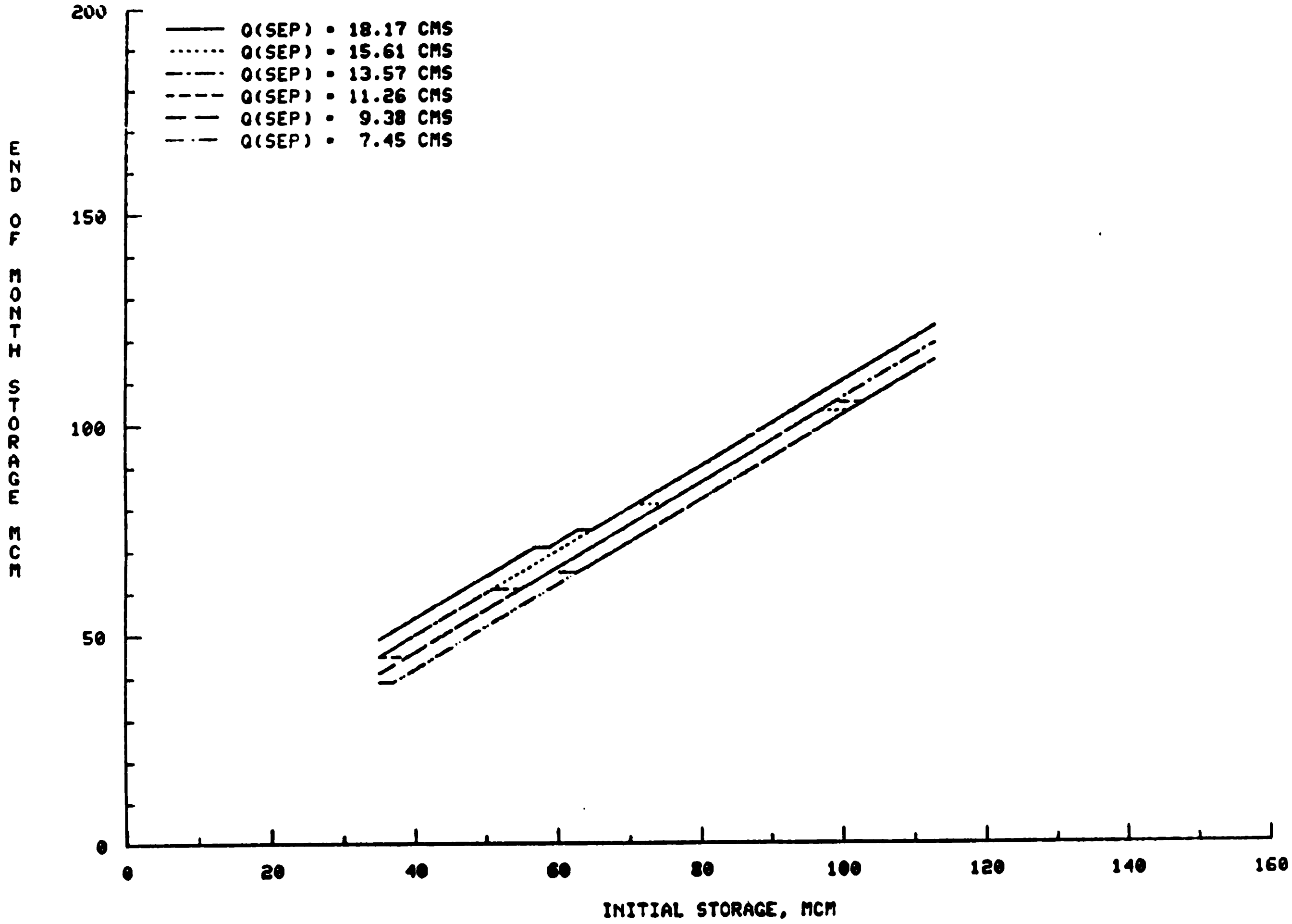


Figure 2.5.22 OPERATING POLICY OF OCTOBER FOR Q(SEP) LESS THAN 19.04 CMS

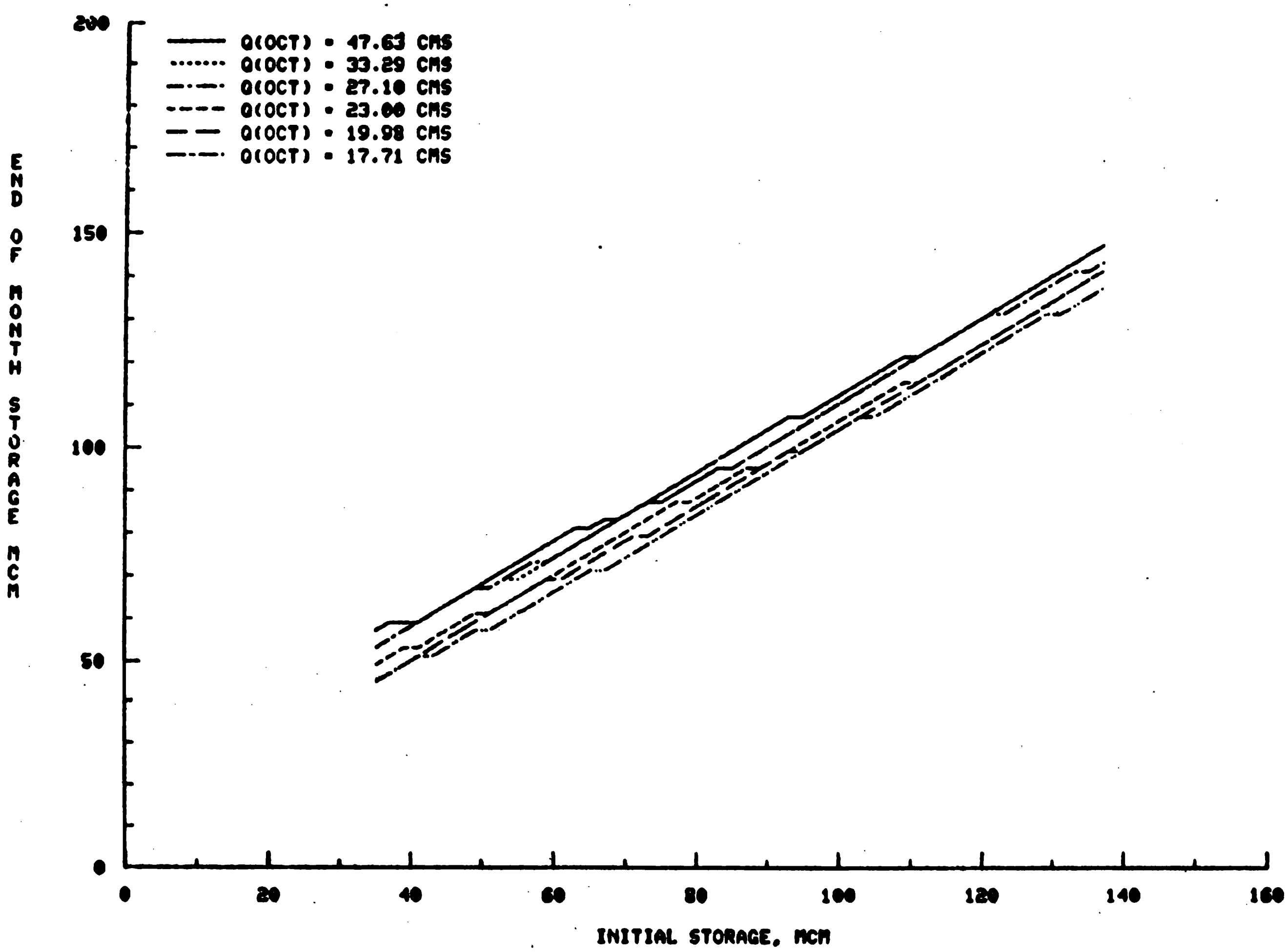


Figure 2.5.23 OPERATING POLICY OF NOVEMBER FOR Q(OCT) GREATER THAN 16.74 CMS

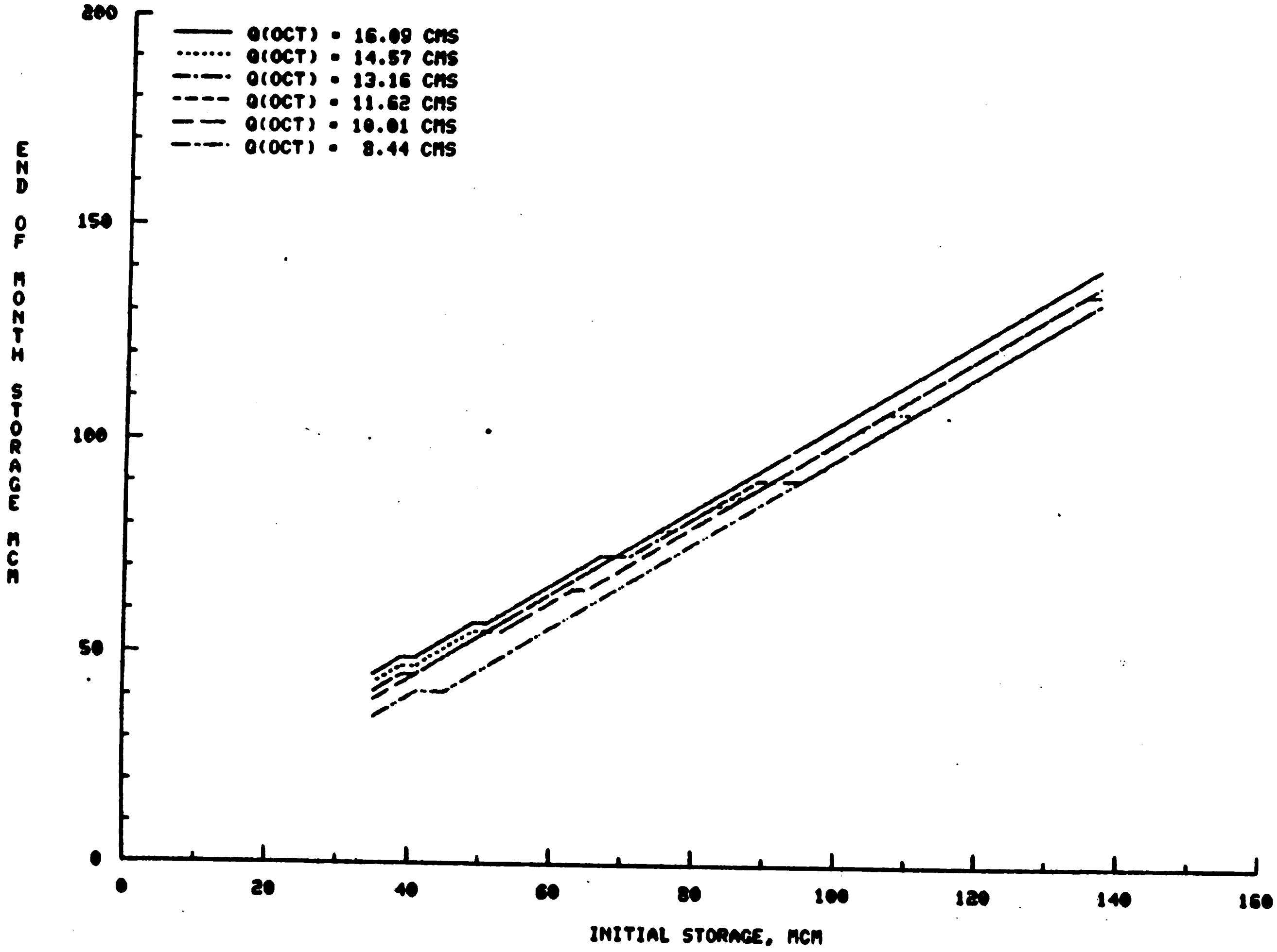


Figure 2.5.24 OPERATING POLICY OF NOVEMBER FOR Q(OCT) LESS THAN 16.74 CMS

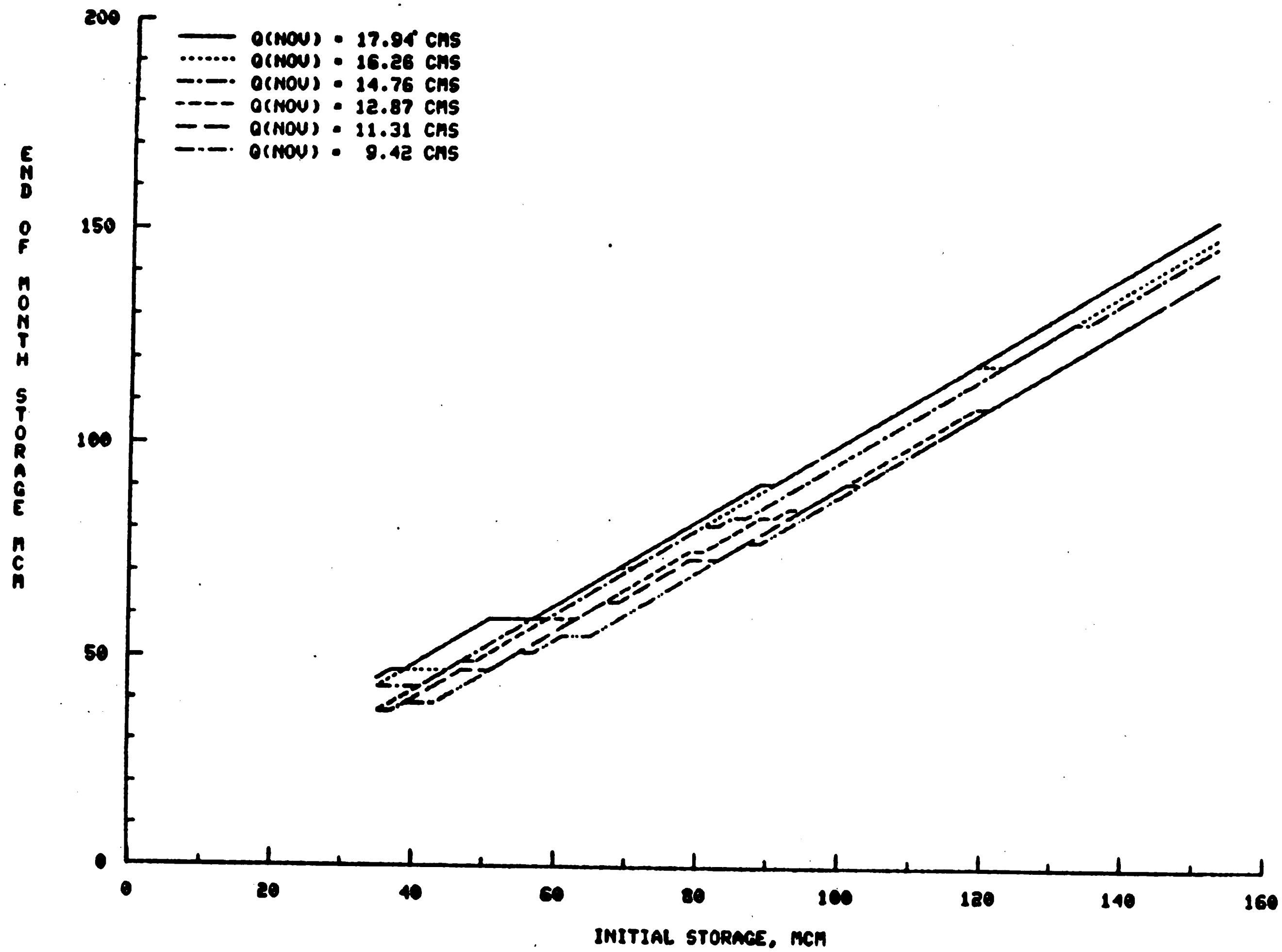


Figure 2.5.25 OPERATING POLICY OF DECEMBER FOR Q(NOV) LESS THAN 18.91 CMS

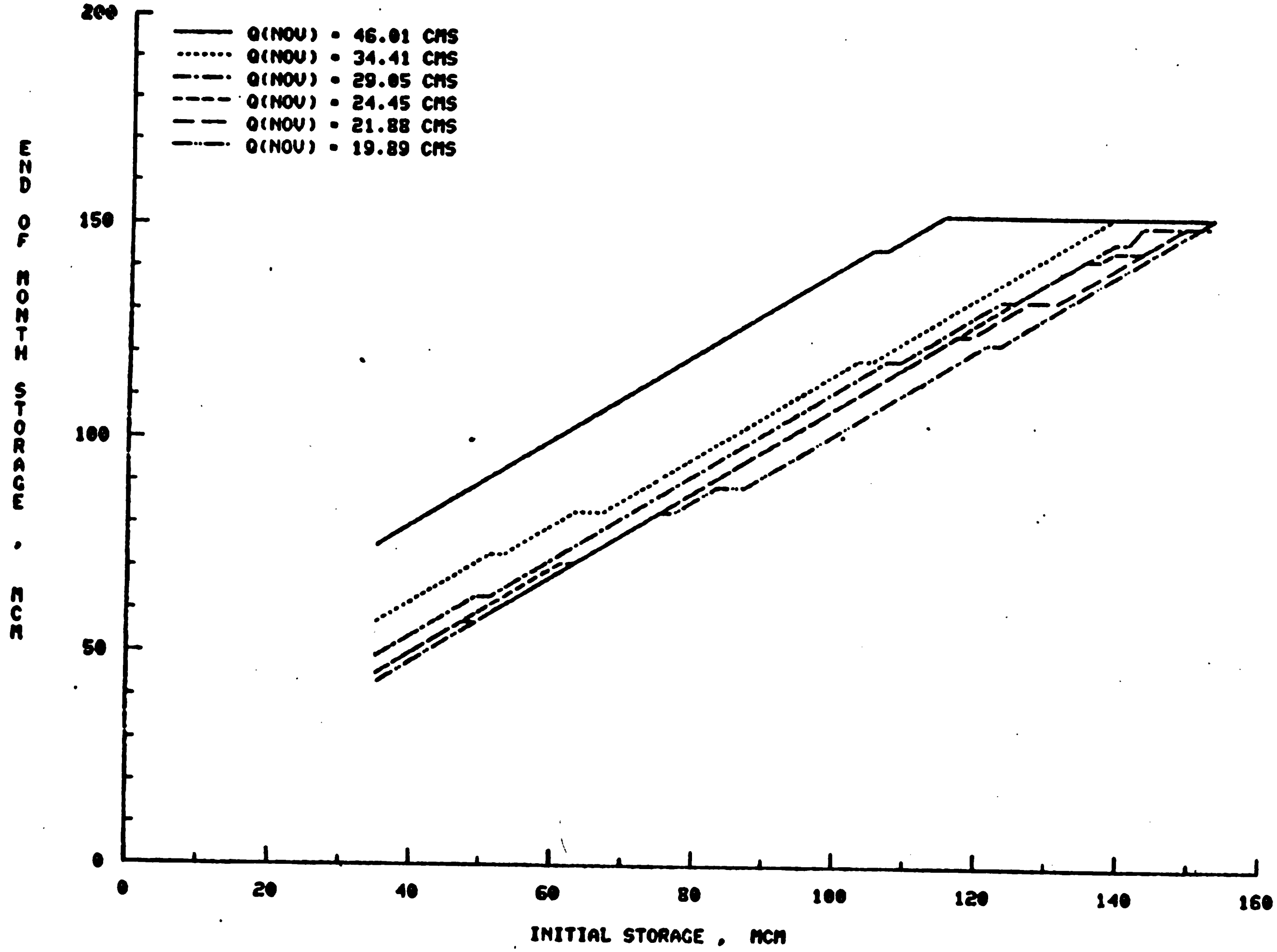


Figure 2.5.26 OPERATION POLICY OF DECEMBER FOR Q(NOV) GREATER THAN 18.91 CMS

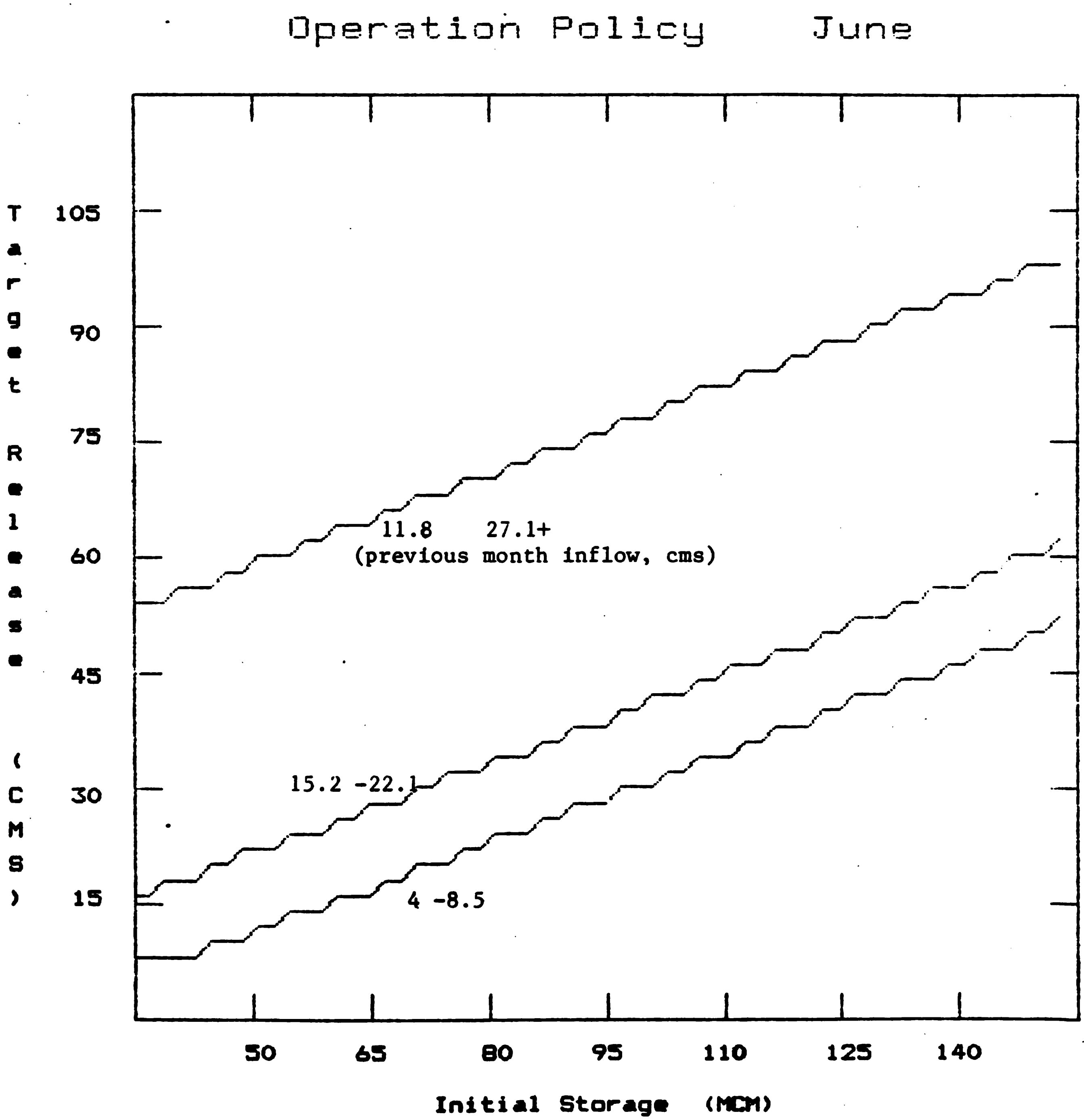


Figure 2.5.27 Optimal Operation Policy for Valdesia Reservoir - Noninverted Form

2.5.4 Risk analysis of monthly operations.

A long term Monte Carlo analysis was performed on the Valdesia system using the optimal storage guidecurves from Program CSUDP output. These guidecurves were input into Program MODSIM, which was then run on a monthly basis using 400 years of stochastically generated inflows and turbine generation hours, as discussed previously. All other data and system specifications displayed in the CSUDP analysis were also used on the MODSIM runs.

A complete set of monthly frequency plots for energy production, releases, and power can be found in Appendix F. For illustration, the corresponding plots for the month of March are given in Figures 2.5.28, 2.5.29 and 2.5.30. Figure 2.5.31 displays mean monthly energy production from the Monte Carlo runs. Although some seasonality is displayed in the means, it does not appear significant. Figure 2.5.32 gives monthly power output at the 50, 25, and 10 percentiles. These plots give some indication of the power output that can be achieved at various levels of risk. It should be noted that the probability of achieving, for example, the 10 percentile level for every successive month in any given year is of course much less than 10 percent.

From these runs, no irrigation shortages were experienced during the entire 400 years simulation. Therefore, it was decided to consider the risks of increasing irrigation supply by 15 percent, which are displayed in Figure 2.5.33. Average risk is around 13 percent. If the irrigation increase was limited to 10 percent, the frequency plots indicate that overall risk would reduce to around 8 percent for any given month, which viewed as a 92% reliability seems acceptable.

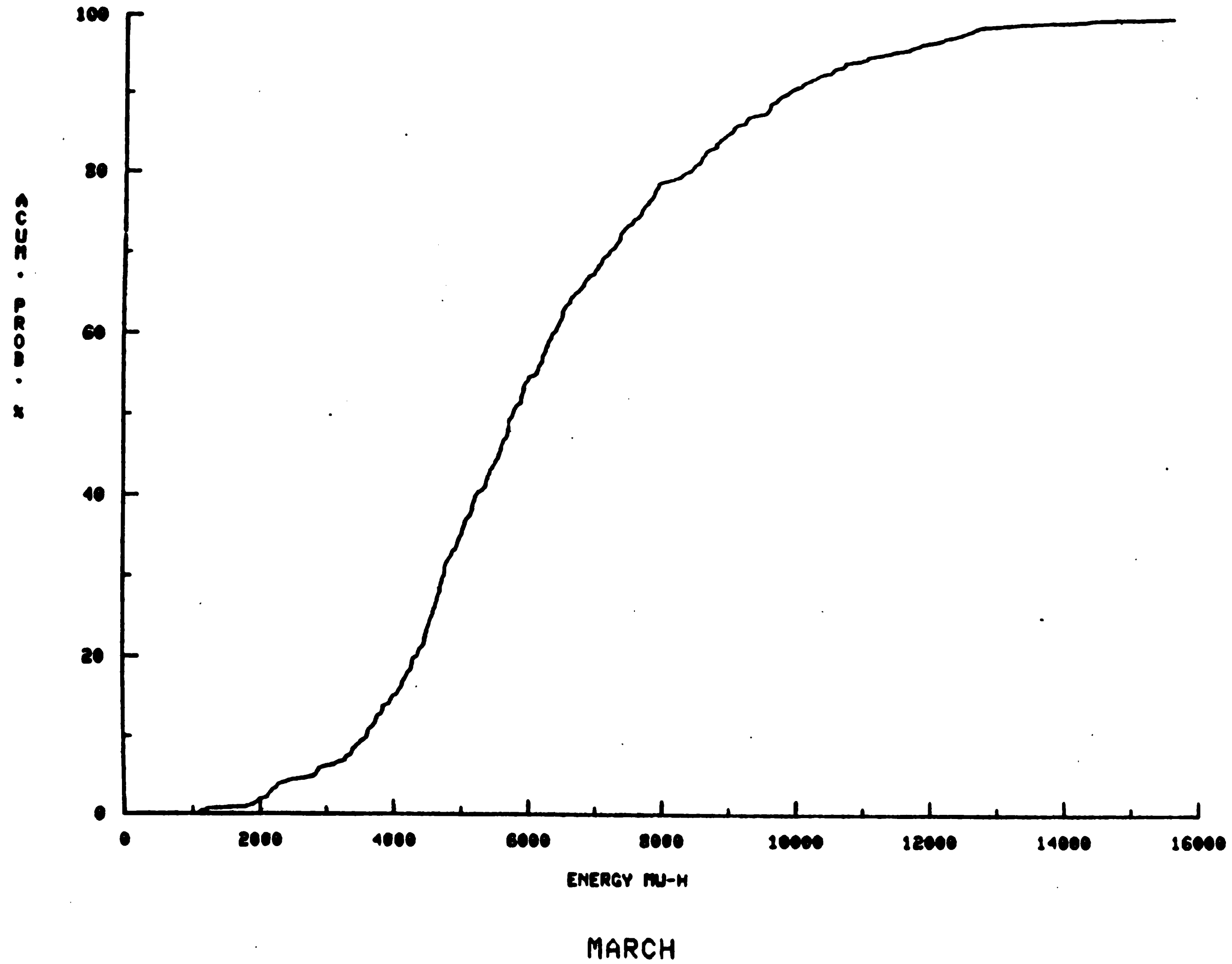
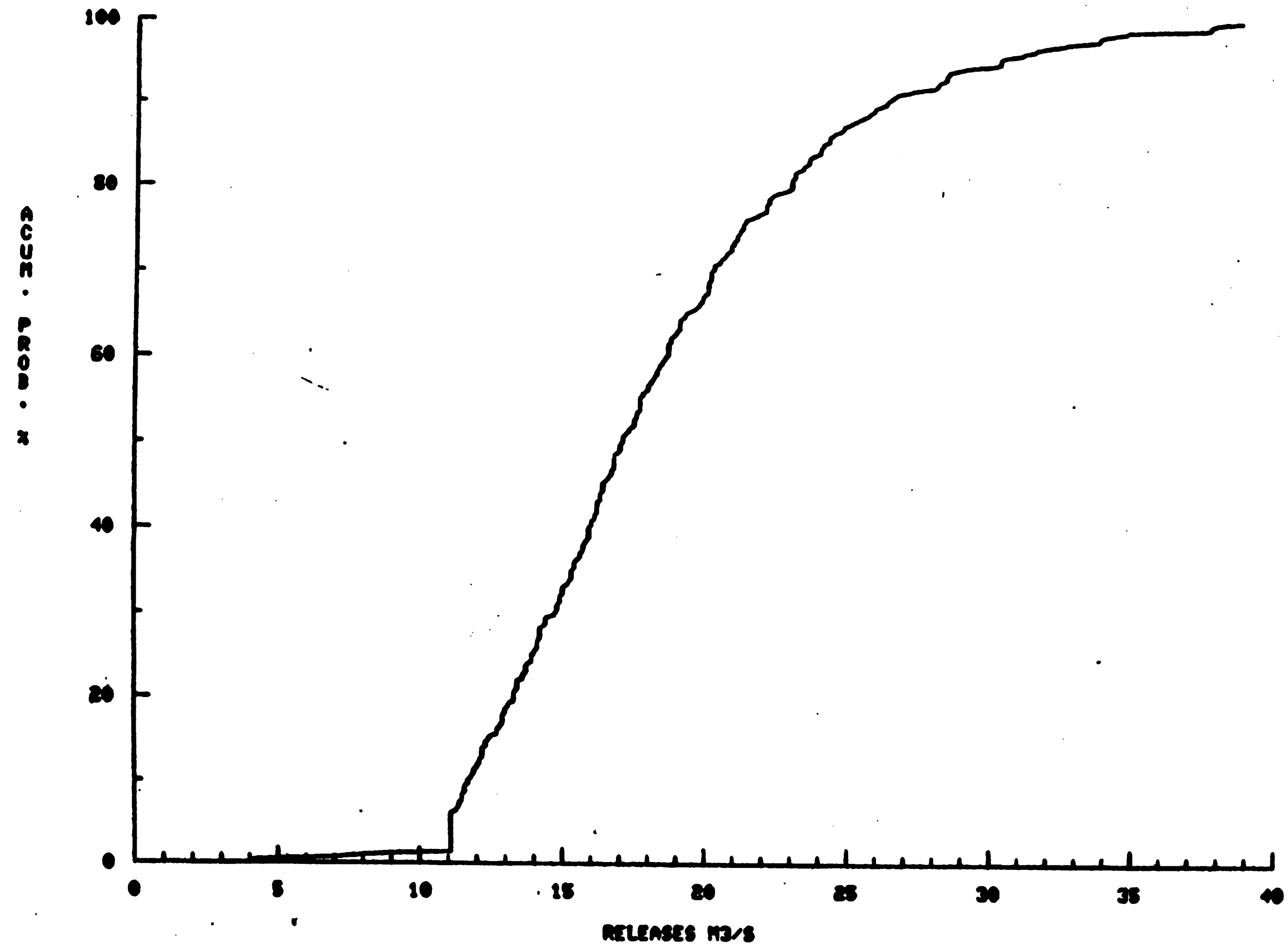
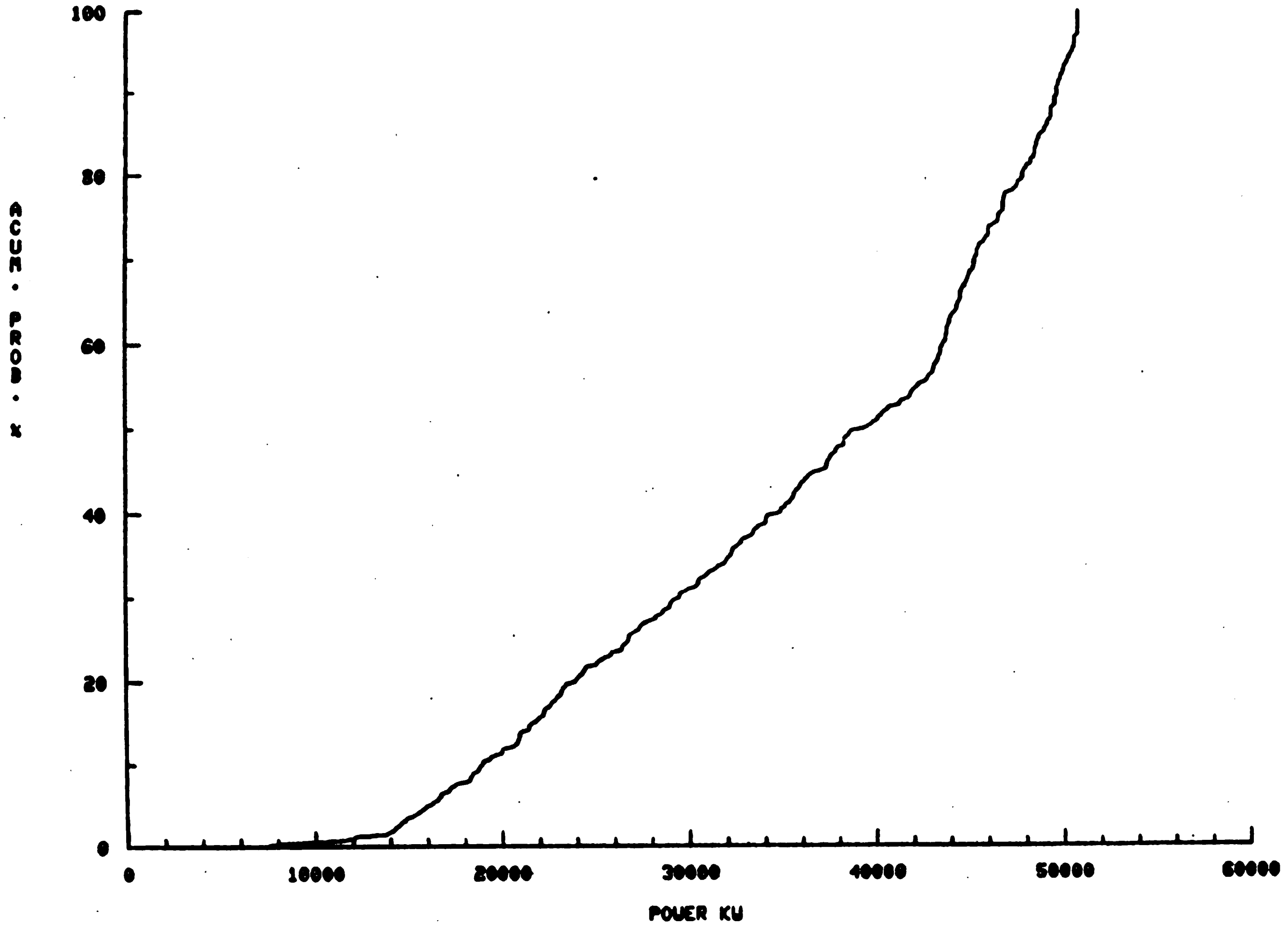


Figure 2.5.28 Frequency Plots for Energy Production from Monte Carlo Analysis.



MARCH

Figure 2.5.29 Frequency Plots for Releases from Monte Carlo Analysis



MARCH

Figure 2.5.30 Frequency Plots for Power Output from Monte Carlo Analysis.

Figure 2.5.31 Long Term Simulated Energy

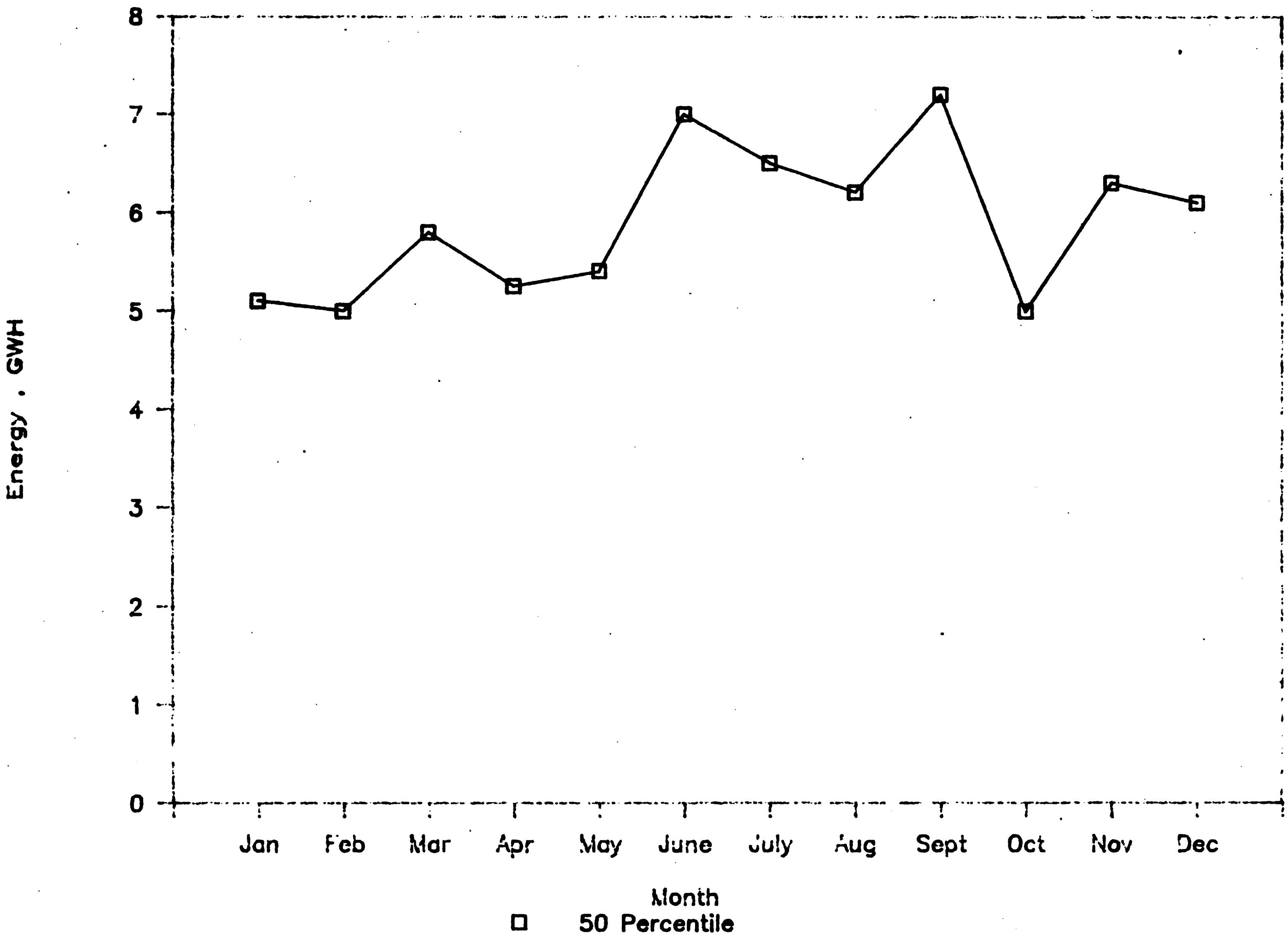


Figure 2.5.32 Long Term Simulated Power

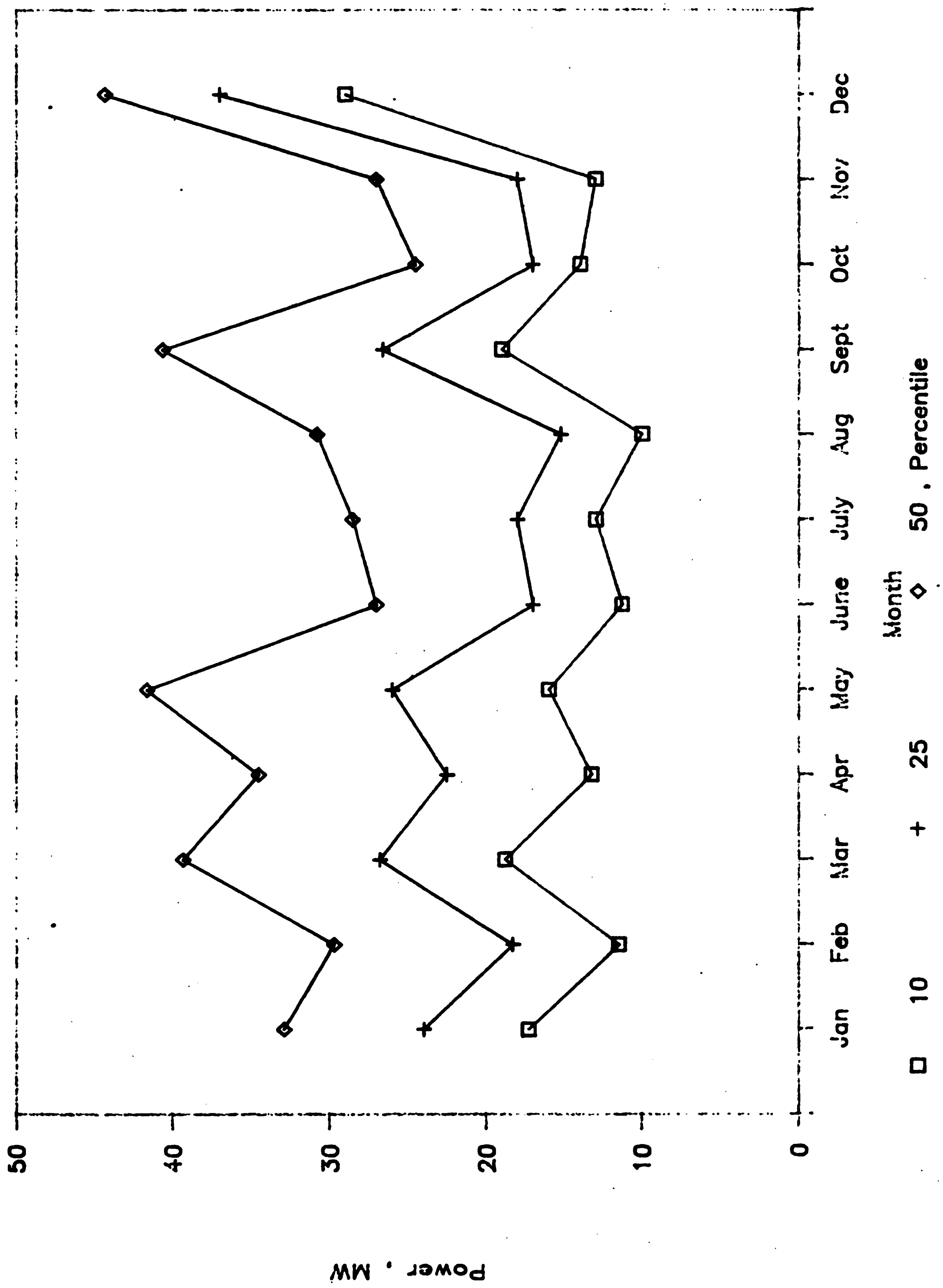
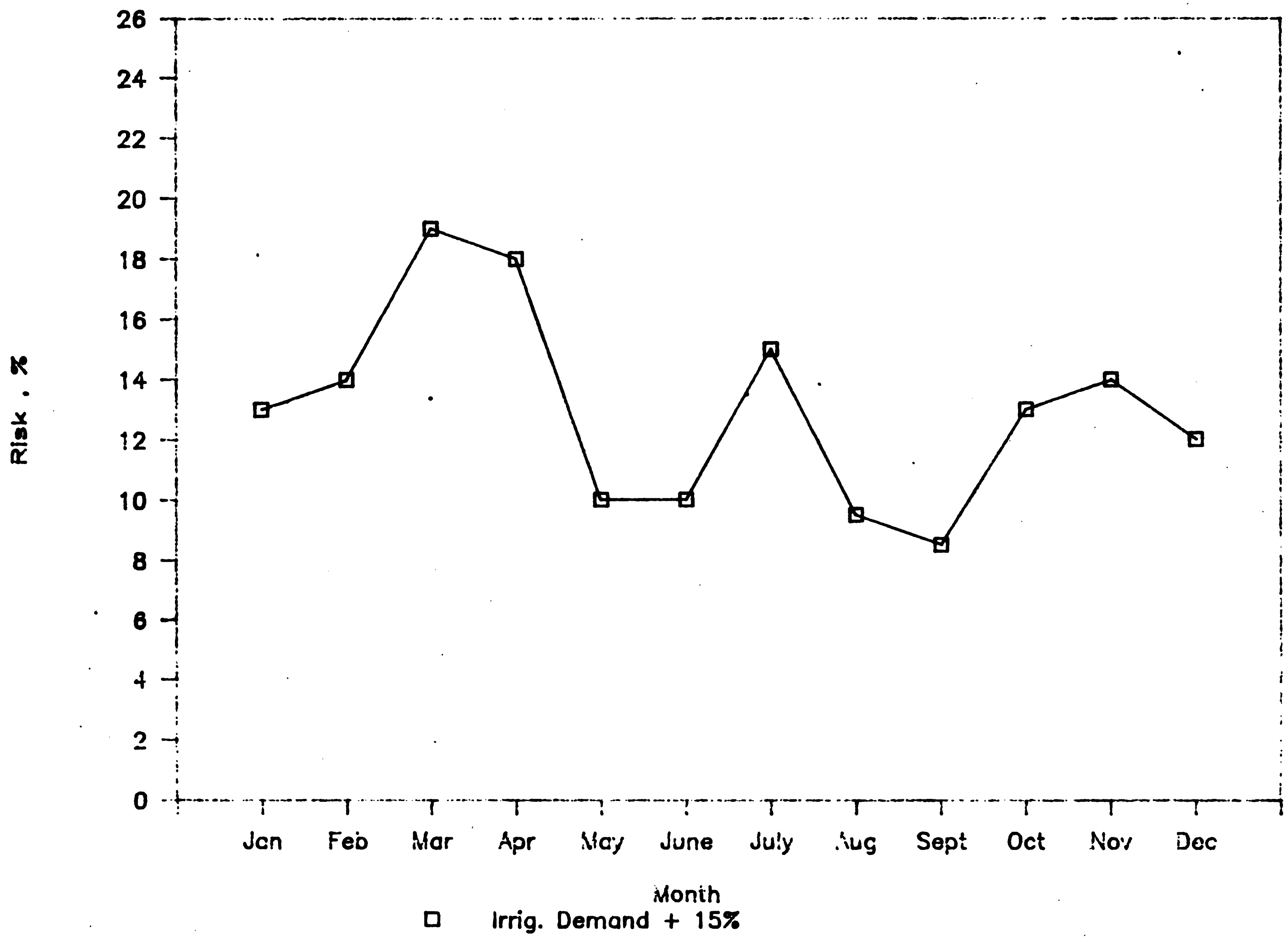


Figure 2.5.33 Risk Level of Meeting Irrigation Demand



2.6 OPTIMAL WEEKLY NORMAL OPERATIONS

2.6.1 Program MODSIM setup and execution.

The optimal stochastic DP operating rules presented in the previous section are intended to be input into Program MODSIM for developing weekly operational strategies in real-time for the Valdesia system. The DP operating rules set monthly storage guidecurves, which are then interpolated into weekly levels. Applying the hierarchical strategy shown previously in Figure 2.1.2, forecasted values of inflows, irrigation demands and energy requirements can be input into MODSIM and then updated on a weekly basis.

Figure 2.6.1 gives the node-link configuration for weekly real-time use of Program MODSIM. This includes each of the irrigation sectors for which irrigation demand estimates have been compiled.

A portion of the echo print of the ORGANIZ data input file for this configuration is shown in Figure 2.6.2. Most of the data in this file relates to physical system features that will not change, though some editing will be required. Notice that the capacity of Las Barias is set at 3 MCM (or 3000 x 10^3m^3), which is less than the 6.05 MCM capacity employed during model calibration. This level is used since it represents the effective conservation capacity of the reservoir, above which there is danger of spill. On a weekly basis, the beginning storage volumes for Valdesia and Las Barias would have to be edited in this file since they will change week by week. A complete explanation on how to do this is included in a companion report to Volume II, the Valdesia System Normal Operations Manual.

The link capacities in the canal are all based on maximum canal capacity at the head of the main canal. The reason is that instead of

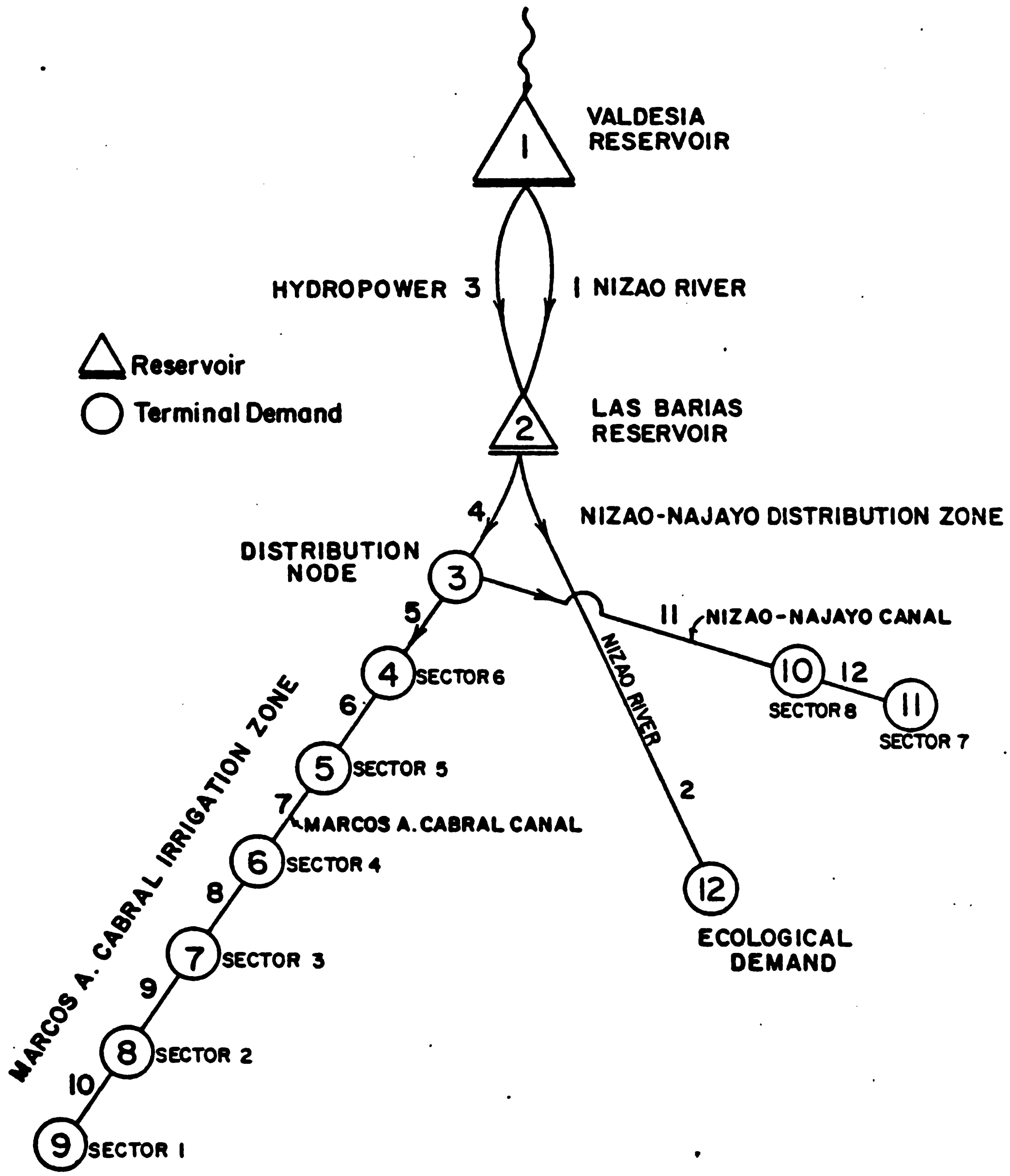


Figure 2.6.1 Node-Link Configuration for the Valdesia System for Weekly Real-Time Operations.

Figure 2.6.2 Echo Print of MODSIM Input Data File ORGANIZ

```
****************************************************************************
*                                                                          *
*         Program  MODSIMX    River Basin Simulation Package               *
*                  Colorado State University    cSu                        *
*       Version:  Valdesia.1a   IBM/PC-XT   December 13, 1985              *
*                                                                          *
****************************************************************************
```

Control Options : DATA is Quarter-Week basis
Metric UNIT is used
Storage PRIORITY is same for each Week in a Quarter
Full OUTPUT for result of reservoir analysis
PLOT of reservoir and/or linkage is requested

VALDESIA TEST, WEEKLY BASIS, 8 IRRIGATION SECTORS, STARTED 84/10/09

Number of Nodes =	12	Number of Reservoirs =	2
Number of Links =	12	Number of River Reaches =	2
The Quarter Operation Starts =	40	Number of Quarters to Simulate =	1
Number of Demand Nodes =	9	Number of Spill Nodes =	2
Yield Node =	0	Number of Import Nodes =	0

Node	Name	Capacities Maximum	Capacities Minimum	Capacities Beginning	Quarterly Demand
1	VALDESIA	153000	35000	93000	0
2	LAS BARI	3000	240	3000	0
3	DISTRIB	0	0	0	0
4	SECTOR06	0	0	0	0
5	SECTOR05	0	0	0	0
6	SECTOR04	0	0	0	0
7	SECTOR03	0	0	0	0
8	SECTOR02	0	0	0	0
9	SECTOR01	0	0	0	0
10	SECTOR08	0	0	0	0
11	SECTOR07	0	0	0	0
12	ECOLOGIC	0	0	0	0

Figure 2.6.2 (continued)

Power Efficiency Table :

Head\Release	0	12096	30240	36288	39312	42336	45360	48384	54432
60	.0000	.6442	.6893	.7085	.7190	.7181	.7133	.7046	.6797
64	.0000	.6346	.6854	.7190	.7344	.7334	.7296	.7219	.6970
67	.0000	.6346	.6893	.7258	.7373	.7430	.7440	.7411	.7430
71	.0000	.6202	.6893	.7354	.7507	.7565	.7498	.7478	.7248
74	.0000	.6144	.6874	.7402	.7526	.7632	.7613	.7574	.7315
77	.0000	.6288	.6912	.7373	.7507	.7584	.7594	.7565	.7373
80	.0000	.6422	.7037	.7421	.7526	.7622	.7670	.7613	.7334

Reservoir 2

Point	Area	Capacity	Head
1	0	0	69
2	52	50	70
3	190	240	72
4	310	450	73
5	460	800	74
6	640	1400	75
7	805	2100	76
8	910	3000	77
9	1000	4000	78
10	1140	6050	80

Constant Power Efficiency = .0000

Groundwater Specifications

Node	Specific Yield	Transmissivity	Infiltration Rate	Distance to Main Channel
1	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000
3	.0000	.0000	.0000	.0000
4	.0000	.0000	.0000	.0000
5	.0000	.0000	.0000	.0000
6	.0000	.0000	.0000	.0000
7	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000

Node	Pumping Capacity	Pumping Rank	Depletion Node	Return Node
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0

Figure 2.6.2 (continued)

Node 9

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 10

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 11

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 12

Quarter	Rank	(Demand is Read via Data File)
1	99	

Reservoir Desired Storage Levels and Ranks

Reservoir 1

		Weekly Distribution											
Quarter	Rank	1	2	3	4	5	6	7	8	9	10	11	12
1	40	.627	.647	.667	.680	.686	.693	.699	.699	.699	.699	.699	.699

Reservoir 2

		Weekly Distribution											
Quarter	Rank	1	2	3	4	5	6	7	8	9	10	11	12
1	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Reservoir Area-Capacity-Head Table and Power Efficiency:

Reservoir 1

Point	Area	Capacity	Head
1	38	0	25
2	150	0	30
3	324	0	35
4	871	0	40
5	1572	1173	45
6	2310	6182	50
7	3406	16214	55
8	4537	32163	60
9	5664	53736	65
10	6677	80145	70
11	7492	113465	75
12	8357	153088	80
13	9000	196481	85
14	9776	243421	90

Figure 2.6.2 (continued)

System Configuration

Link	From Node	to Node	Maximum Capacity	Minimum Capacity	Unit Cost	Loss Coefficient
1	1	2	4233600	0	0	.000
2	2	12	4233600	0	0	.000
3	1	2	54432	0	0	.000
4	2	3	8951	0	0	.000
5	3	4	7258	0	0	.000
6	4	5	7258	0	0	.000
7	5	6	7258	0	0	.000
8	6	7	7258	0	0	.000
9	7	8	7258	0	0	.000
10	8	9	7258	0	0	.000
11	3	10	1693	0	0	.000
12	10	11	1693	0	0	.000

Spill Reservoirs in Order of Preference

2 1

Priorities and Desired Operating Levels are Unique for each Quarter
(Level can vary with Week)

System Demand(s)

Node 4

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 5

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 6

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 7

Quarter	Rank	(Demand is Read via Data File)
1	10	

Node 8

Quarter	Rank	(Demand is Read via Data File)
1	10	

introducing channel losses on each canal reach in Program MODSIM, the irrigation demands for each sector have been adjusted to consider water required at the main canal head to meet crop requirements in that sector, as well as all intermediate losses and application inefficiencies. Future work may involve employing actual crop requirements as demands in MODSIM and then directly including channel loss coefficients and application efficiencies in the model input data. The current version of MODSIM is capable of analyzing the irrigation system with either approach.

The next portion of the echo print lists the priority rankings for system demands. The actual demands are read into a different data file called ADATA. The editing of this file is also explained in the accompanying Valdesia System Normal Operations Manual. As described in Section 2.4.2, each demand node must be supplied with a priority number between 1 and 99, with a lower number representing a higher priority. These ranking factors are translated into negative costs c_{ij} (actually, benefits) and introduced into equation 2.4.1. Details on how this is done in MODSIM can be found in the companion volume "Manuales de Operacion de Modelos Computarizados para la Operacion Normal de Sistemas de Embalses," by Labadie, et al. (1986). These are not actual absolute costs, but only serve to prioritize which sectors should receive water first. It is suggested that operators assign numbers between 10 and 30 for the demands, ordered to reflect which sectors are most in need of water for the current period. It can be seen in this example that all are simply given a ranking of 10 except for the so-called Ecological demand which is given a priority number of 99. This means that it

receives water left over after all irrigation and hydropower requirements have been met.

Continuing on the echo print, the next information relates to reservoir target storage levels and priorities. A ranking factor between 1 and 99 is also assigned to the reservoirs. In this example, Valdesia is given a rank of 40 which means that only after all the irrigation demands have been met will the model attempt to achieve the target storage levels provided by the stochastic DP analysis. The weekly distribution fractions shown for each reservoir give desired storage guidecurve levels represented as the ratio of the guidecurve storage divided by maximum reservoir capacity. During flood prone seasons, these targets will reflect the imposition of a flood pool in the reservoir during those periods. Again, a complete description of how the optimal monthly DP guidecurves are interpolated into weekly levels and edited into this data file in real-time is given in the companion volume Valdesia System Normal Operations Manual. Notice that Las Barias Reservoir is given a rank of 50, which means that only extra water in the system is carried over in this reservoir from week to week. The remaining information in the echo print relates to physical reservoir data that will likely remain unchanged.

An additional data file called ADATA must be prepared by the system operators, which includes:

1. weekly inflow forecasts
2. weekly irrigation demands
3. weekly net evaporation rates
4. weekly hours of turbine generation for meeting energy demands.

For inputing these values, the user may rely on forecasts or typical historical values for that period. Operators are encouraged to try several forecast scenarios and note the impacts on operating policy. ADATA file preparation is accomplished through an easy-to-follow interactive process, which is described in detail in the Valdesia System Normal Operations Manual.

It is expected that operators will make several runs with MODSIM on a weekly basis. For example, initial input of turbine generation hours may result in lower power or energy output than desired, in which case the hours can be appropriately adjusted and the model run again until desired power and energy criteria are met.

During dry periods, it is likely that some shortages will occur. With the priorities used in the example echo print of Figure 2.6.2, the model will first attempt to meet all irrigation demands, which may result in Valdesia Reservoir levels and releases, and hence energy output, much lower than desired. For comparative purposes, a tradeoff analysis can be conducted where the Valdesia priority is changed to, say, 5. This means that the model endeavors to meet the storage targets first, and only leftover water is used to meet irrigation demands. It is likely that for this run, large irrigation shortages will occur, even though energy output will be increased.

Obviously, compromises are called for in this case. Certain sectors may be selected for imposition of temporary shortage by increasing their priority number to, say, 60 and returning the Valdesia rank to 50. In this way, irrigation shortages can be controlled and balanced with energy shortages.

2.6.2 Comparison of historical and optimal operations.

The optimal stochastic DP operating rules were applied to historical data for the period since Hurricane David through 1984 in order to assess the value of using these operating rules as compared to what was actually done historically. The monthly DP storage guidecurves were broken into weekly targets by a simple linear interpolation, and then these storage guidecurves were introduced into MODSIM and run over the historical period covering 221 weeks, starting August 12, 1980.

The more simplified network configuration of Figure 2.4.9 was used instead of Figure 2.6.1, with all the demands for each canal aggregated together. The weekly irrigation demand estimates of Table 2.3.6 were used as well as the monthly net evaporation estimates of Table 2.3.12, which were assumed constant within each month.

To obtain the monthly storage guidecurve levels for the historical period, Program MODSIM was first run on a monthly basis with the optimal DP guidecurves included. The resulting monthly storage levels, which exactly met the optimal targets since this was given the highest priority for these monthly runs, were then linearly interpolated into weekly levels, with consideration given to the disparity between seven day weekly increments and the number of days in each calendar month.

The results of the comparison are shown in the following figures. A comparison of storage levels is given in Figures 2.6.3 and 2.6.4, which indicates that the DP operating rule retains substantially higher storage levels. The lowest level occurs around week 216. Though maintenance of high storage levels is ideal for hydropower, these results suggest that there was sufficient water historically for

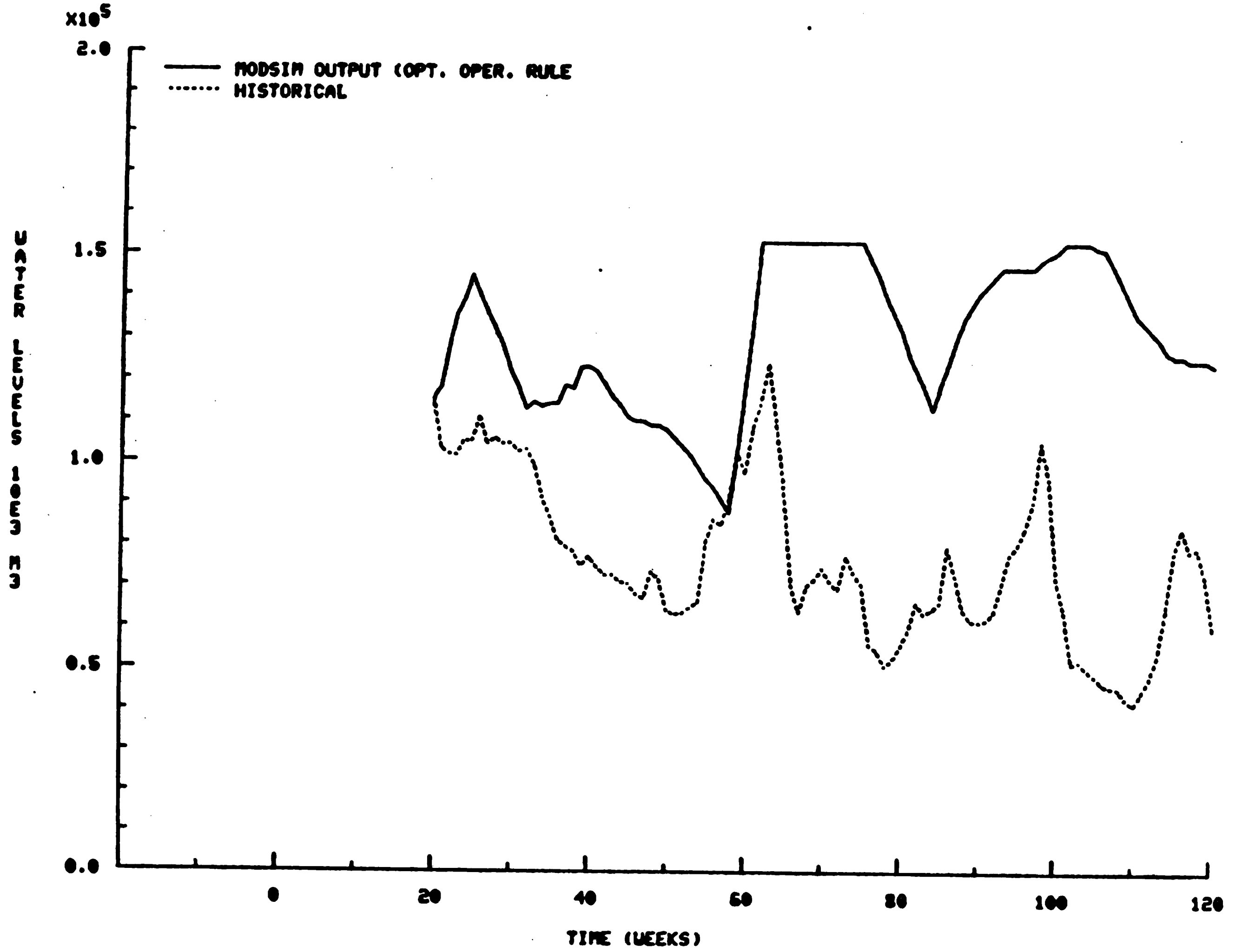


Figure 2.6.3 HISTORICAL AND OPTIMAL WATER LEVELS AT VALDESIA (1980-2)

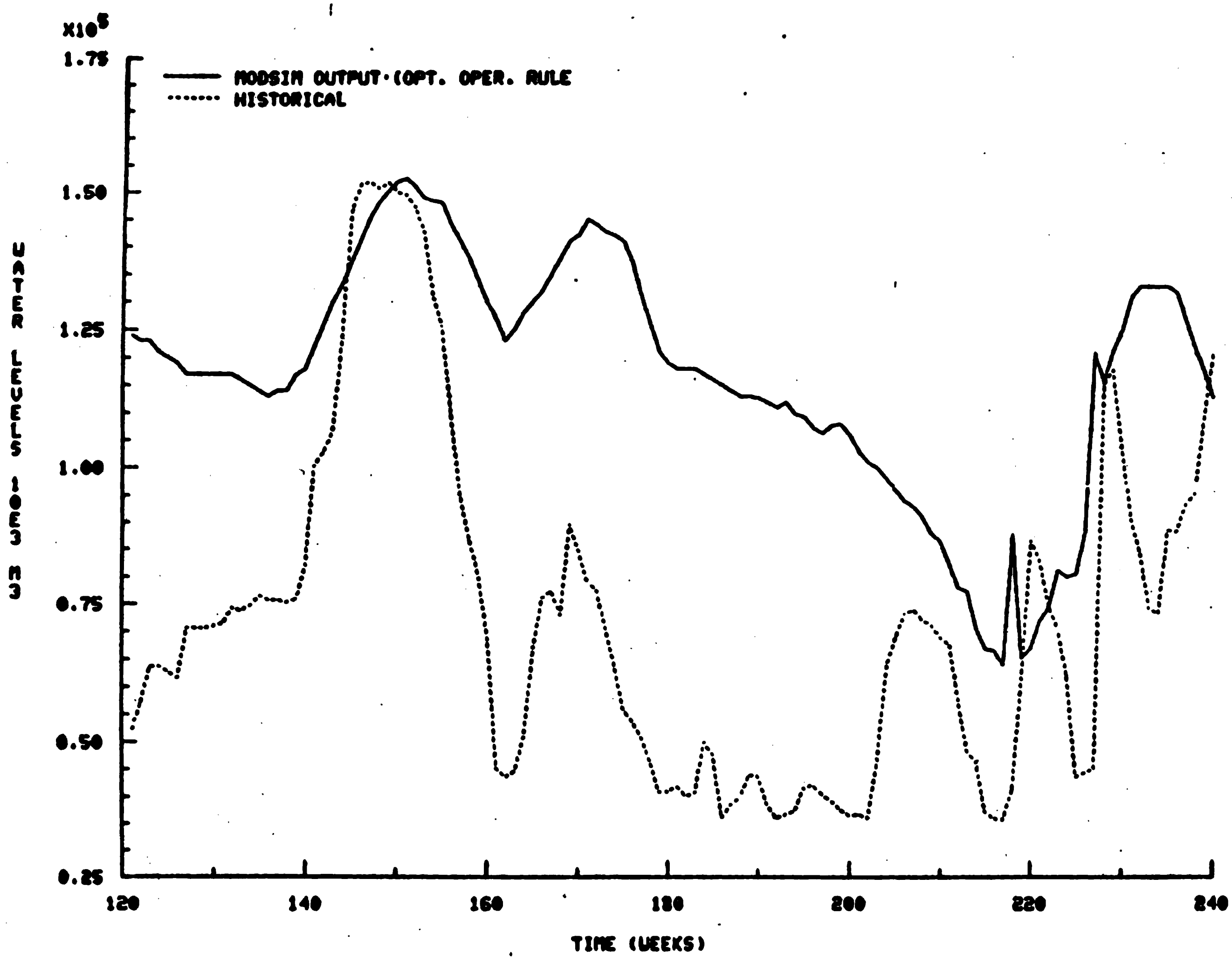


Figure 2.6.4 HISTORICAL AND OPTIMAL WATER LEVELS AT VALDESIA (1982-4)

additional deliveries for domestic supply, or perhaps increased irrigation demand, if the optimal rules were followed. The effects of these increases on energy production would have to be assessed.

Figures 2.6.5 and 2.6.6 compare the average weekly power output. It was first decided to force MODSIM to match the historical power by initially guessing hours of production and then running MODSIM to produce the resulting energy output. The energy output could then be divided by historical power, giving new estimates of generation hours, and the process repeated until MODSIM power matches that which occurred historically. However, because of the higher storage levels produced by following the DP operting rules, power output was found to be considerably higher. Therefore, another iteration was performed where energy output was divided by higher than historical level of 35 MW, and the resulting generation hours reentered into MODSIM. This produced the power output shown, and all other results shown here. The resulting generation hours are compared with what occurred historically in Figures 2.6.7 and 2.6.8. Table 2.6.1 compares the mean and standard deviations of the historical vs. optimal power output and confirms a substantial increase as a result of the latter.

Figures 2.6.9 and 2.6.10 compare the historical weekly energy generation with that which would have been produced using the optimal rules. Table 2.6.1 gives a comparison of the mean and standard deviations, and indicates an 7.9 percent increase in total energy production as a result of using the optimal DP rules, with very similar standard deviation. That is, the seasonal energy variations are quite comparable.

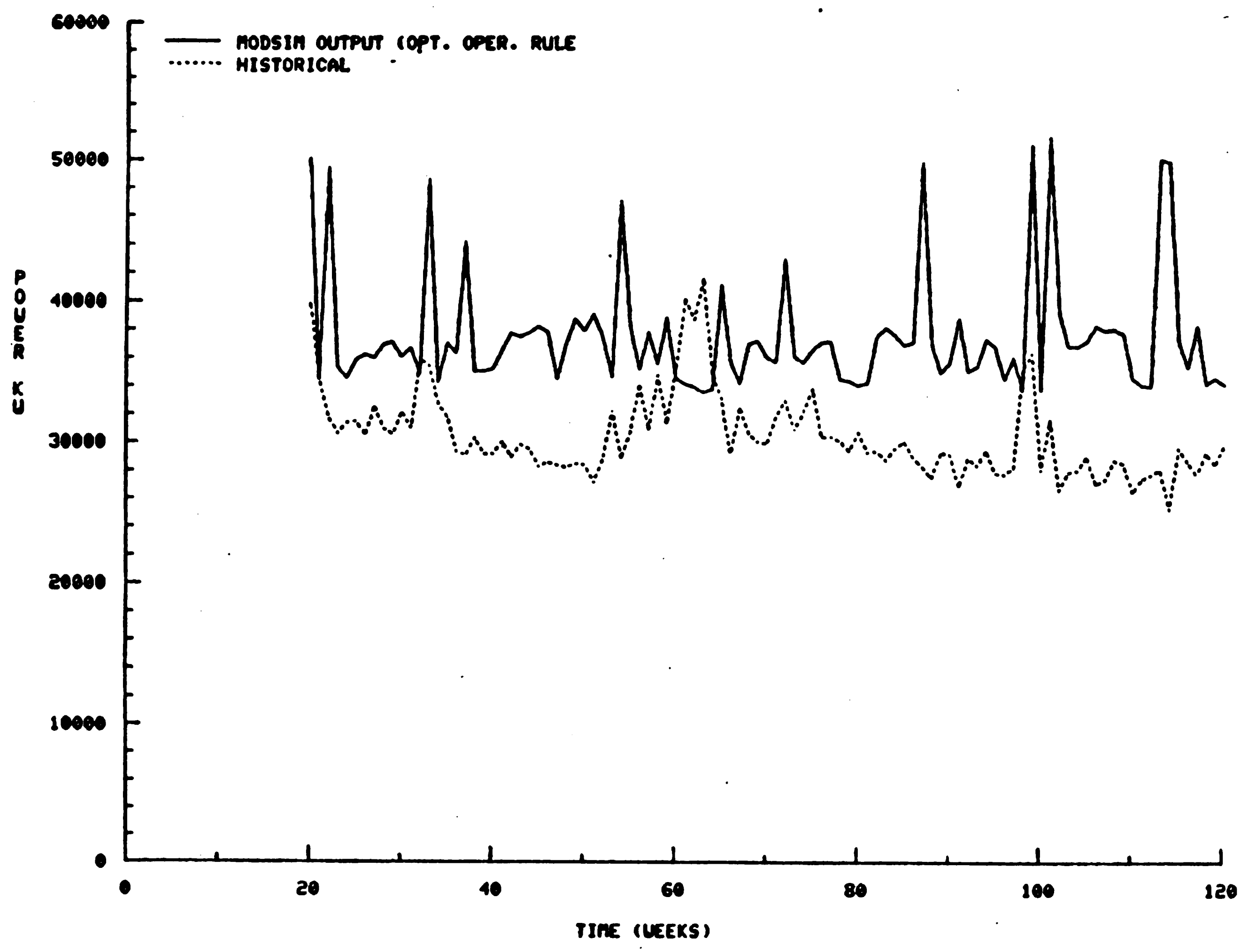


Figure 2.6.5 HISTORICAL AND OPTIMAL POWER AT VALDESIA (1980-2)

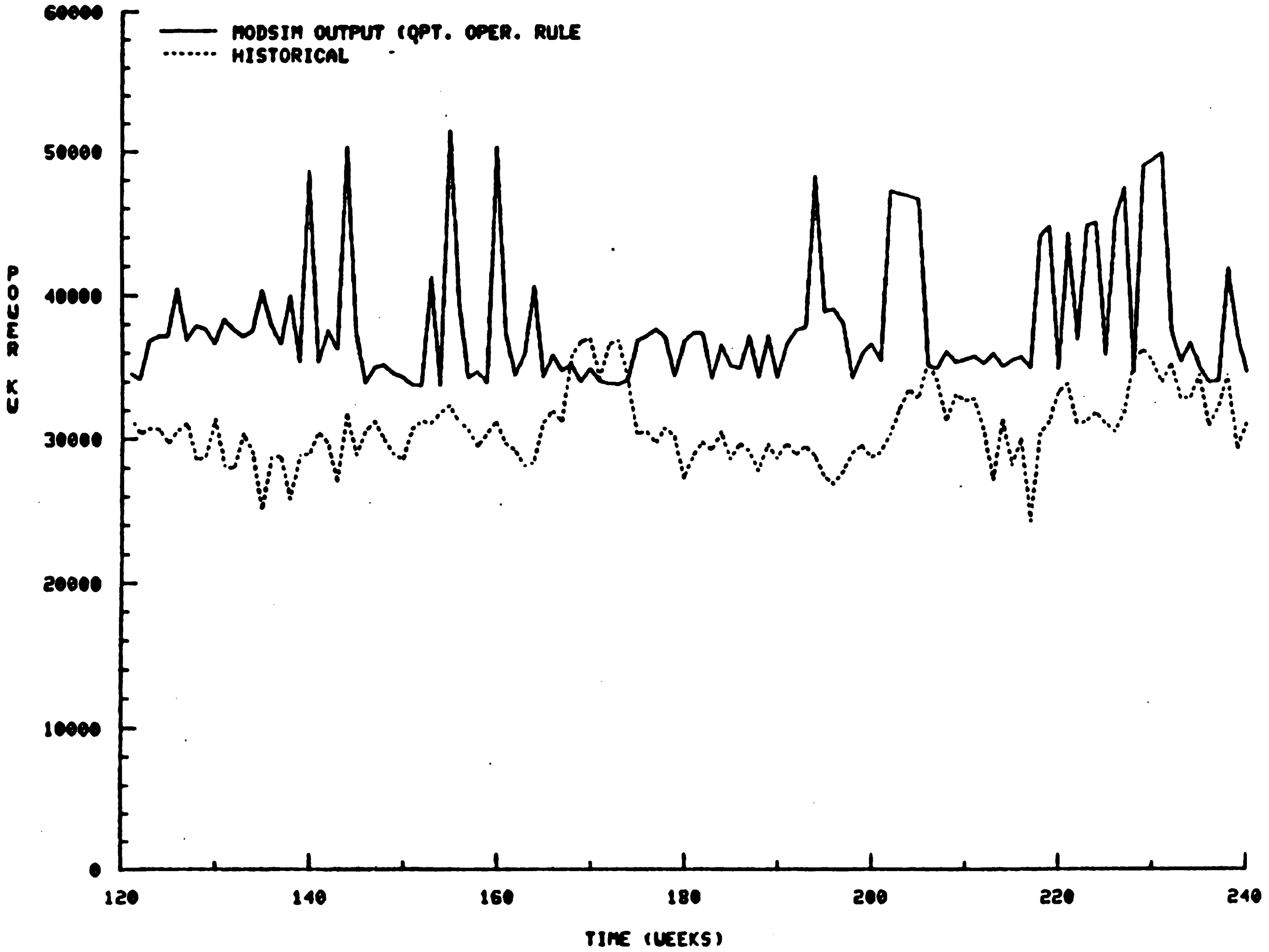


Figure 2.6.6 HISTORICAL AND OPTIMAL POWER AT VALDESIA (1982-4)

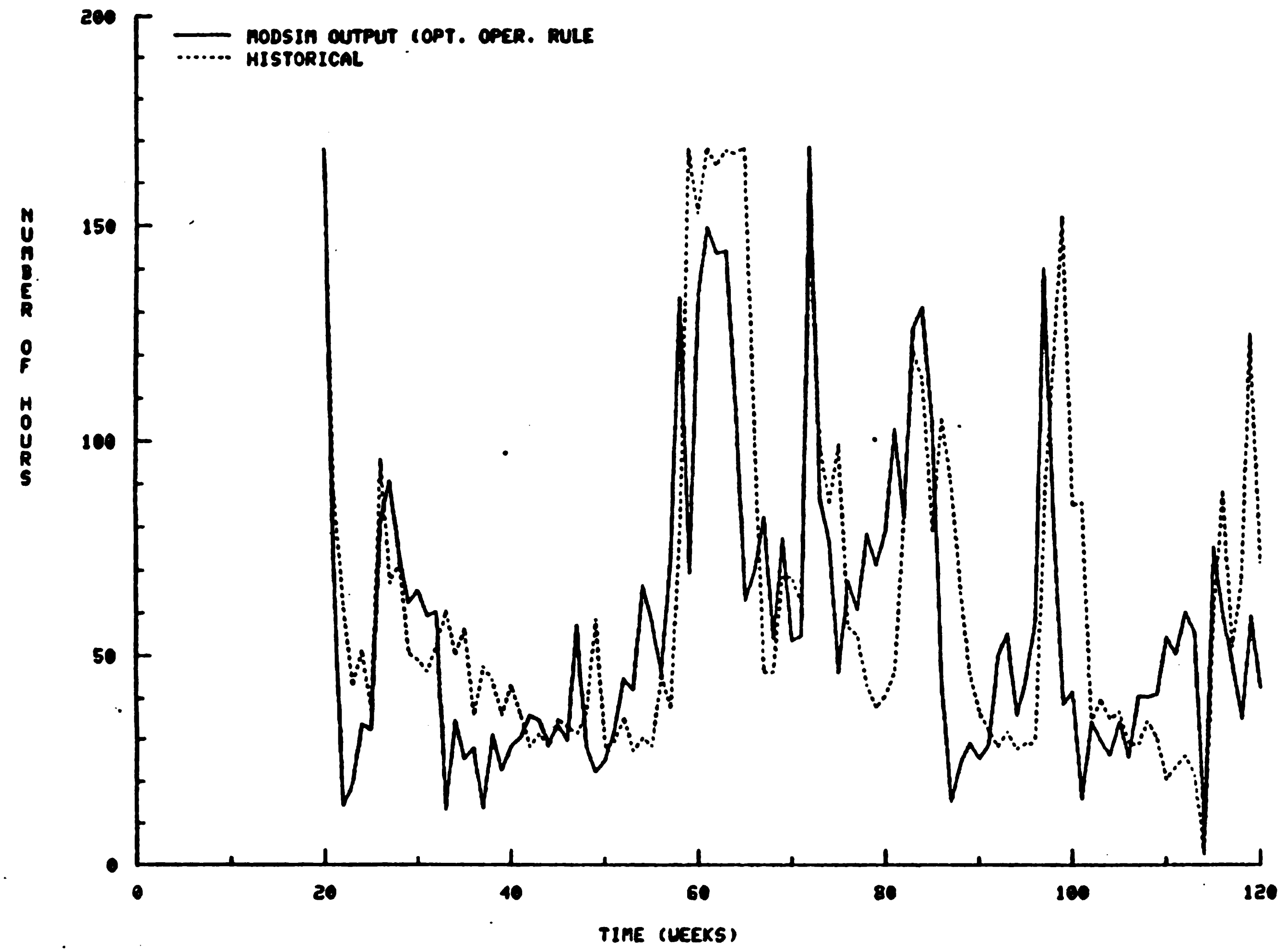


Figure 2.6.7 HISTORICAL AND OPTIMAL NUMBER OF TURBINE OPER. HRS AT VALDESIA(1980-2)

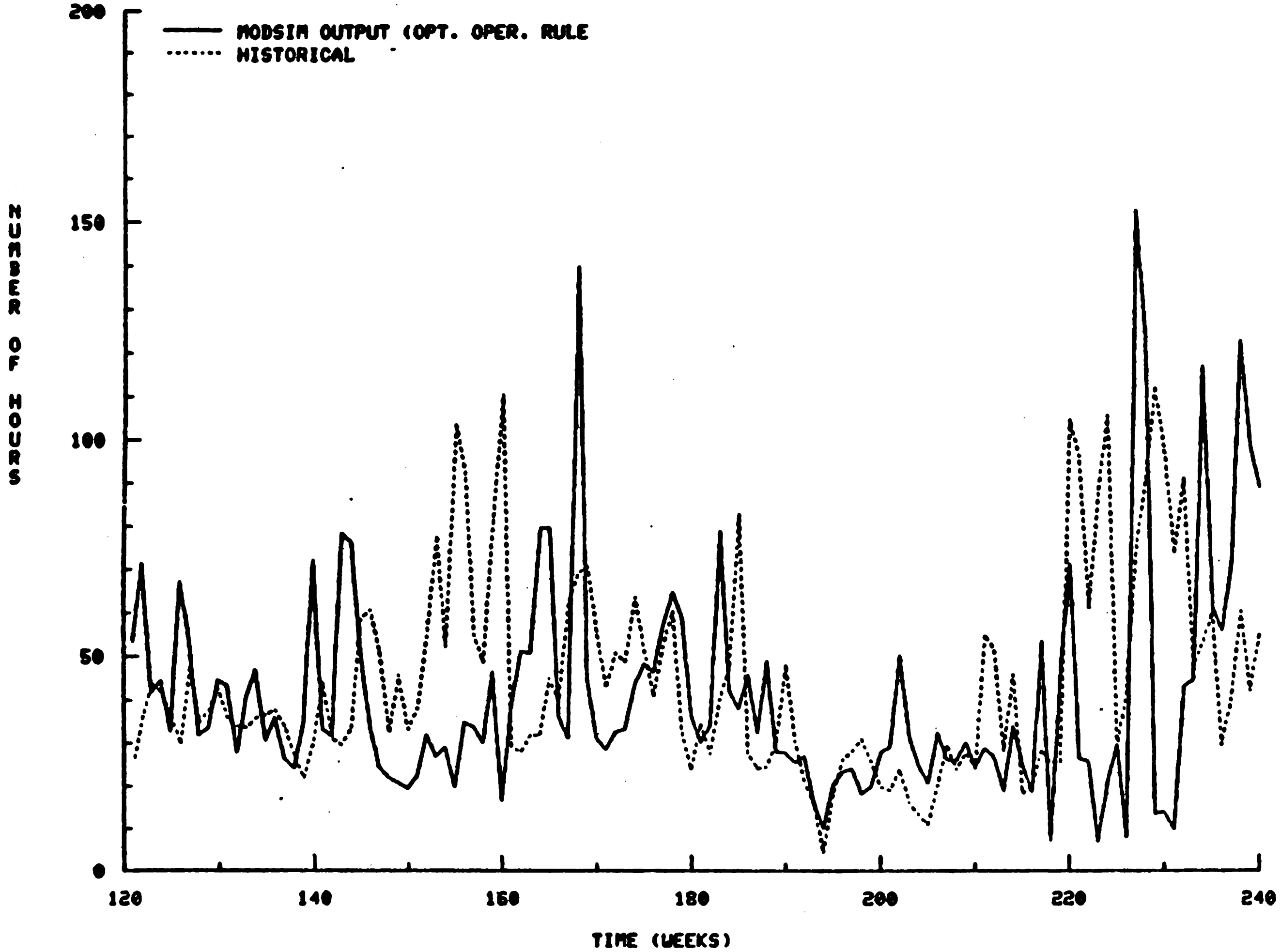


Figure 2.6.8 HISTORICAL AND OPTIMAL NUMBER OF TURBINE OPER. HRS AT VALDESIA(1982-4)

Table 2.6.1

Comparison of Historical and Optimal Operations
[Aug. 12, 1980 to December 31, 1984]

	Historical		Optimal		% change in mean
	mean	standard deviation	mean	standard deviation	
Power					
-weekly (MW)	30.6	2.7	37.8	4.4	+23.5%
Energy					
-weekly (MWH)	1698	1276	1832	1252	+ 7.9%
-annual (GWH)	88.3	-	95.3	-	+ 7.9%
Irrigation Shortages					
-frequency*	25.8%	-	0%	-	no shortages
-ave. annual (m^3/s)†	2.18	-	0	-	

* based on the number of weeks shortages occurred divided by total number of weeks (221).

† only for weeks where shortages occurred.

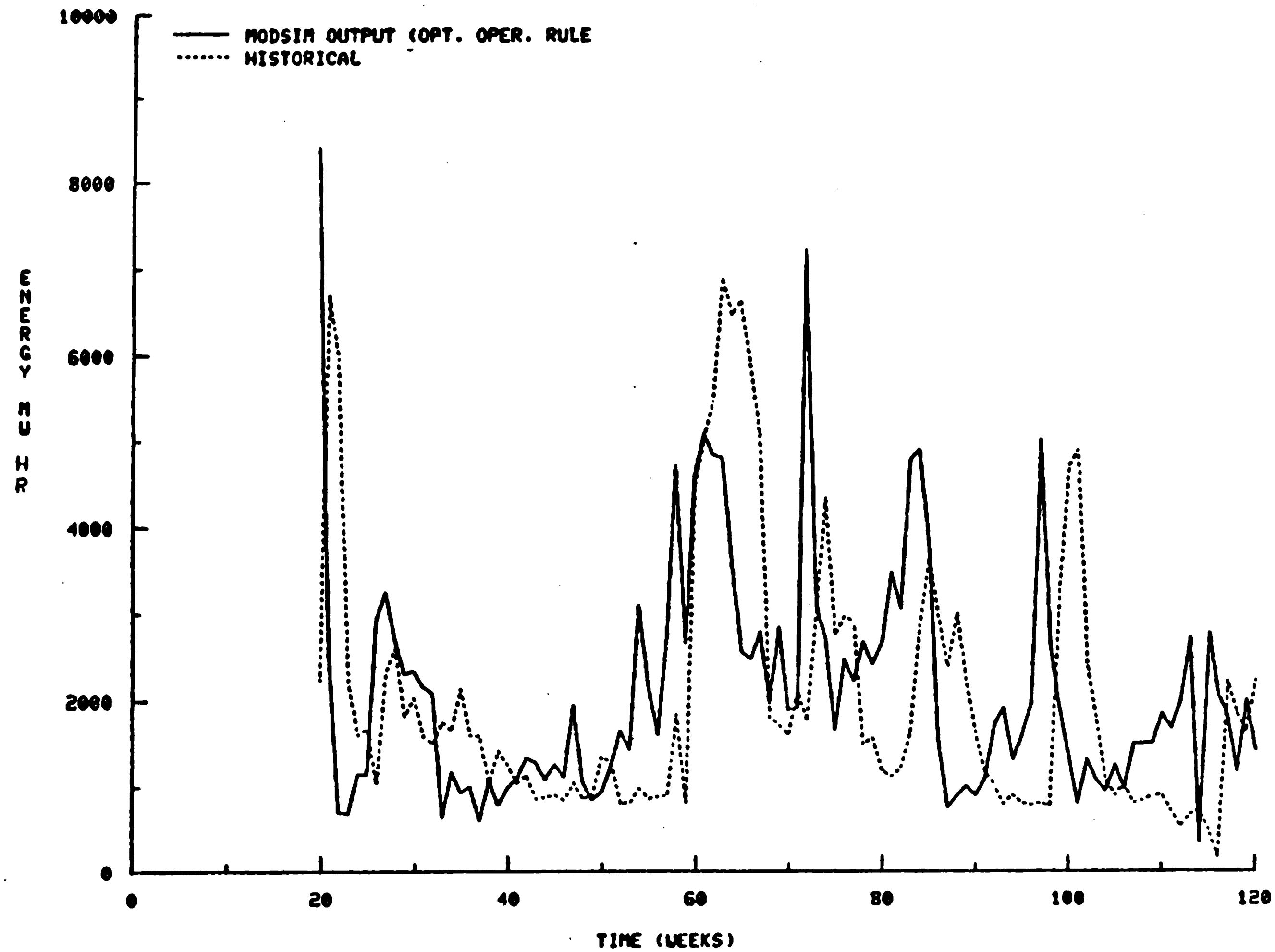


Figure 2.6.9 HISTORICAL AND OPTIMAL ENERGY AT VALDESIA (1980-2)

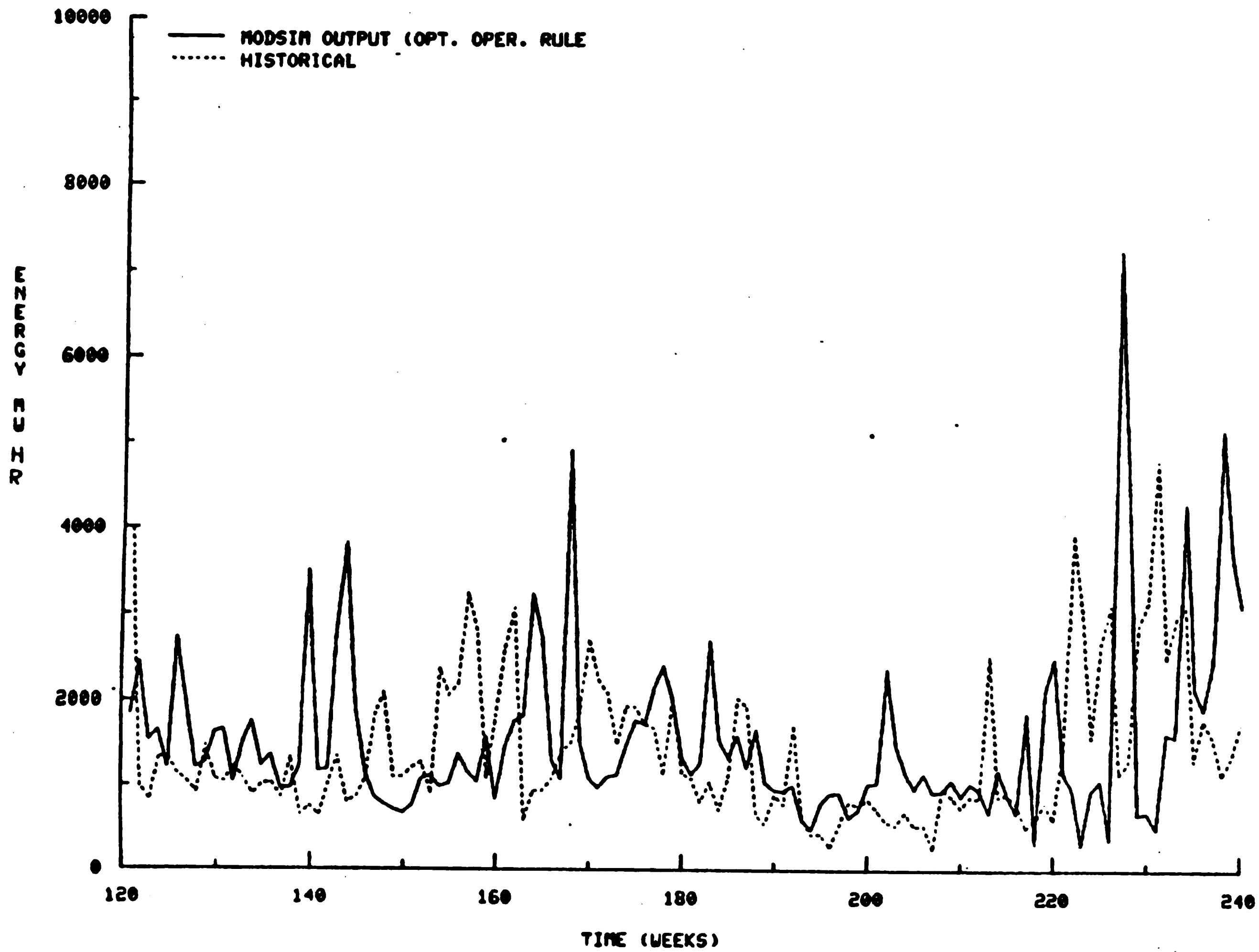


Figure 2.6.10 HISTORICAL AND OPTIMAL ENERGY AT VALDESIA (1982-4)

A comparison of the summarized results in Figures 2.5.31, 2.5.32, and 2.5.33 of the monthly long term Monte Carlo analysis using the optimal DP guidecurves reveals some discrepancy with the results of Table 2.6.1. Even though the latter reflects a weekly analysis, power and energy levels appear much higher than those from the long term monthly analysis. It is believed that the reason for this is the way turbine generation hours were treated. It became clear in the historical analysis that in order to stabilize power capacity, generation hours must be appropriately adjusted. It is clear from Figures 2.6.7 and 2.6.8 that turbine generation hours adjusted for the optimal DP guidecurves differ somewhat from the historical values, even though there is obviously a high correlation. On the other hand, for the Monte Carlo analysis, the generated turbine hours were explicity related to historical values, even though the use of these hours with the optimal DP guidecurves was somewhat inconsistent. For future work, it may be profitable to develop new optimal DP guidecurves which instead of being based on historical turbine generation hours, are based on maintaining a stabilized power output, at least within an acceptable range.

Historical vs. optimal irrigation deliveries are compared in Figures 2.6.11 and 2.6.12, resulting in the historical irrigation shortages shown in Figures 2.6.13 and 2.6.14. There were zero shortages produced as a result of the DP optimal operating rules. Table 2.6.1 indicates that historical shortages were substantial and that use of the DP optimal rules would have greatly benefited irrigation during this time.

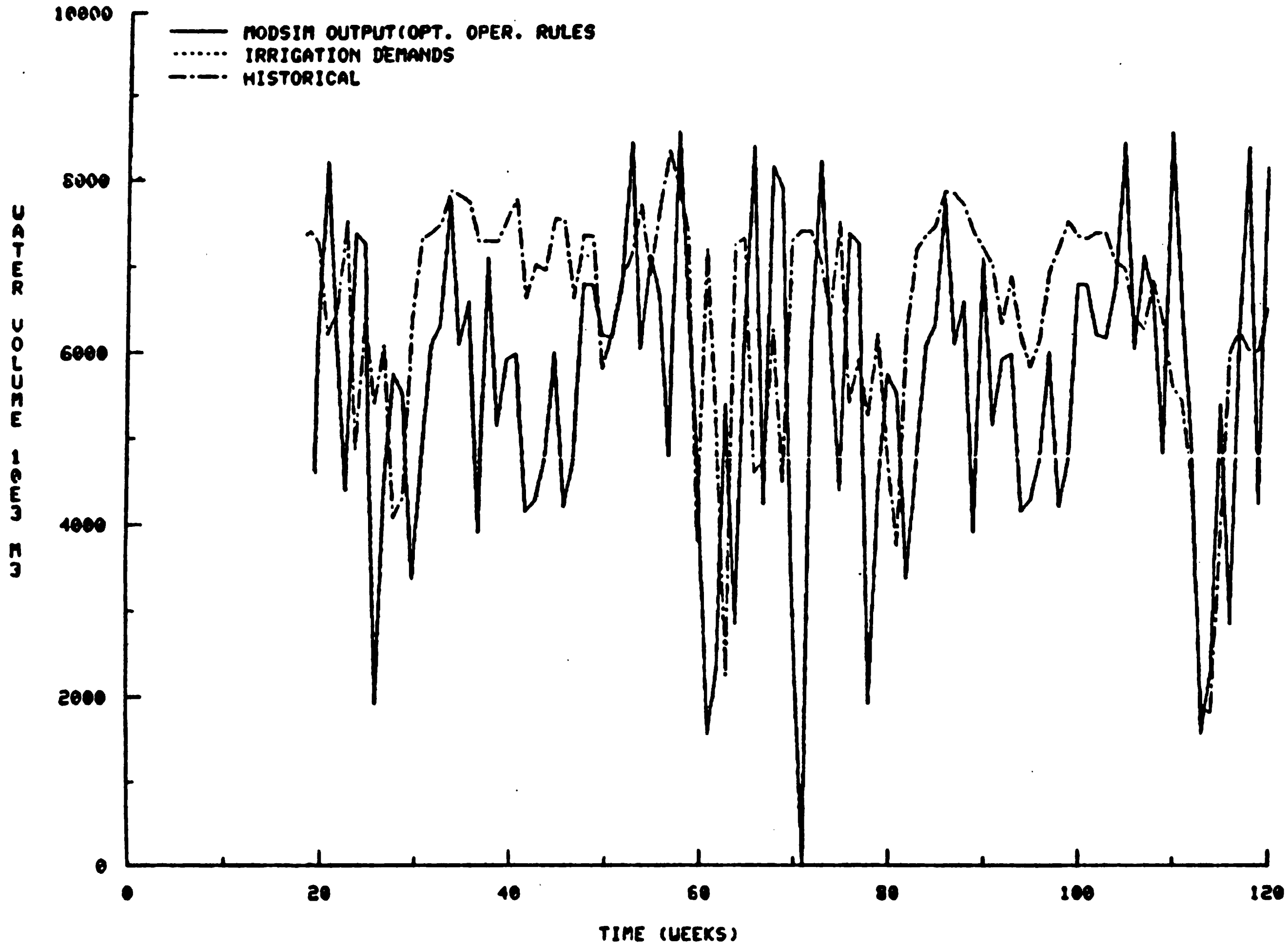


Figure 2.6.11 HISTORICAL AND OPTIMAL IRRIGATION DELIVERIES (1980-2)

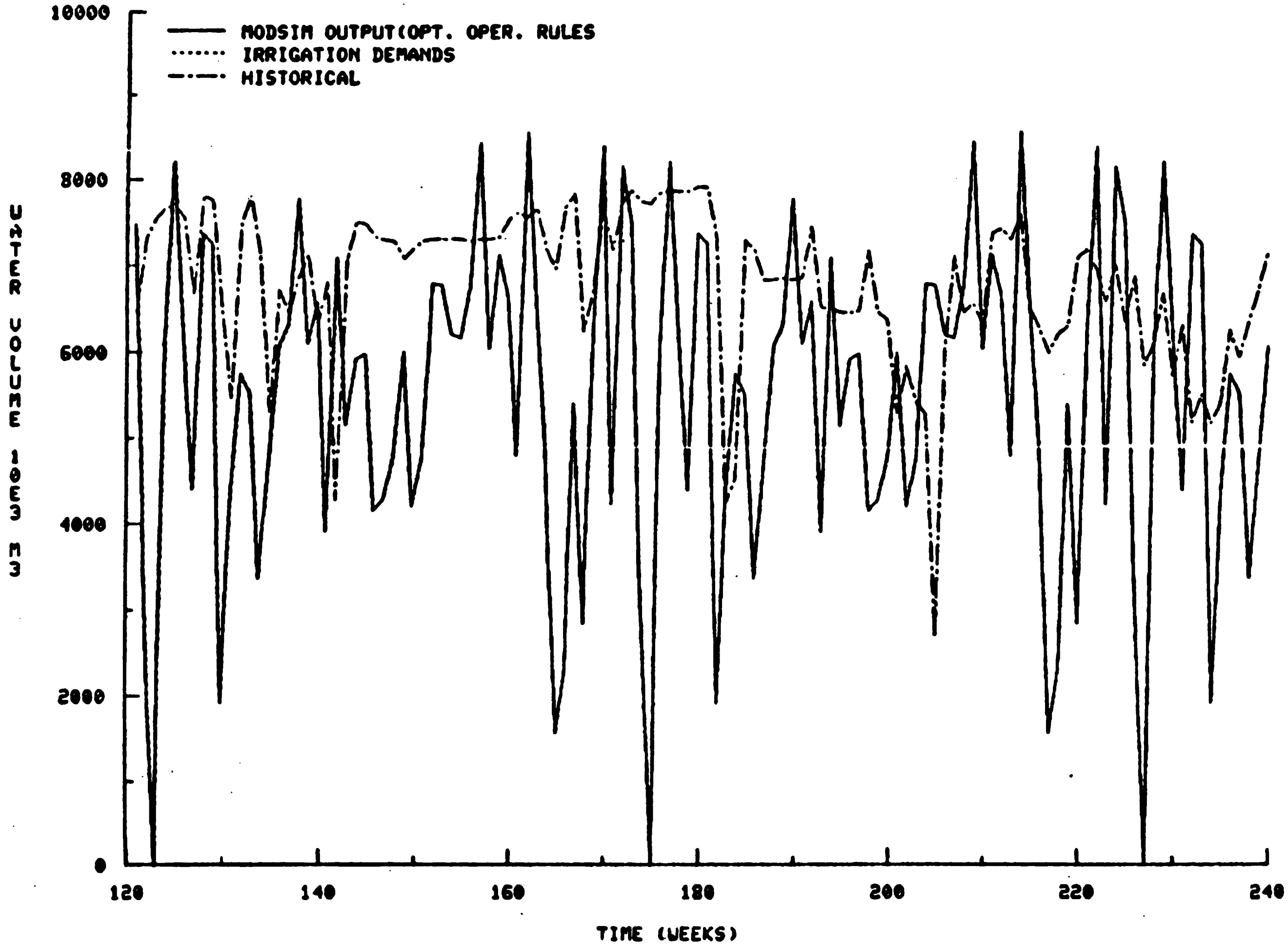


Figure 2.6.12 HISTORICAL AND OPTIMAL IRRIGATION DELIVERIES (1982-4)

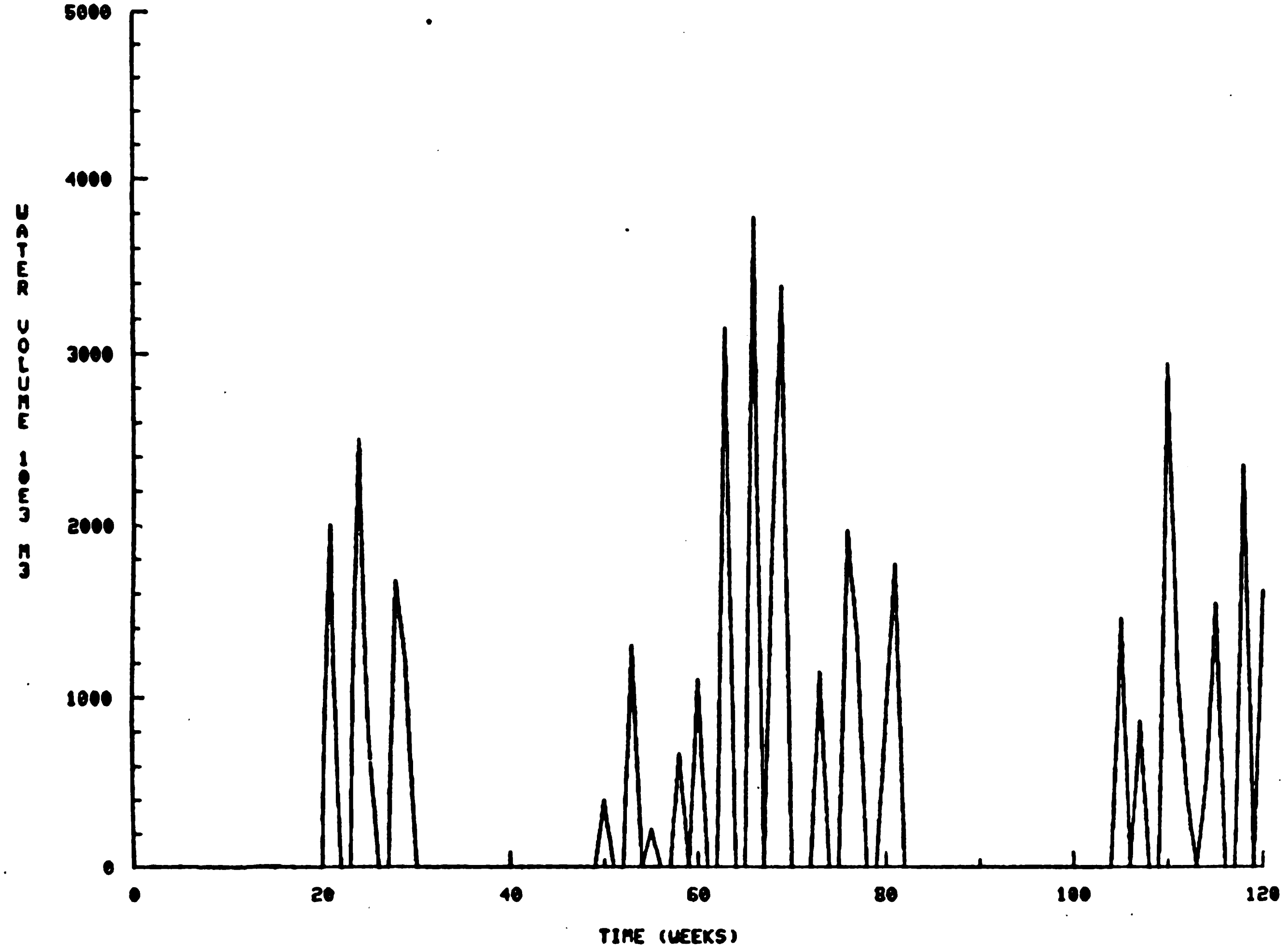


Figure 2.6.13 HISTORICAL IRRIGATION SHORTAGES (1980-2)

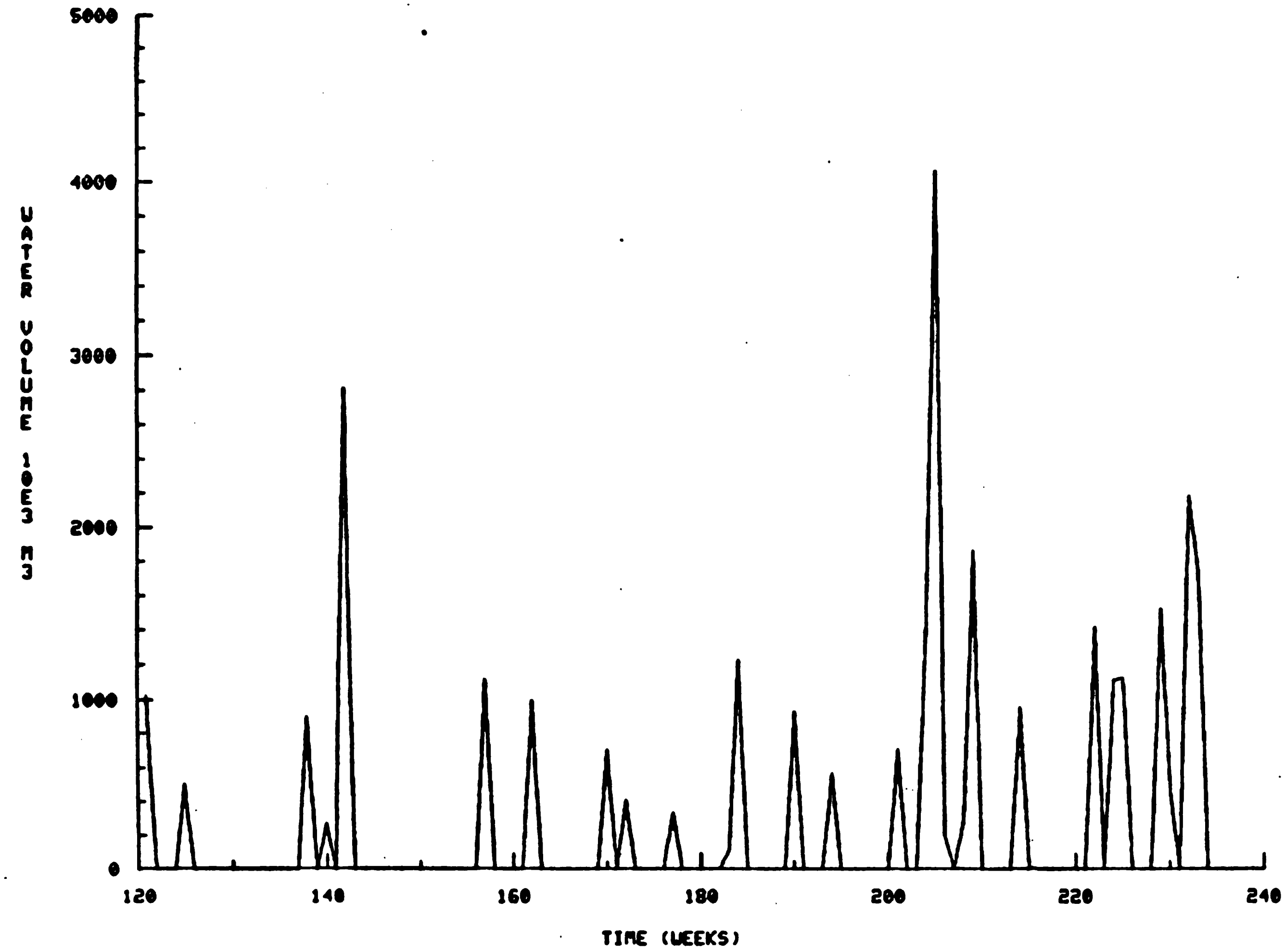


Figure 2.6.14 HISTORICAL IRRIGATION SHORTAGES (1982-4)

Figures 2.6.15 and 2.6.16 provide an indication of excess flows that would have been available as a result of using the optimal DP guidecurves. That is, if the irrigated area was expanded, or upstream diversions to Santo Domingo were desired, then theoretically these flows would have been available.

2.6.3 Economic benefits.

Based on the economic data developed in Section 2.3.5 and the foregoing results of the historical comparison, it is possible to provide some rough estimates as to the increased economic benefits that would have occurred over the historical period, assuming that the optimal DP operating guidecurves were followed.

For hydropower, it was assumed in Section 2.3.5 that if additional annual hydropower energy output of up to 8 GWH could be made available, then a replacement benefit of DR\$0.53/KWH for diesel power plants could be accrued on the increased output. Notice from Table 2.6.1 that the increase in average annual energy as a result of following the optimal guidecurves is 7.0 GWH. Therefore, average annual increased benefits during this historical period would have been:

$$7 \text{ GWH/yr} \times \text{DR\$}0.53/\text{KWH} \times 10^6 = \text{DR\$}3.71 \text{ million}$$

For irrigation benefits, it was assumed that additional water supply would be used to expand the irrigated acreage. It should be noted in this case that the headenders would capture the bulk of the benefit if it is assumed that current cropping patterns would be maintained. However, tailenders would still gain more from use of the water than if historical practices were continued as before. From Figures 2.6.15 and 2.6.16, it is clear that a 10 percent increase in irrigation supply is plausible, and from previous analysis, that there

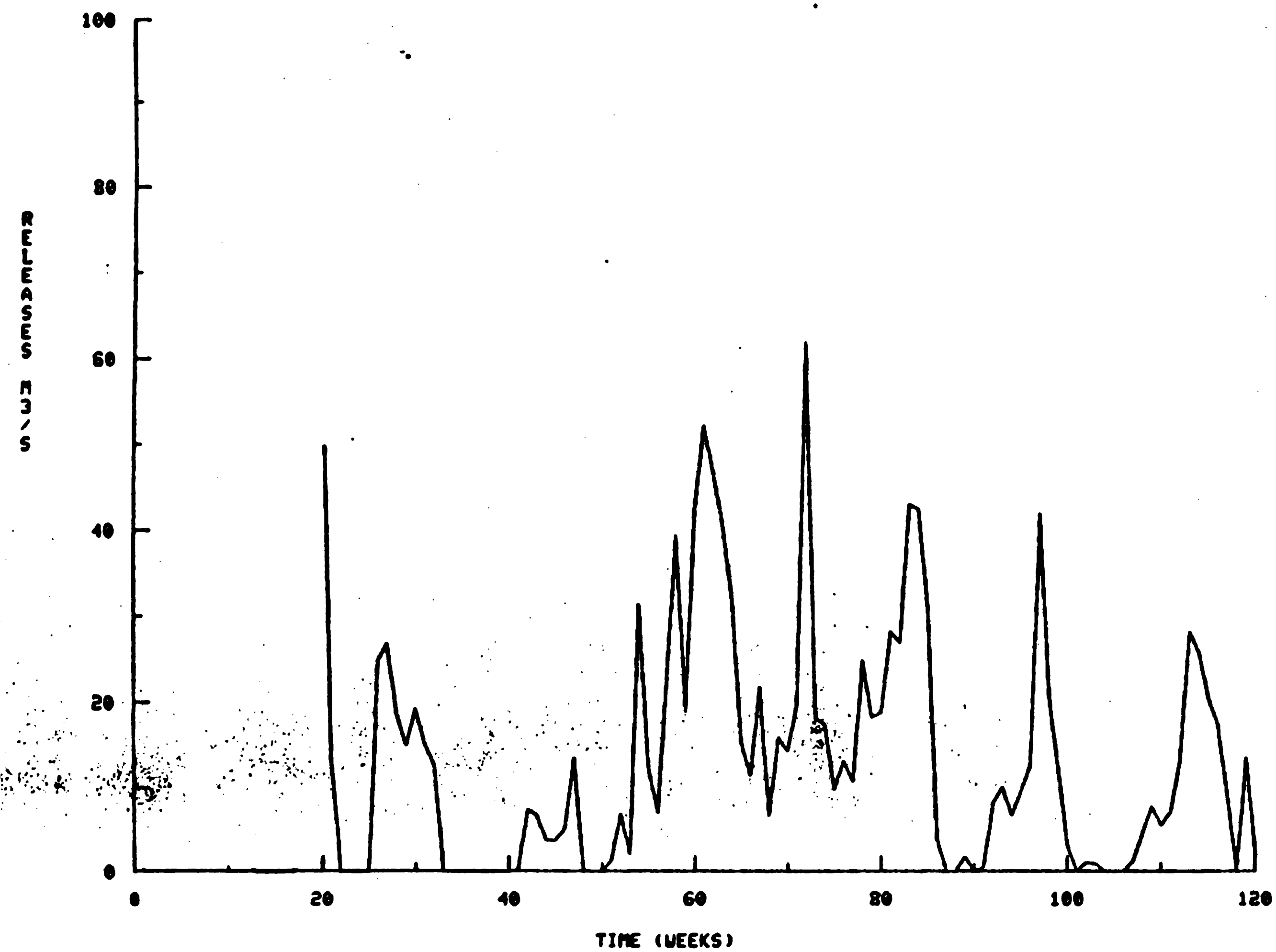


Figure 2.6.15 SPILLS AT LAS BARIAS RES. FROM OPTIMAL GUIDECURVES (1980-2)

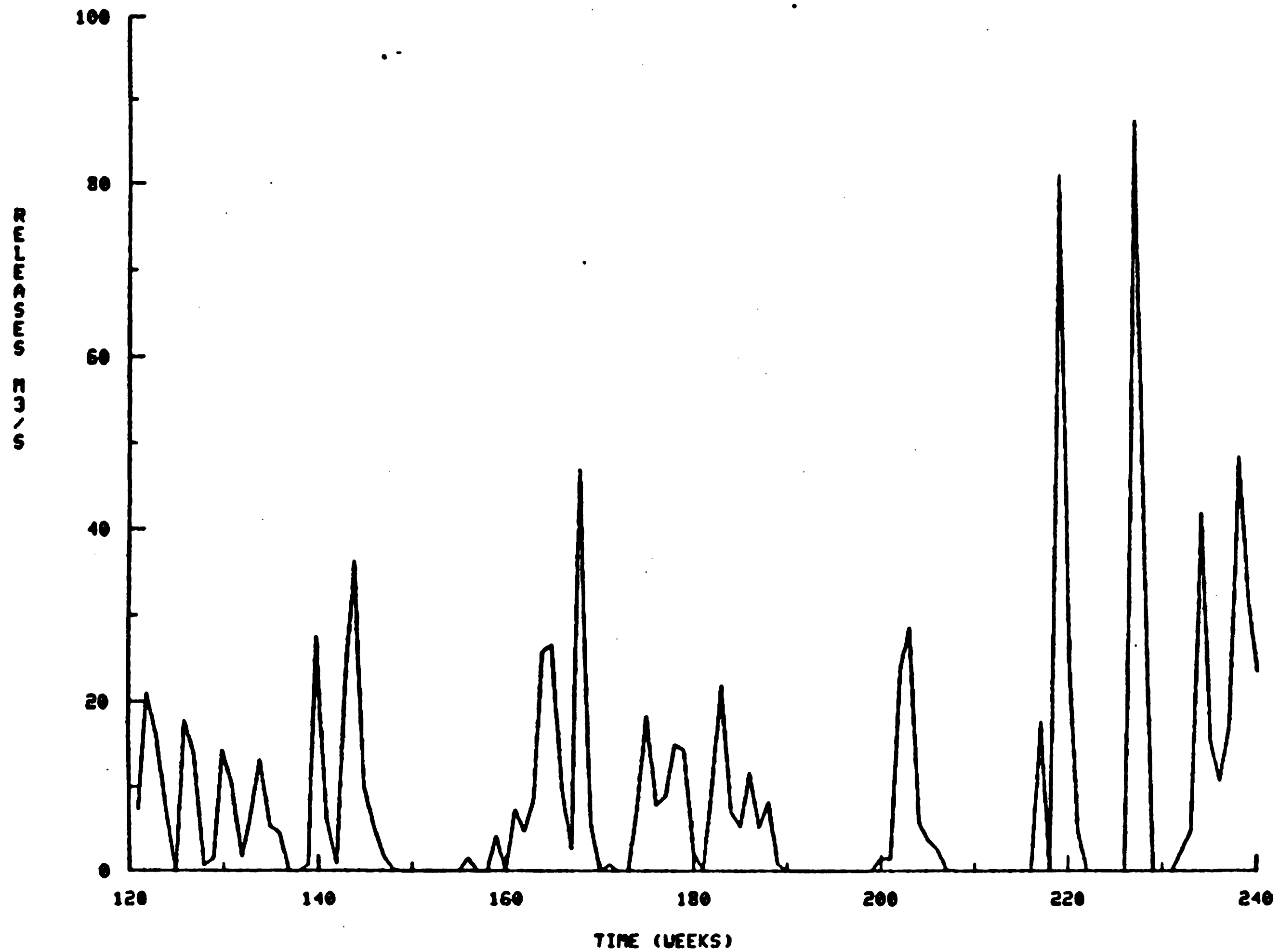


Figure 2.6.16 SPILLS AT LAS BARIAS RES. FROM OPTIMAL GUIDECURVES (1982-4)

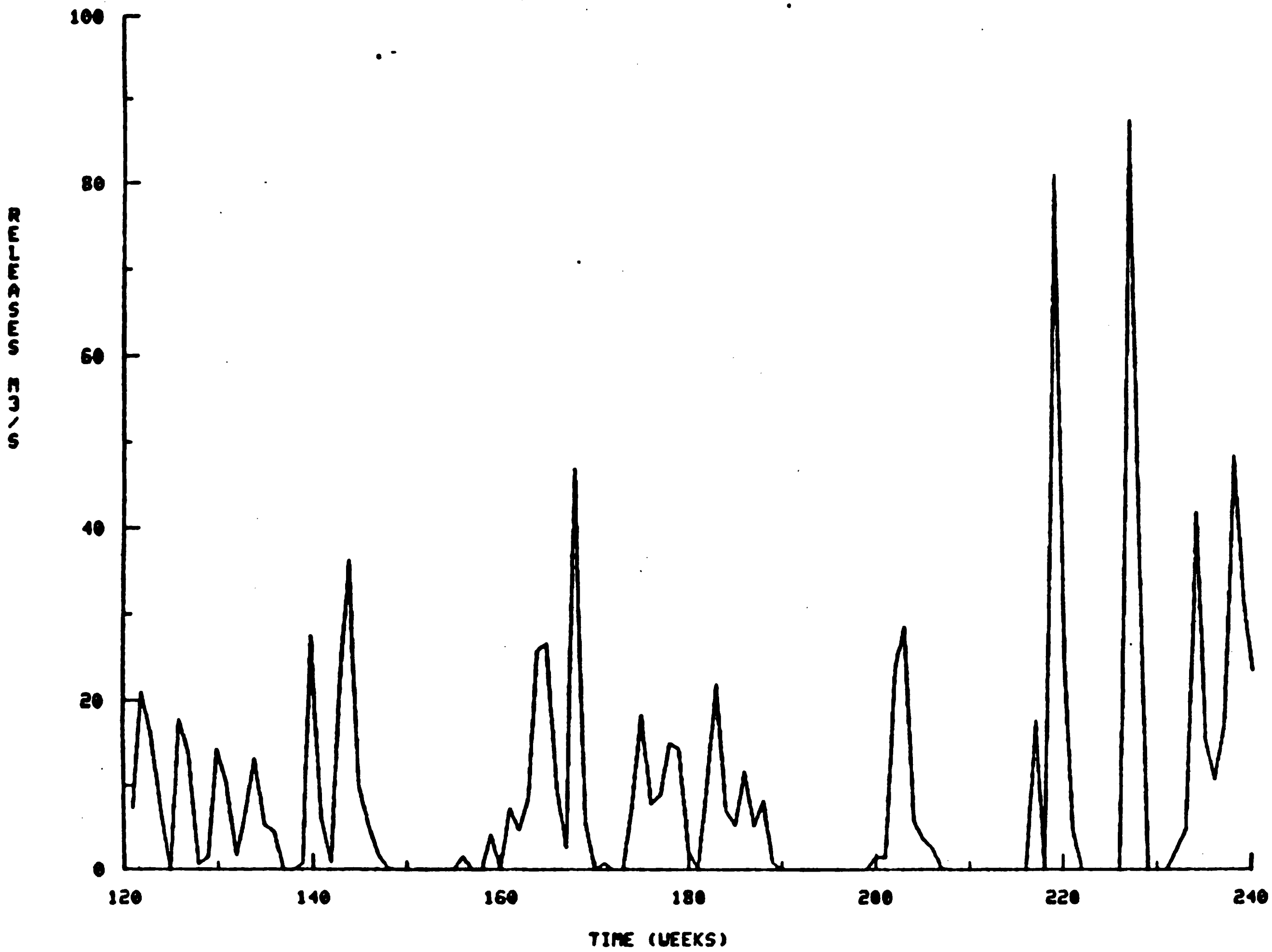


Figure 2.6.16 SPILLS AT LAS BARIAS RES. FROM OPTIMAL GUIDECURVES (1982-4)

should be sufficient additional capacity on the canals to carry the increased flows. Even though there are several weeks where zero excesses occur in Figures 2.6.15 and 2.6.16, a comparison of Figures 2.6.3 and 2.6.4 with 2.6.15 and 2.6.16 reveals that for the most part, spills at Las Barias occur when there is excess capacity in Valdesia above the optimal guidecurve storage levels. This means that some of these spills could be temporarily stored in Valdesia for later release for meeting excess irrigation requirements. It is unlikely that this would greatly effect energy output. However, it would be advantageous in this case to make new runs with Program CSUDP, but constrained now (via penalty terms, as explained previously) to provide a 10 percent increase in irrigation supply.

Assuming that a 10 percent increase in water supply can correlate with a 10 percent increase in irrigated area, then

10% x 4655 ha x DR$6778/ha

= DR$3.15 million [for headenders]

10% x 3264 ha x DR$1665/ha

= DR$0.54 million [for tailenders]

Total increased average annual benefits over the historical period april 1, 1980 to December 31, 1984 estimated as a result of utilizing the optimal operational guidecurves developed in this study are:

DR$3.71	million/yr	(from hydropower)
3.15	million/yr	(from irrigation-headenders)
0.54	million/yr	(from irrigation-tailenders)
DR$7.40	million/yr	TOTAL

The large quantity of excess spills at Las Barias, as shown in Figures 2.6.15 and 2.6.16, provides encouragement that water upstream of Valdesia Reservoir could possibly be diverted for domestic supply to Santo Domingo and other areas. The difficulty is the large variation in flows and the periods of continuous zero excess flows, in some cases extending for 2-1/2 months. The domestic supply would of course need to be consistent year round. The result would be a significant change in Valdesia storage levels and reduced discharges through the power plant for energy production. For future work, it is recommended that a CSUDP-MODSIM analysis be undertaken to determine the detrimental effects on energy production, power capacity and irrigation supply that might occur for various levels of extraction of domestic water.

2.7 CONCLUSIONS AND RECOMMENDATIONS

2.7.1 Summary of Results.

A comprehensive analysis of operation of the Valdesia Reservoir system in the Dominican Republic has been conducted for normal or nonemergency operating conditions. The emphasis has been on development of integrated strategies that incorporate Valdesia Reservoir and powerplant, Las Barias Reservoir downstream, and the major canals Marcos Cabral and Nizao Najayo supplying water to over 10,000 ha of irrigated lands. The objective is to produce practical operating procedures that maximize long term energy production from the powerplant, subject to satisfying irrigation requirements at minimum risk. There is also an interest in determining if additional reliable water supply could be made available from the system for expanded irrigation and/or domestic supply to the City of Santo Domingo. Additional objectives include comparing how the Valdesia system would have performed historically had the optimal guidelines been pursued, versus how the system was actually operated, and providing an economic evaluation of possible increased benefits from improved operations. Analysis of historical operation of the system reveals that consistent operation policies have not been adhered to, as indicated by significant irrigation shortages and highly variable turbine generation hours and energy production.

A hierarchical approach has been selected in which optimal monthly storage guidecurves are developed using stochastic dynamic programming (Program CSUDP), and then input as targets into a network simulation model called MODSIM which can be used interactively on a weekly basis by operations personnel for real-time decision support. In addition, daily guidelines are also provided primarily for power

operations to determine the optimal loading of turbines in the powerplant to maximize efficiency.

The monthly operating targets are based on stochastic analysis of Valdesia Reservoir inflows and are conditioned on a wide range of storage levels and preceeding inflow conditions for any month, whereas the weekly analysis can make use of forecasted inflows, irrigation demands, and energy requirements in real time.

The key to optimal operation of the Valdesia system is synchronization of the power and irrigation uses of the system. This requires accurate assessment of actual crop water requirements and operating strategies that minimize both shortages and wastage. Crop water requirements are estimated using the modified Penman method. Though meteorological data were limited for use of this method, it was still preferred over more approximate techniques. Its use may also provide an impetus for improved data collection and processing. Precipitation contributions to meeting crop demands are estimated using a method developed by Morel-Seytoux and Restrepo (1985). In addition to hydrologic, meteorological, and agronomic data, an attempt has been made to estimate basic costs and benefits associated with Valdesia system operations. These are employed to assess the potential benefits of improving operation of the Valdesia system, in contrast with historical policies.

In order to gain confidence in use of the models for future operations, extensive calibration exercises have been carried out for both the monthly and weekly models. A large data base involving laborious data entry has been developed for this project and used for calibration, as well as development of optimal operating rules. The

calibration results were considered satisfactory for purposes of this project and the calibrated models are considered to be viable operational tools for the Valdesia system. Future updating of model parameters and inputs should be carried out as conditions change.

Optimal monthly storage guidecurves were developed by Program CSUDP with consideration of optimal loading of the two turbines in the powerplant. That is, for various discrete head - discharge combinations a preoptimization analysis was performed that determined how each turbine should be loaded so as to maximize overall efficiency, and hence, energy output. This optimal loading table should prove useful for daily operation of the system.

With development of optimal monthly storage guidecurves using program CSUDP, an attempt was made to test them by assessing the long term risks associated with meeting irrigation demands and maintaining various energy and power output levels.

A Monte Carlo analysis was carried out whereby 400 years of monthly synthetically generated data for inflows and hours of turbine generation were input to Program MODSIM, employing the optimal CSUDP generated storage guidecurves. Hours of turbine generation were included in the bivariate stochastic model because of their high variability and strong correlation to inflows.

Results were extremely encouraging for irrigation supply, with virtually zero risk of incurring shortages noted in the program output. In addition, it was indicated that irrigation deliveries could likely be increased by 10 percent with an associated average monthly reliability of around 92 percent. However, energy and power output levels, though slightly larger on the average than what occurred historically, were

somewhat disappointing. It was finally decided that there was a certain inconsistency between the optimal DP operating rules and the use of the synthetically generated hours of turbine generation in the Monte Carlo analysis, since Program CSUDP had simply used average monthly values for hours of generation. This inconsistency was confirmed by further testing of the optimal DP operating rules on the historical period since Hurricane David. A weekly time interval was used in this case.

It was determined that instead of using historical hours of generation as a reflection of energy demand, it was more reasonable to use power output as a means of comparison. The reason is that examination of historical system operations reveals widely varying levels of turbine generation hours in contrast with relatively stable levels of power capacity at around 30 MW. This indicates that system operators attempt to stabilize power capacity as much as possible for integration into the country's power distribution network, and that this in turn often dictates hours of generation, particularly for periods where outflows are high and therefore releases are also substantial.

The results of this comparison were extremely encouraging, with the optimal DP operating rules producing 23 percent more power and almost 8 percent more energy, with no incurrence of irrigation shortages. An analysis of excess spills at Las Barias resulting from the optimal DP rules revealed that by storing some excess water above the DP guidecurve and then releasing the water later, at least a 10 percent increase in irrigation supply could be maintained at high reliability. From a preliminary economic analysis, which assumes excess water would be applied to irrigating more land for irrigators at the heads and tails of the canals, an estimated additional return of DR$3.69 million per year

could have been realized over the historical period as a result of applying the optimal DP storage guidecurves. Adding in the estimated benefits of increased energy production, the total benefits would have been DR$7.40 million per year.

2.7.2 Future needs.

An accurate hydrological, meteorological, and agronomic data base is essential to effective operation of the Valdesia system, as well as future planned upstream developments and system improvements. Because of data deficiencies encountered in this study, it is suggested that Station Bani, located in the center of the irrigation zone, be equipped with modern instrumentation for more accurately estimating crop water requirements, and that these data be entered and processed in a computer readable form. Another station located on the Nizao-Najayo side would also be a valuable addition to the country's data collection network. In addition, a water level station at the upstream end of Valdesia Reservoir is necessary to provide daily inflow information not only for normal operations, but also for flood and emergency conditions.

It is recommended as MODSIM becomes a consistent real-time operational tool for the Valdesia system, that a computerized data acquisition system be set up whereby data can be remotely accessed and updated in real-time, and directly utilized by Program MODSIM for weekly operational evaluations. Once this is done, the large computerized data base already developed at CSU for this project can be transferred to INDRHI, CDE and other agency computer systems and be readily accessible to all interested personnel.

Of key importance to effective real-time operations using MODSIM is the development of a comprehensive forecasting capability for

streamflows, energy demands, and crop requirements. Future work should focus on combining automated data acquistion and processing capability with modern computer software for efficiently generating and updating these forecasts in real time.

It is proposed for future planning of new facilities in the Nizao River Basin that Programs CSUDP and MODSIM be again employed for optimal location and sizing of these facilities and optimal integration of the operation of all projects in the basin. Extension of the CSUDP-MODSIM hierarchical strategy to other systems such as Tavera-Bao could also be valuable, with the eventual goal of nation wide integrated operational planning. This should include analysis of the power distribution network and both hydro and thermal power facilities since operations at individual projects are greatly affected by contingencies in the power grid.

It is essential as MODSIM is employed in the future, that the data base developed in this study for use with MODSIM be critically examined and updated as necessary since these data are really only valid up to the current point in time. Eventually, perhaps after one year of operational experience has elapsed, new CSUDP operating storage guidecurves can be developed using updated data, including the transition probability matrices.

2.8 REFERENCES

Clausen, R., " The Numerical Solution of Network Problems Using the Out-of-Kilter Algorithm," Rand Corporation, RM-5456-PR, March 1968.

Doorenbos, J. and W. O. Pruitt, Crop Water Requirements, Irrigation and Drainage paper No. 24, FAO, Rome, 1975.

Duncan, R. C., ed., " The Outlook for Primary Commodities, 1984 to 1985," World Bank Staff Commodity Working Papers, Number 11, World Bank, 1984.

Frederiksen, Kamine and Associates, " Informe Preliminar de Diagnostico: Proyecto Nizao-Valdesia, Organizacion de Operacion y Mantenimiento," Santo Domingo, The Dominican Republic, February 1985.

Hargreaves, G. H., World Water for Agriculture, Utah State University, January 1977.

Hydrologic Engineering Center, "Simulation of Flood and Conservation Systems: HEC 5 User's Manual," U.S. Army Corps of Engineers, Davis, California, 1979.

Kincaid, D. C. and d. F. Heerman, "Scheduling Irrigations Using a Programmable Calculator," Agricultural Research Service, ARS-NC-12, U.S. Department of Agriculture, Fort Collins, Colorado, 1974.

Labadie, J., ed., "Application of Dynamic Programming to Water Resources Management," Notes for Short Course, Colorado State University, Fort Collins, Colorado, 1980.

Labadie, J. and C. H. Sullivan, " Computerized Decision Support Systems for Water Managers," Water Resources Planning and Management Journal, ASCE, Vol. 112, No. 3, July 1986, pp 299-307.

Labadie, J., D. G. Fontane, V. Floris, and N-F Chou, " Manuales de Operacion de Modelos Computarizados para la Operacion Normal de Sistemas de Embalses," Water Resources Planning and Management Program, Dept. of Civil Engineering, Colorado State University, Ft. Collins, Colorado, July 1986.

Lenton, R. L. and K. M. Strzepek, "Theoretical and Practical Characteristics of the MIT River Basin Simulation Model," Ralph M. Parsons Laboratory, Report No. 225, Massachusetts Institute of Technology, Cambridge, Massachusetts, August 1977.

Morel-Seytoux, H. and J. Restrepo, "Documentation of Subroutine Rain," Department of Civil Engineering, Colorado State University, Fort Collins, Colorado, June 1985.

Payne-Gamei, " Cogeneration Study of Rio Haina and Boca Chica Sugar Factories: Boca Chica Cogeneration Project," Vol. 1, September 1984.

Reyna E. and M. Paulet, Requerimientos de Agua para agricultura segun el clima de la Republica Dominicana, Secretaria de Estado de Agricultura, Dominican Republic, 1979.

Secretaria de Estado de Agricultura, Exigencias ecologicas de las plantas cultivadas y algunas con potencial economico para la Republica Dominicana, SEA, dominican Republic, 1980.

Shane, R. M. and K. C. Gilbert, "TVA Hydro Scheduling Model: Practical Aspects," Journal of the Water Resorces Division, ASCE, Vol. 108, No. WR1, pp. 1-19, March 1982.

Shaner, W., " Esquema Sobre los Beneficios del Estudio del Embalse de Valdesia," Short Course Notes, Interamerican Institute of Cooperation for Agriculture, Santo Domingo, The Dominican Republic, July 1985.

Sheer, Daniel P. and Dale D. Meredith, " Improve Operation or Build New Projects, "Journal of Water Resources Planning and Management, ASCE, Vol. 110, No. 3, pp. 351-355, July 1984.

Sniedovich, M., " On the Reliability of Reliability Constraints," in Reliability in Water Resources Management, E. A. McBean, K. W. Hipel and T. E. Unny, eds., Water Resources Publications, Ft. Collins, Colorado, 1979.

U. S. Bureau of Reclamation, " Program Description and User Manual for SSARR Model - Streamflow Synthesis and Reservoir Regulation, " North Pacific Division, Program 724-KS-G0010, September 1972

Yakowitz, S. D., "Dynamic Programming Applications in Water Resources," Water Resources Research, Vol. 18, No. 4, pp. 673-696, August 1982.

APPENDIX A

LISTINGS OF PROGRAMS MODPEN AND EFEC

```
      PROGRAM MODPEN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,TAPE8,
     * TAPE9)
C
C     ******************************************************************
C
C             WATER RESOURCES PLANNING AND MANAGEMENT PROGRAM
C                    DEPARTMENT OF CIVIL ENGINEERING
C                       COLORADO STATE UNIVERSITY
C                     FORT COLLINS, COLORADO 80523
C                                 1985
C
C     ******************************************************************
C
C     THIS PROGRAM CALCULATES WEEKLY OR MONTHLY CROP EVAPOTRANSPIRATION BY
C     THE MODIFIED PENNMAN'S METHOD ("CROP WATER REQUIREMENTS", IRRIGATION
C                   AND DRAINAGE PAPER No. 24, FAO, 1975).
C
C     ******************************************************************
C
      DIMENSION TEMP(364),RH(364),OKTAS(364),EA(364),
     1 ED(364),FU(364),U2(364),W1(364),W2(364),CLOUD(364),
     2 RS(364),RA(12),RNS(364),FT(364),FED(364),FNN(364),
     3 RN1(364),RN(364),ETO(52),I1(364),I2(364),I3(364),
     4 AREA(12,10,8),XKC(10,12),ET1(364),C2(12,8),C1(10,12,8),
     5 ET(52,11),ETOM(12),ETM(12,11),TOTAR(12)
C
C      DICTIONARY:
C
C      AREA    : cropping areas in Ha.
C      CLOUD   : cloudiness
C      EA      : saturation vapor pressure (mbar)
C      ED      : vapor pressure from dewpoint (mbar)
C      ET      : weekly crop evapotranspiration (10E3 m3)
C      ETO     : monthly crop evapotranspiration (10E3 m3)
C      ETO     : referential evapotranspiration (mm/day)
C      FED     : correction for vapor pressure
C      FNN     : correction for bright sunshine
C      FT      : correction for temperature on longwave radiation
C      FU      : wind function (km/day)
C      IYEAR   : current year of study
C      I1      : year of study
C      I2      : month of study
C      I3      : day of study
C      NDAY    : number of days per month
C      NN      : name of the station
C      RA      : extraterrestrial radiation (mm/day)
C      RH      : relative humidity (%)
C      RNS     : net shortwave solar radiation (mm/day)
C      RN      : net radiation (mm/day)
C      RN1     : net longwave radiation (mm/day)
C      RS      : solar radiation (mm/day)
C      TEMP    : mean daily temperature ( C)
C      TD      : mean dewpoint daily temperature ( C)
C      U2      : wind velocity (Km/s)
```

```
C       W1     : meigthing factor for effect of radiation
C       W2     : weigthing factor for effect of the aerodynamic term
C       XKC    : crop coefficients
C
C       FILES USED:
C
C       TAPE5 : METEOROLOGICAL INPUT DATA FILE
C       TAPE6 : OUTPUT FILE
C       TAPE7 : MONTHLY CROPPING AREAS (PER SECTOR AND GROUP CROP) INPUT FILE
C       TAPE8 : MONTHLY CROP COEFFICIENTS INPUT FILE
C       TAPE9 : EFFICIENCY AND YEAR OF STUDY DATA
C
      READ(5,1)(I1(I),I2(I),I3(I),TEMP(I),RH(I),OKTAS(I),U2(I),
     9 I=1,364)
      READ(7,2)(((AREA(I4L,I5L,I2L),I2L=1,8),I5L=1,10),I4L=1,12)
      READ(8,3)((XKC(I4L,I2L),I2L=1,12),I4L=1,10)
      READ(9,5)IYEAR
      DATA RA/11.6,13.0,14.6,15.6,16.1,16.1,16.1,15.8,14.9,
     * 13.6,12.0,11.1/
      DO 80 K1=1,12
       DO 82 K2=1,10
        DO 82 K3=1,8
   82    TOTAR(K1)=AREA(K1,K2,K3)+TOTAR(K1)
   80 TOTAR(K1)=TOTAR(K1)/15.9
      DO 10 I=1,364
       EA(I)=10.**(.835866+.026399*TEMP(I))
       ED(I)=EA(I)*RH(I)/100.
       FU(I)=.27*(1.+U2(I)*.24)
       W1(I)=.571-.013523*TEMP(I)+1.82988E-6*(TEMP(I)**3)
       W2(I)=1.-W1(I)
       CLOUD(I)=.98904-.12321*OKTAS(I)+.00297*(OKTAS(I)**2)-
     6 4.808E-5*(OKTAS(I)**4)
       RS(I)=(.31+.49*CLOUD(I))*RA(I2(I))
       RNS(I)=.75*RS(I)
       FT(I)=1.97E-9*((TEMP(I)+273.15)**4)
       FED(I)=.34-.044*(ED(I)**.5)
       FNN(I)=.1+.9*CLOUD(I)
       RN1(I)=FT(I)*FED(I)*FNN(I)
       RN(I)=RNS(I)-RN1(I)
       ET1(I)=W2(I)*RN(I)+W1(I)*FU(I)*(EA(I)-ED(I))
   10 CONTINUE
      WRITE(6,6)'IRRIGATION DEMANDS FOR YEAR ',IYEAR
      WRITE(6,9)'( UNITS IN 10E03 M3, EXCEPT THOSE INDICATED )'
      WRITE(6,7)'PER','SEC.1','SEC.2','SEC.3','SEC.4','SEC.5',
     1 'SEC.6','SEC.7','SEC.8','TO.CAB','TO.NIZ',
     2 'TOTAL','T.M3/S','TOT.MM'
      WRITE(6,8)' MONTHLY  BASIS'
    1 FORMAT(I6,2I2,4F10.2)
      NI=0
      DO 100 IJ1=1,12
       DO 110 IJ2=1,30
  110   ETOM(IJ1)=ET1(IJ2+NI)+ETOM(IJ1)
        ETOM(IJ1)=ETOM(IJ1)/1000.
  100 NI=NI+30
```

```
      N=0
      DO 20 I2L=1,52
       DO 30 I6L=1,7
 30    ETO(I2L)=ET1(I6L+N)+ETO(I2L)
       ETO(I2L)=ETO(I2L)/1000.
 20   N=N+7
      CALL AREAKC(AREA,XKC,C2)
      DO 60 I=1,52
       DO 60 I5=1,8
 60   ET(I,I5)=ETO(I)*C2(I2(I*7),I5)*0.62893*A1(I5)
      DO 200 II1=1,12
       DO 210 II2=1,8
210    ETM(II1,II2)=ETOM(II1)*C2(II1,II2)*A1(II2)*.62893
       ETM(II1,9)=(ETM(II1,1)+ETM(II1,2)+ETM(II1,3)+ETM(II1,4)+
     1  ETM(II1,5)+ETM(II1,6))
       ETM(II1,10)=(ETM(II1,7)+ETM(II1,8))
       ETM(II1,11)=ETM(II1,9)+ETM(II1,10)
200   CONTINUE
      WRITE(6,4)(I,ETM(I,1),ETM(I,2),ETM(I,3),ETM(I,4),ETM(I,5),
     2 ETM(I,6),ETM(I,7),ETM(I,8),ETM(I,9),ETM(I,10),ETM(I,11),
     3 ETM(I,11)/2592.,ETM(I,11)*100./(TOTAR(I)),I=1,12)
      DO 70 I=1,52
        ET(I,9)=(ET(I,1)+ET(I,2)+ET(I,3)+ET(I,4)+ET(I,5)+ET(I,6))
        ET(I,10)=(ET(I,7)+ET(I,8))
        ET(I,11)=ET(I,9)+ET(I,10)
 70   CONTINUE
      WRITE(6,8)' WEEKLY  BASIS'
      WRITE(6,4)(I,ET(I,1),ET(I,2),ET(I,3),ET(I,4),ET(I,5),ET(I,6),
     7 ET(I,7),ET(I,8),ET(I,9),ET(I,10),ET(I,11),ET(I,11)/
     8 604.8,ET(I,11)*100./TOTAR(I2(I*7)),I=1,52)
      WRITE(6,11)'MONTHLY TOTAL CROPPING AREA (HA)'
      WRITE(6,12)(I,TOTAR(I),I=1,12)
  2   FORMAT((8F10.0))
  3   FORMAT((12F5.2))
  4   FORMAT(I3,11F7.0,2F7.2)
  5   FORMAT(3F4.1,F5.2,I5)
 6    FORMAT(40X,A28,I4,/)
 7    FORMAT(A3,13(1X,A6),/)
 8    FORMAT(/,50X,A20,/)
 9    FORMAT(/,35X,A50,/)
 11   FORMAT(/,A50,/)
 12   FORMAT(I10,F10.2)
      STOP
      END
      SUBROUTINE AREAKC(AREA,XKC,C2)
      DIMENSION AREA(12,10,8),C1(10,12,8),C2(12,8),XKC(10,12)
 2    FORMAT(8F9.0)
 3    FORMAT(12F6.2)
      DO 100 J2=1,12
       DO 110 I5=1,8
        DO 120 I4=1,10
         C1(I4,J2,I5)=AREA(J2,I4,I5)*XKC(I4,J2)
      C2(J2,I5)=C2(J2,I5)+C1(I4,J2,I5)
 120      CONTINUE
```

```
 110      CONTINUE
100   CONTINUE
  4   FORMAT(8F10.0)
  5   FORMAT(8F10.0)
      RETURN
      END
```

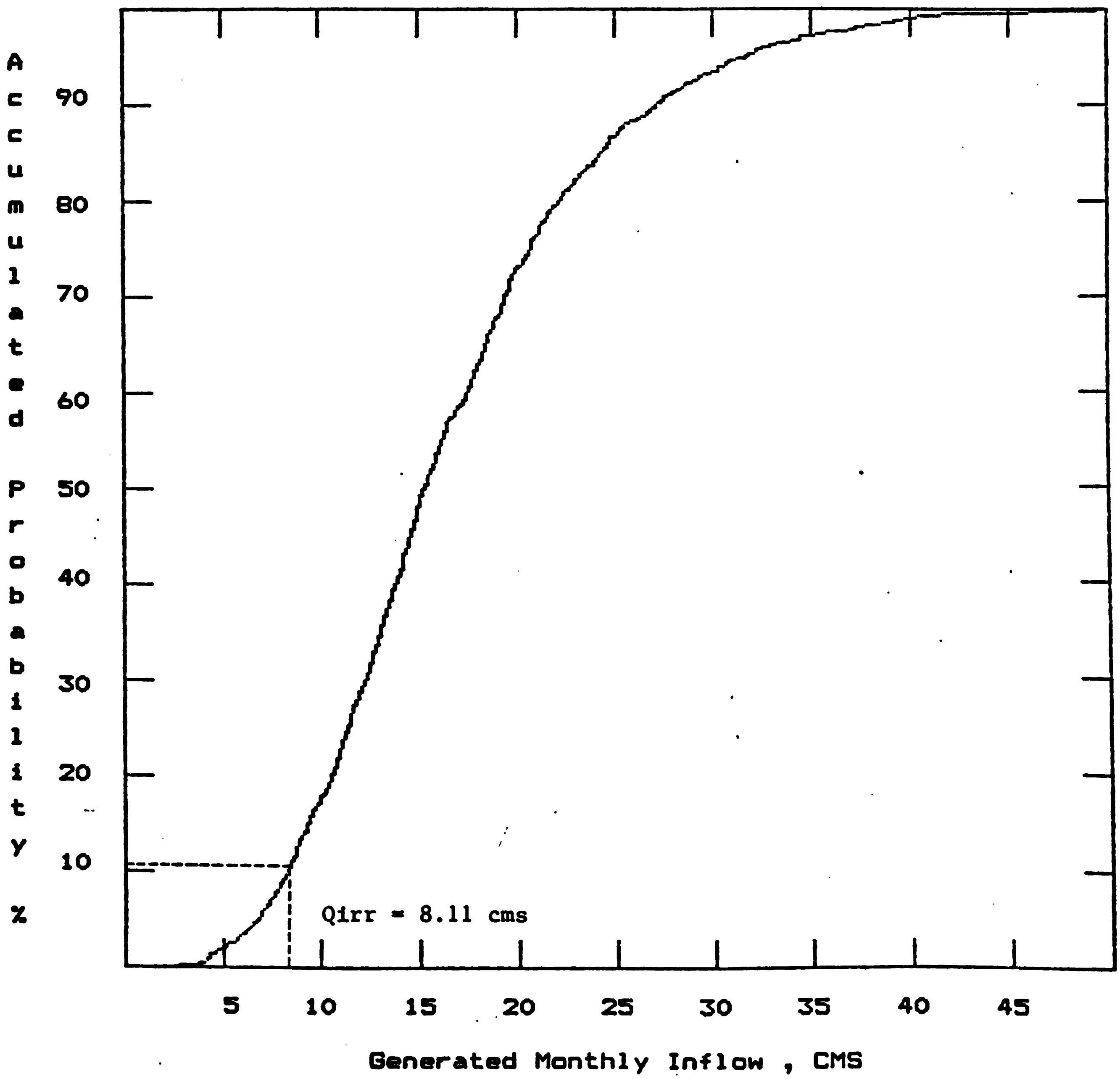
```
      PROGRAM EFEC(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C     **********************************************************************
C
C                 WATER RESOURCES PLANNING AND MANAGEMENT PROGRAM
C                       DEPARTMENT OF CIVIL ENGINEERING
C                          COLORADO STATE UNIVERSITY
C                        FORT COLLINS, COLORADO 80523
C                                    1985
C
C     **********************************************************************
C
C     THIS PROGRAM CALCULATES DAILY, WEEKLY OR MONTHLY EFFECTIVE PRECIPITATION
C     BY THE METHOD DEVELOPED BY H. J. MOREL-SEYTOUX AND J. I. RESTREPO ("SUB-
C     ROUTINE RAIN", DEPT. OF CIVIL ENG., COLORADO STATE UNIVERSITY, 1985).
C
C     **********************************************************************
C
      DIMENSION EP(365),PT(365),DELPE(365),SUM(12)
C
C     DICTIONARY:
C
C    DELPE   : daily effective precipitation depth (cm)
C    DELPWP  : daily infiltration depth due to precipitation (cm)
C    DELZR   : thickness of the root zone (cm)
C    DDP     : daily surface drainage due to precipitation (cm)
C    DELWEP  : daily effective infiltration depth due to precipitation (cm)
C    EP      : evaporation rate (cm/day)
C    ESP     : daily evaporation depth that is intercepted or has fallen into
C              depression storage (cm).  Principles stated by horton (linsley
C              et al., 1982)
C    IYEAR   : year of study
C    NP      : positive dimensionless recharge parameter for the precipitation
C              process
C    P       : daily precipitation depth reaching the ground that does not
C              evaporate (cm)
C    PC      : critical precipitation depth (cm)
C    PT      : total daily precipitation depth (cm)
C    SUM     : total weekly or monthly effective precipitation depth (cm)
C    THEFC   : field capacity moisture (values from 0 to 1)
C    THEO    : actual moisture (values from 0 to 1)
C    TP      : rainfall duration (days)
C    XK      : hydraulic conductivity (cm/day)
C
C    FILES USED:
C
C    TAPE5 : INPUT DATA FILE : FIELD COEFFICIENTS (TP, PC, XK, THEFC,
C            THEO, NP, IYEAR, DELZR) AND METEOROLOGICAL DATA (PT AND EP)
C    TAPE6 : OUTPUT FILE
C
      READ(5,1)TP,PC,XK,THEFC,THEO,NP,IYEAR,DELZR,(PT(I),EP(I),I=1,365)
      DO 10 L1=1,365
       EP(L1)=EP(L1)/10.
       PT(L1)=PT(L1)/10.
```

```
      G1=PC+EP(L1)*TP
      IF(PT(L1).GT.G1)THEN
       ESP=G1*(1-EXP(-PT(L1)/G1))
       P=PT(L1)-ESP
      ELSE
       ESP=PT(L1)
       P=0.
       DELPE(L1)=0.
       DELPWP=0.
       DDP=0.
       DELWEP=0.
       GO TO 10
      ENDIF
       G2=XK*TP
       IF(P.GT.G2)THEN
        DDP=DP-G2
        DELWP=G2
       ELSE
        DDP=0.
        DELWP=P
       ENDIF
       G3=(THEFC-THEO)*DELZR
       IF(DELWP.LT.G3)THEN
        DELWEP=(DELWP**(NP+1))/((NP+1)*(G3**NP))
       ELSE
        DELWEP=DELWP-(NP*G3/(NP+1))
       ENDIF
       DELPE(L1)=DELWP-DELWEP
 10   CONTINUE
      L4=0
      DO 20 L2=1,12
       DO 30 L3=1,30
30      SUM(L2)=SUM(L2)+DELPE(L3+L4)
 20   L4=L4+30
     WRITE(6,3)'EFFECTIVE PRECIPITATION (MM) FOR YEAR ',IYEAR
3    FORMAT(A39,I4,/)
      WRITE(6,2)(I,SUM(I)*10.,I=1,12)
  2   FORMAT(I10,F10.2)
  1   FORMAT(5F5.2,2I5,F5.2/,(10X,2F10.2))
     STOP
     END
```

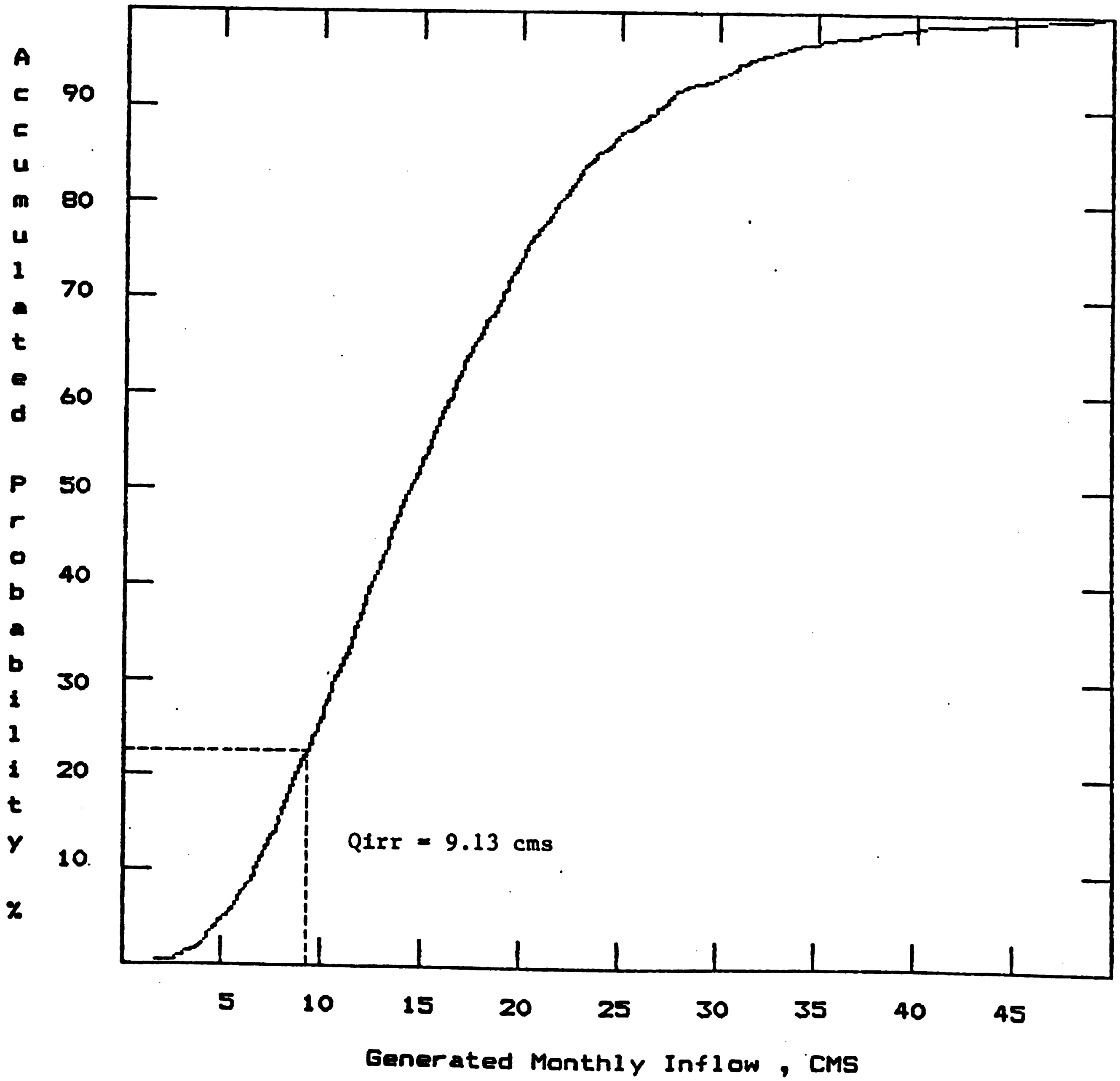
APPENDIX B

MONTHLY FREQUENCY DISTRIBUTIONS FOR STOCHASTICALLY GENERATED VALDESIA INFLOWS

Probability Distribution of Generated Monthly Inflow

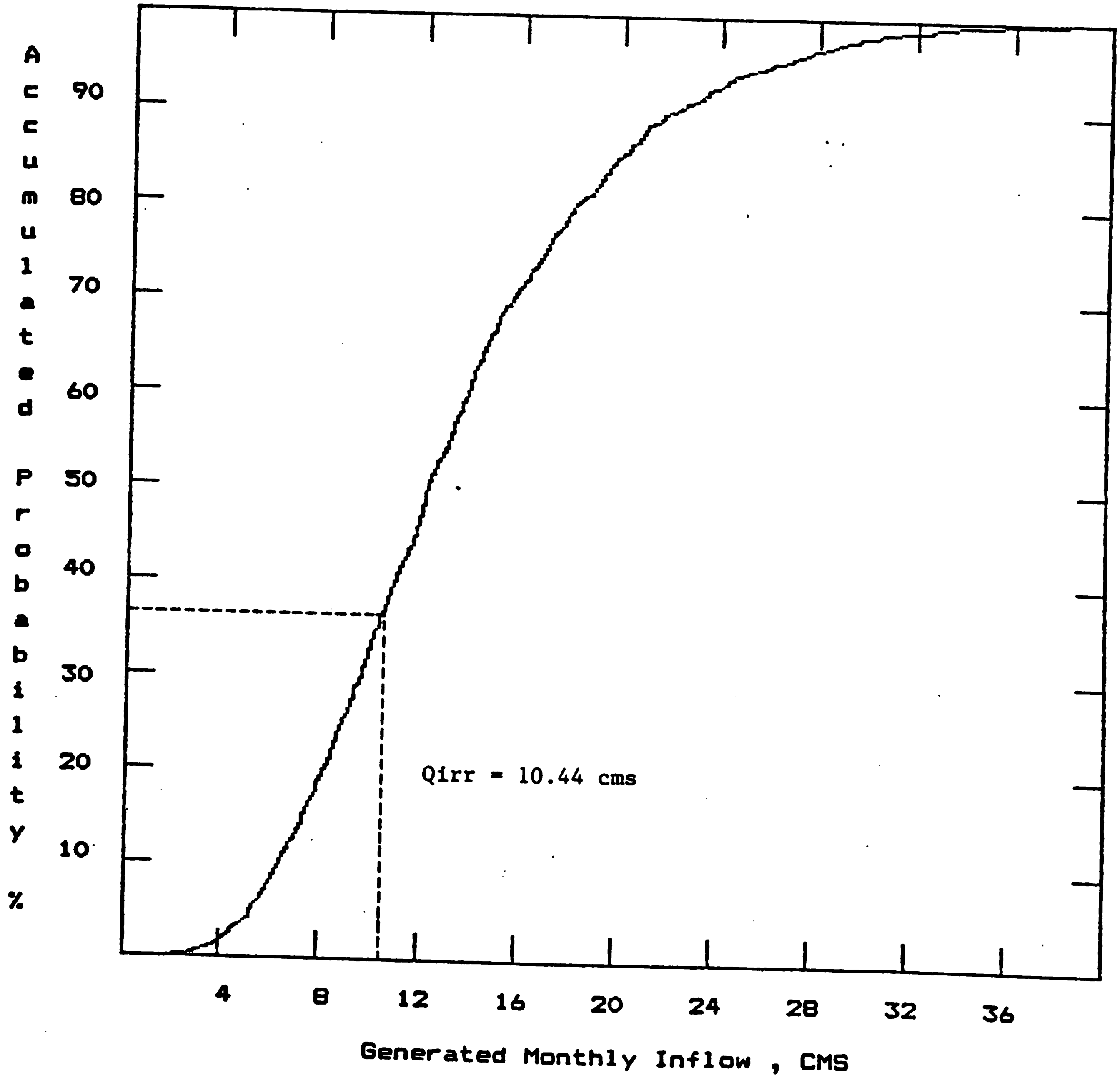


January



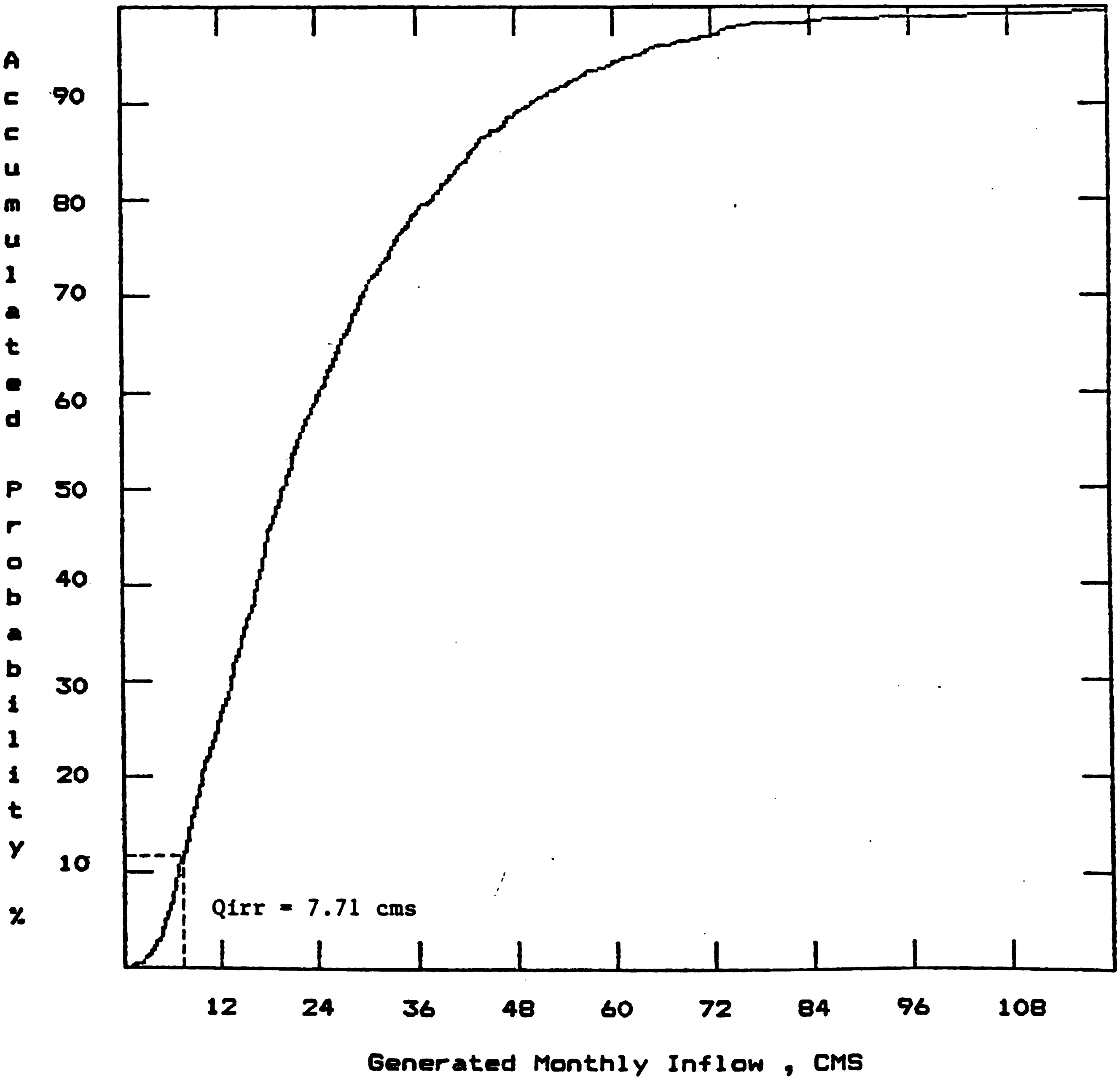
Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 9.13 cms
5
10
15
20
25
30
35
40
45
Generated Monthly Inflow , CMS

February

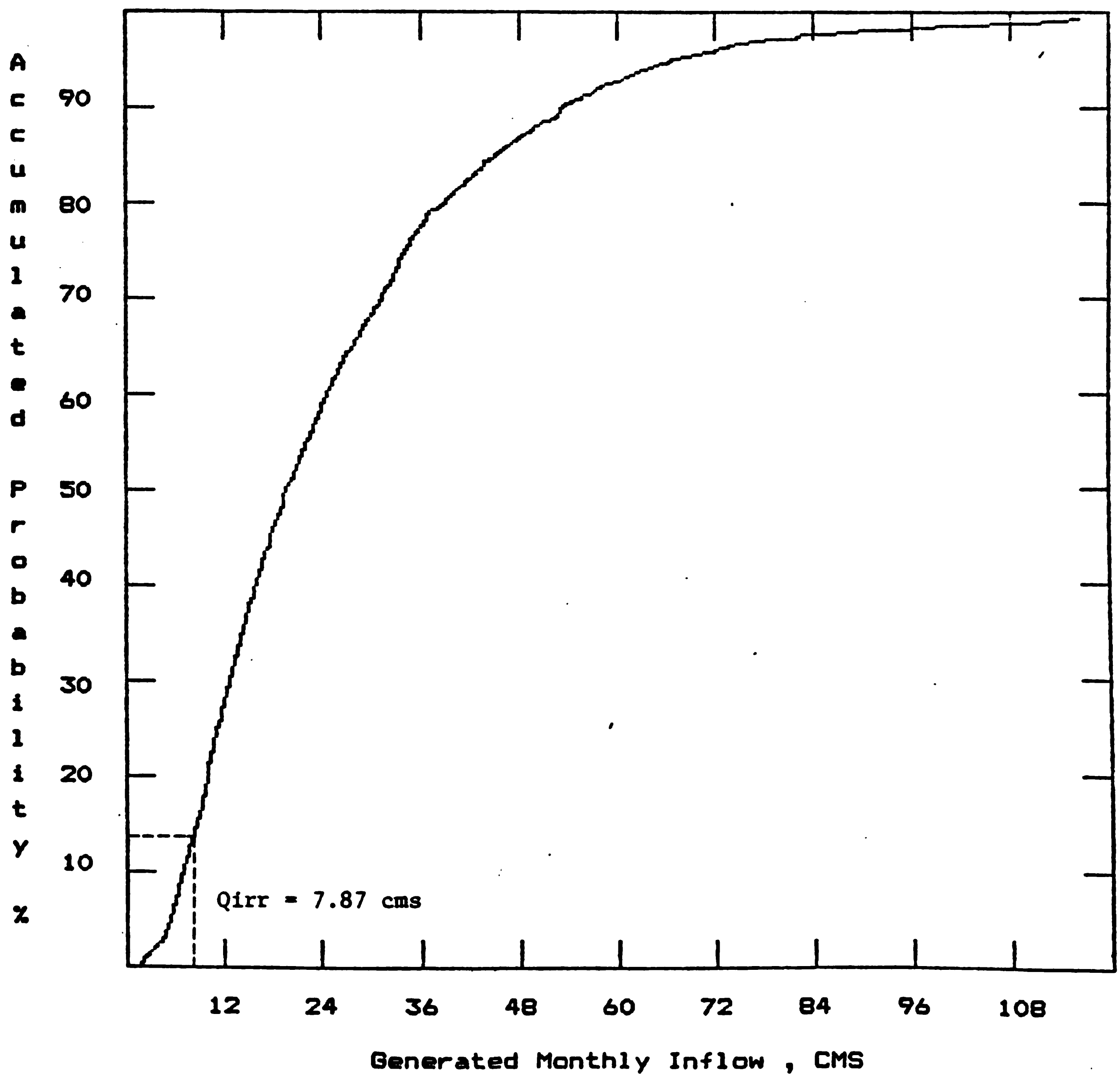


Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 10.44 cms
4
8
12
16
20
24
28
32
36
Generated Monthly Inflow , CMS

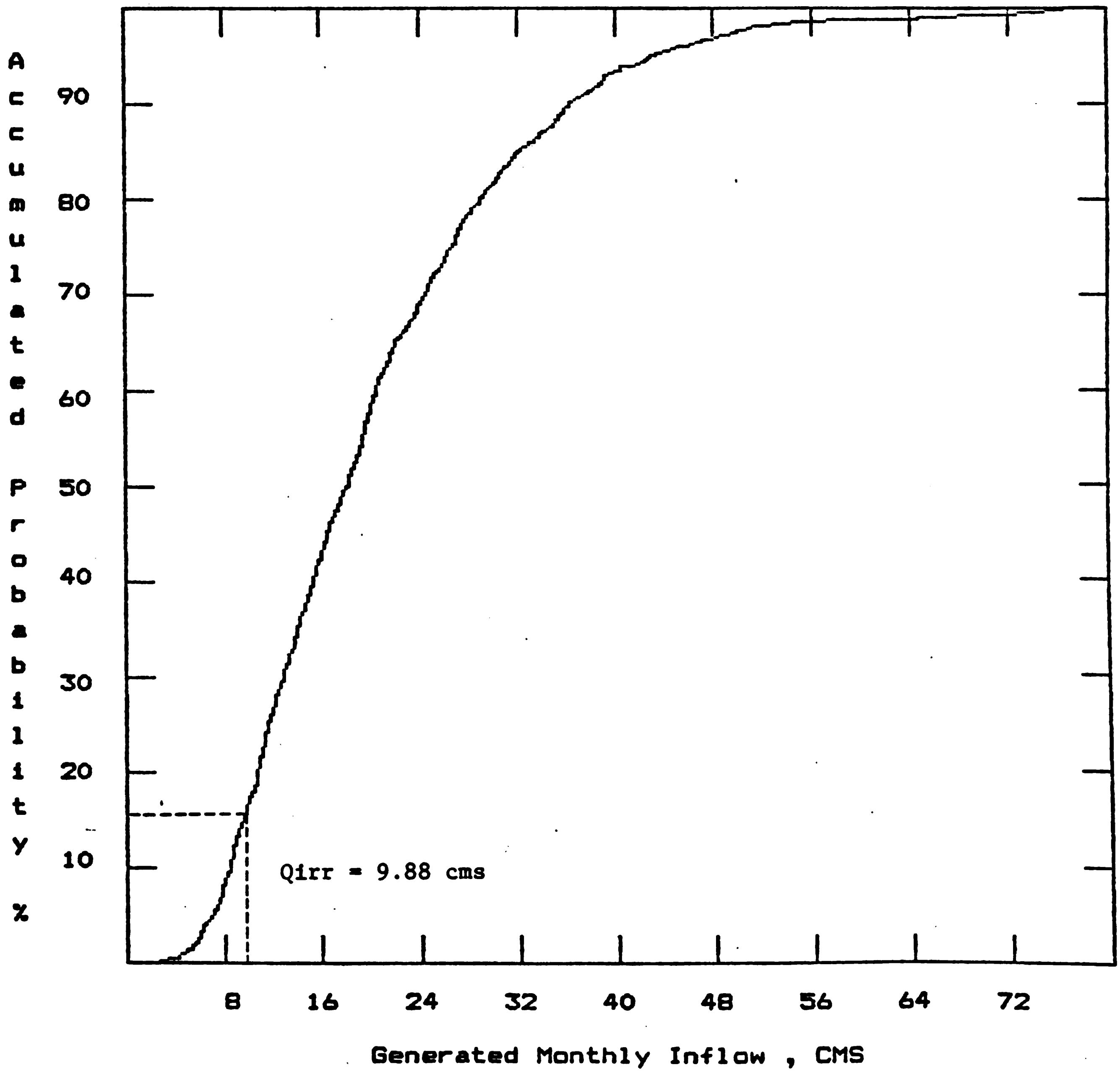
April


Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 7.71 cms
12
24
36
48
60
72
84
96
108
Generated Monthly Inflow , CMS

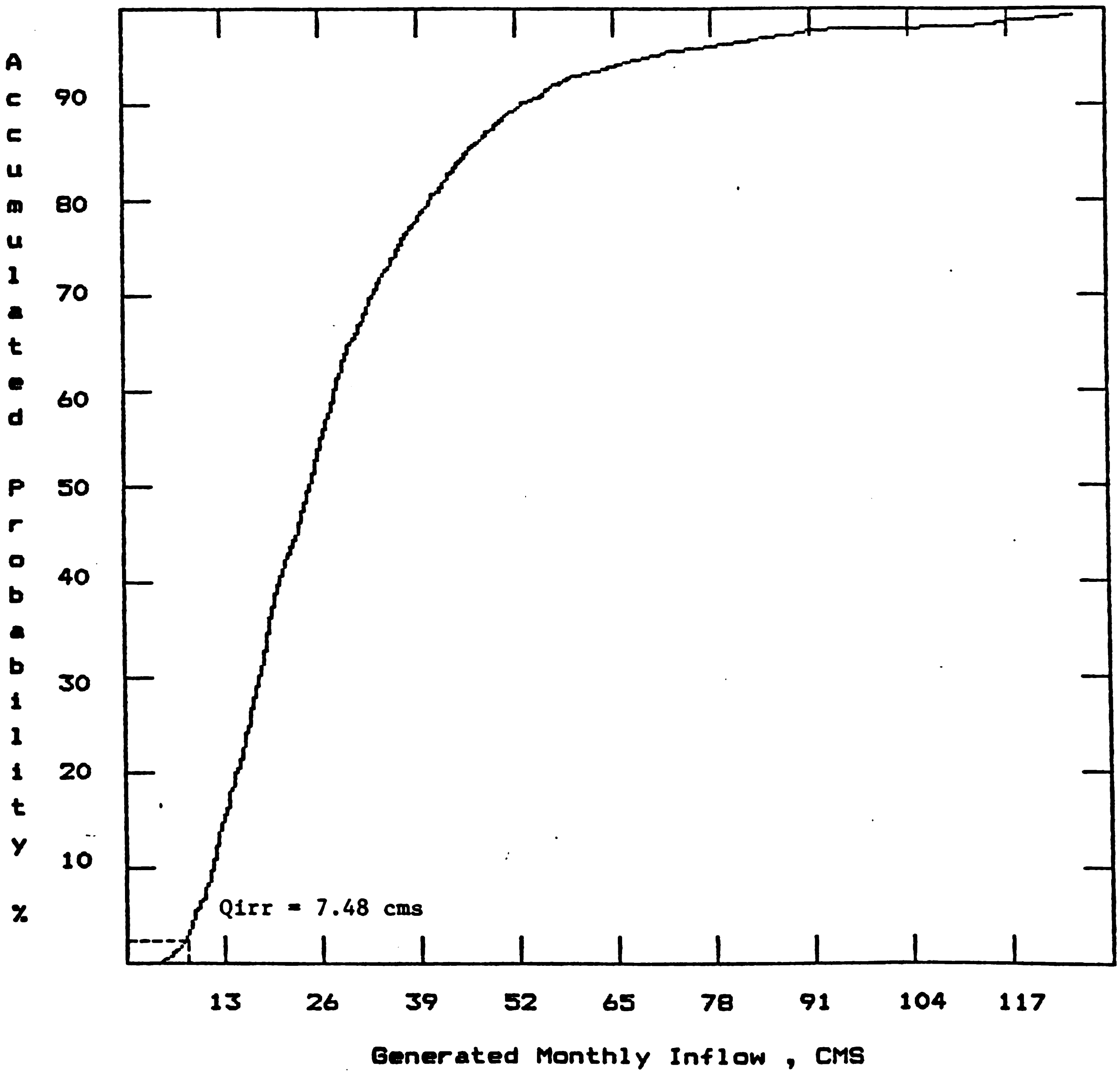
May


Accumulated Probability %
10
20
30
40
50
60
70
80
90
Qirr = 7.87 cms
12
24
36
48
60
72
84
96
108
Generated Monthly Inflow , CMS

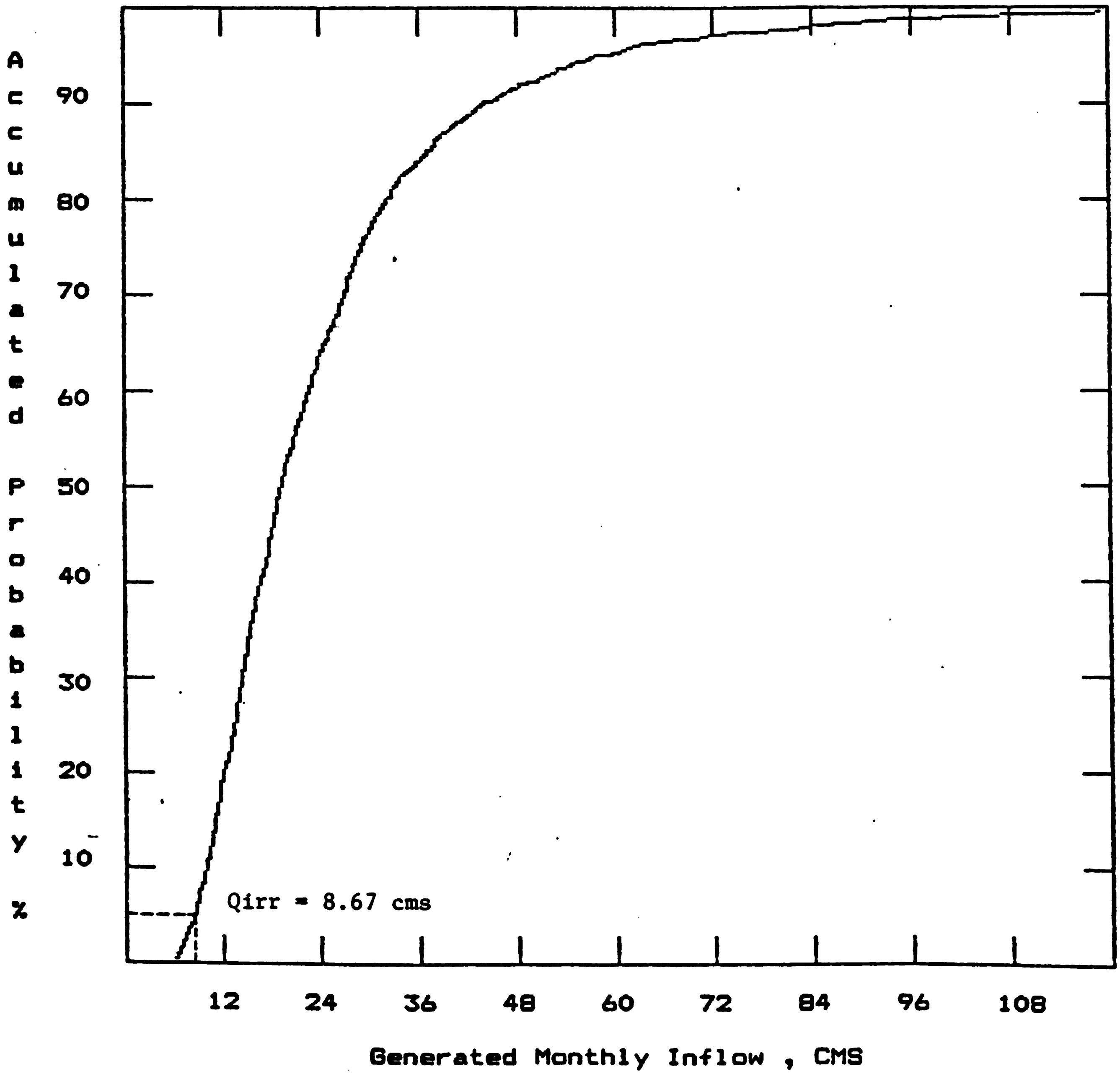
June


Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 9.88 cms
8
16
24
32
40
48
56
64
72
Generated Monthly Inflow , CMS

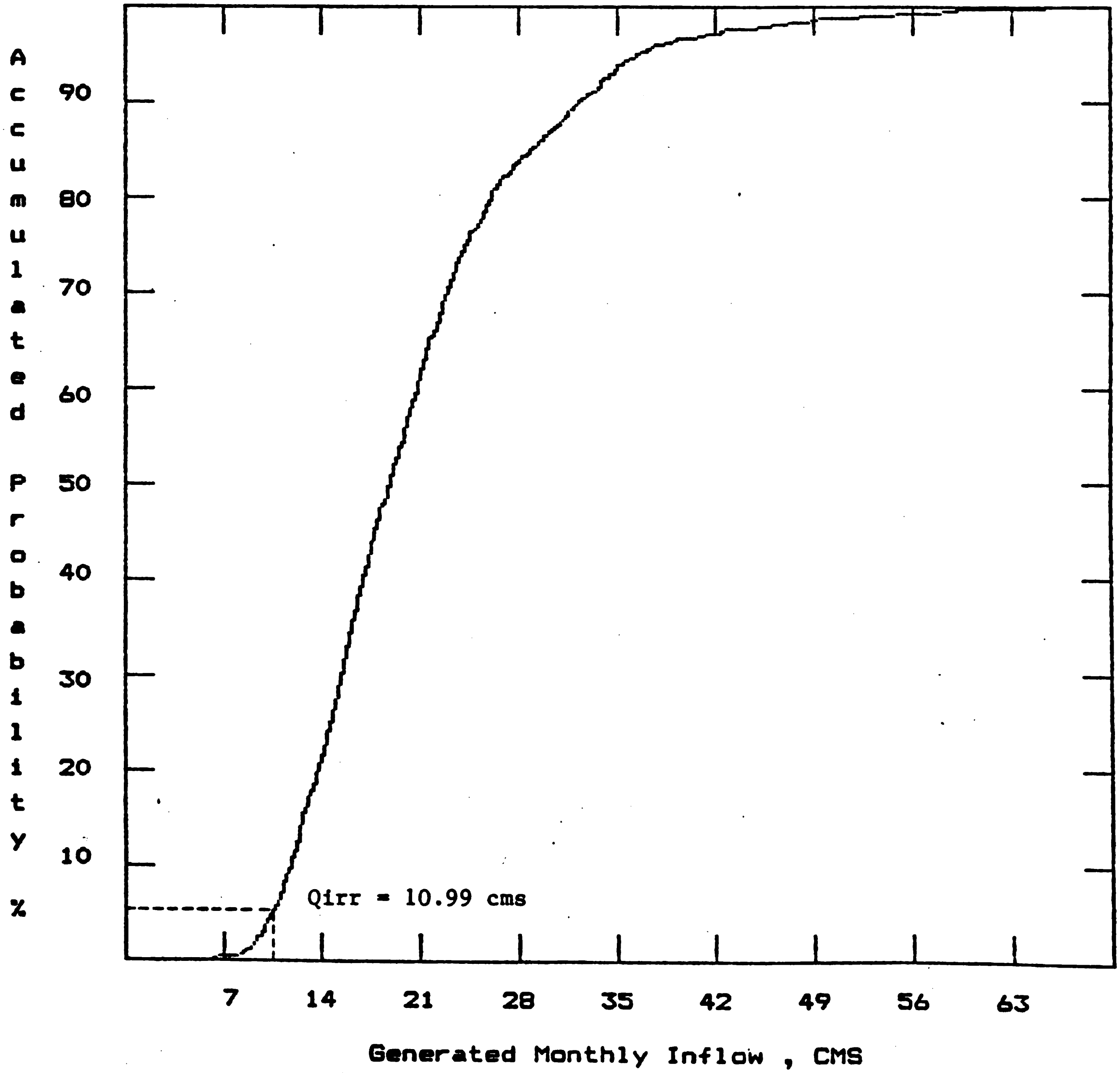
July


Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 7.48 cms
13
26
39
52
65
78
91
104
117
Generated Monthly Inflow , CMS

August

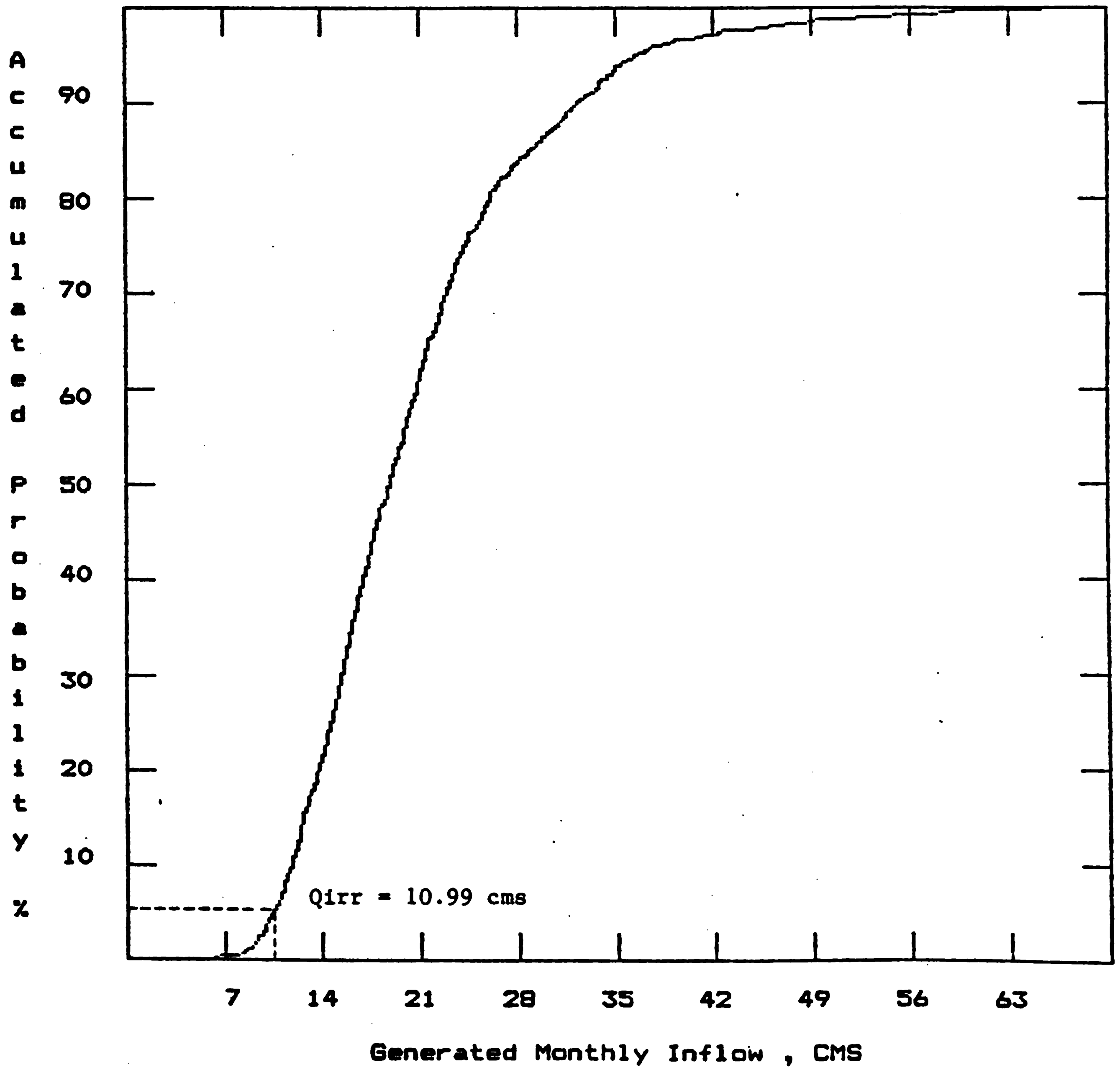

Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 8.67 cms
12
24
36
48
60
72
84
96
108
Generated Monthly Inflow , CMS

September

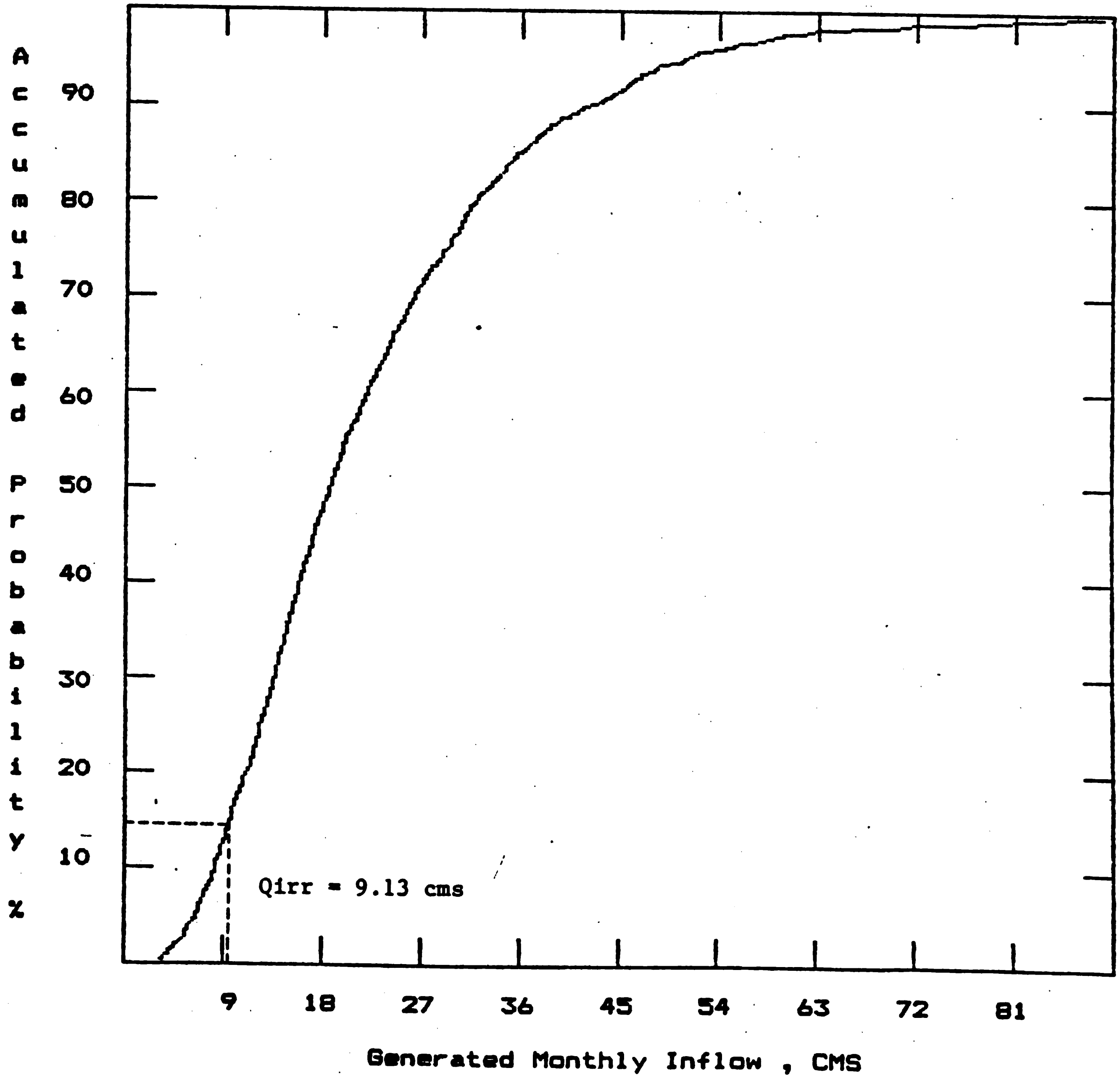


Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 10.99 cms
7
14
21
28
35
42
49
56
63
Generated Monthly Inflow , CMS

November


Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 10.99 cms
7
14
21
28
35
42
49
56
63
Generated Monthly Inflow , CMS

November



Accumulated Probability %
90
80
70
60
50
40
30
20
10
Qirr = 9.13 cms
9
18
27
36
45
54
63
72
81
Generated Monthly Inflow , CMS

December

APPENDIX C

MONTHLY INFLOW TRANSITION PROBABILITY MATRICES

(b) From January To February , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	4.0087	6.1114	7.8893	9.8973	11.740	13.528	15.542	17.757	20.398	24.194	29.196	38.625
01	5.4373	0.6182	0.2182	0.1091	0.0182	0.0182	0.0000	0.0182	0.0000	0.0000	0.0000	0.0000	0.0000
		34	12	6	1	1	0	1	0	0	0	0	0
02	7.6887	0.1636	0.2545	0.2909	0.2000	0.0545	0.0182	0.0182	0.0000	0.0000	0.0000	0.0000	0.0000
		9	14	16	11	3	1	1	0	0	0	0	0
03	9.4965	0.0917	0.1284	0.2936	0.1927	0.1560	0.0734	0.0459	0.0183	0.0000	0.0000	0.0000	0.0000
		10	14	32	21	17	8	5	2	0	0	0	0
04	11.477	0.0180	0.0541	0.2703	0.2613	0.1441	0.1261	0.0631	0.0360	0.0180	0.0090	0.0000	0.0000
		2	6	30	29	16	14	7	4	2	1	0	0
05	13.117	0.0000	0.0273	0.1091	0.2000	0.2455	0.1455	0.1364	0.0909	0.0273	0.0182	0.0000	0.0000
		0	3	12	22	27	16	15	10	3	2	0	0
06	14.603	0.0000	0.0273	0.1000	0.1000	0.1636	0.1364	0.1909	0.1545	0.0909	0.0273	0.0091	0.0000
		0	3	11	11	18	15	21	17	10	3	1	0
07	16.293	0.0000	0.0091	0.0273	0.1000	0.1364	0.1727	0.1636	0.1727	0.1091	0.0818	0.0273	0.0000
		0	1	3	11	15	19	18	19	12	9	3	0
08	18.472	0.0000	0.0000	0.0091	0.0182	0.0273	0.2000	0.1727	0.1909	0.1909	0.1727	0.0182	0.0000
		0	0	1	2	3	22	19	21	21	19	2	0
09	20.683	0.0000	0.0091	0.0000	0.0182	0.0727	0.0818	0.1636	0.1636	0.2364	0.1455	0.0909	0.0182
		0	1	0	2	8	9	18	18	26	16	10	2
10	24.433	0.0000	0.0000	0.0000	0.0000	0.0182	0.0455	0.0455	0.1364	0.2182	0.3545	0.1455	0.0364
		0	0	0	0	2	5	5	15	24	39	16	4
11	29.233	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182	0.0000	0.0364	0.1455	0.2727	0.2727	0.2545
		0	0	0	0	0	1	0	2	8	15	15	14
12	37.399	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0364	0.0727	0.1091	0.1455	0.6364
		0	0	0	0	0	0	0	2	4	6	8	35

(d) From March to April , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	4.3508	5.9561	7.4184	8.9743	10.322	11.737	13.075	14.619	16.921	20.014	23.931	30.353
01	3.9725	0.4545	0.1273	0.1818	0.1091	0.0545	0.0364	0.0182	0.0000	0.0000	0.0182	0.0000	0.0000
		25	7	10	6	3	2	1	0	0	1	0	0
02	5.7109	0.1455	0.2000	0.2727	0.1091	0.1455	0.0909	0.0182	0.0000	0.0182	0.0000	0.0000	0.0000
		8	11	15	6	8	5	1	0	1	0	0	0
03	7.1656	0.1000	0.1182	0.2273	0.1545	0.1091	0.1273	0.0364	0.0455	0.0455	0.0273	0.0091	0.0000
		11	13	25	17	12	14	4	5	5	3	1	0
04	8.8120	0.0182	0.0727	0.1818	0.2000	0.1364	0.0909	0.0909	0.1182	0.0727	0.0182	0.0000	0.0000
		2	8	20	22	15	10	10	13	8	2	0	0
05	10.275	0.0455	0.0727	0.1000	0.1818	0.1636	0.1636	0.0818	0.1273	0.0455	0.0182	0.0000	0.0000
		5	8	11	20	18	18	9	14	5	2	0	0
06	12.016	0.0273	0.0364	0.1364	0.0636	0.1545	0.1455	0.1636	0.0727	0.0909	0.0727	0.0273	0.0091
		3	4	15	7	17	16	18	8	10	8	3	1
07	13.763	0.0000	0.0273	0.0545	0.1182	0.1000	0.1273	0.1273	0.1545	0.1182	0.1273	0.0364	0.0091
		0	3	6	13	11	14	14	17	13	14	4	1
08	15.501	0.0000	0.0091	0.0364	0.0364	0.1364	0.1000	0.1818	0.1455	0.1636	0.1455	0.0182	0.0273
		0	1	4	4	15	11	20	16	18	16	2	3
09	17.678	0.0000	0.0000	0.0182	0.1000	0.0727	0.0818	0.1364	0.1455	0.1364	0.1818	0.0909	0.0364
		0	0	2	11	8	9	15	16	15	20	10	4
10	21.527	0.0091	0.0000	0.0182	0.0364	0.0273	0.1000	0.1091	0.1364	0.1545	0.1818	0.1182	0.1091
		1	0	2	4	3	11	12	15	17	20	13	12
11	26.341	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1091	0.0727	0.2000	0.3091	0.1818	0.1273
		0	0	0	0	0	0	6	4	11	17	10	7
12	34.457	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0364	0.1273	0.1273	0.2182	0.4909
		0	0	0	0	0	0	0	2	7	7	12	27

(e) From April to May , 1100 data

Level	Mark	01	02	03	04	05	06	07	08	09	10	11	12
	Mark	4.0241	6.1822	8.4843	11.781	15.218	18.337	22.153	27.156	33.337	43.358	55.936	83.589
01	4.3508	0.4000	0.2000	0.2364	0.0545	0.0182	0.0000	0.0364	0.0364	0.0182	0.0000	0.0000	0.0000
		22	11	13	3	1	0	2	2	1	0	0	0
02	5.9561	0.1818	0.1455	0.2727	0.1636	0.0727	0.0909	0.0182	0.0364	0.0182	0.0000	0.0000	0.0000
		10	8	15	9	4	5	1	2	1	0	0	0
03	7.4184	0.0909	0.1636	0.1727	0.1727	0.1091	0.1636	0.0727	0.0182	0.0273	0.0091	0.0000	0.0000
		10	18	19	19	12	18	8	2	3	1	0	0
04	8.9743	0.0545	0.0727	0.1727	0.1636	0.1636	0.1727	0.1182	0.0727	0.0091	0.0000	0.0000	0.0000
		6	8	19	18	18	19	13	8	1	0	0	0
05	10.322	0.0364	0.0273	0.1364	0.1455	0.1545	0.1364	0.0727	0.1091	0.1091	0.0545	0.0182	0.0000
		4	3	15	16	17	15	8	12	12	6	2	0
06	11.737	0.0182	0.0273	0.1091	0.1364	0.1636	0.0545	0.1182	0.1273	0.1364	0.1091	0.0000	0.0000
		2	3	12	15	18	6	13	14	15	12	0	0
07	13.075	0.0000	0.0182	0.1091	0.1273	0.0727	0.1182	0.1182	0.1727	0.1091	0.0818	0.0545	0.0182
		0	2	12	14	8	13	13	19	12	9	6	2
08	14.619	0.0000	0.0091	0.0364	0.0636	0.1818	0.1364	0.1455	0.1182	0.1182	0.1000	0.0545	0.0364
		0	1	4	7	20	15	16	13	13	11	6	4
09	16.921	0.0091	0.0091	0.0091	0.0273	0.0636	0.0727	0.1909	0.1364	0.2091	0.1091	0.1091	0.0545
		1	1	1	3	7	8	21	15	23	12	12	6
10	20.014	0.0000	0.0000	0.0000	0.0364	0.0364	0.0818	0.0909	0.1636	0.1636	0.2727	0.0727	0.0818
		0	0	0	4	4	9	10	18	18	30	8	9
11	23.931	0.0000	0.0000	0.0000	0.0364	0.0182	0.0364	0.0545	0.0545	0.0909	0.3273	0.1818	0.2000
		0	0	0	2	1	2	3	3	5	18	10	11
12	30.353	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0364	0.0364	0.1091	0.2000	0.2000	0.4182
		0	0	0	0	0	0	2	2	6	11	11	23

(f) From May to June , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	4.0005	6.3710	8.8024	11.431	14.444	17.989	22.483	28.019	34.578	45.814	59.784	97.299
01	4.0241	0.3636	0.3091	0.2000	0.0727	0.0545	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		20	17	11	4	3	0	0	0	0	0	0	0
02	6.1822	0.2364	0.0909	0.2364	0.2364	0.0727	0.1091	0.0182	0.0000	0.0000	0.0000	0.0000	0.0000
		13	5	13	13	4	6	1	0	0	0	0	0
03	8.4843	0.1273	0.1091	0.2273	0.1545	0.1455	0.1000	0.0636	0.0545	0.0091	0.0091	0.0000	0.0000
		14	12	25	17	16	11	7	6	1	1	0	0
04	11.781	0.0364	0.1000	0.1818	0.1636	0.2182	0.1091	0.0455	0.0909	0.0455	0.0000	0.0000	0.0091
		4	11	20	18	24	12	5	10	5	0	0	1
05	15.218	0.0273	0.0273	0.1818	0.1364	0.1182	0.1273	0.1636	0.1000	0.0636	0.0455	0.0091	0.0000
		3	3	20	15	13	14	18	11	7	5	1	0
06	18.337	0.0091	0.0273	0.0545	0.1636	0.1636	0.1818	0.1455	0.0818	0.1182	0.0455	0.0091	0.0000
		1	3	6	18	18	20	16	9	13	5	1	0
07	22.153	0.0000	0.0182	0.0545	0.1091	0.1182	0.1182	0.1545	0.2000	0.0727	0.1182	0.0364	0.0000
		0	2	6	12	13	13	17	22	8	13	4	0
08	27.156	0.0000	0.0091	0.0636	0.0364	0.0727	0.1636	0.2091	0.1091	0.1818	0.1091	0.0364	0.0091
		0	1	7	4	8	18	23	12	20	12	4	1
09	33.337	0.0000	0.0091	0.0182	0.0455	0.0909	0.0727	0.1182	0.1273	0.1909	0.2273	0.0545	0.0455
		0	1	2	5	10	8	13	14	21	25	6	5
10	43.358	0.0000	0.0000	0.0000	0.0364	0.0091	0.0636	0.0636	0.1636	0.1818	0.2636	0.1455	0.0727
		0	0	0	4	1	7	7	18	20	29	16	8
11	55.936	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182	0.0909	0.1091	0.2727	0.2182	0.2909
		0	0	0	0	0	0	1	5	6	15	12	16
12	83.589	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182	0.0364	0.0545	0.1636	0.0909	0.2000	0.4364
		0	0	0	0	0	1	2	3	9	5	11	24

(g) From June to July , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	5.7850	7.9154	9.6742	11.845	14.233	16.714	19.446	22.400	26.659	32.556	39.482	55.894
01	4.0005	0.5273	0.2182	0.1455	0.0727	0.0364	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		29	12	8	4	2	0	0	0	0	0	0	0
02	6.3710	0.2000	0.2364	0.3636	0.1273	0.0727	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		11	13	20	7	4	0	0	0	0	0	0	0
03	8.8024	0.1000	0.1091	0.2818	0.2455	0.1636	0.0636	0.0182	0.0000	0.0182	0.0000	0.0000	0.0000
		11	12	31	27	18	7	2	0	2	0	0	0
04	11.431	0.0182	0.0909	0.2455	0.2000	0.1909	0.1455	0.0727	0.0182	0.0182	0.0000	0.0000	0.0000
		2	10	27	22	21	16	8	2	2	0	0	0
05	14.444	0.0091	0.0455	0.1273	0.2000	0.1545	0.1364	0.1818	0.0818	0.0545	0.0091	0.0000	0.0000
		1	5	14	22	17	15	20	9	6	1	0	0
06	17.989	0.0091	0.0091	0.0636	0.1545	0.1364	0.2273	0.1818	0.1091	0.0727	0.0273	0.0091	0.0000
		1	1	7	17	15	25	20	12	8	3	1	0
07	22.483	0.0000	0.0091	0.0182	0.0545	0.1636	0.1273	0.2182	0.1909	0.0909	0.1273	0.0000	0.0000
		0	1	2	6	18	14	24	21	10	14	0	0
08	28.019	0.0000	0.0000	0.0091	0.0364	0.1000	0.1727	0.1364	0.2000	0.1727	0.1182	0.0455	0.0091
		0	0	1	4	11	19	15	22	19	13	5	1
09	34.578	0.0000	0.0000	0.0000	0.0091	0.0273	0.1000	0.0909	0.2000	0.2364	0.2091	0.0909	0.0364
		0	0	0	1	3	11	10	22	26	23	10	4
10	45.814	0.0000	0.0000	0.0091	0.0000	0.0091	0.0091	0.0818	0.1182	0.2182	0.3273	0.1182	0.1091
		0	0	1	0	1	1	9	13	24	36	13	12
11	59.784	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182	0.0364	0.1091	0.1818	0.2545	0.1818	0.2182
		0	0	0	0	0	1	2	6	10	14	10	12
12	97.299	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182	0.0000	0.0545	0.0545	0.1091	0.2909	0.4727
		0	0	0	0	0	1	0	3	3	6	16	26

(h) From July to August , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	7.7630	10.646	13.213	16.576	19.307	22.898	26.456	30.446	36.775	46.200	60.206	111.41
01	5.7850	0.4364 24	0.2545 14	0.1818 10	0.0727 4	0.0364 2	0.0182 1	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0
02	7.9154	0.1667 9	0.2222 12	0.2963 16	0.1481 8	0.1111 6	0.0185 1	0.0370 2	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0
03	9.6742	0.0901 10	0.1802 20	0.2072 23	0.2342 26	0.1712 19	0.0721 8	0.0450 5	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0
04	11.845	0.0636 7	0.0455 5	0.2636 29	0.1455 16	0.1273 14	0.1455 16	0.0909 10	0.0455 5	0.0545 6	0.0182 2	0.0000 0	0.0000 0
05	14.233	0.0364 4	0.0091 1	0.1909 21	0.2091 23	0.1636 18	0.1273 14	0.1091 12	0.0909 10	0.0364 4	0.0273 3	0.0000 0	0.0000 0
06	16.714	0.0091 1	0.0182 2	0.0364 4	0.1364 15	0.2091 23	0.1818 20	0.1091 12	0.1727 19	0.0727 8	0.0545 6	0.0000 0	0.0000 0
07	19.446	0.0000 0	0.0000 0	0.0182 2	0.0727 8	0.1182 13	0.1000 11	0.1636 18	0.2273 25	0.1545 17	0.1182 13	0.0273 3	0.0000 0
08	22.400	0.0000 0	0.0091 1	0.0455 5	0.0455 5	0.0545 6	0.1545 17	0.1818 20	0.0909 10	0.1818 20	0.1909 21	0.0364 4	0.0091 1
09	26.659	0.0000 0	0.0000 0	0.0000 0	0.0273 3	0.0636 7	0.1091 12	0.1636 18	0.1545 17	0.2091 23	0.2091 23	0.0364 4	0.0273 3
10	32.556	0.0000 0	0.0000 0	0.0000 0	0.0182 2	0.0182 2	0.0909 10	0.1000 11	0.1455 16	0.1818 20	0.1818 20	0.1727 19	0.0909 10
11	39.482	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0182 1	0.1091 6	0.1455 8	0.3091 17	0.2182 12	0.2000 11
12	55.894	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0182 1	0.0364 2	0.0727 4	0.0909 5	0.2364 13	0.5455 30

(i) From August to September , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	7.4465	9.3810	11.259	13.565	15.606	18.174	21.029	24.876	29.388	37.564	50.860	86.017
01	7.7630	0.3455	0.3091	0.1818	0.0909	0.0364	0.0364	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		19	17	10	5	2	2	0	0	0	0	0	0
02	10.646	0.1091	0.1636	0.3636	0.1455	0.0727	0.0364	0.0364	0.0727	0.0000	0.0000	0.0000	0.0000
		6	9	20	8	4	2	2	4	0	0	0	0
03	13.213	0.1091	0.1182	0.1818	0.2636	0.1182	0.0818	0.0636	0.0364	0.0273	0.0000	0.0000	0.0000
		12	13	20	29	13	9	7	4	3	0	0	0
04	16.576	0.1000	0.0909	0.1455	0.1455	0.1455	0.1182	0.1182	0.0545	0.0545	0.0273	0.0000	0.0000
		11	10	16	16	16	13	13	6	6	3	0	0
05	19.307	0.0364	0.0364	0.1909	0.0909	0.1182	0.1818	0.1273	0.0727	0.0818	0.0364	0.0273	0.0000
		4	4	21	10	13	20	14	8	9	4	3	0
06	22.898	0.0091	0.0273	0.0727	0.1273	0.1636	0.1364	0.1091	0.1182	0.1455	0.0818	0.0091	0.0000
		1	3	8	14	18	15	12	13	16	9	1	0
07	26.456	0.0000	0.0000	0.0455	0.0818	0.1727	0.1091	0.1909	0.1727	0.1182	0.0818	0.0182	0.0091
		0	0	5	9	19	12	21	19	13	9	2	1
08	30.446	0.0091	0.0000	0.0545	0.0909	0.0818	0.1455	0.1182	0.1455	0.1000	0.1909	0.0364	0.0273
		1	0	6	10	9	16	13	16	11	21	4	3
09	36.775	0.0000	0.0000	0.0273	0.0545	0.0727	0.0727	0.1091	0.1727	0.1636	0.1636	0.1091	0.0545
		0	0	3	6	8	8	12	19	18	18	12	6
10	46.200	0.0000	0.0000	0.0091	0.0273	0.0636	0.1182	0.1091	0.1364	0.1636	0.1727	0.1273	0.0727
		0	0	1	3	7	13	12	15	18	19	14	8
11	60.206	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0545	0.0909	0.2000	0.3091	0.1818	0.1636
		0	0	0	0	0	0	3	5	11	17	10	9
12	111.41	0.0000	0.0000	0.0000	0.0000	0.0182	0.0000	0.0182	0.0182	0.0909	0.1818	0.1636	0.5091
		0	0	0	0	1	0	1	1	5	10	9	28

(j) From September to October , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	8.4400	10.010	11.616	13.156	14.574	16.091	17.709	19.979	22.997	27.103	33.291	47.626
01	7.4465	0.3519 19	0.1111 6	0.2963 16	0.0741 4	0.0185 1	0.0741 4	0.0370 2	0.0000 0	0.0370 2	0.0000 0	0.0000 0	0.0000 0
02	9.3810	0.1964 11	0.1429 8	0.1250 7	0.2321 13	0.0714 4	0.0893 5	0.0536 3	0.0357 2	0.0536 3	0.0000 0	0.0000 0	0.0000 0
03	11.259	0.0818 9	0.1636 18	0.2000 22	0.1909 21	0.0818 9	0.1000 11	0.1091 12	0.0545 6	0.0091 1	0.0000 0	0.0091 1	0.0000 0
04	13.565	0.0545 6	0.1091 12	0.1364 15	0.1636 18	0.1455 16	0.1000 11	0.1000 11	0.0727 8	0.0636 7	0.0455 5	0.0091 1	0.0000 0
05	15.606	0.0727 8	0.0364 4	0.1818 20	0.1000 11	0.1909 21	0.1182 13	0.0909 10	0.0545 6	0.0545 6	0.0727 8	0.0182 2	0.0091 1
06	18.174	0.0091 1	0.0273 3	0.0727 8	0.1455 16	0.1091 12	0.1545 17	0.1727 19	0.1000 11	0.0818 9	0.1000 11	0.0273 3	0.0000 0
07	21.029	0.0000 0	0.0273 3	0.0818 9	0.1000 11	0.1455 16	0.1455 16	0.1182 13	0.1909 21	0.1455 16	0.0273 3	0.0000 0	0.0182 2
08	24.876	0.0000 0	0.0000 0	0.0545 6	0.0636 7	0.1364 15	0.1273 14	0.1182 13	0.0909 10	0.1545 17	0.1545 17	0.0909 10	0.0091 1
09	29.388	0.0091 1	0.0091 1	0.0545 6	0.0545 6	0.0636 7	0.0455 5	0.1273 14	0.1727 19	0.1455 16	0.1636 18	0.0818 9	0.0727 8
10	37.564	0.0000 0	0.0000 0	0.0000 0	0.0273 3	0.0636 7	0.1000 11	0.0909 10	0.1636 18	0.1636 18	0.2182 24	0.0818 9	0.0909 10
11	50.860	0.0000 0	0.0000 0	0.0000 0	0.0182 1	0.0364 2	0.0364 2	0.0364 2	0.0909 5	0.2000 11	0.1818 10	0.2545 14	0.1455 8
12	86.017	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0182 1	0.0182 1	0.0727 4	0.0727 4	0.2545 14	0.1091 6	0.4545 25

(k) From October to November , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	9.4234	11.310	12.869	14.762	16.259	17.935	19.885	21.879	24.449	29.050	34.409	46.006
01	8.4400	0.4909	0.2364	0.1455	0.0364	0.0545	0.0364	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		27	13	8	2	3	2	0	0	0	0	0	0
02	10.010	0.1273	0.1455	0.2909	0.1455	0.0909	0.1091	0.0182	0.0182	0.0364	0.0000	0.0000	0.0182
		7	8	16	8	5	6	1	1	2	0	0	1
03	11.616	0.0459	0.0826	0.2018	0.1927	0.2018	0.1009	0.0642	0.0642	0.0183	0.0275	0.0000	0.0000
		5	9	22	21	22	11	7	7	2	3	0	0
04	13.156	0.0450	0.0991	0.1712	0.1441	0.1532	0.1261	0.0901	0.0631	0.0360	0.0450	0.0270	0.0000
		5	11	19	16	17	14	10	7	4	5	3	0
05	14.574	0.0636	0.0455	0.1000	0.1091	0.1727	0.1182	0.0909	0.1273	0.1182	0.0364	0.0182	0.0000
		7	5	11	12	19	13	10	14	13	4	2	0
06	16.091	0.0273	0.0000	0.1273	0.1545	0.1273	0.1636	0.1818	0.0909	0.0818	0.0455	0.0000	0.0000
		3	0	14	17	14	18	20	10	9	5	0	0
07	17.709	0.0000	0.0545	0.0818	0.1182	0.1273	0.0818	0.1545	0.0818	0.1636	0.0909	0.0091	0.0364
		0	6	9	13	14	9	17	9	18	10	1	4
08	19.979	0.0000	0.0182	0.0545	0.1000	0.0545	0.1091	0.1364	0.1455	0.1455	0.1455	0.0364	0.0545
		0	2	6	11	6	12	15	16	16	16	4	6
09	22.997	0.0000	0.0091	0.0364	0.0364	0.0545	0.0545	0.0818	0.1636	0.1545	0.2182	0.1091	0.0818
		0	1	4	4	6	6	9	18	17	24	12	9
10	27.103	0.0000	0.0091	0.0091	0.0273	0.0182	0.1364	0.1455	0.1455	0.1545	0.1455	0.1364	0.0727
		0	1	1	3	2	15	16	16	17	16	15	8
11	33.291	0.0000	0.0000	0.0000	0.0364	0.0182	0.0545	0.0545	0.1091	0.1091	0.2909	0.1636	0.1636
		0	0	0	2	1	3	3	6	6	16	9	9
12	47.626	0.0000	0.0000	0.0000	0.0182	0.0182	0.0182	0.0364	0.1091	0.1091	0.2000	0.1636	0.3273
		0	0	0	1	1	1	2	6	6	11	9	18

(1) From November to December , 1100 data

Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	5.1575	7.5630	9.7400	12.589	14.874	17.343	20.320	24.207	29.173	36.263	46.281	68.123
01	9.4234	0.4444	0.1667	0.1852	0.1111	0.0185	0.0556	0.0000	0.0000	0.0185	0.0000	0.0000	0.0000
		24	9	10	6	1	3	0	0	1	0	0	0
02	11.310	0.2321	0.2321	0.2500	0.1429	0.0357	0.0179	0.0536	0.0357	0.0000	0.0000	0.0000	0.0000
		13	13	14	8	2	1	3	2	0	0	0	0
03	12.869	0.1364	0.1273	0.2091	0.1818	0.1545	0.1182	0.0455	0.0091	0.0182	0.0000	0.0000	0.0000
		15	14	23	20	17	13	5	1	2	0	0	0
04	14.762	0.0091	0.1000	0.1909	0.2000	0.1364	0.1364	0.0909	0.1000	0.0273	0.0091	0.0000	0.0000
		1	11	21	22	15	15	10	11	3	1	0	0
05	16.259	0.0091	0.0455	0.1727	0.1273	0.1909	0.1636	0.0818	0.1364	0.0545	0.0091	0.0091	0.0000
		1	5	19	14	21	18	9	15	6	1	1	0
06	17.935	0.0000	0.0182	0.1182	0.1000	0.1636	0.1545	0.1455	0.0727	0.1091	0.0909	0.0273	0.0000
		0	2	13	11	18	17	16	8	12	10	3	0
07	19.885	0.0000	0.0091	0.0455	0.1000	0.1364	0.1273	0.2000	0.1182	0.1455	0.0909	0.0273	0.0000
		0	1	5	11	15	14	22	13	16	10	3	0
08	21.879	0.0000	0.0000	0.0273	0.0818	0.1000	0.1091	0.1636	0.1545	0.1273	0.1364	0.0909	0.0091
		0	0	3	9	11	12	18	17	14	15	10	1
09	24.449	0.0000	0.0000	0.0182	0.0636	0.0455	0.0818	0.1545	0.2000	0.1636	0.1636	0.0364	0.0727
		0	0	2	7	5	9	17	22	18	18	4	8
10	29.050	0.0091	0.0000	0.0000	0.0182	0.0273	0.0636	0.0818	0.1182	0.2182	0.2364	0.1455	0.0818
		1	0	0	2	3	7	9	13	24	26	16	9
11	34.409	0.0000	0.0000	0.0000	0.0000	0.0364	0.0182	0.0182	0.1091	0.2000	0.2727	0.1636	0.1818
		0	0	0	0	2	1	1	6	11	15	9	10
12	46.006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0364	0.0545	0.2545	0.1636	0.4909
		0	0	0	0	0	0	0	2	3	14	9	27

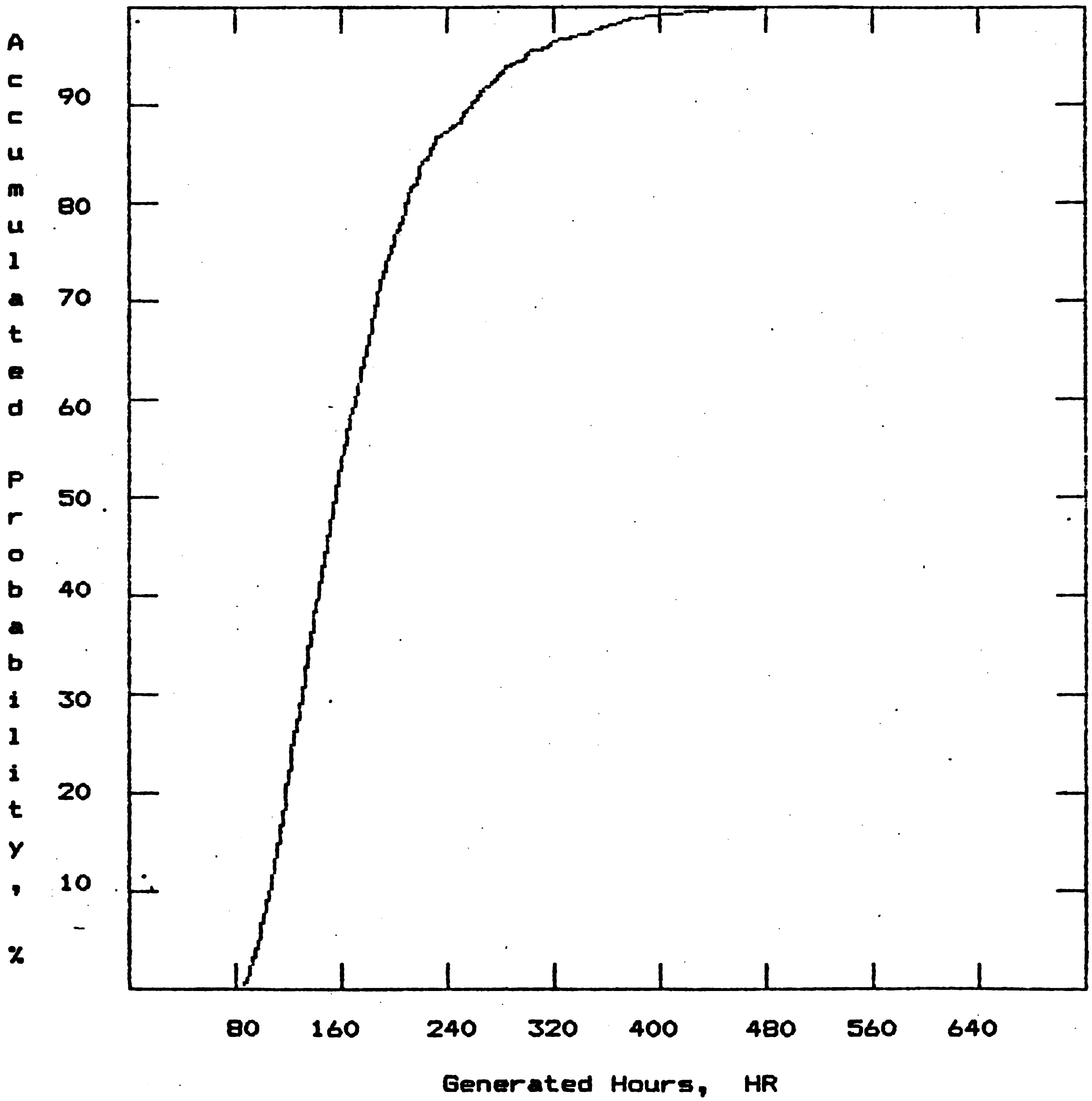
12x12 Transitional Probability Matrix of Generated Monthly Inflow ,
Data in (Probability)/(Frequency) , Mark in CMS

(a) From December to January , 1050 data

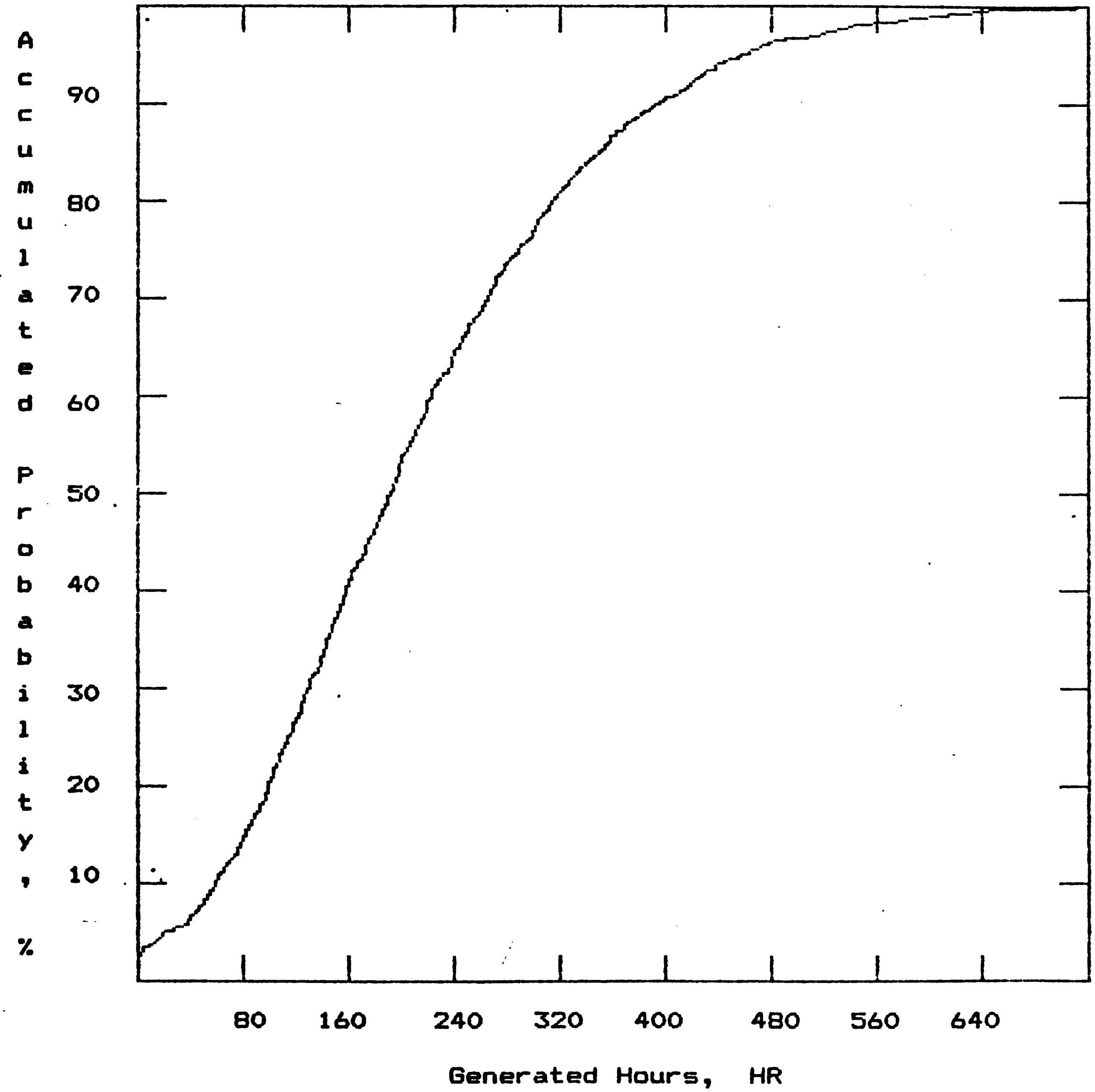
Level		01	02	03	04	05	06	07	08	09	10	11	12
	Mark	5.5102	7.6897	9.4707	11.486	13.111	14.608	16.288	18.488	20.666	24.367	29.279	37.493
01	5.2181	0.5882	0.2157	0.1961	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		30	11	10	0	0	0	0	0	0	0	0	0
02	7.5660	0.1667	0.3148	0.2778	0.1481	0.0741	0.0185	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		9	17	15	8	4	1	0	0	0	0	0	0
03	9.7260	0.0833	0.1481	0.3426	0.2130	0.1204	0.0741	0.0093	0.0093	0.0000	0.0000	0.0000	0.0000
		9	16	37	23	13	8	1	1	0	0	0	0
04	12.574	0.0392	0.0294	0.1667	0.2059	0.2059	0.1176	0.0882	0.0882	0.0392	0.0196	0.0000	0.0000
		4	3	17	21	21	12	9	9	4	2	0	0
05	14.887	0.0000	0.0097	0.1262	0.2621	0.1553	0.1650	0.1262	0.1068	0.0388	0.0097	0.0000	0.0000
		0	1	13	27	16	17	13	11	4	1	0	0
06	17.367	0.0000	0.0377	0.0755	0.0849	0.1698	0.2264	0.1792	0.1226	0.0377	0.0472	0.0189	0.0000
		0	4	8	9	18	24	19	13	4	5	2	0
07	20.308	0.0000	0.0000	0.0288	0.0962	0.1442	0.1346	0.2404	0.1923	0.1154	0.0481	0.0000	0.0000
		0	0	3	10	15	14	25	20	12	5	0	0
08	24.184	0.0000	0.0094	0.0000	0.0283	0.1415	0.1792	0.1321	0.1226	0.2358	0.1415	0.0094	0.0000
		0	1	0	3	15	19	14	13	25	15	1	0
09	29.177	0.0000	0.0000	0.0095	0.0381	0.0190	0.0571	0.1333	0.2000	0.2857	0.1524	0.1048	0.0000
		0	0	1	4	2	6	14	21	30	16	11	0
10	36.336	0.0000	0.0000	0.0000	0.0094	0.0000	0.0377	0.0849	0.1038	0.1792	0.3396	0.1604	0.0849
		0	0	0	1	0	4	9	11	19	36	17	9
11	46.261	0.0000	0.0000	0.0000	0.0185	0.0185	0.0000	0.0185	0.0926	0.0741	0.3704	0.2037	0.2037
		0	0	0	1	1	0	1	5	4	20	11	11
12	69.050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0196	0.0196	0.1176	0.1961	0.6471
		0	0	0	0	0	0	0	1	1	6	10	33

APPENDIX D

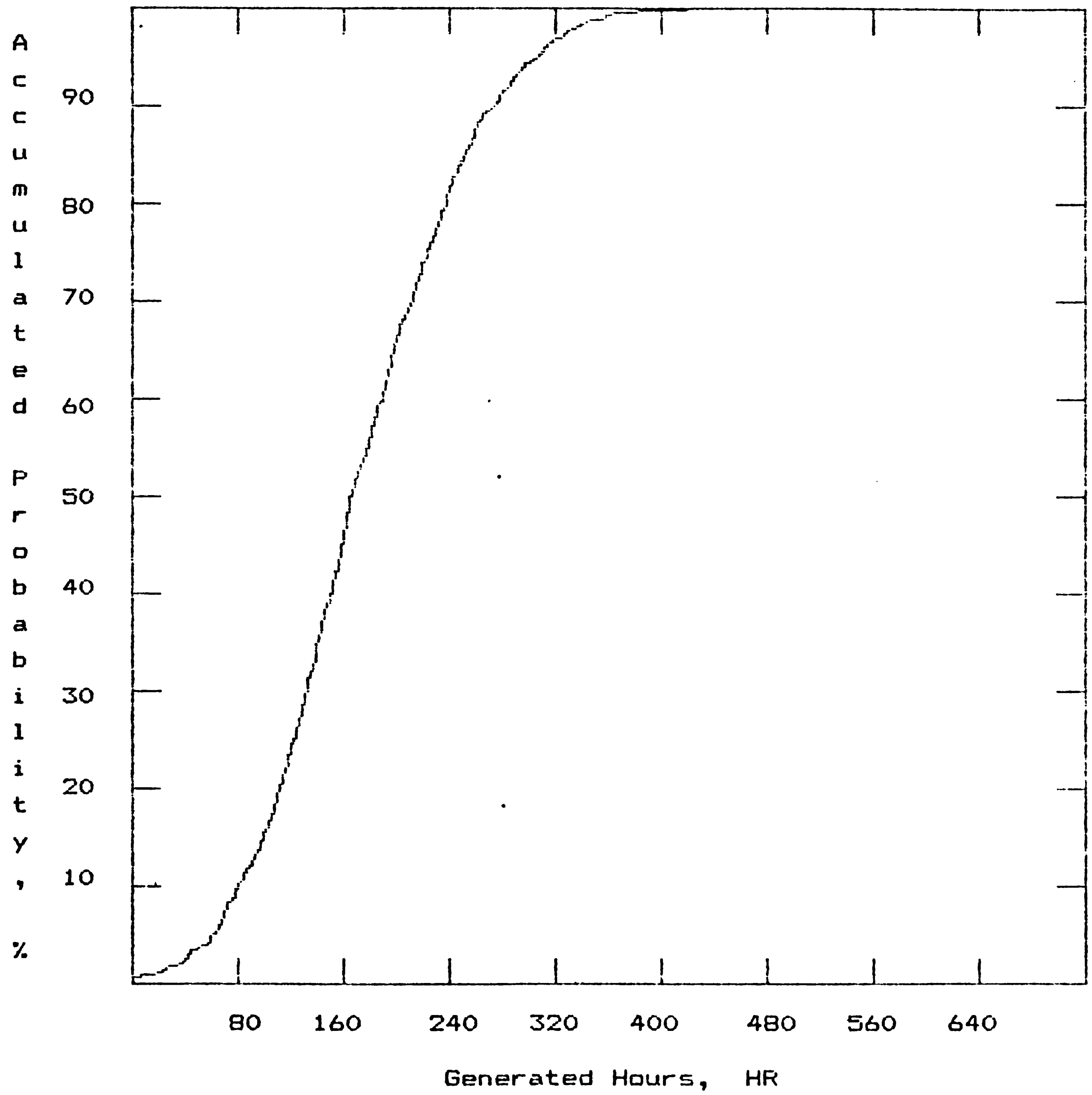
MONTHLY FREQUENCY DISTRIBUTIONS FOR STOCHASTICALLY GENERATED TURBINE HOURS


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

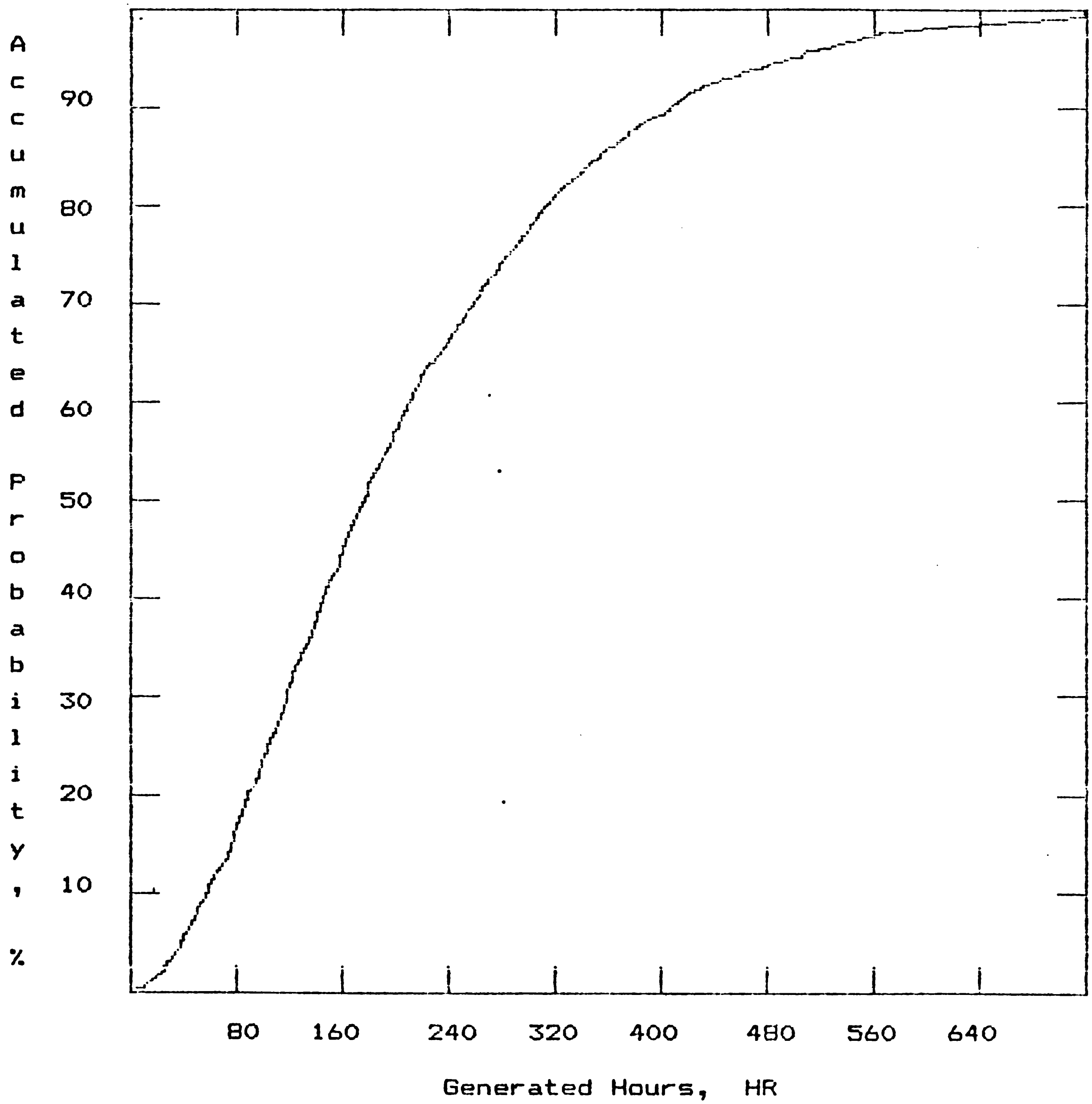
January


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

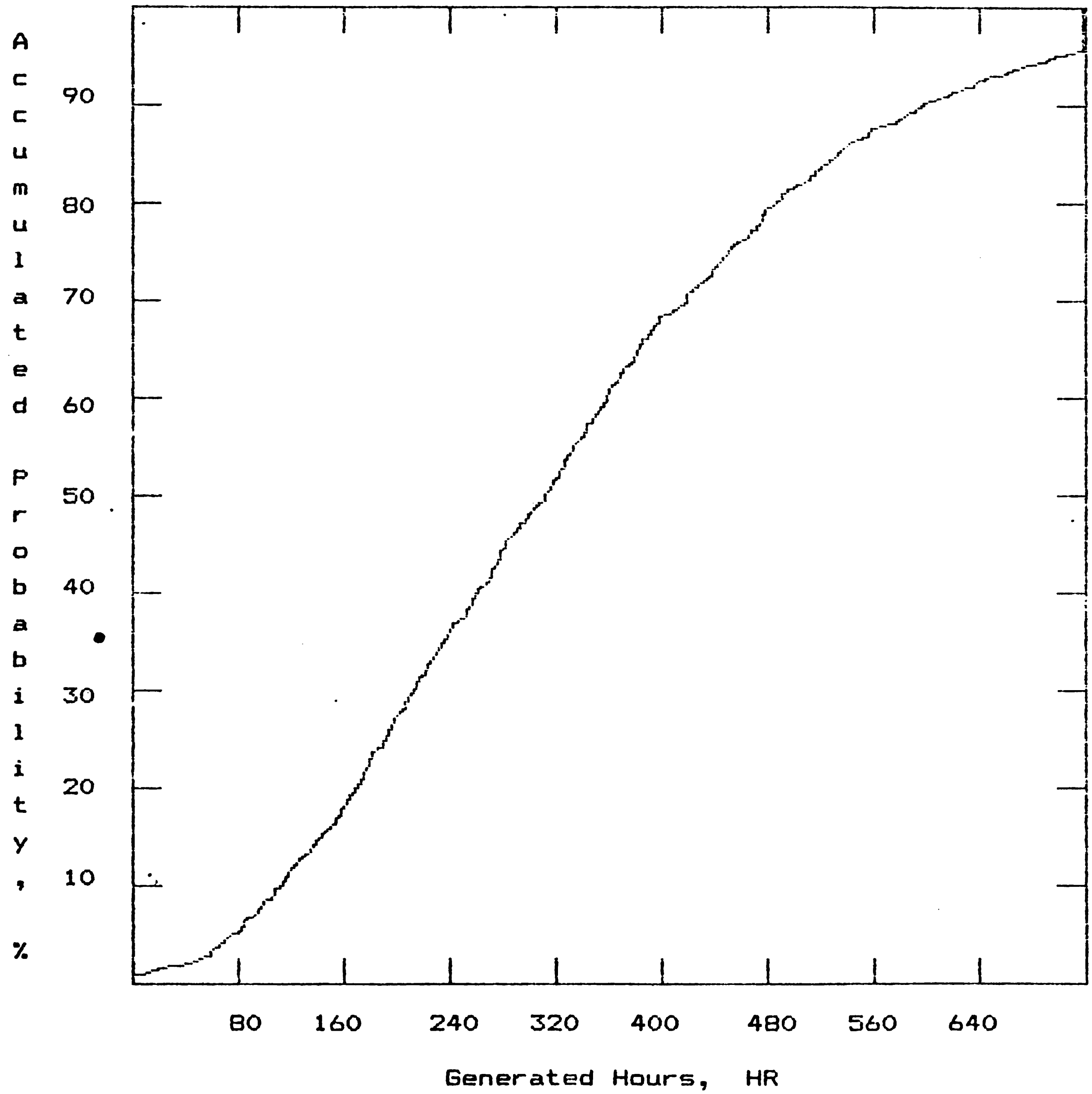
February


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

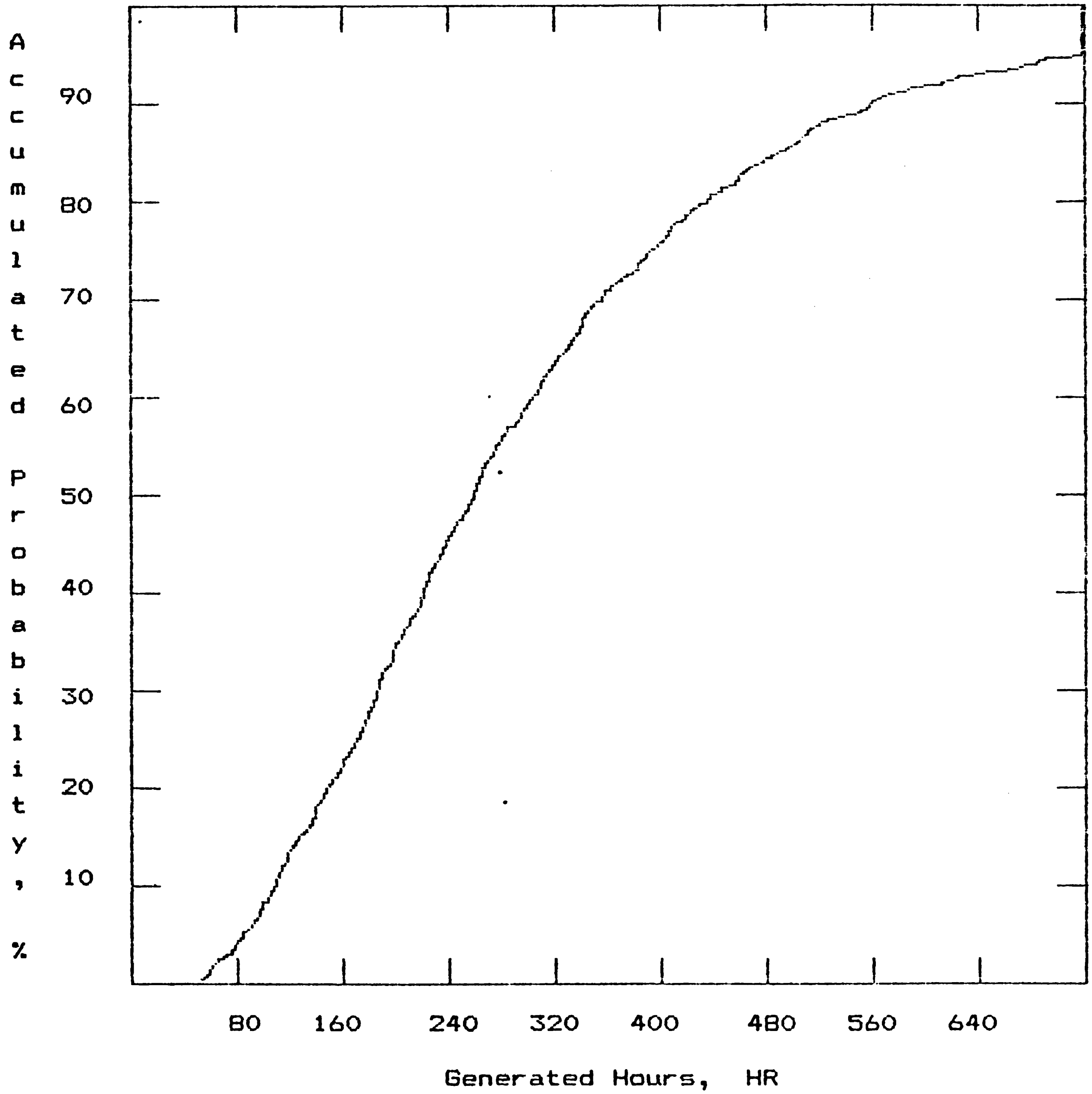
April


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

May

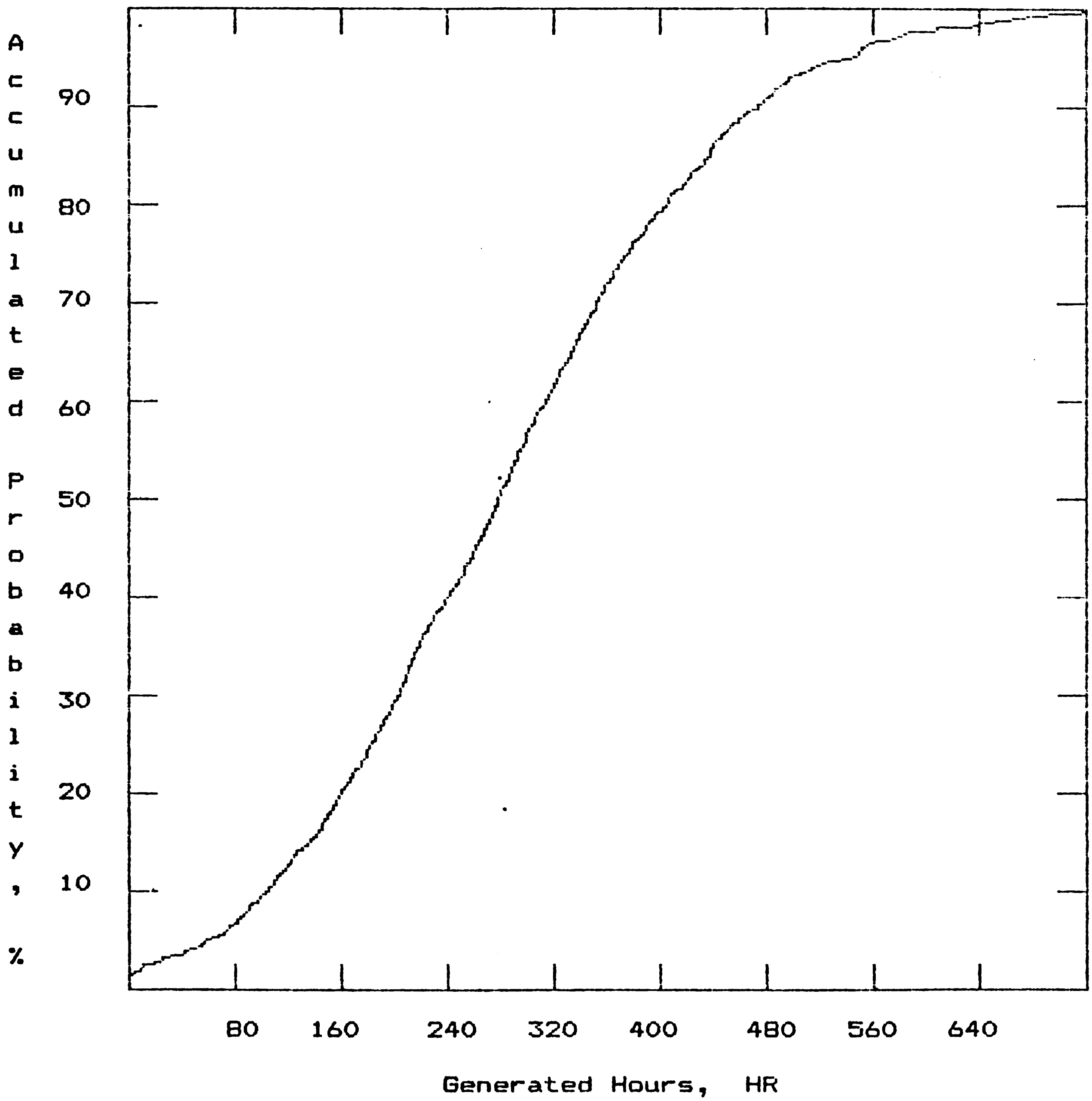

Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

June

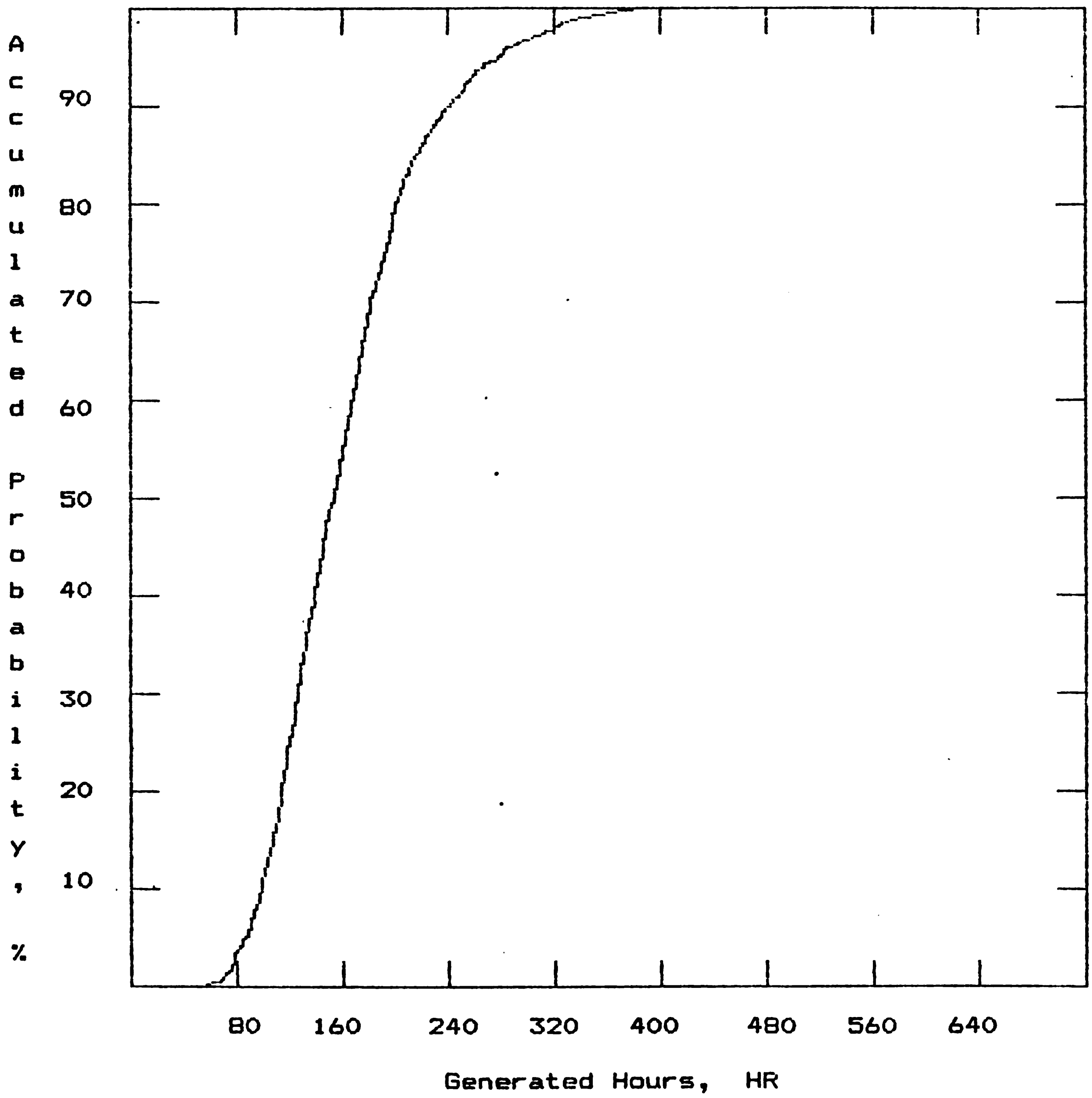


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

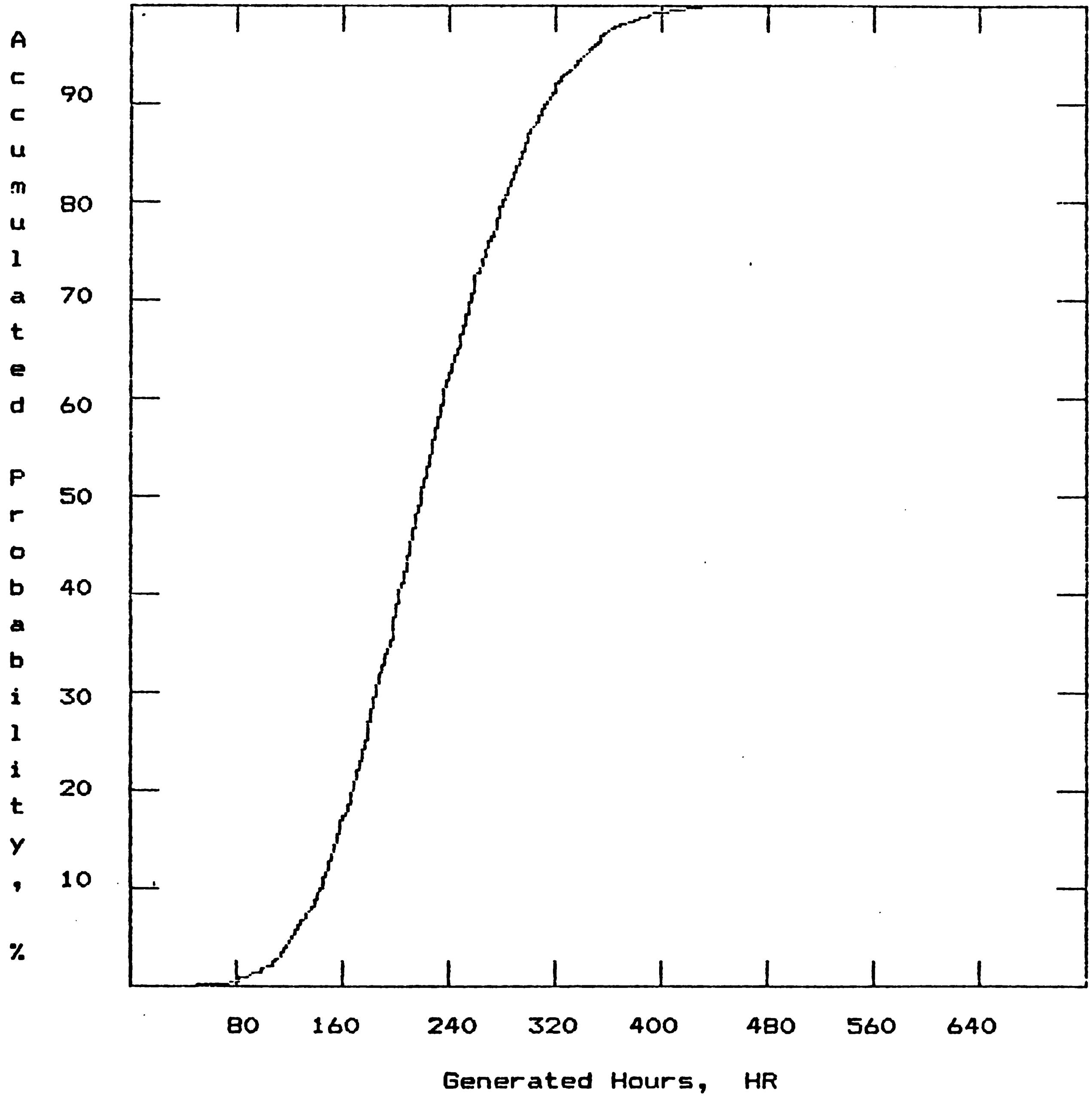
July


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

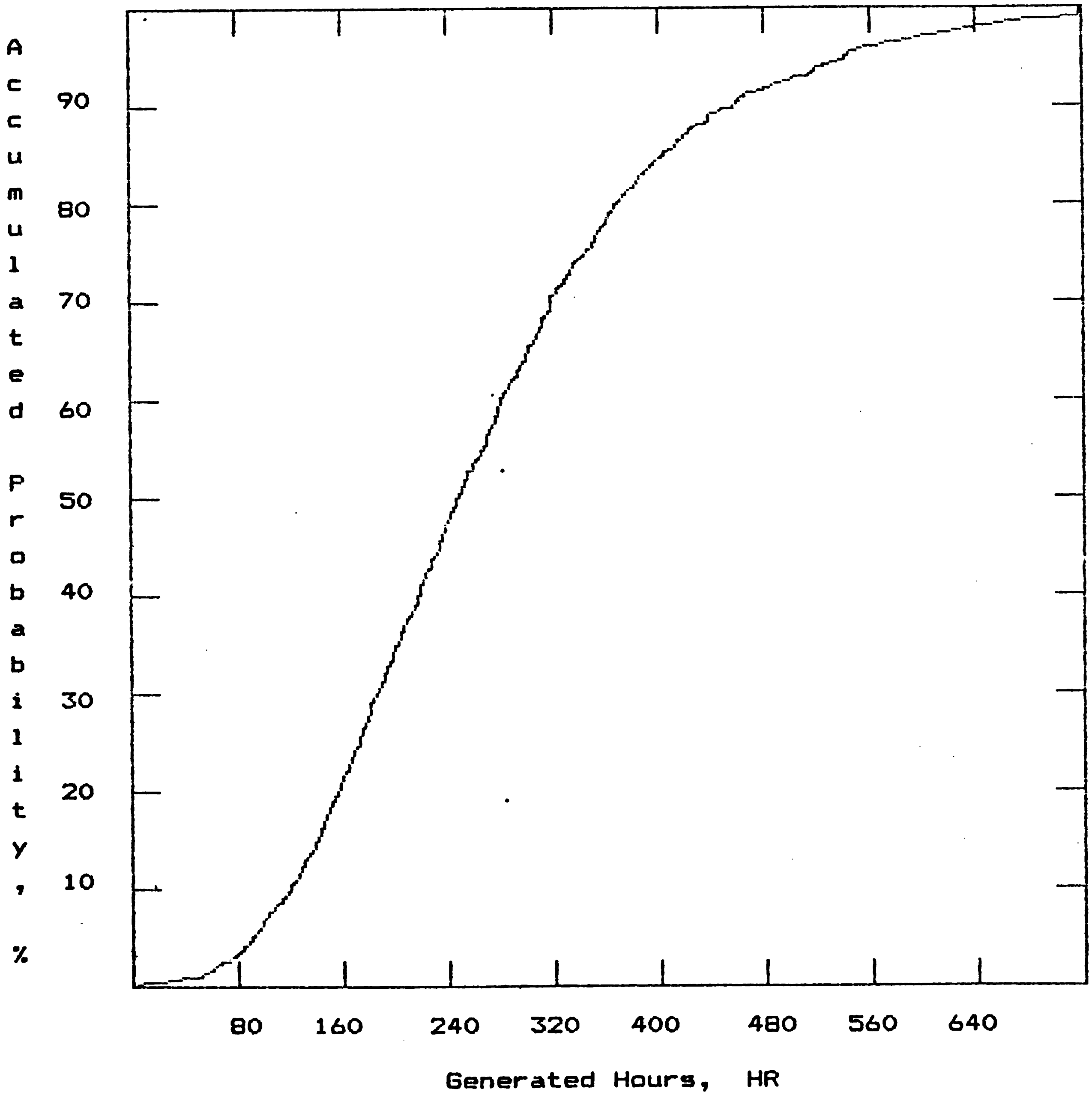
August


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

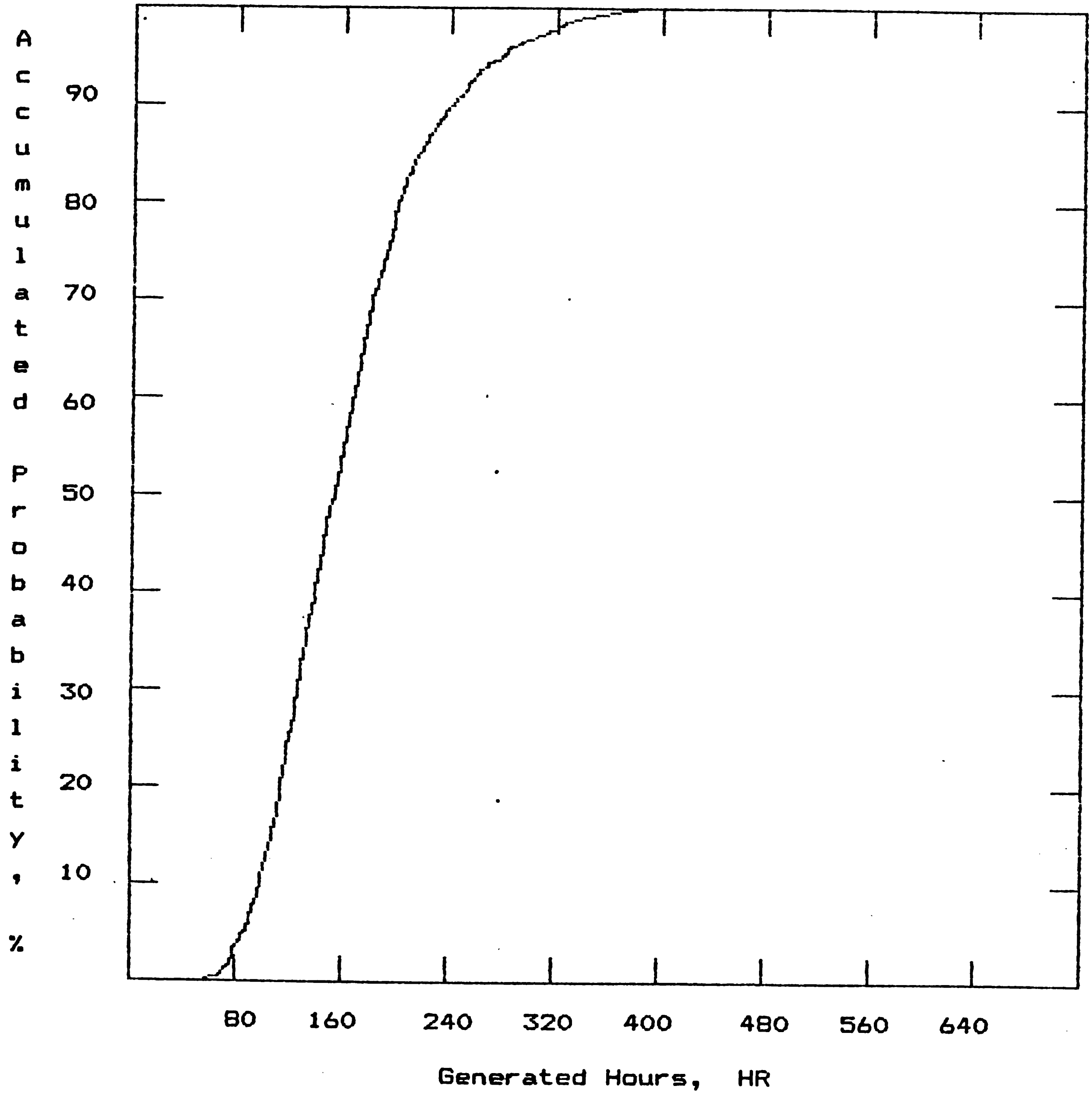
December


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

October


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

November


Accumulated Probability, %
90
80
70
60
50
40
30
20
10
80
160
240
320
400
480
560
640
Generated Hours, HR

December

APPENDIX E

TABLES OF MONTHLY OPTIMAL STORAGE GUIDECURVES FROM CSUDP

Optimal Stationary Operation Policies for each Month , Inflow in CMS , Storage in MCM

January

Previous Inflow	5.158	7.563	9.740	12.589	14.874	17.343	20.320	24.207	29.173	36.263	46.281	68.123
Limits	6.5960	8.3060	11.245	13.809	16.002	18.742	22.079	26.356	32.026	42.556	50.928	

Initial	End-of-Month Target Storage											
35.	37.	39.	39.	43.	45.	47.	47.	49.	53.	57.	61.	69.
37.	39.	41.	41.	45.	45.	49.	49.	51.	55.	59.	63.	71.
39.	41.	43.	43.	47.	47.	51.	51.	53.	57.	59.	63.	73.
41.	41.	45.	45.	49.	49.	53.	53.	55.	57.	61.	63.	75.
43.	43.	45.	47.	51.	51.	53.	55.	57.	59.	63.	65.	77.
45.	45.	47.	49.	53.	53.	55.	57.	59.	61.	65.	67.	79.
47.	45.	49.	51.	55.	55.	55.	59.	59.	63.	67.	69.	79.
49.	47.	51.	53.	55.	57.	57.	59.	61.	65.	69.	71.	81.
51.	49.	51.	55.	55.	59.	59.	61.	63.	67.	71.	73.	83.
53.	51.	53.	55.	57.	61.	61.	63.	65.	69.	73.	75.	85.
55.	53.	55.	57.	59.	63.	63.	65.	67.	71.	75.	77.	87.
57.	55.	55.	59.	61.	65.	65.	67.	69.	73.	77.	79.	89.
59.	55.	57.	61.	63.	67.	67.	69.	71.	75.	79.	79.	91.
61.	55.	59.	63.	65.	67.	69.	69.	73.	75.	81.	81.	93.
63.	57.	61.	65.	67.	67.	71.	71.	75.	77.	83.	83.	95.
65.	59.	63.	67.	69.	69.	71.	73.	77.	79.	83.	85.	97.
67.	61.	65.	67.	71.	71.	71.	75.	79.	81.	85.	87.	99.
69.	63.	67.	69.	71.	73.	73.	77.	81.	83.	87.	89.	101.
71.	65.	69.	71.	73.	75.	75.	79.	83.	83.	89.	87.	103.
73.	65.	71.	71.	75.	77.	77.	81.	85.	85.	91.	89.	103.
75.	67.	73.	73.	77.	79.	79.	83.	87.	87.	93.	89.	103.
77.	69.	75.	75.	79.	81.	81.	85.	89.	89.	95.	91.	105.
79.	71.	77.	77.	81.	83.	83.	87.	91.	91.	97.	93.	107.
81.	73.	79.	79.	83.	85.	85.	89.	93.	93.	99.	95.	109.
83.	75.	81.	81.	85.	87.	87.	91.	95.	95.	101.	97.	111.
85.	77.	83.	83.	87.	89.	89.	93.	97.	97.	103.	99.	113.
87.	79.	83.	85.	89.	91.	91.	95.	99.	97.	105.	101.	115.
89.	81.	83.	87.	91.	93.	93.	97.	101.	99.	105.	103.	117.
91.	83.	85.	89.	93.	95.	93.	99.	103.	101.	107.	103.	119.
93.	85.	87.	91.	95.	97.	95.	101.	105.	103.	109.	105.	121.
95.	87.	89.	93.	97.	99.	97.	103.	107.	105.	111.	107.	123.
97.	89.	91.	95.	99.	99.	99.	105.	109.	107.	113.	109.	125.
99.	91.	91.	97.	101.	101.	101.	107.	111.	109.	115.	111.	127.
101.	93.	93.	99.	103.	103.	103.	109.	113.	109.	117.	113.	129.
103.	95.	95.	101.	105.	105.	105.	111.	115.	111.	119.	115.	131.
105.	97.	97.	103.	107.	107.	107.	113.	117.	113.	121.	117.	133.
107.	99.	99.	105.	107.	109.	109.	115.	119.	115.	123.	119.	133.
109.	101.	101.	107.	109.	111.	111.	117.	121.	117.	125.	121.	135.
111.	103.	103.	109.	111.	113.	113.	119.	123.	119.	127.	123.	137.
113.	105.	105.	109.	111.	115.	115.	121.	123.	121.	129.	125.	139.
115.	107.	107.	111.	113.	117.	117.	123.	125.	123.	131.	127.	141.
117.	109.	109.	111.	115.	119.	119.	125.	127.	125.	133.	129.	143.
119.	111.	111.	113.	117.	121.	121.	127.	129.	127.	135.	131.	145.
121.	113.	113.	115.	119.	123.	123.	129.	131.	129.	137.	133.	147.
123.	115.	115.	117.	121.	125.	125.	131.	133.	131.	139.	133.	149.
125.	117.	117.	119.	123.	127.	127.	133.	133.	133.	141.	135.	151.

127.	119.	119.	121.	125.	129.	129.	135.	135.	135.	143.	137.	153.
129.	121.	121.	121.	127.	131.	131.	137.	137.	137.	145.	139.	153.
131.	123.	123.	123.	129.	133.	133.	139.	139.	139.	147.	141.	153.
133.	125.	125.	125.	131.	135.	135.	141.	141.	141.	149.	141.	153.
135.	127.	127.	127.	133.	137.	137.	143.	143.	143.	151.	143.	153.
137.	129.	129.	129.	135.	139.	137.	145.	145.	145.	151.	145.	153.
139.	131.	131.	131.	137.	141.	139.	145.	147.	147.	153.	147.	153.
141.	133.	133.	133.	139.	143.	141.	145.	149.	149.	153.	149.	153.
143.	135.	135.	135.	141.	145.	141.	147.	151.	151.	153.	151.	153.
145.	137.	137.	137.	143.	147.	143.	149.	153.	153.	153.	153.	153.
147.	139.	139.	139.	143.	149.	145.	151.	153.	153.	153.	153.	153.
149.	141.	141.	141.	143.	151.	147.	153.	153.	153.	153.	153.	153.
151.	143.	143.	143.	145.	153.	149.	153.	153.	153.	153.	153.	153.
153.	145.	145.	145.	147.	153.	151.	153.	153.	153.	153.	153.	153.

February

Previous Inflow	5.510	7.690	9.471	11.486	13.111	14.608	16.288	18.488	20.666	24.367	29.279	37.493
Limits	6.9350	8.4200	10.654	12.370	13.890	15.300	17.510	19.441	22.240	27.220	31.829	
Initial	End-of-Month Target Storage											
35.	35.	35.	37.	37.	41.	41.	41.	45.	45.	51.	57.	61.
37.	35.	37.	39.	39.	41.	43.	43.	47.	47.	51.	59.	63.
39.	35.	37.	39.	41.	43.	45.	45.	49.	49.	53.	61.	63.
41.	35.	39.	41.	43.	43.	47.	47.	51.	51.	55.	63.	65.
43.	37.	39.	41.	43.	45.	47.	49.	53.	53.	57.	65.	65.
45.	37.	41.	43.	45.	47.	47.	51.	55.	55.	59.	65.	67.
47.	39.	43.	45.	47.	49.	49.	51.	57.	55.	61.	67.	69.
49.	41.	45.	45.	47.	51.	51.	53.	59.	55.	61.	69.	71.
51.	43.	47.	47.	49.	51.	53.	55.	61.	57.	63.	71.	73.
53.	45.	49.	49.	51.	53.	55.	55.	63.	59.	65.	73.	75.
55.	47.	51.	51.	51.	55.	55.	57.	65.	61.	65.	75.	77.
57.	49.	51.	53.	53.	57.	57.	59.	67.	63.	67.	77.	79.
59.	49.	51.	55.	55.	59.	59.	61.	69.	65.	69.	79.	81.
61.	49.	53.	57.	57.	61.	59.	63.	71.	67.	71.	81.	83.
63.	51.	55.	59.	59.	61.	61.	65.	73.	69.	73.	83.	83.
65.	53.	57.	59.	61.	63.	63.	67.	75.	71.	75.	85.	85.
67.	55.	59.	59.	63.	65.	65.	69.	77.	73.	77.	87.	87.
69.	57.	61.	61.	65.	67.	67.	71.	79.	75.	79.	89.	89.
71.	59.	63.	63.	67.	67.	67.	73.	81.	77.	81.	91.	91.
73.	61.	65.	65.	69.	69.	69.	75.	83.	79.	83.	93.	93.
75.	63.	67.	67.	71.	71.	71.	77.	85.	81.	85.	95.	95.
77.	63.	69.	69.	73.	73.	73.	79.	87.	83.	87.	97.	97.
79.	65.	71.	71.	75.	75.	75.	79.	87.	85.	89.	99.	99.
81.	67.	71.	73.	77.	77.	77.	81.	87.	87.	91.	101.	101.
83.	69.	71.	75.	79.	79.	79.	83.	89.	89.	93.	103.	103.
85.	71.	73.	77.	81.	81.	81.	85.	91.	91.	95.	105.	105.
87.	73.	75.	79.	83.	83.	83.	87.	93.	93.	97.	107.	107.
89.	75.	77.	81.	85.	85.	85.	89.	95.	95.	99.	109.	109.
91.	77.	79.	83.	87.	87.	87.	91.	97.	97.	101.	111.	111.
93.	79.	81.	85.	89.	89.	89.	93.	99.	99.	103.	113.	113.
95.	81.	83.	87.	91.	91.	91.	95.	101.	101.	105.	113.	115.
97.	83.	85.	89.	93.	93.	93.	97.	103.	103.	107.	113.	117.
99.	85.	87.	91.	95.	95.	95.	99.	105.	105.	109.	115.	119.
101.	87.	89.	91.	97.	97.	97.	101.	107.	107.	111.	115.	121.
103.	89.	91.	91.	97.	99.	99.	103.	109.	107.	113.	115.	123.
105.	91.	93.	93.	97.	101.	101.	105.	111.	109.	115.	117.	125.
107.	93.	95.	95.	99.	103.	103.	107.	113.	111.	117.	117.	127.
109.	95.	95.	97.	101.	105.	105.	109.	115.	113.	119.	119.	129.
111.	97.	97.	99.	103.	107.	107.	111.	117.	115.	121.	121.	131.
113.	99.	99.	101.	105.	109.	109.	113.	119.	117.	123.	123.	133.
115.	101.	101.	103.	107.	111.	111.	115.	121.	119.	125.	125.	135.
117.	103.	103.	105.	109.	113.	113.	117.	121.	121.	127.	127.	137.
119.	105.	105.	107.	111.	115.	115.	119.	123.	123.	129.	129.	139.
121.	107.	107.	109.	113.	117.	117.	121.	125.	125.	131.	131.	141.
123.	109.	109.	111.	115.	119.	119.	121.	127.	125.	133.	133.	143.
125.	111.	111.	113.	117.	121.	121.	123.	127.	127.	133.	135.	145.

127.	113.	113.	115.	119.	123.	123.	125.	129.	129.	133.	137.	147.
129.	115.	115.	117.	121.	125.	125.	127.	131.	131.	135.	139.	149.
131.	117.	117.	119.	123.	127.	127.	127.	133.	133.	137.	141.	151.
133.	119.	119.	121.	125.	129.	129.	129.	135.	135.	139.	143.	153.
135.	121.	121.	123.	127.	131.	131.	131.	137.	137.	141.	145.	153.
137.	123.	123.	123.	129.	133.	133.	133.	139.	139.	143.	147.	153.
139.	125.	125.	125.	131.	135.	135.	135.	141.	141.	145.	149.	153.
141.	127.	127.	127.	133.	137.	137.	137.	143.	143.	147.	151.	153.
143.	129.	129.	129.	135.	139.	139.	139.	145.	145.	149.	153.	153.
145.	131.	131.	131.	137.	141.	141.	141.	147.	147.	151.	153.	153.
147.	133.	133.	133.	139.	143.	143.	143.	149.	149.	153.	153.	153.
149.	135.	135.	135.	141.	145.	143.	145.	151.	149.	153.	153.	153.
151.	137.	137.	137.	143.	147.	143.	147.	153.	151.	153.	153.	153.
153.	139.	139.	139.	145.	149.	145.	149.	153.	153.	153.	153.	153.

March

Previous Inflow	4.009	6.111	7.889	9.897	11.740	13.528	15.542	17.757	20.398	24.194	29.196	38.625
Limits		5.2930	6.7930	8.8600	10.771	12.600	14.516	16.617	19.089	21.967	27.168	31.841
Initial	End-of-Month Target Storage											
35.	35.	35.	35.	35.	35.	35.	37.	37.	37.	39.	41.	51.
37.	35.	35.	35.	35.	35.	35.	37.	37.	37.	41.	43.	53.
39.	35.	35.	35.	35.	35.	35.	37.	37.	39.	43.	45.	55.
41.	35.	35.	35.	37.	37.	37.	37.	39.	41.	45.	47.	57.
43.	35.	35.	35.	37.	39.	39.	39.	39.	43.	47.	49.	57.
45.	35.	37.	37.	39.	39.	39.	39.	41.	43.	47.	51.	59.
47.	35.	39.	39.	39.	39.	39.	39.	43.	43.	49.	53.	59.
49.	37.	39.	39.	41.	41.	41.	41.	45.	45.	51.	55.	59.
51.	39.	39.	39.	43.	43.	43.	43.	47.	47.	53.	57.	61.
53.	39.	41.	41.	43.	43.	43.	45.	47.	49.	55.	59.	61.
55.	39.	43.	43.	43.	43.	43.	47.	49.	51.	57.	61.	61.
57.	41.	43.	43.	45.	45.	45.	49.	49.	53.	59.	63.	63.
59.	43.	43.	45.	47.	47.	47.	51.	51.	55.	61.	65.	65.
61.	43.	45.	45.	49.	49.	49.	53.	53.	57.	63.	65.	67.
63.	43.	47.	47.	51.	51.	51.	55.	55.	59.	65.	67.	69.
65.	45.	49.	49.	53.	53.	53.	57.	57.	61.	65.	69.	71.
67.	47.	51.	51.	55.	55.	55.	59.	59.	61.	67.	71.	73.
69.	49.	53.	53.	57.	57.	57.	61.	61.	63.	69.	73.	75.
71.	51.	53.	55.	59.	59.	59.	61.	63.	63.	71.	75.	77.
73.	53.	53.	57.	61.	61.	61.	61.	65.	65.	73.	77.	79.
75.	55.	55.	59.	63.	61.	63.	63.	67.	67.	75.	79.	81.
77.	57.	57.	61.	65.	63.	65.	65.	69.	69.	77.	81.	83.
79.	59.	59.	63.	67.	65.	67.	67.	71.	71.	79.	83.	85.
81.	61.	61.	65.	69.	67.	69.	69.	73.	73.	81.	85.	87.
83.	63.	63.	65.	69.	69.	71.	71.	75.	75.	83.	87.	89.
85.	65.	65.	67.	71.	71.	73.	73.	77.	77.	85.	89.	91.
87.	65.	67.	69.	73.	71.	73.	75.	79.	79.	87.	91.	93.
89.	67.	69.	69.	75.	73.	75.	77.	81.	81.	89.	93.	95.
91.	69.	71.	71.	77.	75.	77.	79.	83.	83.	91.	95.	97.
93.	71.	73.	73.	79.	77.	79.	81.	85.	85.	93.	97.	99.
95.	73.	75.	75.	81.	79.	81.	83.	87.	87.	95.	99.	101.
97.	75.	77.	77.	83.	81.	83.	85.	89.	89.	97.	101.	103.
99.	77.	79.	79.	85.	83.	85.	87.	91.	91.	99.	103.	105.
101.	79.	81.	81.	85.	85.	87.	89.	93.	93.	101.	105.	107.
103.	81.	83.	83.	87.	87.	87.	91.	95.	95.	103.	107.	109.
105.	83.	85.	85.	89.	89.	89.	93.	97.	97.	105.	109.	111.
107.	85.	85.	87.	91.	91.	91.	95.	99.	99.	107.	111.	113.
109.	87.	87.	89.	93.	93.	93.	97.	101.	101.	109.	113.	115.
111.	89.	89.	91.	95.	95.	95.	99.	103.	103.	111.	113.	115.
113.	91.	91.	93.	97.	97.	97.	101.	105.	105.	113.	115.	117.
115.	93.	93.	95.	99.	99.	99.	103.	107.	107.	115.	117.	119.
117.	95.	95.	97.	101.	101.	101.	105.	109.	109.	117.	119.	121.
119.	97.	97.	99.	103.	103.	103.	107.	111.	111.	119.	121.	123.
121.	99.	99.	101.	105.	105.	105.	109.	113.	113.	121.	123.	125.
123.	101.	101.	103.	107.	107.	107.	111.	115.	115.	121.	125.	127.
125.	103.	103.	105.	109.	109.	109.	113.	117.	117.	121.	127.	129.

127.	105.	105.	107.	111.	111.	111.	115.	119.	119.	123.	127.	131.
129.	107.	107.	109.	113.	113.	113.	117.	121.	119.	125.	129.	133.
131.	109.	109.	111.	115.	115.	115.	119.	123.	119.	123.	131.	135.
133.	111.	111.	111.	117.	117.	117.	121.	123.	121.	125.	133.	137.
135.	113.	113.	113.	119.	119.	119.	123.	123.	123.	127.	135.	139.
137.	115.	115.	115.	121.	121.	121.	125.	125.	125.	129.	137.	141.
139.	117.	117.	117.	123.	123.	123.	127.	127.	127.	131.	139.	143.
141.	119.	119.	119.	125.	125.	125.	129.	129.	129.	133.	141.	145.
143.	121.	121.	121.	127.	127.	127.	131.	131.	131.	135.	143.	147.
145.	123.	123.	123.	129.	129.	129.	131.	133.	133.	137.	145.	149.
147.	125.	125.	125.	129.	131.	131.	133.	135.	135.	139.	147.	151.
149.	127.	127.	127.	131.	133.	133.	135.	137.	137.	141.	149.	153.
151.	129.	129.	129.	133.	133.	135.	137.	139.	139.	143.	151.	153.
153.	131.	131.	131.	135.	135.	137.	139.	141.	141.	145.	153.	153.

April

Previous Inflow Limits	3.973	5.711	7.166	8.812	10.275	12.016	13.763	15.501	17.678	21.527	26.341	34.457
		5.1490	6.1740	8.0050	9.5120	11.034	12.925	14.606	16.387	19.218	24.387	28.491
Initial	End-of-Month Target Storage											
35.	35.	35.	35.	35.	35.	35.	35.	35.	35.	37.	41.	47.
37.	35.	35.	35.	35.	35.	35.	35.	35.	35.	37.	43.	49.
39.	35.	35.	35.	35.	35.	35.	35.	37.	35.	39.	45.	51.
41.	35.	35.	35.	35.	35.	35.	37.	39.	37.	41.	47.	51.
43.	35.	35.	35.	35.	35.	35.	39.	41.	39.	41.	49.	53.
45.	35.	35.	35.	37.	37.	37.	41.	43.	41.	43.	51.	55.
47.	35.	35.	37.	39.	39.	39.	43.	45.	43.	45.	53.	57.
49.	35.	37.	37.	41.	41.	41.	45.	45.	45.	47.	55.	59.
51.	35.	39.	39.	43.	43.	43.	47.	47.	47.	47.	57.	61.
53.	37.	41.	41.	45.	45.	45.	47.	49.	49.	49.	59.	63.
55.	39.	43.	43.	47.	47.	47.	49.	51.	51.	51.	61.	65.
57.	41.	45.	45.	49.	47.	49.	51.	53.	53.	53.	63.	67.
59.	43.	47.	47.	51.	49.	51.	51.	55.	55.	55.	65.	69.
61.	45.	49.	49.	53.	49.	53.	53.	57.	57.	57.	67.	71.
63.	47.	51.	51.	53.	51.	55.	55.	59.	59.	59.	69.	73.
65.	49.	53.	53.	55.	53.	57.	57.	61.	61.	61.	71.	75.
67.	51.	55.	55.	57.	55.	59.	59.	63.	63.	63.	73.	77.
69.	53.	55.	57.	59.	57.	61.	61.	65.	65.	65.	75.	79.
71.	55.	55.	59.	61.	59.	61.	63.	67.	67.	67.	77.	81.
73.	57.	57.	61.	61.	61.	63.	65.	69.	69.	69.	79.	83.
75.	59.	59.	61.	63.	63.	65.	67.	71.	71.	71.	81.	85.
77.	61.	61.	61.	65.	65.	67.	69.	73.	73.	73.	83.	87.
79.	63.	63.	63.	67.	67.	69.	71.	73.	75.	75.	85.	89.
81.	65.	65.	65.	69.	69.	71.	73.	75.	77.	77.	87.	91.
83.	67.	67.	67.	71.	71.	73.	75.	77.	79.	79.	89.	93.
85.	69.	69.	69.	73.	73.	73.	77.	77.	81.	81.	91.	95.
87.	71.	71.	71.	75.	75.	75.	79.	79.	83.	83.	93.	97.
89.	73.	73.	73.	77.	77.	77.	81.	81.	85.	85.	95.	99.
91.	75.	75.	75.	79.	79.	79.	83.	83.	87.	87.	97.	101.
93.	77.	77.	77.	81.	81.	81.	85.	85.	89.	87.	99.	103.
95.	79.	79.	79.	83.	83.	83.	87.	87.	91.	89.	101.	105.
97.	81.	81.	81.	85.	85.	85.	89.	89.	93.	91.	103.	107.
99.	83.	83.	83.	87.	87.	87.	91.	91.	95.	93.	105.	109.
101.	85.	85.	85.	89.	89.	89.	93.	93.	97.	95.	107.	111.
103.	87.	87.	87.	91.	91.	91.	95.	95.	97.	95.	109.	113.
105.	89.	89.	89.	93.	93.	93.	97.	97.	99.	97.	111.	115.
107.	91.	91.	91.	95.	95.	95.	99.	99.	101.	99.	113.	117.
109.	93.	93.	93.	97.	97.	97.	101.	101.	103.	101.	115.	119.
111.	95.	95.	95.	99.	99.	99.	101.	103.	105.	103.	117.	121.
113.	97.	97.	97.	101.	99.	101.	103.	105.	107.	105.	119.	123.
115.	99.	99.	99.	103.	101.	103.	105.	107.	109.	107.	121.	125.
117.	101.	101.	101.	105.	101.	105.	107.	109.	111.	109.	123.	127.
119.	103.	103.	103.	107.	103.	107.	109.	111.	113.	111.	125.	129.
121.	105.	105.	105.	109.	105.	109.	111.	113.	115.	113.	127.	131.
123.	107.	107.	107.	111.	107.	111.	111.	115.	117.	115.	129.	133.
125.	109.	109.	109.	113.	109.	113.	113.	117.	119.	117.	131.	135.

127.	111.	111.	111.	115.	111.	115.	115.	119.	119.	119.	133.	137.
129.	113.	113.	113.	117.	113.	117.	117.	121.	121.	121.	135.	139.
131.	115.	115.	115.	119.	115.	117.	119.	123.	123.	123.	137.	141.
133.	117.	117.	117.	121.	117.	119.	121.	125.	125.	125.	139.	143.
135.	119.	119.	119.	123.	119.	119.	123.	127.	127.	127.	141.	145.
137.	119.	121.	121.	125.	121.	121.	125.	129.	129.	127.	143.	147.
139.	121.	123.	123.	127.	123.	123.	127.	129.	131.	129.	145.	147.
141.	123.	125.	125.	129.	125.	125.	129.	131.	133.	131.	145.	149.
143.	125.	127.	127.	131.	127.	127.	131.	133.	135.	133.	147.	151.
145.	127.	129.	129.	133.	129.	129.	133.	135.	137.	135.	149.	151.
147.	129.	131.	131.	135.	131.	131.	135.	137.	139.	135.	149.	153.
149.	131.	133.	133.	135.	133.	133.	137.	139.	141.	137.	151.	153.
151.	133.	135.	135.	137.	135.	135.	139.	139.	143.	137.	153.	153.
153.	135.	137.	137.	139.	137.	137.	141.	141.	145.	137.	151.	153.

May

Previous Inflow Limits	4.351	5.956	7.418	8.974	10.322	11.737	13.075	14.619	16.921	20.014	23.931	30.353
		5.3470	6.5040	8.2510	9.6860	11.035	12.284	13.846	15.650	18.196	22.292	26.061
Initial	End-of-Month Target Storage											
35.	35.	37.	37.	37.	39.	39.	39.	47.	47.	57.	55.	75.
37.	35.	35.	35.	39.	41.	41.	41.	49.	49.	59.	57.	77.
39.	35.	37.	37.	41.	43.	43.	43.	51.	51.	61.	59.	79.
41.	37.	39.	39.	43.	45.	45.	45.	53.	53.	63.	59.	81.
43.	37.	41.	41.	45.	47.	47.	47.	55.	55.	65.	59.	83.
45.	37.	43.	43.	47.	49.	49.	49.	57.	57.	67.	59.	85.
47.	39.	43.	45.	49.	51.	51.	51.	59.	59.	67.	61.	87.
49.	41.	45.	47.	51.	53.	53.	53.	61.	61.	69.	63.	89.
51.	43.	47.	49.	51.	55.	55.	55.	63.	63.	71.	65.	91.
53.	45.	49.	51.	51.	57.	57.	57.	65.	65.	73.	67.	93.
55.	47.	49.	53.	53.	59.	59.	59.	67.	67.	73.	69.	95.
57.	49.	49.	53.	55.	61.	61.	61.	69.	69.	75.	71.	97.
59.	51.	51.	55.	57.	61.	63.	63.	71.	71.	75.	73.	99.
61.	53.	53.	57.	59.	63.	65.	65.	73.	73.	75.	75.	101.
63.	55.	55.	59.	61.	65.	67.	67.	75.	75.	77.	75.	103.
65.	57.	57.	61.	63.	67.	69.	69.	77.	77.	79.	77.	105.
67.	59.	59.	63.	65.	69.	71.	71.	79.	79.	81.	79.	107.
69.	61.	61.	65.	67.	71.	73.	73.	81.	81.	83.	81.	109.
71.	63.	63.	67.	69.	73.	75.	75.	81.	83.	85.	83.	111.
73.	65.	65.	69.	71.	75.	77.	77.	81.	85.	87.	85.	113.
75.	67.	67.	71.	73.	77.	79.	79.	81.	87.	89.	87.	115.
77.	69.	69.	73.	75.	79.	81.	81.	81.	89.	91.	89.	117.
79.	71.	71.	75.	77.	79.	83.	83.	83.	91.	93.	91.	119.
81.	73.	73.	75.	79.	79.	85.	85.	85.	93.	95.	93.	121.
83.	75.	75.	75.	81.	81.	87.	87.	87.	95.	95.	95.	123.
85.	77.	77.	77.	83.	83.	89.	89.	89.	93.	97.	97.	125.
87.	79.	79.	79.	85.	85.	89.	91.	91.	95.	99.	99.	127.
89.	81.	81.	81.	87.	87.	91.	93.	93.	95.	101.	101.	129.
91.	83.	83.	83.	89.	89.	93.	95.	95.	95.	103.	103.	131.
93.	85.	85.	85.	89.	91.	93.	97.	97.	97.	105.	105.	133.
95.	87.	87.	87.	91.	93.	93.	99.	99.	99.	107.	107.	135.
97.	89.	89.	89.	93.	95.	95.	101.	101.	101.	109.	109.	137.
99.	91.	91.	91.	95.	97.	97.	103.	103.	103.	111.	111.	139.
101.	93.	93.	93.	97.	99.	99.	105.	105.	105.	113.	113.	141.
103.	95.	95.	95.	99.	101.	101.	107.	107.	107.	115.	115.	143.
105.	97.	97.	97.	99.	103.	103.	109.	109.	109.	117.	117.	145.
107.	99.	99.	99.	101.	105.	105.	111.	111.	111.	119.	119.	147.
109.	101.	101.	101.	101.	107.	107.	113.	113.	113.	121.	121.	149.
111.	103.	103.	103.	103.	107.	109.	115.	115.	113.	123.	123.	151.
113.	105.	105.	105.	105.	109.	111.	117.	117.	113.	125.	125.	153.
115.	107.	107.	107.	107.	109.	113.	119.	119.	113.	127.	127.	153.
117.	109.	109.	109.	109.	111.	115.	121.	121.	115.	129.	129.	153.
119.	111.	111.	111.	111.	113.	117.	123.	123.	117.	131.	131.	153.
121.	113.	113.	113.	113.	113.	119.	125.	125.	119.	133.	133.	153.
123.	115.	115.	115.	115.	115.	121.	125.	127.	121.	135.	135.	153.
125.	117.	117.	117.	117.	117.	123.	127.	129.	123.	137.	137.	153.

127.	119.	119.	119.	119.	119.	125.	127.	131.	125.	139.	139.	153.
129.	121.	121.	121.	121.	121.	127.	127.	133.	127.	141.	141.	153.
131.	123.	123.	123.	123.	123.	129.	129.	133.	129.	143.	143.	153.
133.	125.	125.	125.	125.	125.	129.	131.	135.	131.	145.	145.	153.
135.	127.	127.	127.	127.	127.	129.	133.	135.	131.	147.	147.	153.
137.	129.	129.	129.	129.	129.	131.	135.	135.	131.	149.	149.	153.
139.	131.	131.	131.	131.	131.	133.	137.	137.	133.	151.	151.	153.
141.	133.	133.	133.	133.	133.	133.	139.	139.	133.	153.	153.	153.
143.	135.	135.	135.	135.	135.	135.	141.	141.	135.	153.	153.	153.
145.	137.	137.	137.	137.	137.	137.	143.	143.	137.	153.	153.	153.
147.	139.	139.	139.	139.	139.	139.	145.	145.	139.	153.	153.	153.
149.	141.	141.	141.	141.	141.	141.	147.	147.	141.	153.	153.	153.
151.	143.	143.	143.	143.	143.	143.	149.	149.	143.	153.	153.	153.
153.	145.	145.	145.	145.	145.	145.	151.	151.	145.	153.	153.	153.

June

Previous Inflow: 4.024 6.182 8.484 11.781 15.218 18.337 22.153 27.156 33.337 43.358 55.936 83.589

Limits: 5.3660 6.8950 9.9660 13.533 16.773 20.087 24.552 29.811 38.052 50.282 63.229

Initial	End-of-Month Target Storage											
35.	35.	37.	37.	37.	39.	45.	45.	45.	45.	53.	75.	69.
37.	35.	37.	39.	39.	41.	47.	47.	47.	47.	55.	77.	71.
39.	37.	37.	39.	41.	41.	49.	49.	49.	49.	57.	79.	71.
41.	37.	39.	39.	43.	43.	47.	51.	47.	51.	59.	81.	71.
43.	39.	41.	41.	41.	45.	49.	53.	49.	53.	61.	83.	71.
45.	41.	41.	43.	43.	47.	49.	55.	49.	55.	63.	83.	73.
47.	41.	43.	43.	45.	49.	51.	53.	51.	57.	65.	85.	75.
49.	41.	41.	45.	47.	51.	53.	55.	53.	59.	63.	87.	77.
51.	43.	43.	47.	49.	53.	55.	55.	55.	61.	65.	89.	79.
53.	45.	45.	49.	51.	55.	57.	57.	57.	63.	65.	91.	81.
55.	47.	47.	51.	53.	57.	59.	59.	59.	65.	67.	93.	83.
57.	47.	49.	49.	55.	59.	61.	61.	61.	67.	69.	95.	85.
59.	49.	51.	51.	57.	61.	63.	63.	63.	69.	71.	97.	87.
61.	51.	53.	53.	59.	63.	65.	65.	65.	71.	71.	99.	89.
63.	53.	55.	55.	61.	65.	67.	67.	67.	73.	73.	101.	91.
65.	55.	57.	57.	63.	67.	69.	69.	69.	75.	75.	103.	93.
67.	57.	59.	59.	65.	69.	71.	71.	71.	77.	77.	105.	95.
69.	59.	61.	61.	67.	71.	73.	73.	73.	79.	79.	107.	97.
71.	61.	63.	63.	69.	73.	75.	75.	75.	81.	81.	109.	99.
73.	63.	65.	65.	71.	75.	77.	77.	77.	83.	83.	111.	101.
75.	65.	67.	67.	73.	77.	79.	79.	79.	85.	85.	113.	103.
77.	67.	69.	69.	75.	79.	81.	81.	81.	87.	87.	115.	103.
79.	69.	71.	71.	77.	81.	83.	83.	83.	85.	89.	117.	105.
81.	71.	73.	73.	79.	83.	85.	85.	85.	87.	91.	119.	107.
83.	73.	73.	75.	81.	85.	87.	87.	87.	87.	93.	121.	109.
85.	75.	75.	77.	81.	85.	87.	89.	89.	89.	95.	123.	111.
87.	77.	77.	79.	83.	87.	89.	91.	91.	91.	97.	125.	113.
89.	79.	79.	81.	85.	87.	91.	93.	93.	93.	99.	127.	115.
91.	81.	81.	83.	87.	89.	93.	95.	95.	95.	101.	129.	117.
93.	83.	83.	85.	89.	91.	95.	97.	97.	97.	103.	131.	119.
95.	85.	85.	87.	91.	93.	95.	99.	99.	99.	105.	133.	121.
97.	87.	87.	89.	93.	95.	97.	99.	101.	101.	107.	135.	123.
99.	89.	89.	91.	95.	97.	97.	101.	103.	103.	109.	137.	125.
101.	91.	91.	93.	97.	99.	99.	103.	105.	105.	111.	139.	127.
103.	93.	93.	95.	99.	101.	101.	105.	107.	107.	113.	141.	129.
105.	95.	95.	97.	101.	103.	103.	107.	107.	109.	115.	143.	131.
107.	97.	97.	99.	103.	105.	105.	109.	109.	111.	117.	145.	133.
109.	99.	99.	101.	105.	105.	107.	111.	111.	111.	119.	147.	135.
111.	101.	101.	103.	107.	107.	109.	111.	113.	113.	121.	149.	137.
113.	103.	103.	105.	109.	109.	111.	113.	115.	115.	123.	151.	139.
115.	105.	105.	107.	111.	111.	113.	113.	117.	117.	125.	153.	141.
117.	107.	107.	109.	113.	113.	115.	115.	119.	117.	127.	153.	143.
119.	109.	109.	111.	111.	115.	117.	117.	121.	119.	129.	153.	145.
121.	111.	111.	111.	113.	113.	119.	119.	121.	119.	131.	153.	147.
123.	113.	113.	113.	115.	115.	121.	121.	123.	121.	133.	153.	149.
125.	115.	115.	115.	117.	117.	121.	123.	123.	123.	135.	153.	151.

127.	117.	117.	117.	119.	119.	123.	125.	125.	125.	137.	153.	153.
129.	119.	119.	119.	121.	121.	125.	127.	127.	127.	139.	153.	153.
131.	121.	121.	121.	123.	123.	127.	129.	129.	129.	141.	153.	153.
133.	123.	123.	123.	125.	125.	127.	129.	129.	129.	143.	153.	153.
135.	125.	125.	125.	127.	127.	127.	131.	131.	131.	145.	153.	153.
137.	127.	127.	127.	129.	129.	129.	133.	133.	133.	147.	153.	153.
139.	129.	129.	129.	129.	129.	129.	135.	135.	135.	149.	153.	153.
141.	131.	131.	131.	131.	131.	131.	137.	137.	137.	151.	153.	153.
143.	129.	129.	129.	129.	129.	133.	139.	139.	139.	153.	153.	153.
145.	129.	129.	129.	131.	131.	135.	141.	141.	141.	151.	153.	153.
147.	129.	131.	131.	133.	131.	137.	143.	143.	143.	153.	153.	153.
149.	131.	131.	133.	135.	135.	139.	141.	145.	145.	153.	153.	153.
151.	133.	133.	135.	137.	137.	141.	143.	147.	147.	153.	153.	153.
153.	135.	135.	137.	139.	139.	143.	145.	149.	149.	153.	153.	153.

July

Previous Inflow	4.001	6.371	8.802	11.431	14.444	17.989	22.483	28.019	34.578	45.[illegible]14	59.784	97.2[illegible]
Limits	5.5670	7.1740	10.138	12.898	16.113	19.859	24.962	31.513	39.128	53.552	67.877	

Initial	End-of-Month Target Storage											
35.	35.	35.	35.	35.	37.	39.	45.	47.	53.	59.	61.	57.
37.	35.	35.	35.	35.	37.	41.	47.	49.	55.	61.	63.	57.
39.	35.	35.	35.	37.	39.	43.	49.	51.	57.	63.	65.	57.
41.	35.	35.	35.	39.	41.	45.	49.	51.	59.	65.	65.	59.
43.	35.	35.	37.	41.	43.	47.	49.	53.	61.	67.	67.	61.
45.	35.	35.	39.	43.	45.	49.	51.	55.	63.	69.	69.	63.
47.	35.	37.	41.	45.	47.	51.	53.	57.	65.	71.	71.	65.
49.	37.	39.	43.	47.	49.	53.	55.	59.	67.	73.	73.	67.
51.	39.	41.	45.	49.	51.	55.	57.	61.	69.	73.	75.	69.
53.	41.	43.	47.	51.	53.	57.	59.	63.	71.	73.	77.	71.
55.	43.	45.	49.	53.	53.	59.	61.	65.	73.	75.	77.	73.
57.	45.	47.	51.	55.	55.	59.	63.	67.	73.	75.	79.	75.
59.	47.	49.	53.	57.	57.	59.	65.	69.	75.	77.	81.	77.
61.	49.	51.	55.	57.	59.	61.	67.	71.	75.	79.	81.	79.
63.	51.	53.	57.	59.	61.	63.	69.	73.	75.	81.	81.	81.
65.	53.	55.	59.	61.	63.	65.	71.	75.	77.	83.	83.	83.
67.	55.	57.	61.	63.	65.	67.	73.	77.	79.	83.	85.	85.
69.	57.	59.	63.	65.	67.	69.	75.	77.	81.	83.	87.	87.
71.	59.	61.	65.	67.	69.	71.	77.	79.	83.	83.	89.	89.
73.	61.	63.	67.	69.	71.	73.	77.	79.	85.	85.	91.	91.
75.	63.	65.	69.	71.	73.	75.	79.	81.	87.	87.	93.	93.
77.	65.	67.	69.	73.	75.	77.	81.	83.	89.	87.	95.	95.
79.	67.	69.	71.	75.	77.	79.	83.	85.	91.	89.	97.	97.
81.	69.	71.	73.	77.	79.	81.	85.	87.	91.	91.	99.	99.
83.	71.	73.	73.	77.	81.	83.	87.	89.	93.	91.	101.	101.
85.	73.	73.	75.	79.	83.	85.	89.	91.	95.	91.	103.	103.
87.	75.	75.	77.	81.	85.	87.	91.	91.	97.	91.	105.	105.
89.	77.	77.	79.	83.	87.	89.	93.	93.	97.	91.	107.	107.
91.	79.	79.	81.	85.	87.	91.	93.	95.	97.	91.	109.	109.
93.	81.	81.	83.	87.	89.	91.	93.	97.	99.	93.	111.	111.
95.	83.	83.	85.	89.	91.	93.	95.	99.	101.	95.	109.	113.
97.	85.	85.	87.	91.	93.	95.	97.	101.	103.	97.	111.	115.
99.	87.	87.	89.	93.	95.	97.	99.	103.	105.	99.	109.	117.
101.	89.	89.	91.	95.	97.	99.	101.	105.	107.	101.	111.	119.
103.	91.	91.	93.	97.	97.	101.	103.	107.	107.	101.	113.	121.
105.	93.	93.	95.	99.	99.	103.	105.	109.	109.	103.	115.	123.
107.	95.	95.	97.	101.	101.	105.	105.	109.	111.	105.	115.	125.
109.	97.	97.	99.	103.	103.	107.	107.	109.	113.	107.	117.	127.
111.	99.	99.	101.	105.	105.	109.	109.	111.	115.	109.	119.	125.
113.	101.	101.	103.	107.	107.	109.	111.	113.	117.	111.	121.	127.
115.	103.	103.	103.	109.	109.	111.	113.	115.	117.	113.	123.	129.
117.	105.	105.	105.	111.	111.	113.	113.	117.	117.	115.	125.	131.
119.	107.	107.	107.	113.	113.	115.	115.	117.	117.	117.	121.	129.
121.	109.	109.	109.	115.	115.	115.	115.	117.	117.	117.	121.	133.
123.	111.	111.	111.	117.	117.	117.	117.	117.	117.	121.	123.	133.
125.	113.	113.	113.	117.	117.	117.	117.	117.	117.	117.	121.	135.

127.	115.	115.	115.	117.	117.	117.	117.	117.	117.	117.	123.	137.
129.	117.	117.	117.	117.	117.	117.	117.	117.	119.	119.	125.	139.
131.	119.	119.	119.	119.	117.	117.	117.	117.	121.	121.	127.	141.
133.	117.	121.	121.	121.	119.	117.	119.	119.	121.	123.	129.	141.
135.	119.	123.	123.	123.	117.	117.	117.	117.	121.	125.	131.	143.
137.	119.	125.	125.	125.	119.	117.	117.	117.	125.	127.	133.	145.
139.	123.	127.	127.	127.	117.	117.	117.	117.	127.	129.	133.	147.
141.	125.	129.	129.	129.	117.	117.	117.	119.	129.	131.	133.	149.
143.	127.	127.	131.	129.	117.	117.	117.	117.	131.	133.	135.	151.
145.	127.	129.	133.	127.	119.	117.	119.	119.	133.	135.	137.	153.
147.	127.	129.	135.	129.	117.	117.	121.	121.	133.	137.	137.	153.
149.	129.	131.	137.	131.	117.	117.	123.	123.	133.	139.	139.	153.
151.	129.	135.	139.	117.	117.	119.	125.	125.	135.	141.	141.	153.
153.	131.	137.	141.	117.	117.	119.	127.	127.	137.	143.	143.	153.

August

Previous Inflow	5.785	7.915	9.674	11.845	14.233	16.714	19.446	22.400	26.659	32.556	39.482	55.894
Limits	7.1880	8.5270	10.839	13.034	15.505	18.246	20.569	24.613	29.083	36.335	43.221	

Initial	End-of-Month Target Storage											
35.	37.	43.	43.	49.	51.	57.	61.	61.	67.	75.	95.	95.
37.	37.	45.	45.	51.	53.	59.	63.	61.	69.	77.	97.	95.
39.	39.	47.	47.	53.	55.	59.	65.	63.	71.	79.	99.	95.
41.	41.	49.	49.	55.	57.	61.	67.	65.	73.	81.	101.	95.
43.	43.	51.	51.	57.	59.	63.	69.	67.	75.	83.	101.	95.
45.	45.	53.	53.	59.	61.	65.	71.	69.	77.	85.	101.	97.
47.	47.	55.	55.	61.	63.	67.	73.	71.	79.	87.	101.	99.
49.	49.	55.	57.	63.	65.	69.	75.	73.	81.	89.	101.	101.
51.	51.	55.	59.	65.	67.	71.	75.	75.	83.	91.	103.	101.
53.	53.	55.	61.	67.	69.	73.	77.	77.	85.	93.	105.	103.
55.	55.	57.	63.	69.	71.	75.	79.	79.	87.	95.	107.	105.
57.	57.	59.	65.	71.	73.	77.	81.	81.	89.	95.	107.	107.
59.	59.	61.	67.	71.	75.	79.	83.	83.	91.	95.	109.	109.
61.	61.	63.	69.	71.	77.	81.	85.	85.	93.	95.	111.	111.
63.	63.	65.	71.	73.	77.	83.	87.	87.	95.	95.	113.	113.
65.	65.	67.	73.	75.	79.	85.	89.	89.	97.	97.	115.	115.
67.	67.	69.	75.	77.	81.	87.	91.	91.	99.	99.	117.	117.
69.	69.	71.	77.	79.	83.	89.	93.	91.	101.	101.	117.	119.
71.	71.	73.	79.	79.	85.	91.	95.	91.	103.	103.	117.	121.
73.	73.	75.	81.	81.	87.	93.	97.	91.	105.	105.	117.	123.
75.	75.	77.	83.	83.	89.	93.	99.	91.	105.	107.	117.	125.
77.	77.	79.	85.	85.	91.	93.	101.	93.	107.	107.	117.	127.
79.	79.	81.	87.	87.	93.	95.	103.	95.	107.	107.	117.	129.
81.	81.	83.	89.	89.	95.	97.	105.	97.	107.	107.	117.	131.
83.	83.	85.	89.	91.	97.	99.	107.	99.	107.	107.	121.	133.
85.	85.	87.	89.	93.	99.	101.	109.	101.	109.	109.	121.	133.
87.	87.	89.	91.	95.	101.	103.	109.	103.	111.	111.	123.	133.
89.	89.	91.	91.	97.	103.	105.	109.	105.	113.	113.	123.	133.
91.	91.	93.	93.	99.	105.	107.	107.	107.	115.	115.	125.	133.
93.	93.	93.	95.	101.	107.	107.	109.	107.	117.	117.	125.	133.
95.	95.	95.	97.	103.	107.	109.	111.	109.	117.	119.	127.	133.
97.	97.	97.	99.	103.	107.	111.	113.	111.	117.	121.	129.	133.
99.	99.	99.	101.	103.	109.	111.	115.	113.	117.	123.	131.	133.
101.	101.	101.	103.	103.	111.	111.	117.	115.	117.	123.	133.	133.
103.	103.	103.	105.	105.	111.	113.	117.	115.	117.	123.	133.	133.
105.	105.	105.	107.	107.	113.	115.	117.	115.	117.	121.	133.	133.
107.	107.	107.	109.	109.	113.	115.	117.	117.	117.	123.	133.	133.
109.	109.	109.	111.	111.	113.	117.	117.	117.	117.	123.	133.	133.
111.	111.	111.	113.	113.	115.	117.	117.	117.	117.	123.	133.	133.
113.	113.	113.	115.	115.	115.	117.	119.	119.	119.	125.	133.	133.
115.	115.	115.	117.	117.	117.	117.	121.	121.	121.	123.	133.	133.
117.	117.	117.	117.	117.	117.	117.	123.	123.	123.	123.	133.	133.
119.	117.	117.	117.	117.	117.	117.	123.	123.	125.	125.	133.	133.
121.	117.	117.	117.	117.	117.	117.	123.	125.	127.	127.	133.	133.
123.	117.	117.	117.	117.	117.	117.	123.	123.	127.	129.	133.	133.
125.	117.	117.	117.	117.	117.	117.	123.	125.	131.	131.	133.	133.

127.	117.	117.	117.	117.	117.	117.	123.	127.	131.	133.	133.	133.
129.	117.	117.	117.	117.	117.	117.	123.	127.	129.	133.	133.	133.
131.	117.	119.	117.	119.	119.	119.	123.	127.	131.	133.	133.	133.
133.	119.	121.	117.	121.	121.	121.	123.	127.	131.	133.	133.	133.
135.	117.	117.	117.	123.	123.	123.	125.	127.	131.	133.	133.	133.
137.	119.	117.	117.	117.	117.	125.	127.	127.	131.	133.	133.	133.
139.	127.	117.	117.	117.	117.	127.	129.	131.	131.	133.	133.	133.
141.	127.	117.	117.	121.	121.	125.	131.	131.	131.	133.	133.	133.
143.	133.	117.	117.	123.	123.	127.	131.	131.	133.	133.	133.	133.
145.	133.	117.	117.	123.	123.	127.	133.	133.	133.	133.	133.	133.
147.	133.	117.	117.	123.	123.	127.	133.	133.	133.	133.	133.	133.
149.	133.	117.	117.	123.	127.	129.	133.	133.	133.	133.	133.	133.
151.	133.	117.	117.	127.	127.	131.	133.	133.	133.	133.	133.	133.
153.	117.	117.	117.	127.	127.	131.	133.	133.	133.	133.	133.	133.

September

Previous Inflow	7.763	10.646	13.213	16.576	19.307	22.898	26.456	30.445	36.775	46.200	60.206	111.410
Limits	9.3300	11.663	14.840	18.018	20.707	24.803	23.122	33.263	40.871	52.939	70.433	
Initial	End-of-Month Target Storage											
35.	35.	37.	37.	41.	41.	47.	49.	47.	53.	53.	73.	75.
37.	35.	39.	39.	41.	43.	49.	51.	49.	55.	55.	73.	77.
39.	37.	41.	41.	41.	45.	51.	53.	51.	57.	57.	73.	79.
41.	39.	43.	43.	43.	47.	53.	55.	53.	59.	59.	75.	81.
43.	41.	45.	45.	45.	49.	55.	57.	55.	61.	61.	75.	83.
45.	43.	47.	47.	47.	51.	57.	59.	57.	63.	63.	77.	85.
47.	45.	49.	49.	49.	53.	59.	61.	59.	63.	65.	79.	87.
49.	47.	51.	51.	51.	55.	61.	63.	61.	63.	67.	81.	89.
51.	49.	53.	53.	53.	57.	61.	63.	63.	65.	69.	83.	89.
53.	51.	55.	55.	55.	59.	61.	65.	65.	67.	71.	85.	89.
55.	53.	57.	57.	57.	61.	63.	67.	67.	69.	73.	87.	91.
57.	55.	59.	59.	59.	63.	65.	69.	69.	71.	75.	89.	91.
59.	57.	61.	61.	61.	65.	67.	71.	71.	73.	77.	91.	91.
61.	57.	63.	63.	63.	67.	69.	73.	73.	75.	79.	93.	93.
63.	59.	65.	65.	65.	69.	71.	75.	75.	77.	81.	95.	95.
65.	61.	67.	67.	67.	71.	73.	77.	77.	79.	83.	97.	97.
67.	63.	69.	69.	69.	73.	75.	79.	79.	81.	85.	99.	99.
69.	65.	71.	71.	71.	75.	77.	81.	81.	81.	87.	101.	101.
71.	67.	73.	73.	73.	77.	79.	83.	83.	83.	89.	103.	103.
73.	69.	75.	75.	75.	79.	79.	85.	85.	85.	91.	105.	105.
75.	71.	77.	75.	77.	81.	81.	87.	87.	87.	93.	107.	107.
77.	73.	77.	77.	77.	83.	83.	89.	87.	89.	95.	109.	109.
79.	75.	79.	79.	79.	85.	85.	91.	87.	91.	97.	111.	111.
81.	77.	81.	79.	79.	87.	87.	93.	89.	93.	99.	113.	113.
83.	79.	81.	81.	81.	89.	89.	95.	91.	95.	101.	113.	113.
85.	81.	83.	83.	83.	91.	91.	97.	93.	97.	103.	113.	113.
87.	83.	85.	85.	85.	91.	93.	99.	95.	99.	105.	113.	113.
89.	85.	87.	87.	87.	91.	95.	101.	97.	101.	107.	113.	113.
91.	87.	89.	89.	89.	93.	97.	103.	99.	103.	109.	113.	113.
93.	89.	91.	91.	91.	95.	99.	105.	101.	105.	111.	113.	113.
95.	91.	93.	93.	93.	97.	101.	107.	103.	107.	113.	113.	113.
97.	93.	95.	95.	95.	99.	103.	109.	105.	109.	113.	113.	113.
99.	95.	97.	97.	97.	101.	105.	111.	107.	111.	113.	113.	113.
101.	97.	99.	99.	99.	103.	107.	111.	109.	113.	113.	113.	113.
103.	99.	101.	101.	101.	105.	109.	111.	111.	113.	113.	113.	113.
105.	101.	103.	103.	103.	107.	111.	113.	111.	113.	113.	113.	113.
107.	103.	105.	105.	105.	109.	113.	113.	113.	113.	113.	113.	113.
109.	105.	107.	107.	107.	111.	113.	113.	113.	113.	113.	113.	113.
111.	107.	109.	109.	109.	113.	113.	113.	113.	113.	113.	113.	113.
113.	109.	111.	109.	111.	113.	113.	113.	113.	113.	113.	113.	113.
115.	111.	111.	111.	111.	113.	113.	113.	113.	113.	113.	113.	113.
117.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
119.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
121.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
123.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
125.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.

127.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
129.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
131.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
133.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.

October

Previous Inflow	7.447	9.381	11.259	13.565	15.606	18.174	21.029	24.876	29.388	37.564	50.860	86.017
Limits		8.6950	10.170	12.308	14.603	16.851	19.401	22.768	27.162	32.440	44.292	58.197
Initial	End-of-Month Target Storage											
35.	39.	41.	45.	45.	45.	49.	49.	53.	51.	57.	57.	67.
37.	39.	43.	45.	47.	47.	51.	51.	55.	51.	59.	59.	69.
39.	41.	45.	45.	49.	49.	53.	53.	55.	53.	59.	61.	71.
41.	43.	47.	47.	51.	51.	55.	55.	57.	55.	61.	63.	73.
43.	45.	49.	49.	53.	53.	57.	57.	59.	57.	63.	65.	75.
45.	47.	51.	51.	55.	55.	59.	59.	61.	59.	63.	67.	77.
47.	49.	53.	53.	57.	57.	61.	61.	61.	61.	65.	69.	79.
49.	51.	55.	55.	59.	59.	63.	63.	63.	63.	67.	71.	81.
51.	53.	57.	57.	61.	61.	65.	65.	65.	65.	69.	73.	83.
53.	55.	59.	59.	61.	63.	67.	67.	67.	67.	71.	75.	85.
55.	57.	61.	61.	61.	65.	69.	69.	69.	69.	73.	77.	87.
57.	59.	63.	63.	63.	67.	71.	69.	71.	71.	75.	79.	89.
59.	61.	65.	65.	65.	69.	71.	71.	73.	73.	77.	79.	91.
61.	63.	65.	67.	67.	71.	73.	73.	75.	75.	79.	81.	93.
63.	65.	65.	69.	69.	73.	75.	75.	77.	77.	81.	83.	93.
65.	67.	67.	71.	71.	75.	75.	75.	79.	79.	83.	83.	93.
67.	69.	69.	73.	73.	77.	77.	77.	81.	81.	85.	85.	95.
69.	71.	71.	75.	75.	79.	79.	79.	83.	81.	87.	87.	97.
71.	73.	73.	77.	77.	81.	81.	81.	85.	83.	89.	89.	99.
73.	75.	75.	79.	79.	81.	83.	83.	87.	85.	91.	91.	101.
75.	77.	77.	81.	81.	81.	85.	85.	89.	87.	93.	93.	103.
77.	79.	79.	83.	83.	83.	87.	87.	91.	87.	95.	95.	103.
79.	81.	81.	85.	85.	85.	89.	89.	93.	89.	97.	97.	105.
81.	83.	83.	87.	87.	87.	91.	91.	95.	91.	99.	99.	107.
83.	85.	85.	89.	89.	89.	93.	93.	97.	93.	101.	101.	109.
85.	87.	87.	91.	91.	91.	95.	95.	99.	95.	103.	103.	111.
87.	89.	89.	93.	93.	93.	97.	97.	101.	97.	105.	105.	113.
89.	91.	91.	95.	95.	95.	99.	99.	101.	99.	107.	107.	115.
91.	93.	93.	97.	97.	97.	101.	101.	103.	101.	109.	109.	117.
93.	95.	95.	99.	99.	99.	103.	103.	105.	103.	111.	111.	119.
95.	97.	97.	101.	101.	101.	105.	105.	107.	105.	113.	113.	121.
97.	99.	99.	103.	103.	103.	107.	107.	109.	107.	115.	115.	123.
99.	101.	101.	105.	105.	103.	109.	109.	111.	109.	117.	117.	125.
101.	103.	103.	105.	107.	103.	111.	111.	113.	111.	119.	119.	127.
103.	105.	105.	105.	109.	105.	113.	113.	113.	113.	121.	121.	129.
105.	107.	107.	107.	111.	107.	115.	115.	115.	115.	123.	123.	129.
107.	109.	109.	109.	113.	109.	117.	117.	117.	117.	125.	125.	131.
109.	111.	111.	111.	115.	111.	119.	119.	119.	119.	127.	127.	133.
111.	113.	113.	113.	117.	113.	121.	121.	121.	121.	129.	129.	135.
113.	115.	115.	115.	119.	115.	123.	123.	123.	123.	131.	131.	137.

November

Previous	8.440	10.010	11.616	13.156	14.574	16.091	17.709	19.979	22.997	27.103	33.291	47.626
Inflow												
Limits		9.3160	10.584	12.476	13.880	15.333	16.743	18.661	21.423	24.7[illegible]0	30.468	36.716
Initial	End-of-Month Target Storage											
35.	35.	39.	41.	41.	43.	45.	45.	45.	49.	53.	53.	57.
37.	37.	41.	43.	43.	45.	47.	47.	47.	51.	55.	55.	59.
39.	39.	43.	45.	45.	47.	49.	49.	49.	53.	57.	57.	59.
41.	41.	45.	45.	45.	47.	49.	51.	51.	53.	59.	59.	59.
43.	41.	47.	47.	47.	49.	51.	51.	53.	55.	61.	61.	61.
45.	41.	49.	49.	49.	51.	53.	53.	55.	57.	63.	63.	63.
47.	43.	51.	51.	51.	53.	55.	55.	57.	59.	65.	65.	65.
49.	45.	53.	53.	53.	55.	57.	57.	59.	61.	67.	67.	67.
51.	47.	55.	55.	55.	55.	57.	57.	61.	61.	67.	67.	69.
53.	49.	55.	57.	57.	57.	59.	59.	63.	63.	69.	69.	71.
55.	51.	57.	59.	59.	59.	61.	61.	65.	65.	71.	69.	73.
57.	53.	59.	61.	61.	61.	63.	63.	67.	67.	73.	71.	75.
59.	55.	61.	63.	63.	63.	65.	65.	69.	69.	73.	73.	77.
61.	57.	63.	65.	65.	65.	67.	67.	69.	71.	75.	75.	79.
63.	59.	65.	67.	67.	67.	69.	69.	71.	73.	77.	77.	81.
65.	61.	65.	69.	69.	69.	71.	71.	73.	75.	79.	79.	81.
67.	63.	67.	71.	71.	71.	73.	71.	75.	77.	81.	81.	83.
69.	65.	69.	73.	73.	73.	73.	73.	77.	79.	83.	83.	83.
71.	67.	71.	75.	73.	75.	75.	75.	79.	81.	85.	85.	85.
73.	69.	73.	77.	75.	77.	77.	77.	79.	83.	87.	87.	87.
75.	71.	75.	79.	77.	79.	79.	79.	81.	85.	87.	87.	89.
77.	73.	77.	79.	79.	79.	81.	81.	83.	87.	89.	89.	91.
79.	75.	79.	81.	81.	81.	83.	83.	85.	87.	91.	91.	93.
81.	77.	81.	83.	83.	83.	85.	85.	87.	89.	93.	93.	95.
83.	79.	83.	85.	85.	85.	87.	87.	89.	91.	95.	95.	97.
85.	81.	85.	87.	85.	87.	89.	89.	91.	93.	95.	95.	99.
87.	83.	87.	89.	87.	87.	91.	91.	93.	95.	97.	97.	101.
89.	85.	89.	91.	89.	89.	93.	93.	95.	95.	99.	99.	103.
91.	87.	91.	91.	91.	91.	95.	95.	97.	97.	101.	101.	105.
93.	89.	91.	93.	93.	93.	97.	97.	99.	99.	103.	103.	107.
95.	91.	91.	95.	95.	95.	99.	99.	99.	101.	105.	105.	107.
97.	93.	93.	97.	97.	97.	101.	101.	101.	103.	107.	107.	109.
99.	95.	95.	99.	99.	99.	103.	103.	103.	105.	109.	109.	111.
101.	97.	97.	101.	101.	101.	105.	105.	105.	107.	111.	111.	113.
103.	99.	99.	103.	103.	103.	107.	107.	107.	109.	113.	113.	115.
105.	101.	101.	105.	105.	105.	109.	107.	109.	111.	115.	115.	117.
107.	103.	103.	107.	107.	107.	111.	109.	111.	113.	117.	117.	119.
109.	105.	105.	109.	109.	107.	113.	111.	113.	115.	119.	119.	121.
111.	107.	107.	111.	111.	107.	115.	113.	115.	115.	121.	121.	121.
113.	109.	109.	113.	113.	109.	117.	115.	117.	117.	123.	123.	123.
115.	111.	111.	115.	115.	111.	119.	117.	119.	119.	125.	125.	125.
117.	113.	113.	117.	117.	113.	121.	119.	121.	121.	127.	127.	127.
119.	115.	115.	119.	119.	115.	123.	121.	123.	123.	129.	129.	129.
121.	117.	117.	121.	121.	117.	125.	123.	125.	125.	131.	131.	131.
123.	119.	119.	123.	123.	119.	127.	125.	127.	127.	131.	133.	133.
125.	121.	121.	125.	125.	121.	129.	127.	129.	129.	133.	135.	135.

127.	123.	123.	127.	127.	123.	131.	129.	131.	131.	135.	137.	137.
129.	125.	125.	129.	129.	125.	133.	131.	133.	133.	137.	139.	139.
131.	127.	127.	131.	131.	127.	135.	131.	135.	135.	139.	141.	141.
133.	129.	129.	133.	133.	129.	137.	133.	137.	137.	141.	143.	143.
135.	131.	131.	135.	135.	131.	139.	135.	139.	139.	141.	145.	145.
137.	133.	133.	137.	135.	133.	141.	137.	141.	141.	143.	147.	147.

December

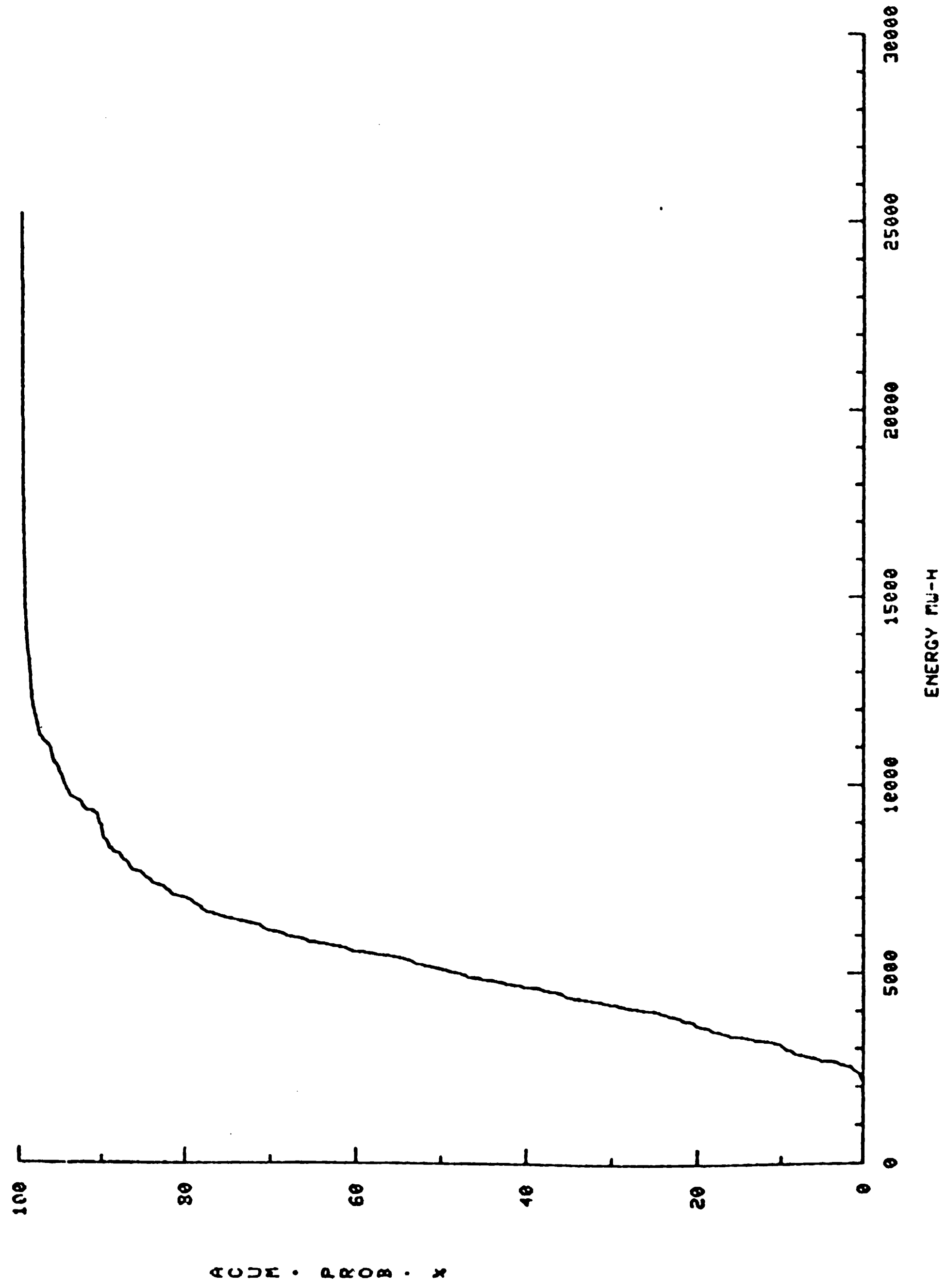
Previous Inflow Limits: 9.403 10.553 11.310 11.960 12.849 13.877 14.762 15.537 16.2[illegible] 17.015 17.935 18.906 19.[illegible] 20.906 21.975 23.011 24.1[illegible] 26.161 29.4[illegible] 32.444 34.4[illegible] [illegible]

Initial	End-of-Month Target Storage											
35.	37.	37.	37.	43.	43.	45.	47.	49.	51.	[illegible]	[illegible]	[illegible]
37.	37.	37.	39.	43.	45.	47.	47.	51.	53.	51.	65.	[illegible]
39.	39.	39.	41.	43.	47.	47.	49.	53.	53.	[illegible]	65.	[illegible]
41.	39.	41.	43.	43.	47.	49.	51.	55.	55.	[illegible]	65.	[illegible]
43.	[illegible]	43.	45.	[illegible]	47.	51.	53.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45.	41.	45.	47.	47.	47.	53.	55.	55.	59.	59.	67.	[illegible]
47.	43.	47.	49.	49.	49.	55.	57.	57.	61.	61.	69.	[illegible]
49.	45.	47.	49.	51.	51.	57.	59.	59.	63.	63.	[illegible]	[illegible]
51.	47.	47.	51.	53.	53.	59.	61.	61.	65.	65.	[illegible]	[illegible]
53.	49.	49.	53.	55.	55.	59.	61.	63.	65.	67.	[illegible]	[illegible]
55.	51.	51.	55.	57.	57.	59.	[illegible]	65.	65.	[illegible]	[illegible]	[illegible]
57.	51.	53.	57.	59.	59.	59.	65.	67.	67.	71.	[illegible]	[illegible]
59.	53.	55.	59.	59.	61.	61.	67.	69.	69.	73.	[illegible]	[illegible]
61.	55.	57.	59.	61.	63.	63.	69.	71.	71.	75.	83.	[illegible]
63.	55.	59.	59.	63.	65.	65.	71.	73.	[illegible]	77.	[illegible]	[illegible]
65.	55.	61.	61.	65.	67.	67.	73.	75.	[illegible]	[illegible]	[illegible]	[illegible]
67.	57.	63.	63.	67.	69.	69.	75.	75.	77.	79.	[illegible]	[illegible]
69.	59.	63.	65.	69.	71.	71.	77.	77.	79.	81.	[illegible]	[illegible]
71.	61.	65.	67.	71.	71.	73.	79.	79.	81.	83.	91.	[illegible]
73.	63.	67.	69.	73.	73.	75.	81.	81.	83.	85.	[illegible]	[illegible]
75.	65.	69.	71.	75.	75.	77.	83.	83.	85.	87.	[illegible]	[illegible]
77.	67.	71.	73.	77.	77.	79.	85.	85.	[illegible]	[illegible]	95.	[illegible]
79.	69.	73.	75.	79.	79.	81.	87.	87.	87.	91.	[illegible]	[illegible]
81.	71.	73.	75.	81.	81.	83.	89.	89.	89.	93.	97.	[illegible]
83.	73.	73.	77.	81.	83.	85.	91.	91.	91.	95.	99.	[illegible]
85.	75.	75.	79.	83.	85.	87.	93.	93.	93.	[illegible]	[illegible]	[illegible]
87.	77.	77.	81.	83.	87.	89.	95.	95.	95.	99.	[illegible]	[illegible]
89.	77.	79.	83.	85.	89.	91.	97.	97.	97.	101.	[illegible]	[illegible]
91.	79.	81.	83.	87.	91.	91.	99.	99.	99.	103.	107.	131.
93.	81.	83.	85.	89.	93.	93.	101.	101.	101.	105.	109.	[illegible]
95.	83.	85.	85.	91.	95.	95.	103.	103.	103.	107.	111.	[illegible]
97.	85.	87.	87.	93.	97.	97.	103.	105.	105.	109.	113.	[illegible]
99.	87.	89.	89.	95.	99.	99.	103.	107.	107.	111.	115.	[illegible]
101.	89.	91.	91.	97.	101.	101.	103.	109.	109.	113.	117.	141.
103.	91.	91.	93.	99.	103.	103.	105.	111.	111.	115.	[illegible]	[illegible]
105.	93.	93.	95.	101.	105.	105.	107.	113.	113.	117.	121.	145.
107.	95.	95.	97.	103.	107.	107.	109.	115.	115.	119.	123.	145.
109.	97.	97.	99.	105.	109.	109.	111.	117.	117.	121.	125.	147.
111.	99.	99.	101.	107.	111.	111.	113.	119.	119.	123.	127.	149.
113.	101.	101.	103.	109.	113.	113.	115.	121.	121.	125.	127.	[illegible]
115.	103.	103.	105.	111.	115.	115.	117.	123.	123.	[illegible]	[illegible]	[illegible]
117.	105.	105.	107.	113.	117.	117.	119.	125.	125.	127.	[illegible]	[illegible]
119.	107.	107.	109.	115.	119.	119.	121.	127.	127.	[illegible]	[illegible]	[illegible]
121.	109.	109.	109.	117.	119.	121.	123.	[illegible]	129.	[illegible]	[illegible]	[illegible]
123.	111.	111.	111.	119.	119.	[illegible]	125.	[illegible]	131.	[illegible]	[illegible]	[illegible]
125.	113.	113.	113.	121.	121.	[illegible]	127.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

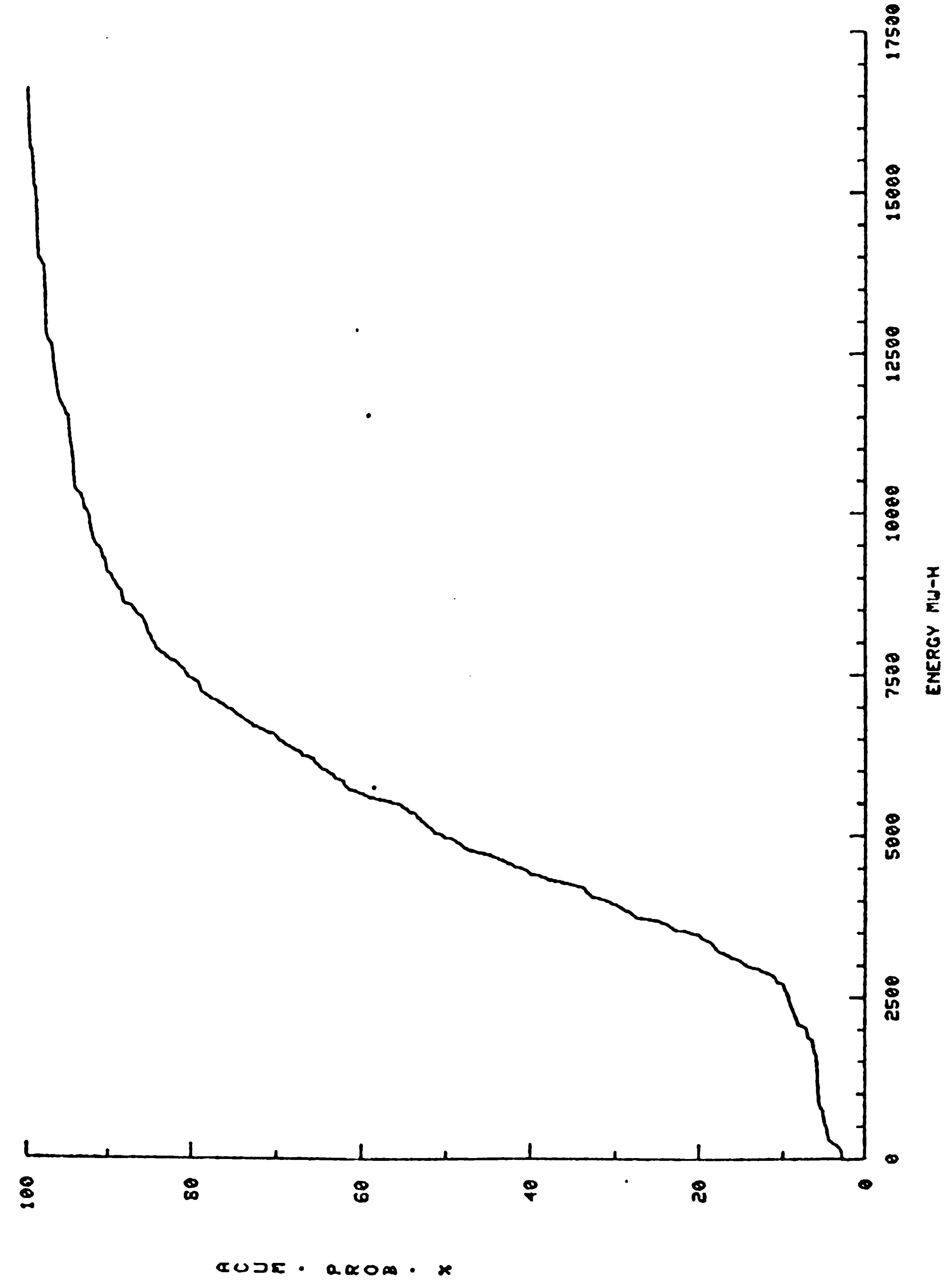
127.	115.	115.	115.	123.	123.	127.	129.	135.	135.	137.	141.	153.
129.	117.	117.	117.	125.	125.	129.	131.	137.	137.	139.	143.	153.
131.	119.	119.	119.	127.	127.	131.	133.	139.	139.	139.	145.	[illegible]
133.	121..	121.	121.	129.	129.	133.	135.	141.	141.	141.	147.	153.
135.	123.	123.	123.	129.	131.	135.	137.	141.	143.	143.	149.	153.
137.	125.	125.	125.	131.	133.	137.	139.	141.	145.	145.	151.	153
139.	127.	127.	127.	133.	135.	139.	139.	141.	145.	147.	153.	153.
141.	129.	129.	129.	135.	137.	141.	141.	143.	145.	149.	153.	153.
143.	131.	131.	131.	137.	139.	143.	143.	145.	145.	151.	153.	153.
145.	133.	133.	133.	139.	141.	145.	145.	147.	147.	151.	153.	153.
147.	135.	135.	135.	141.	143.	147.	147.	149.	149.	151.	153.	[illegible]
149.	137.	137.	137.	143.	145.	149.	149.	151.	151.	151.	153.	[illegible]
151.	139.	139.	139.	145.	147.	151.	151.	151.	[illegible]	[illegible]	[illegible]	[illegible]
153.	141.	141.	141.	147.	149.	153.	153.	153.	153.	151.	153.	153.

APPENDIX F

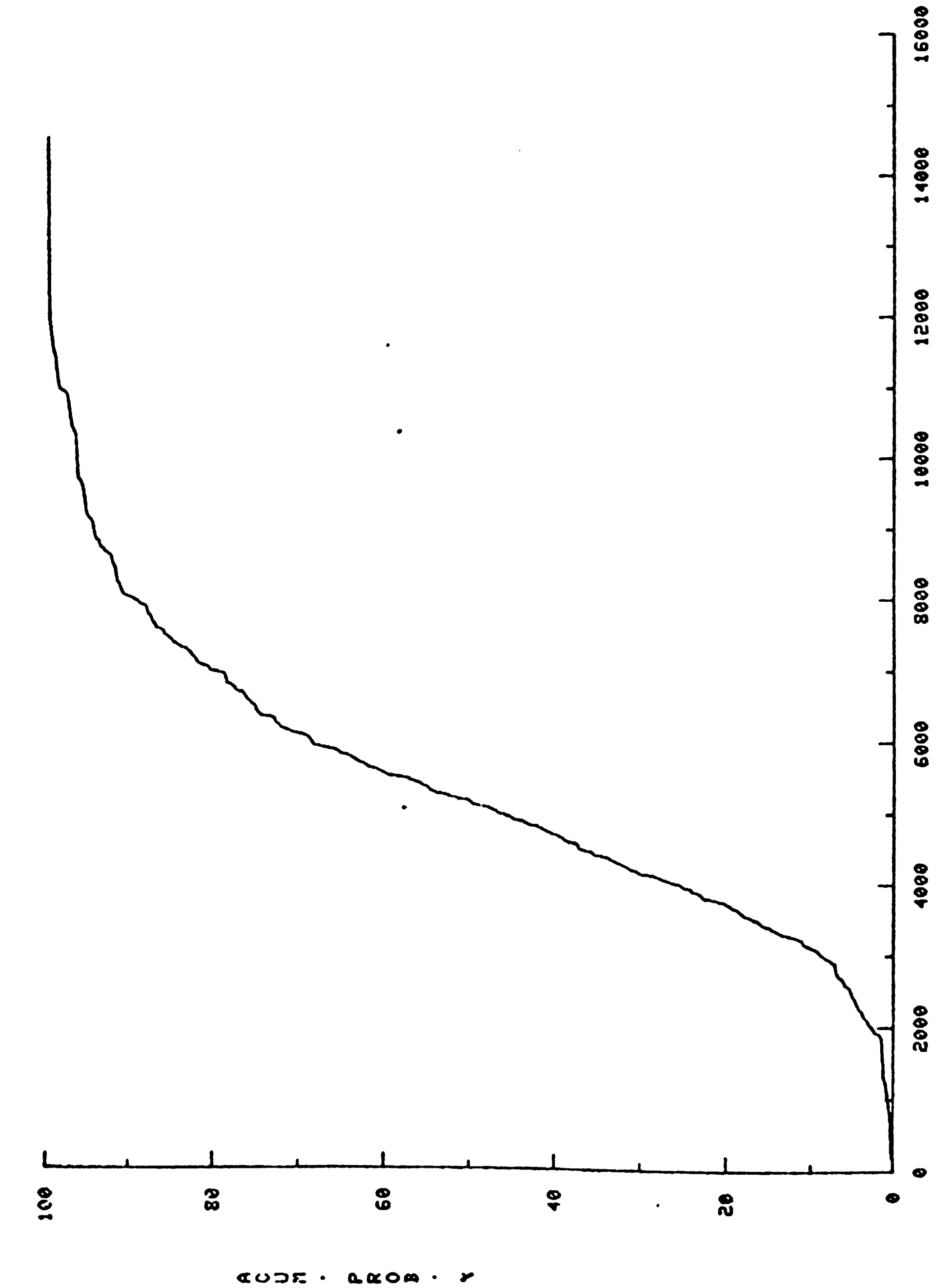
MONTHLY FREQUENCY DISTRIBUTION FOR ENERGY, RELEASES AND POWER UNDER CSUDP POLICIES


0
20
40
60
80
100
0
5000
10000
15000
20000
25000
30000
ENERGY MW-H

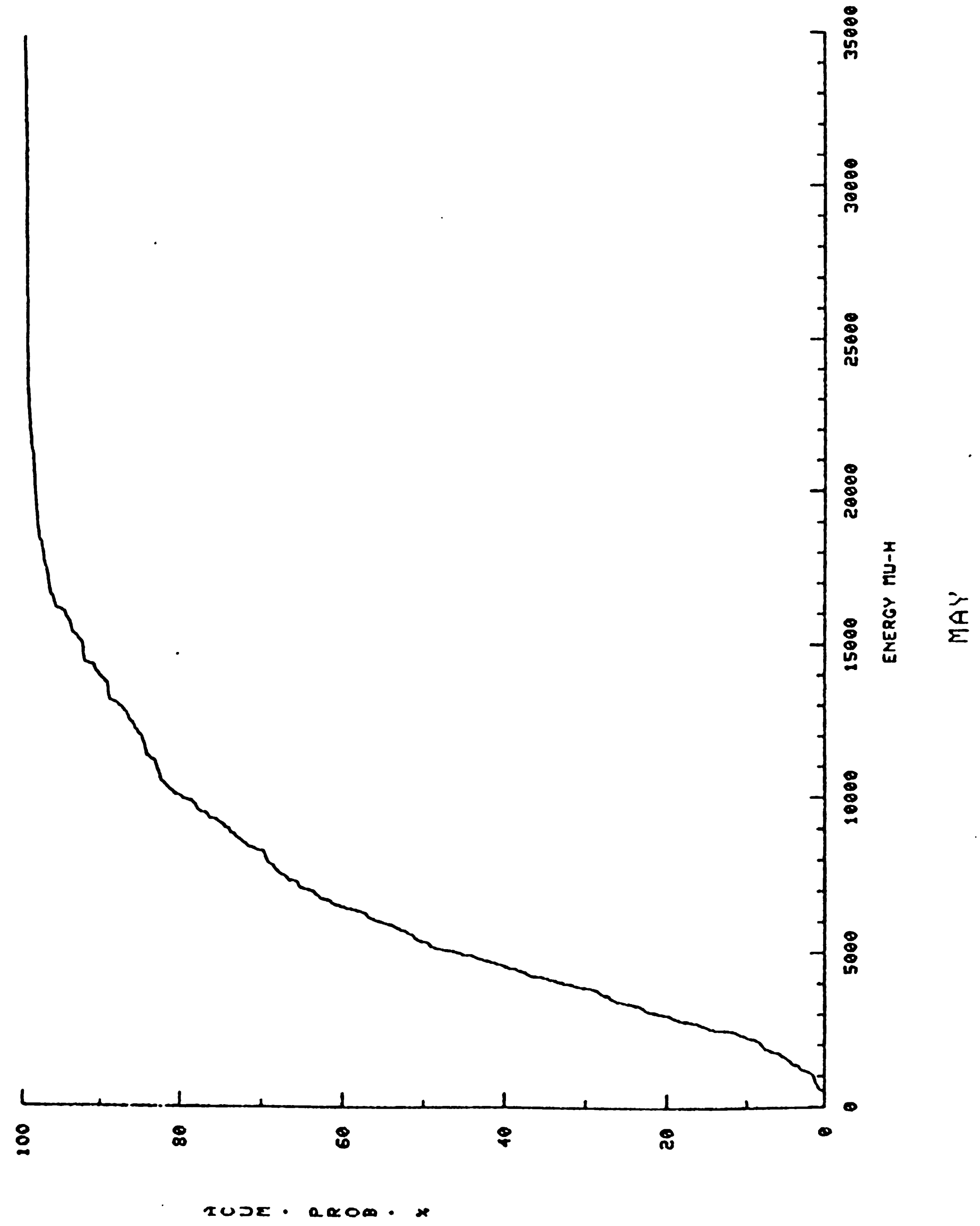
JANUARY

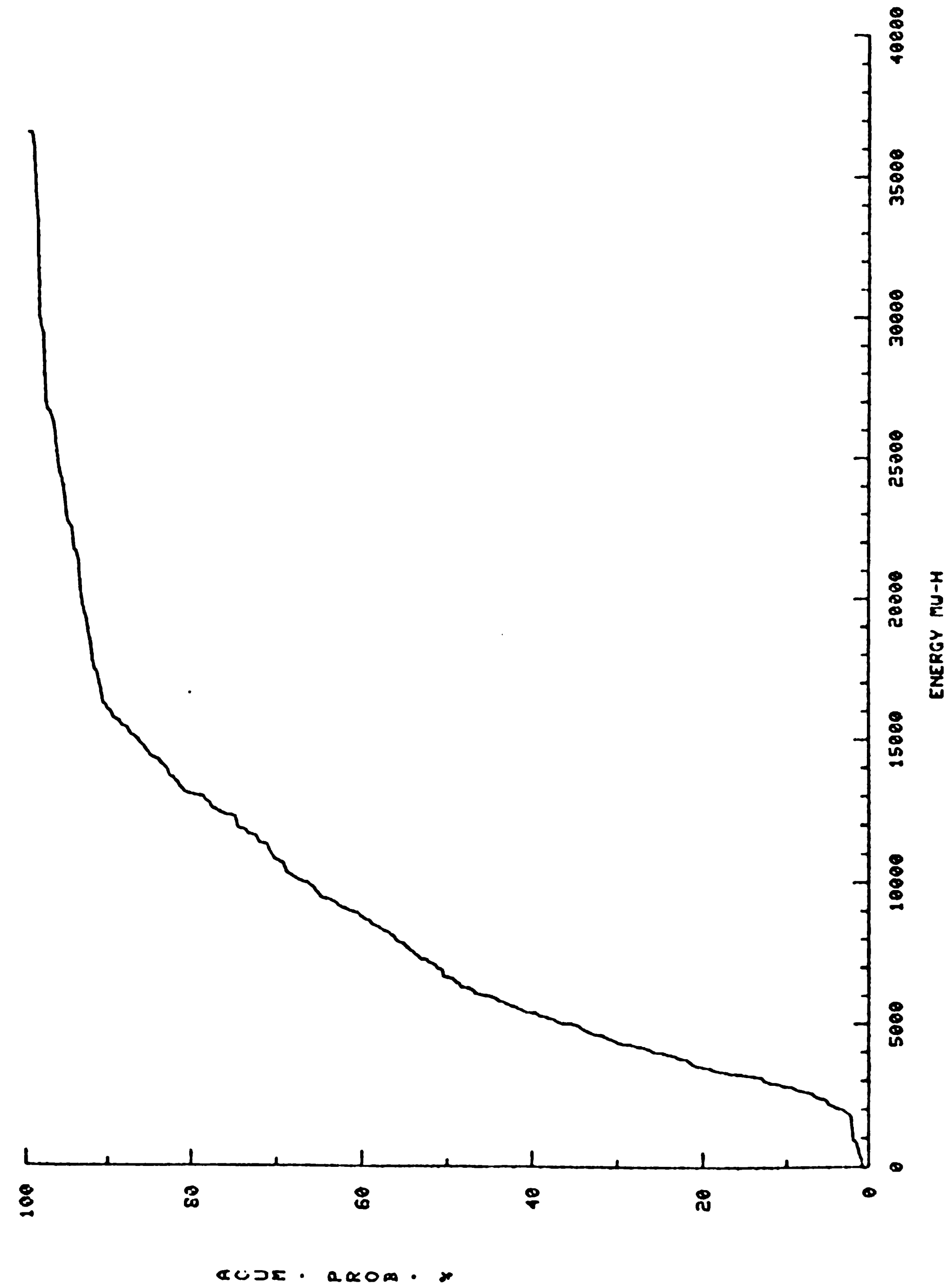

0
2500
5000
7500
10000
12500
15000
17500
ENERGY MW-H
0
20
40
60
80
100

FEBRUARY

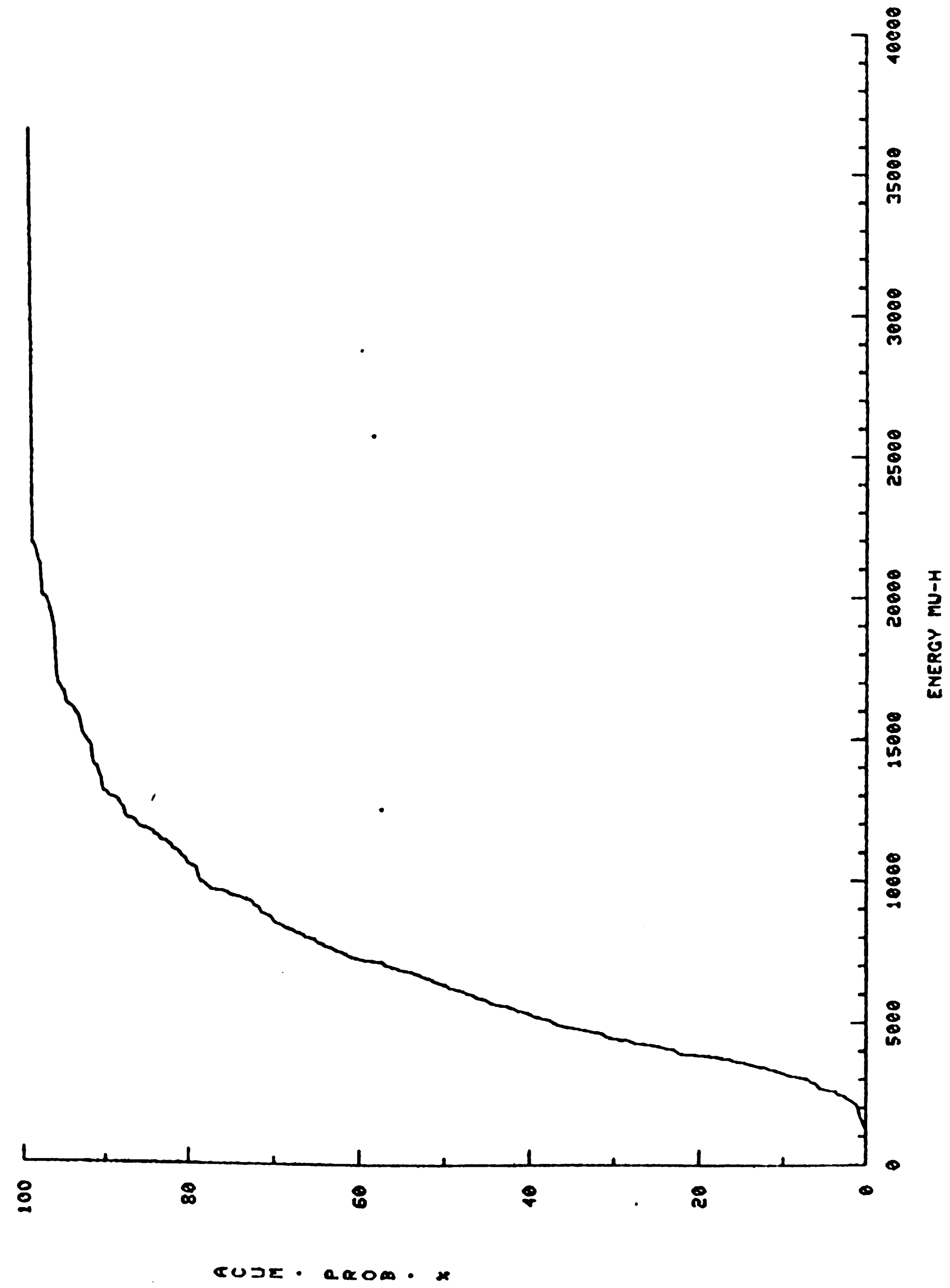

ENERGY MW-H
0
2000
4000
6000
8000
10000
12000
14000
16000
100
80
60
40
20
0

APRIL

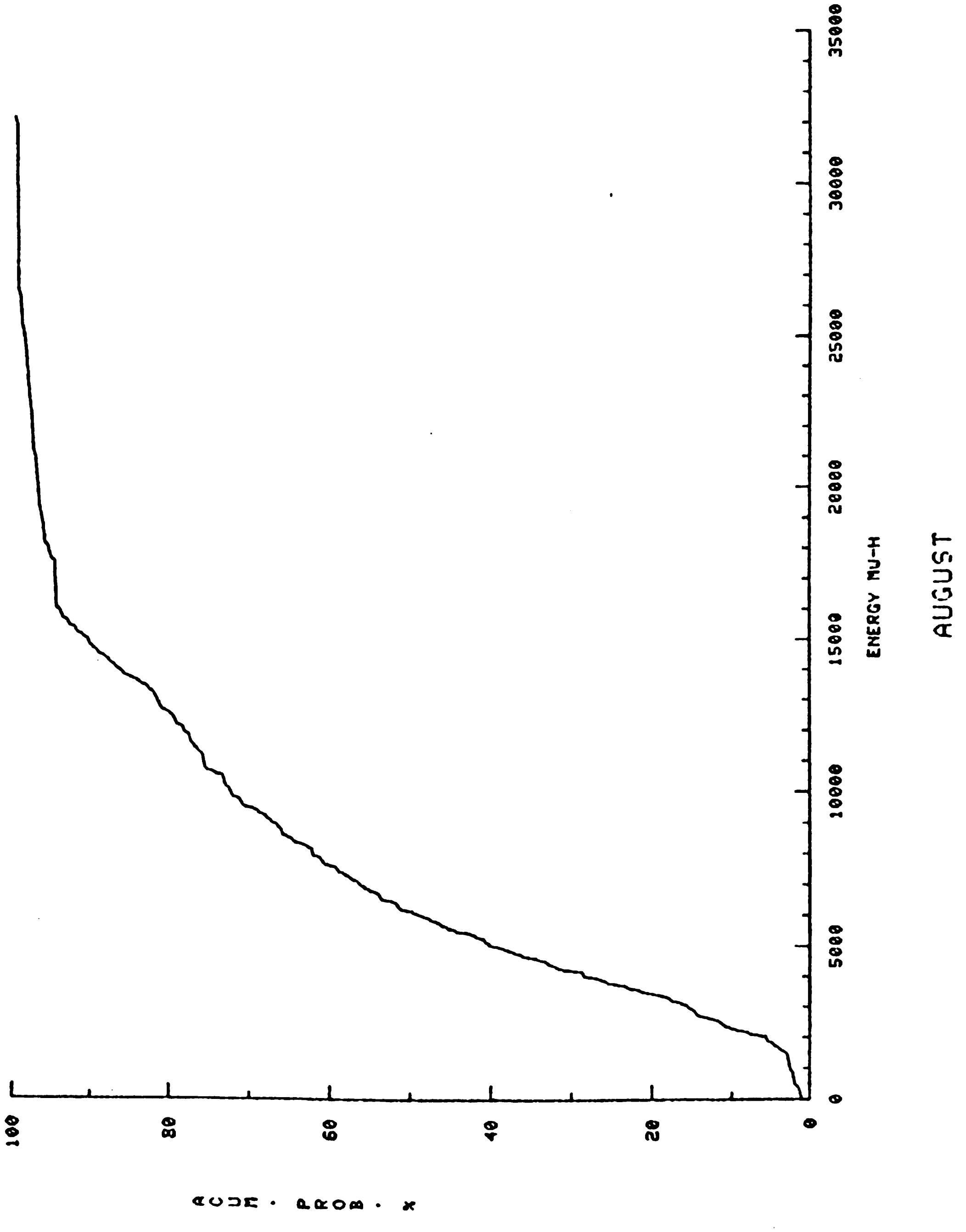

0
20
40
60
80
100
0
5000
10000
15000
20000
25000
30000
35000
ENERGY MU-H
MAY

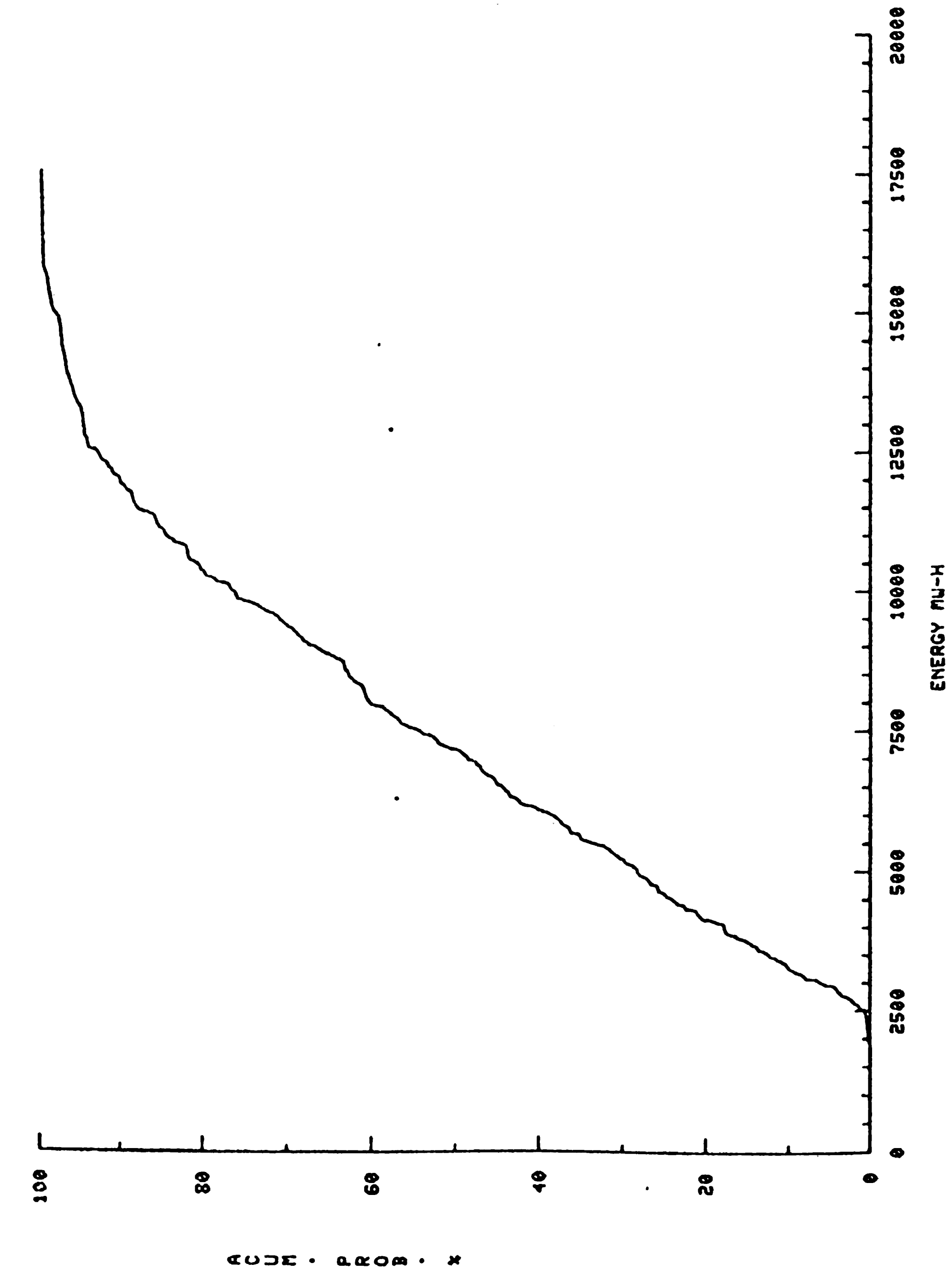

0
5000
10000
15000
20000
25000
30000
35000
40000
ENERGY MW-H
0
20
40
60
80
100
CUM. PROB. %

JUNE


100
80
60
40
20
0
5000
10000
15000
20000
25000
30000
35000
40000
ENERGY MW-H

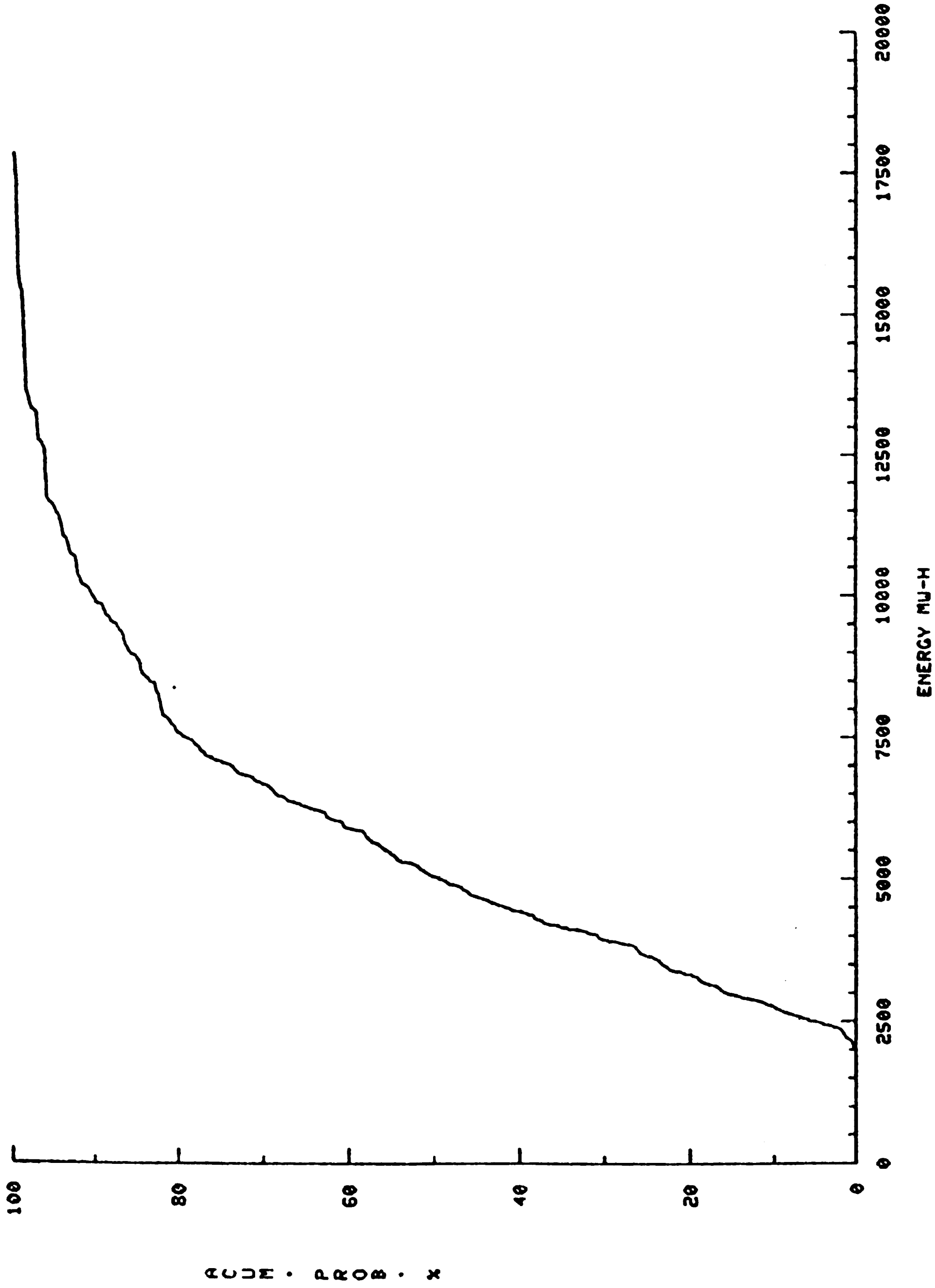
JULY


100
80
60
40
20
0
5000
10000
15000
20000
25000
30000
35000
ENERGY MW-H
AUGUST



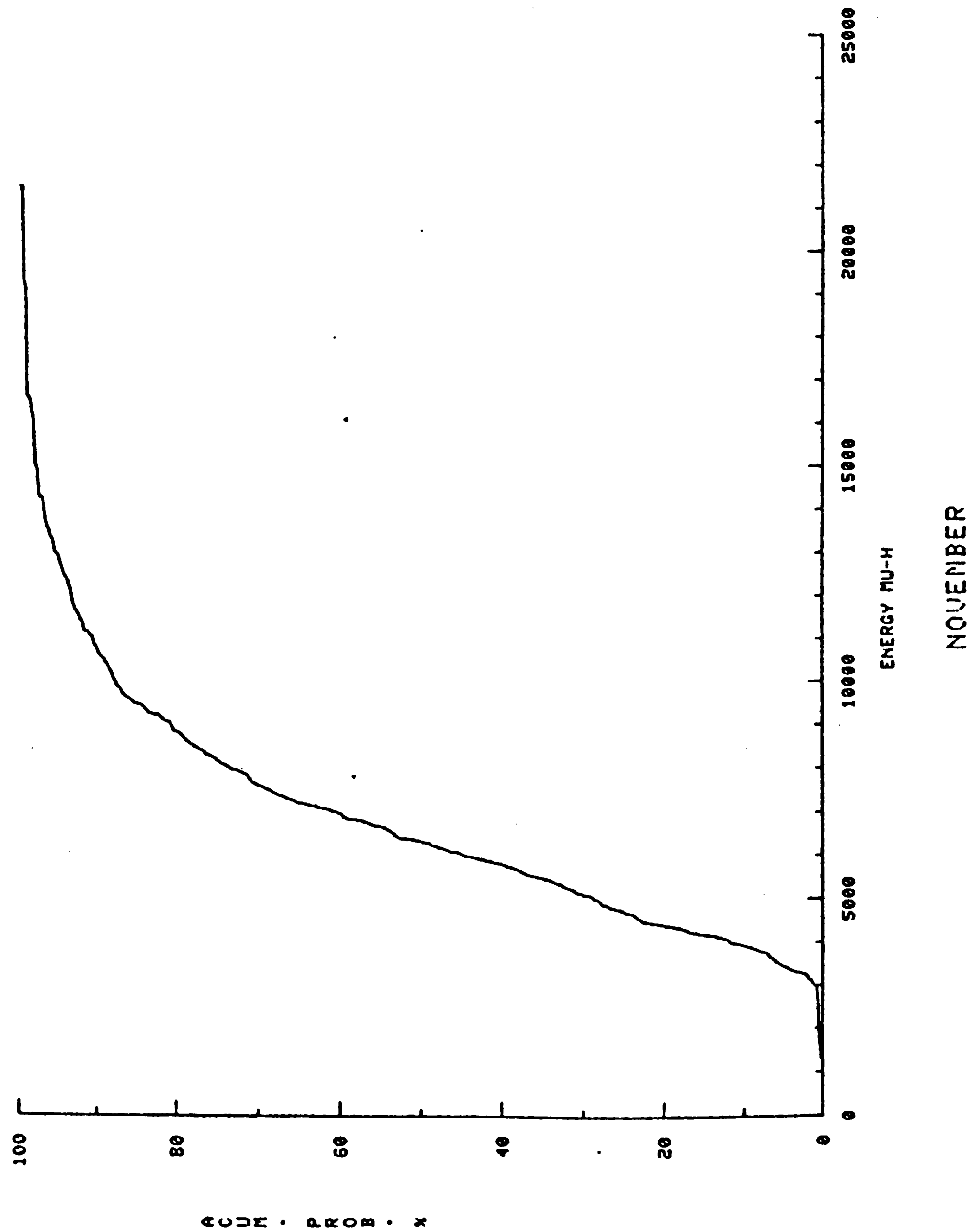
ENERGY MW-H
0
2500
5000
7500
10000
12500
15000
17500
20000
100
80
60
40
20
0
% PROB. EXCD

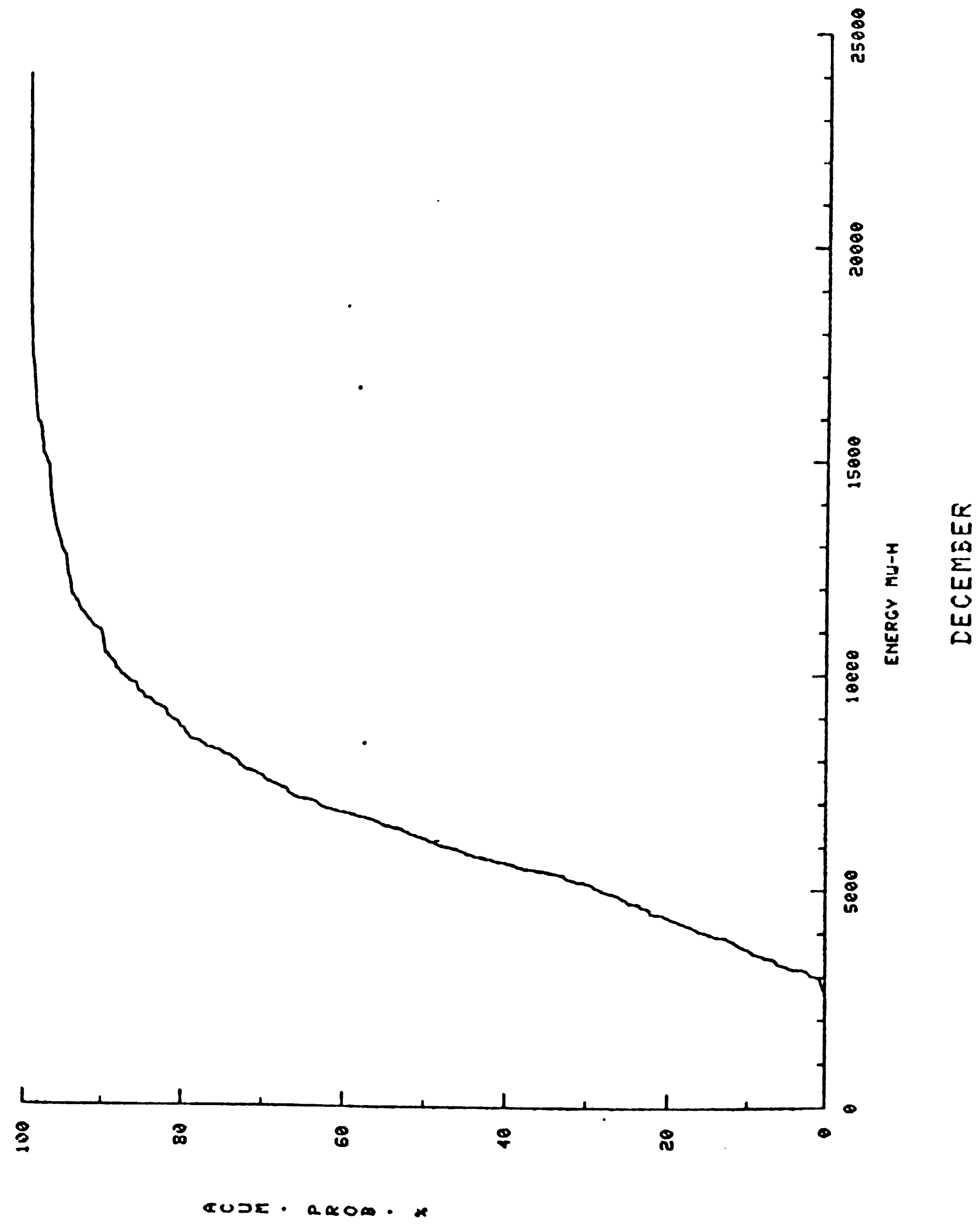
SEPTEMBER

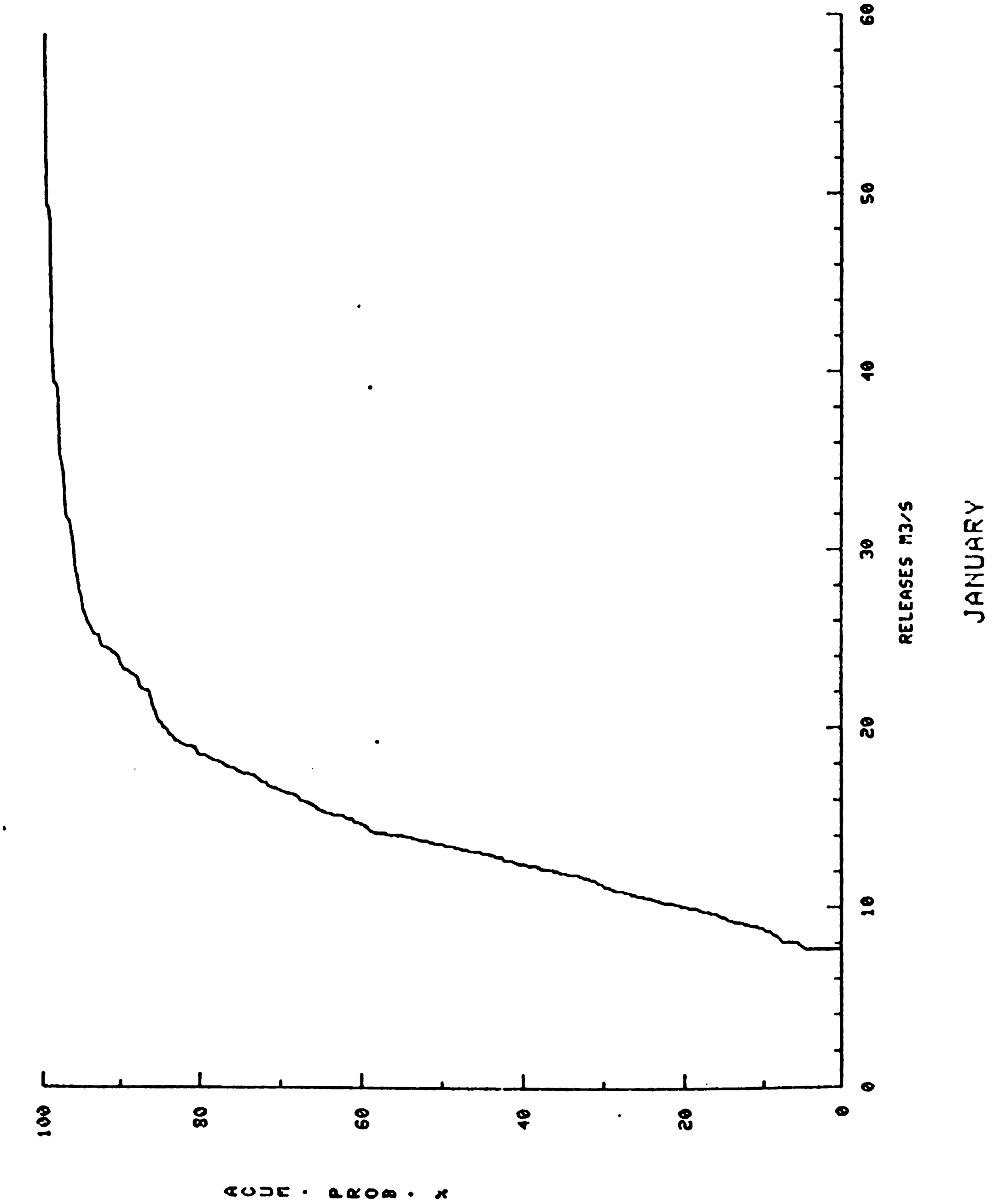


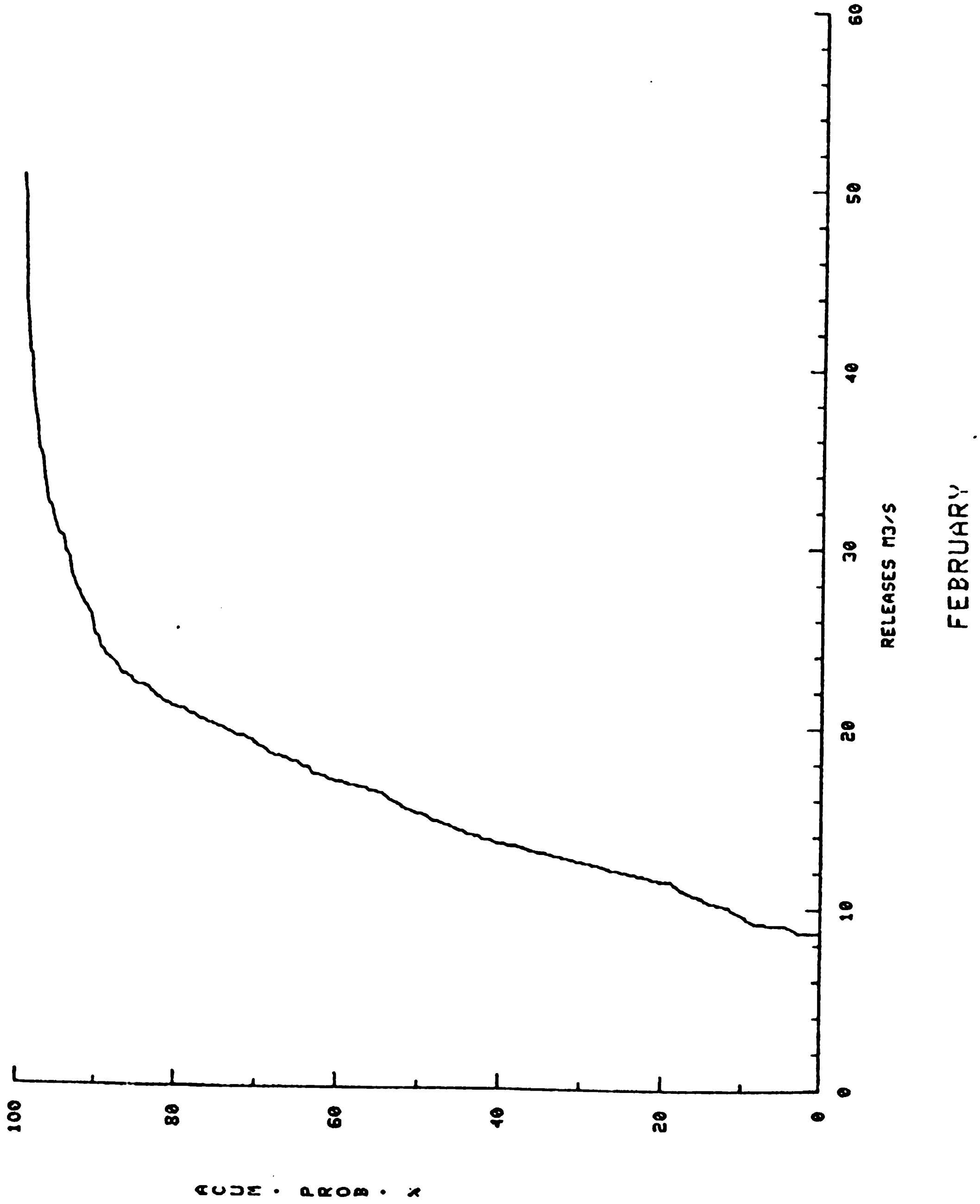
100
80
60
40
20
0
CUM. PROB. %
0
2500
5000
7500
10000
12500
15000
17500
20000
ENERGY MW-H

OCTOBER

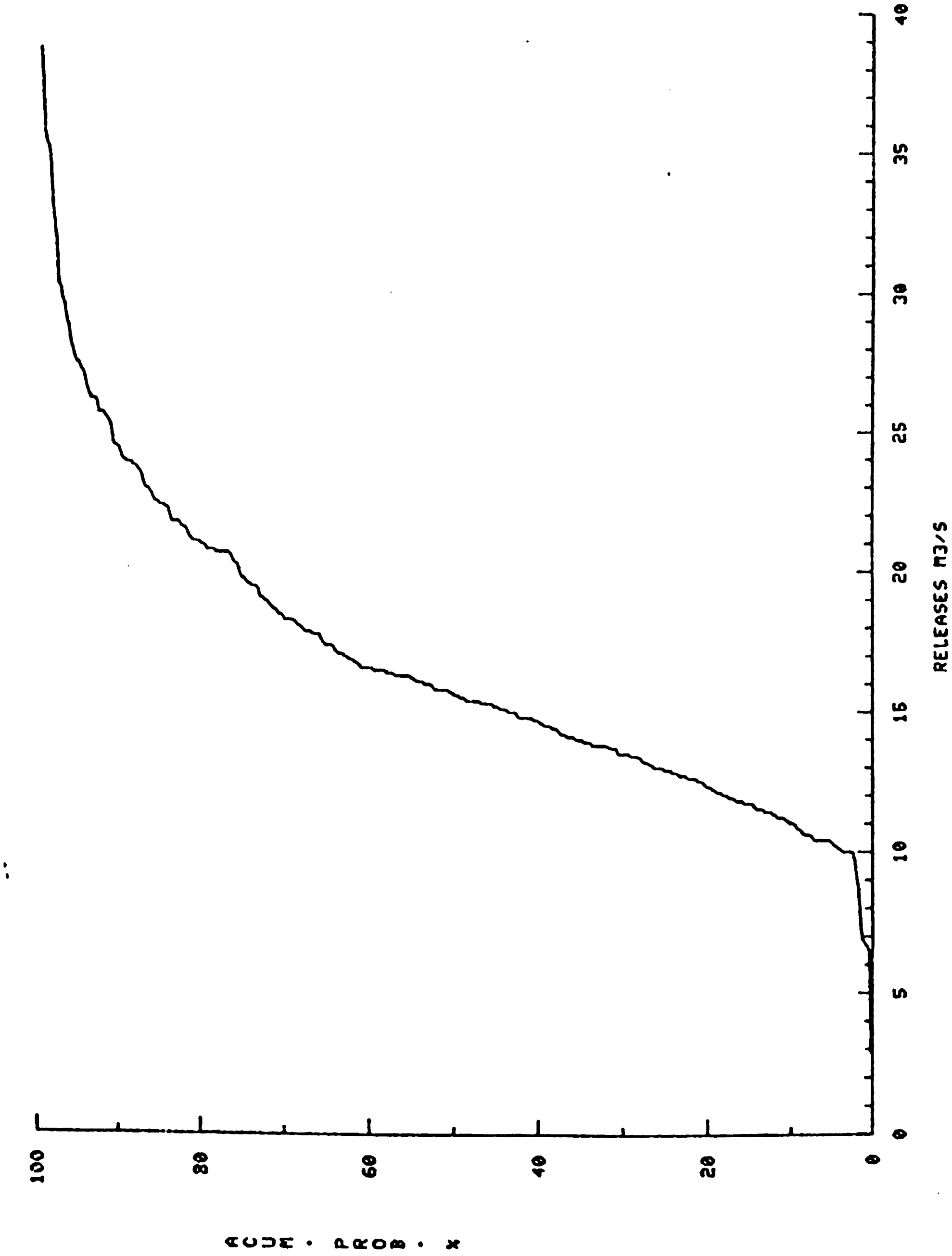

CUM. PROB. %
0
20
40
60
80
100
0
5000
10000
15000
20000
25000
ENERGY MU-H
NOVEMBER


ENERGY MW-H
CUM. PROB. %
0
5000
10000
15000
20000
25000
0
20
40
60
80
100
DECEMBER

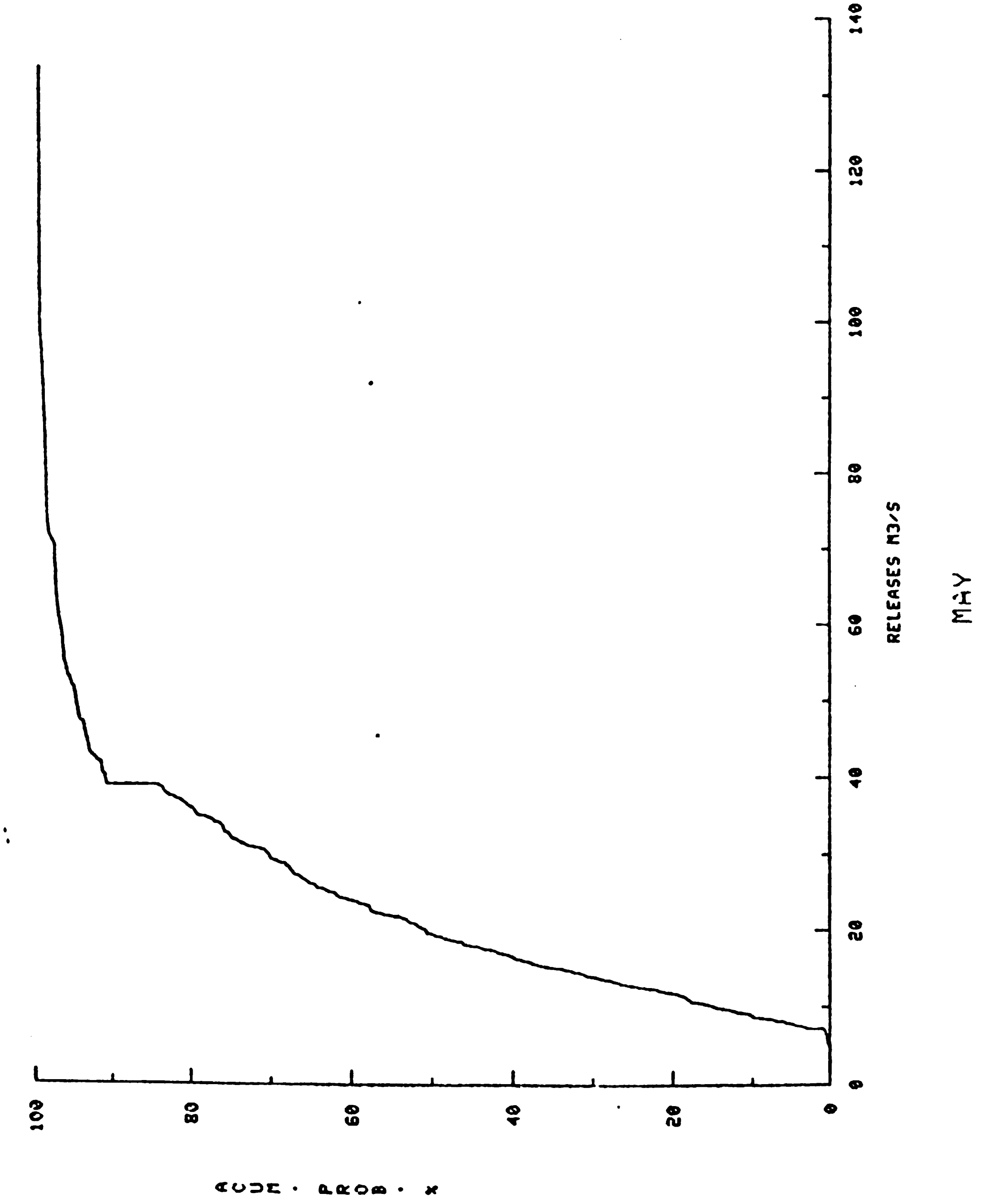

100
80
60
40
20
0
0
10
20
30
40
50
60
RELEASES M3/S
JANUARY



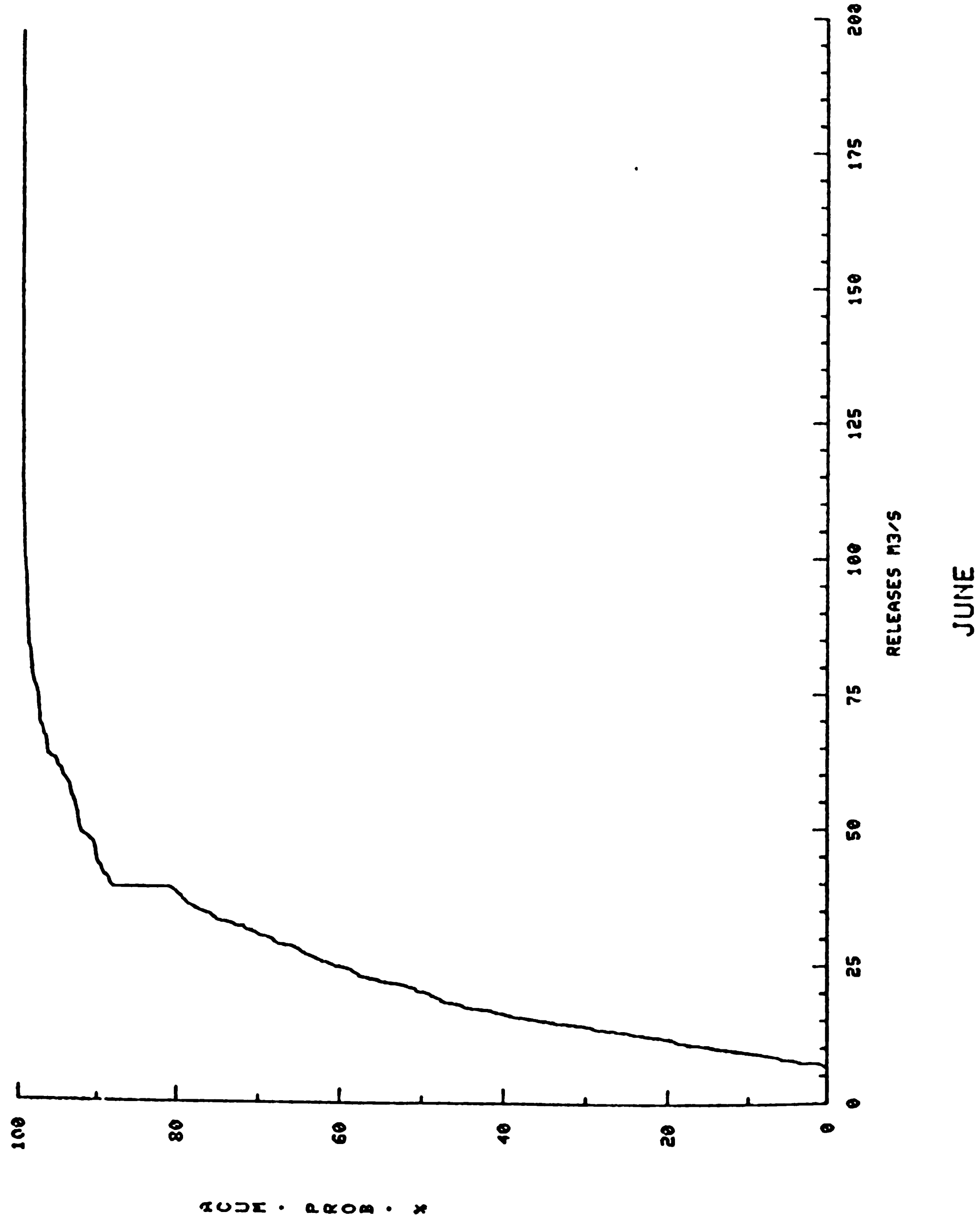
CUM. PROB. %
100
80
60
40
20
0
10
20
30
40
50
60
RELEASES M3/S
FEBRUARY

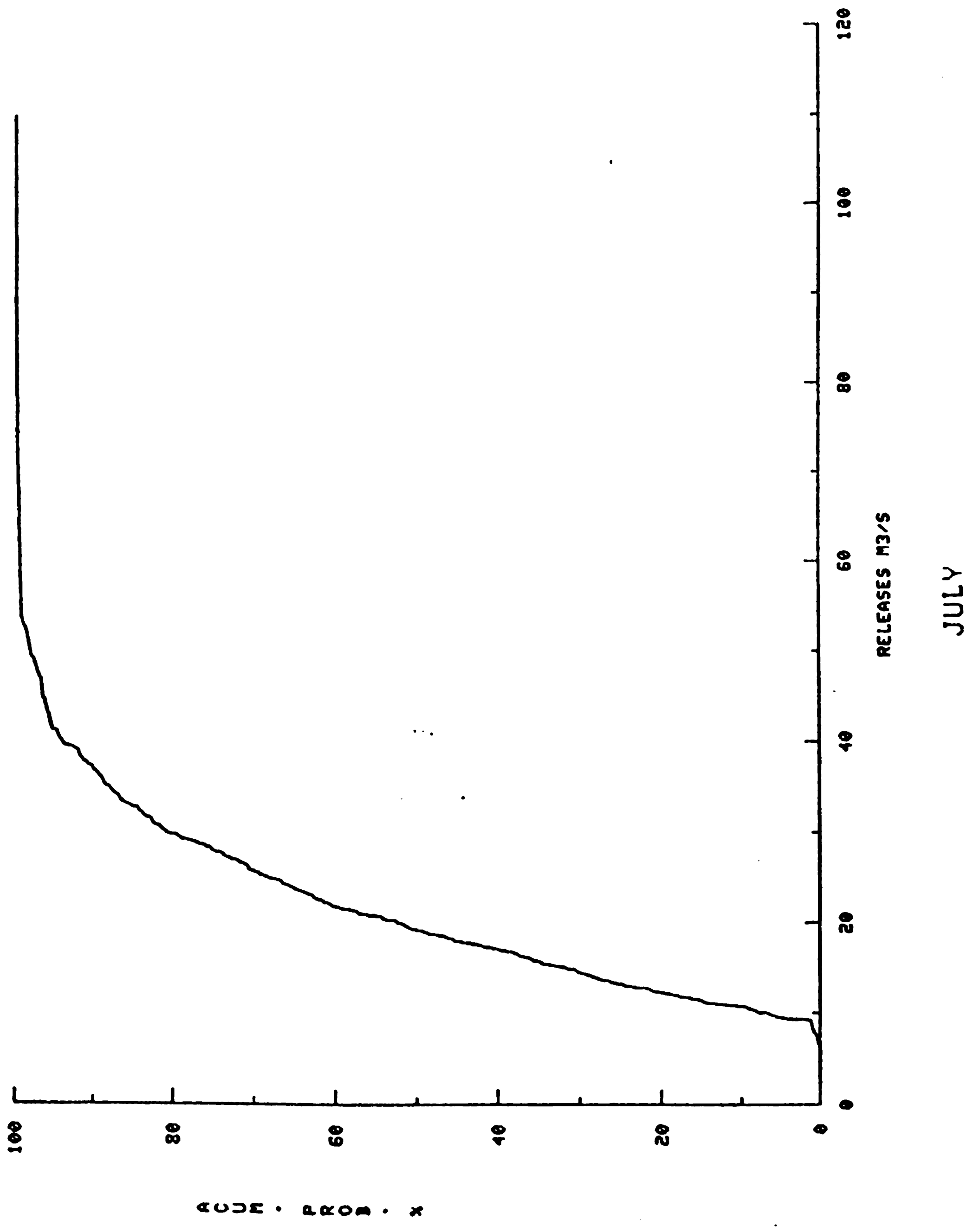


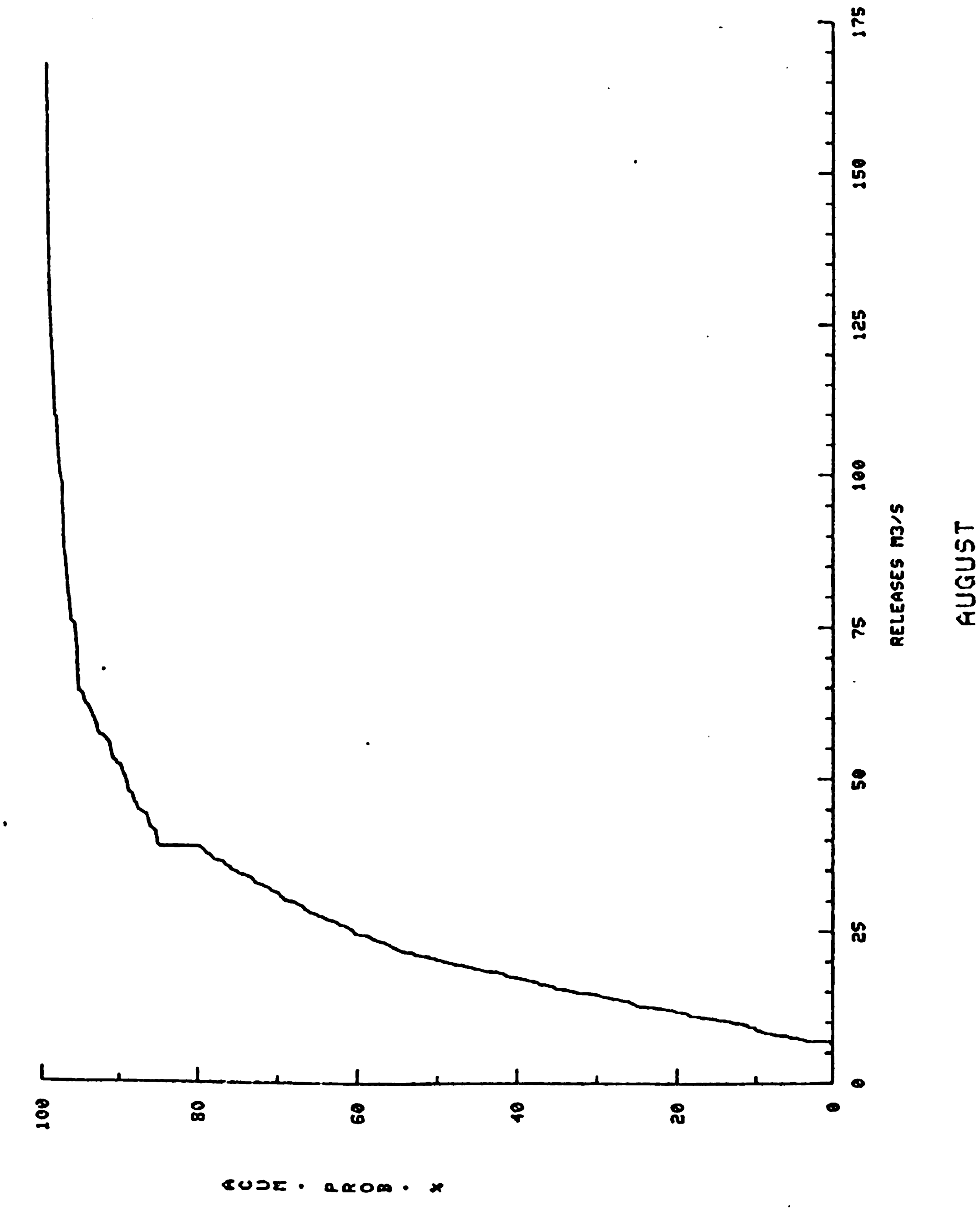
APRIL

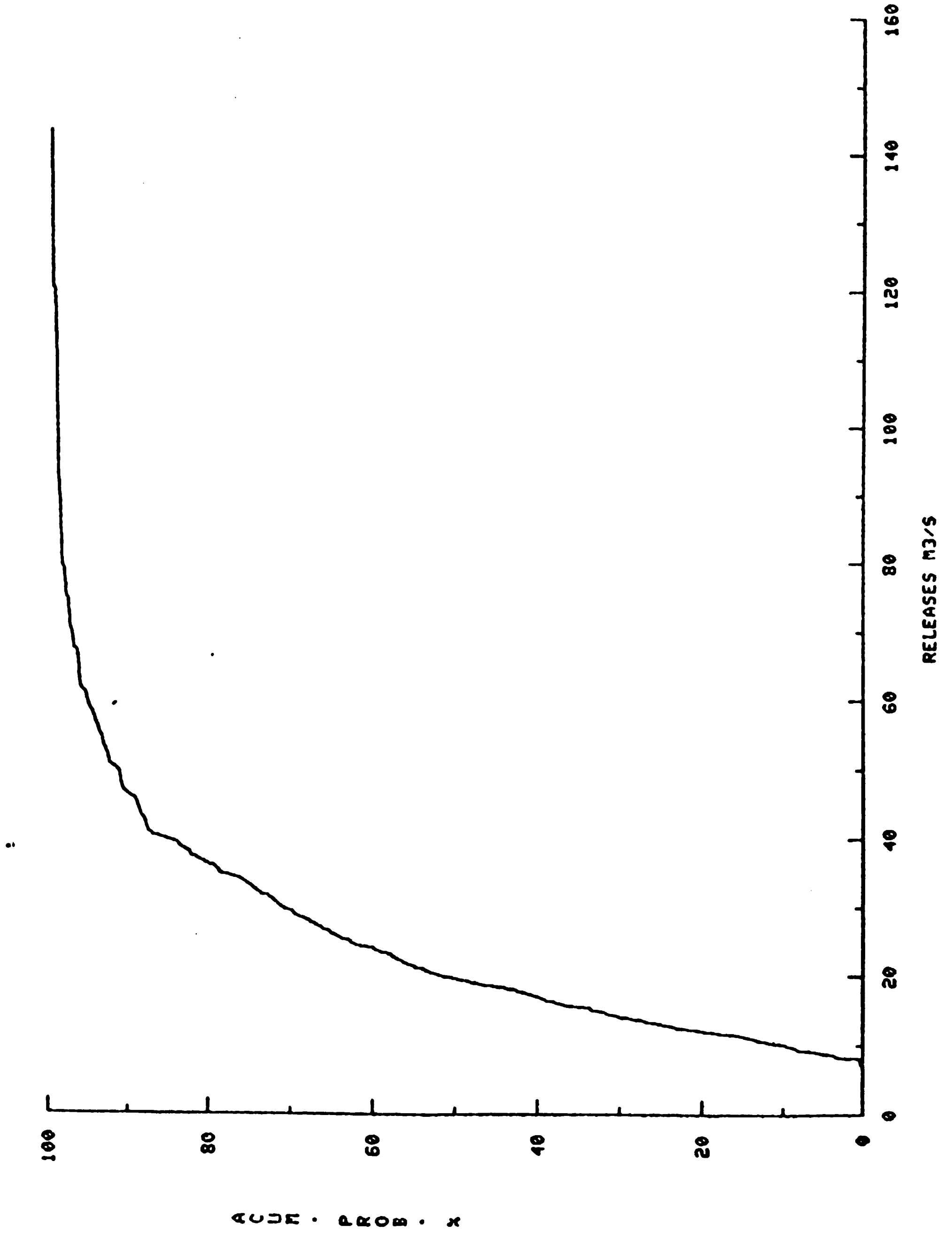


0
20
40
60
80
100
120
140
RELEASES M3/S
0
20
40
60
80
100
MAY

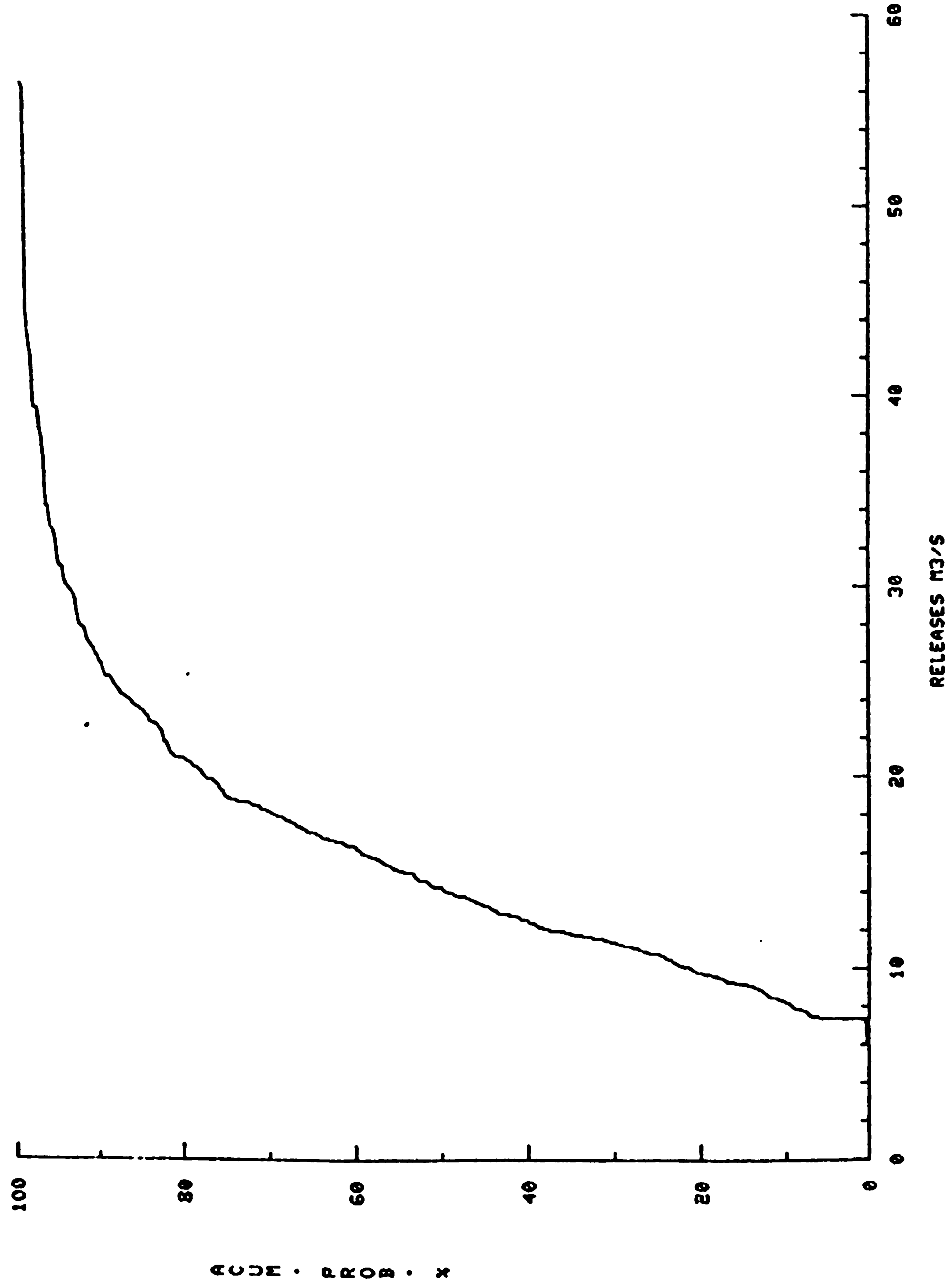

0
20
40
60
80
100
0
25
50
75
100
125
150
175
200
RELEASES M3/S
JUNE


RELEASES M3/S
JULY
0
20
40
60
80
100
120
0
20
40
60
80
100

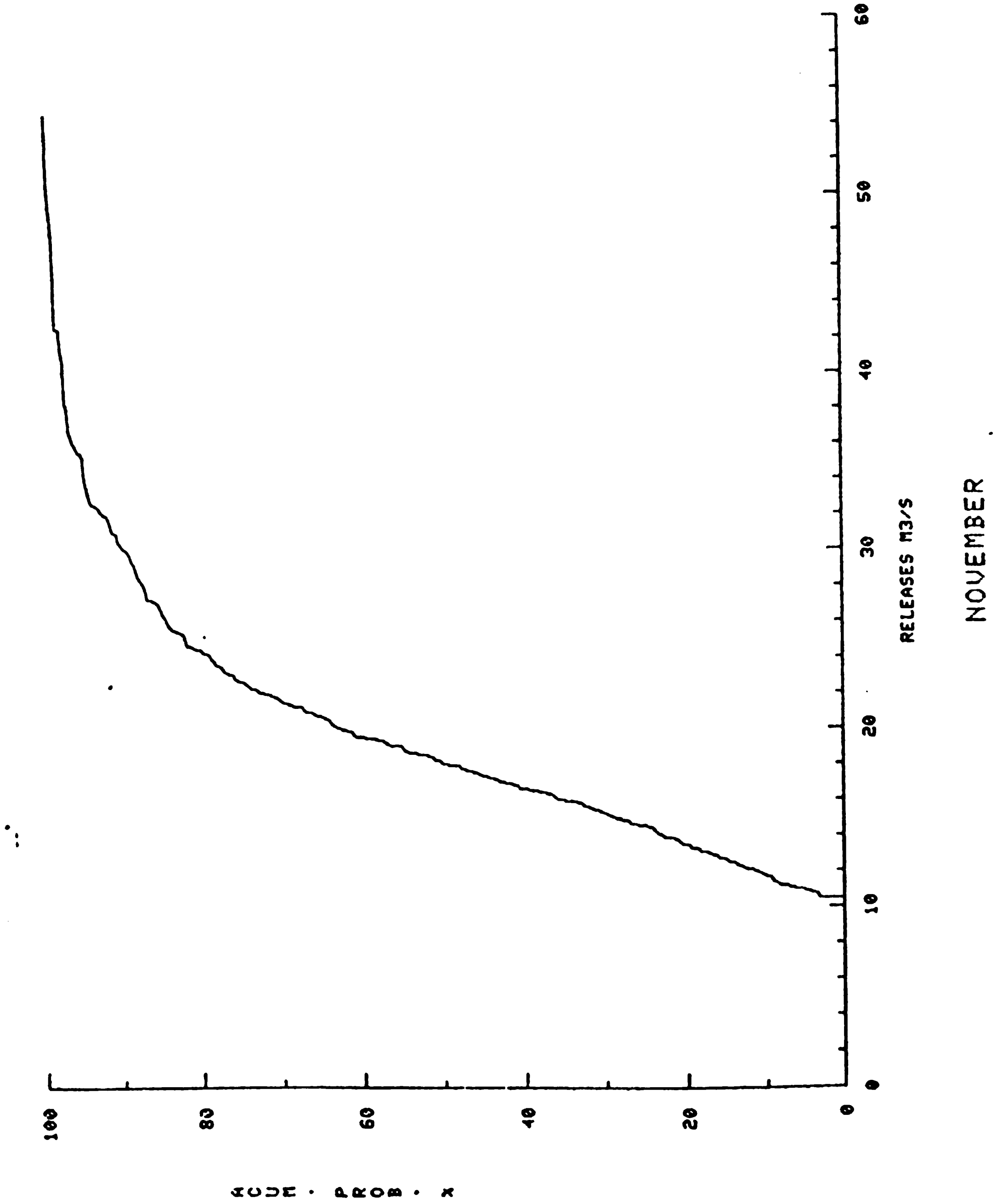

0
25
50
75
100
125
150
175
RELEASES M3/S
AUGUST
100
80
60
40
20
0

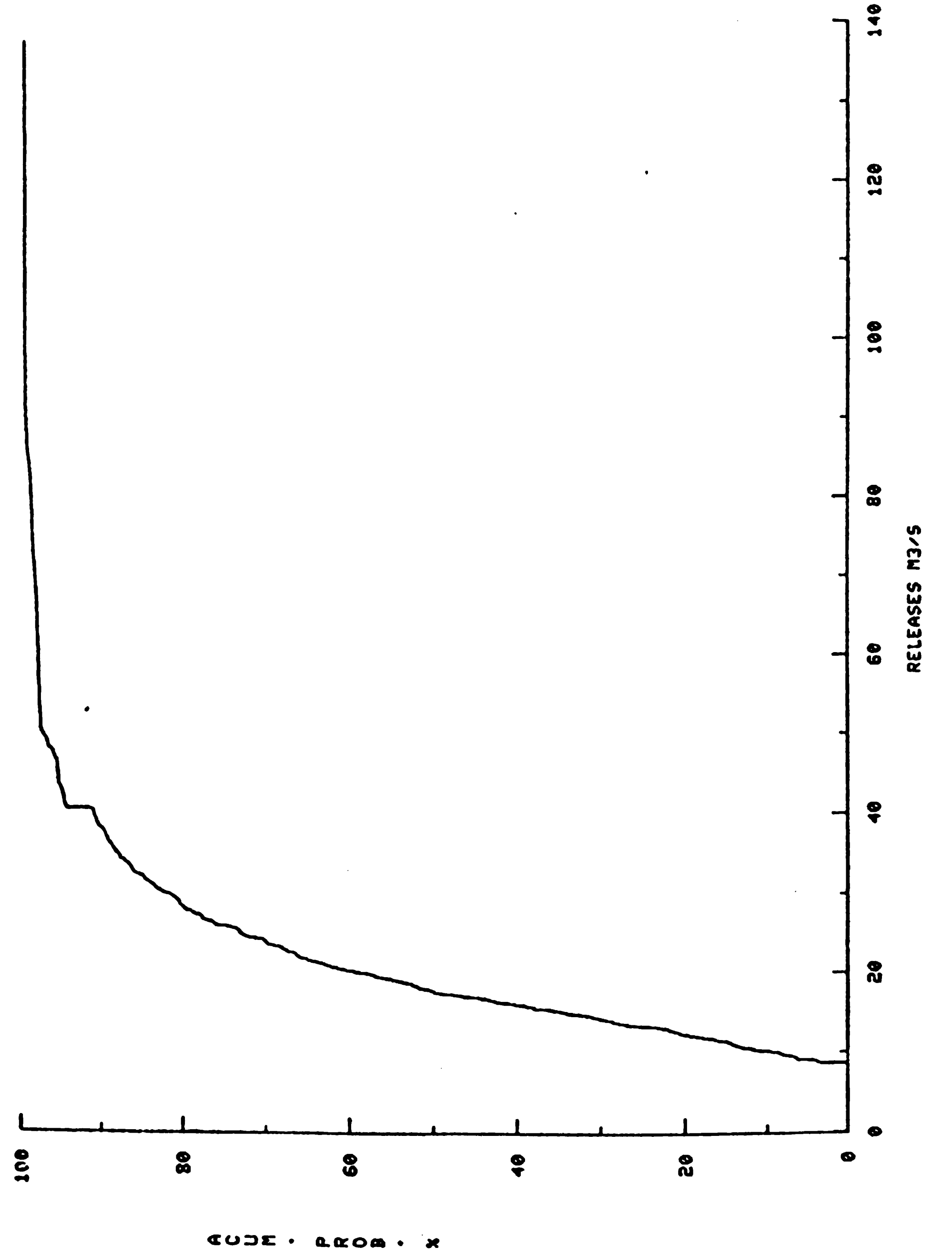


SEPTEMBER

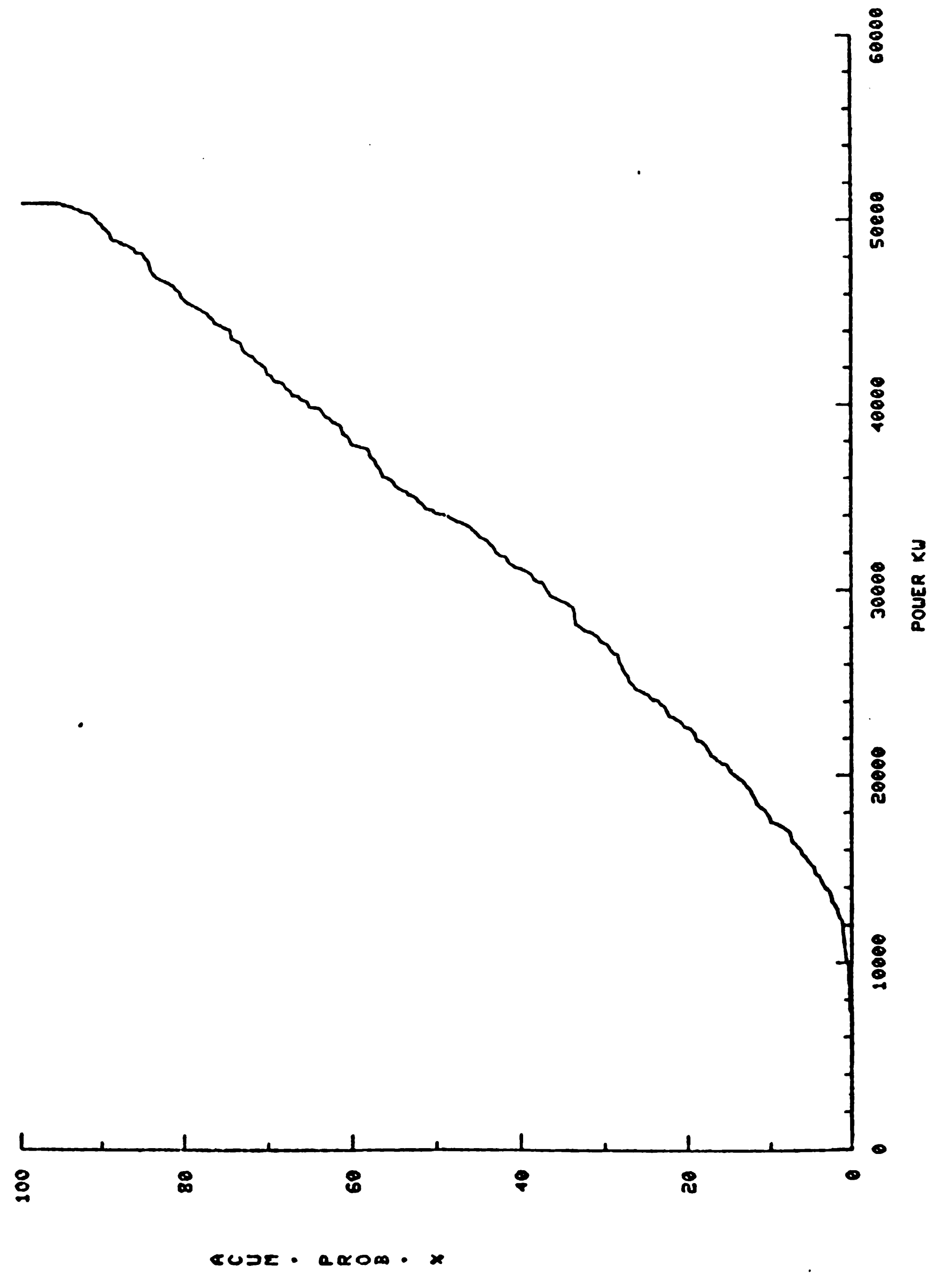


OCTOBER

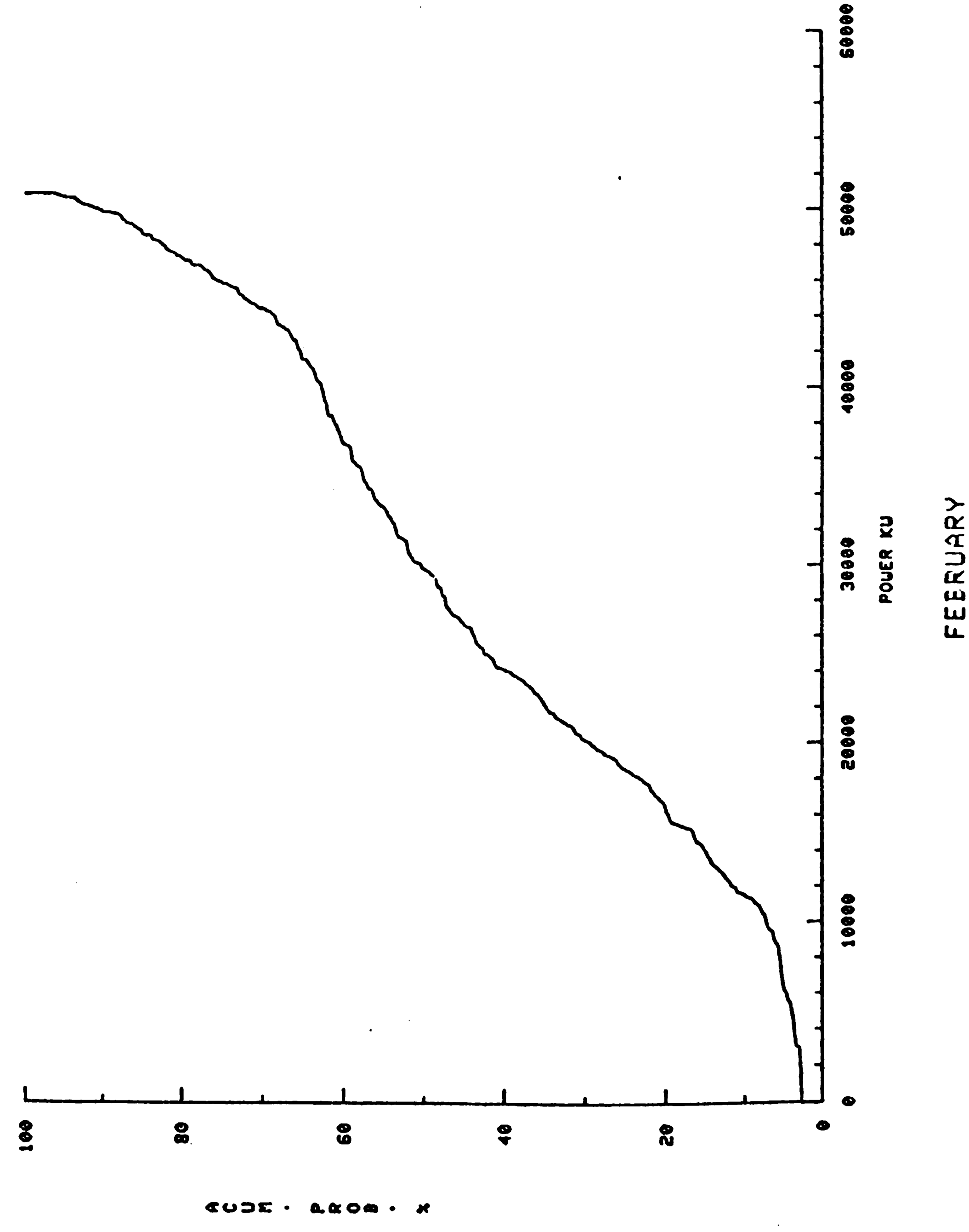

100
80
60
40
20
0
0
10
20
30
40
50
60
RELEASES M3/S
NOVEMBER

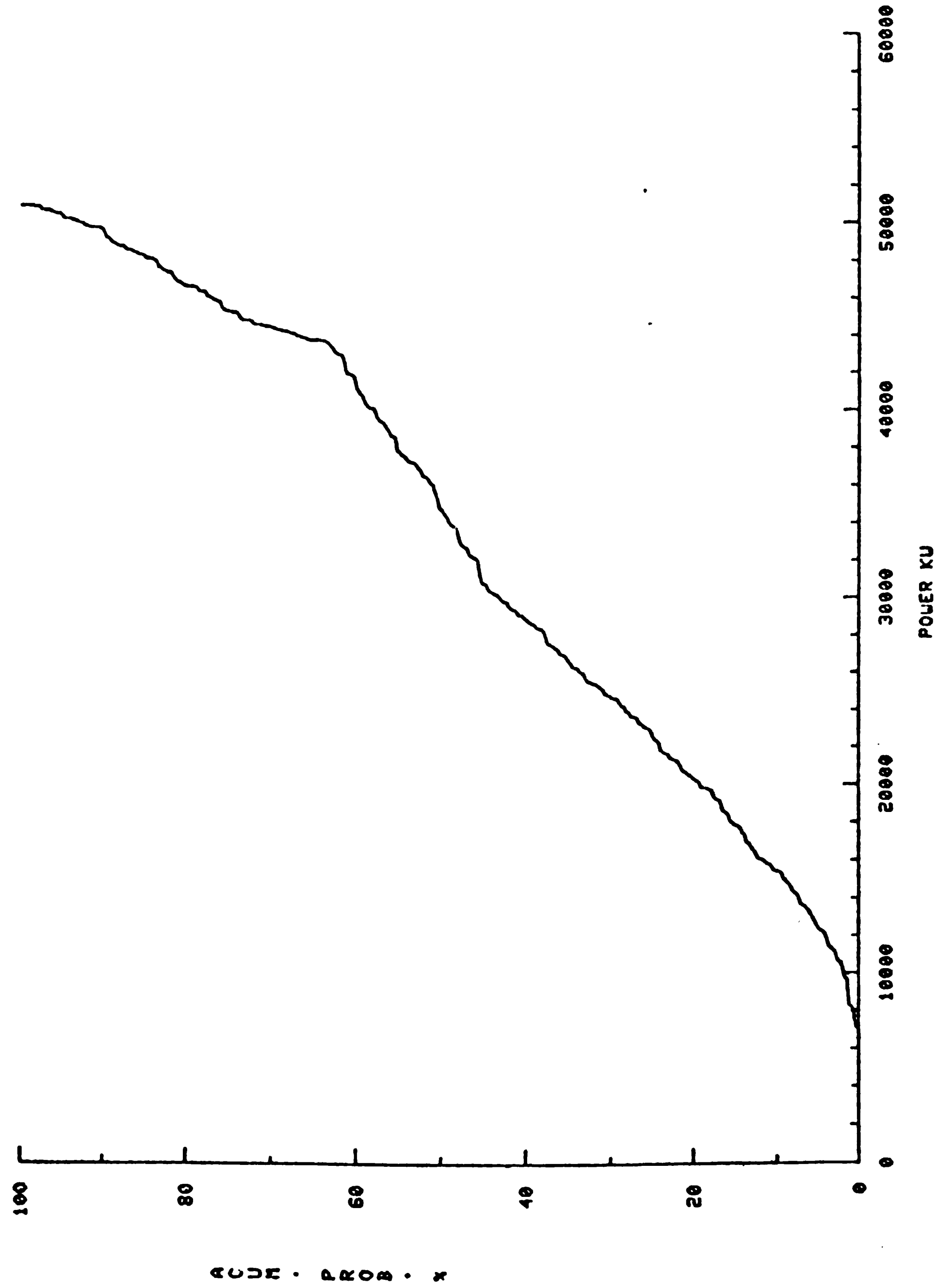


DECEMBER

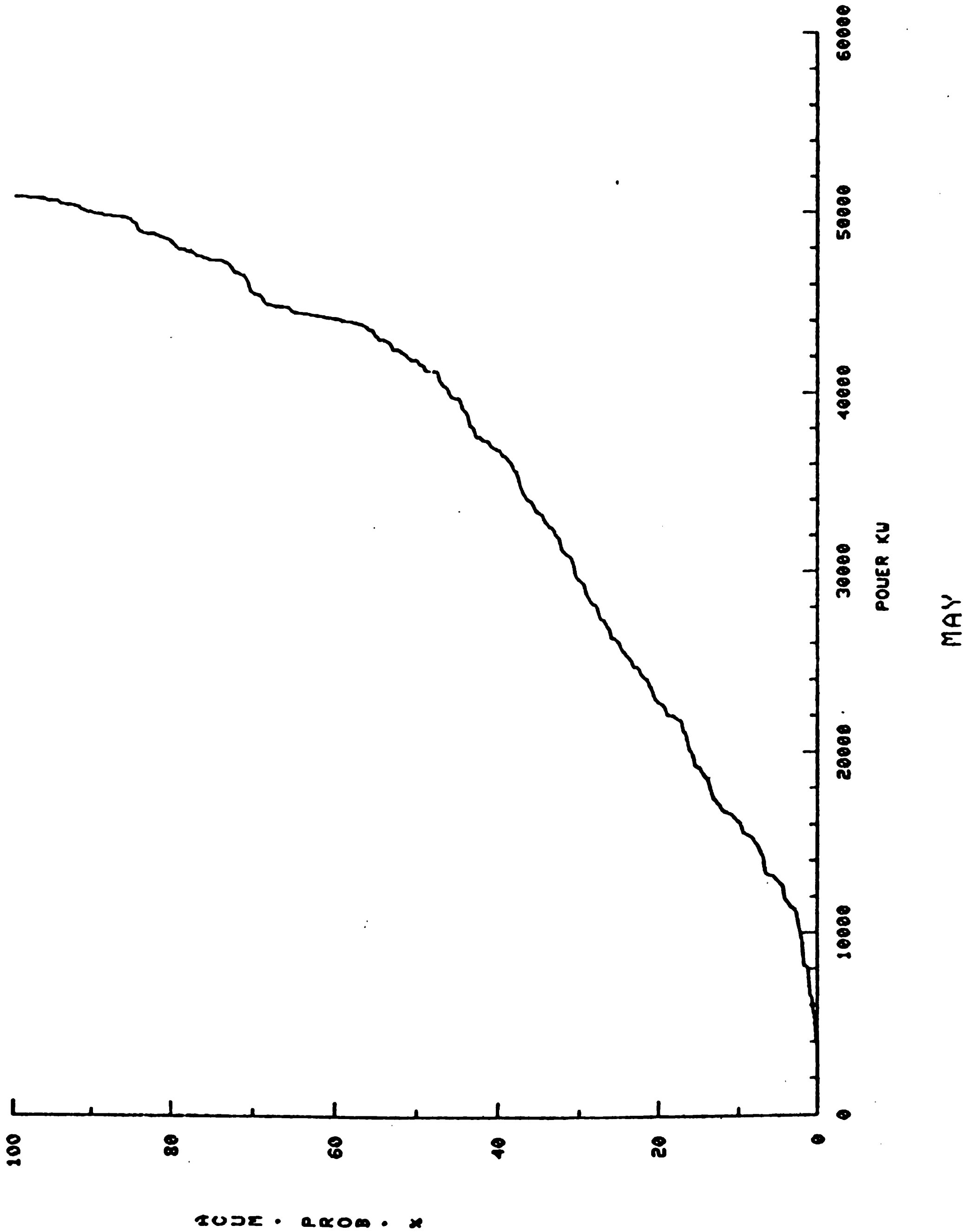

CUM. PROB. %
100
80
60
40
20
0
10000
20000
30000
40000
50000
60000
POWER KW

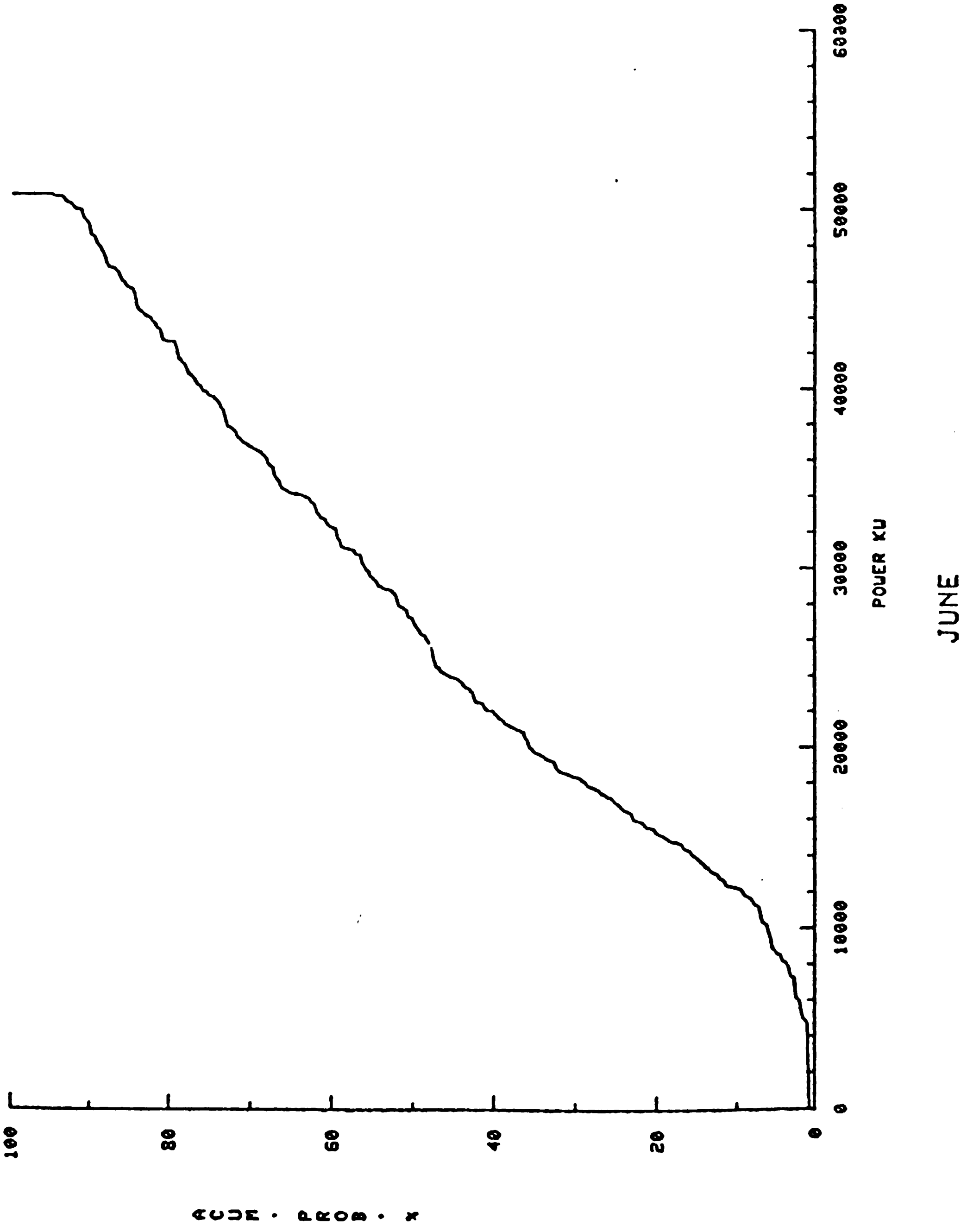
JANUARY

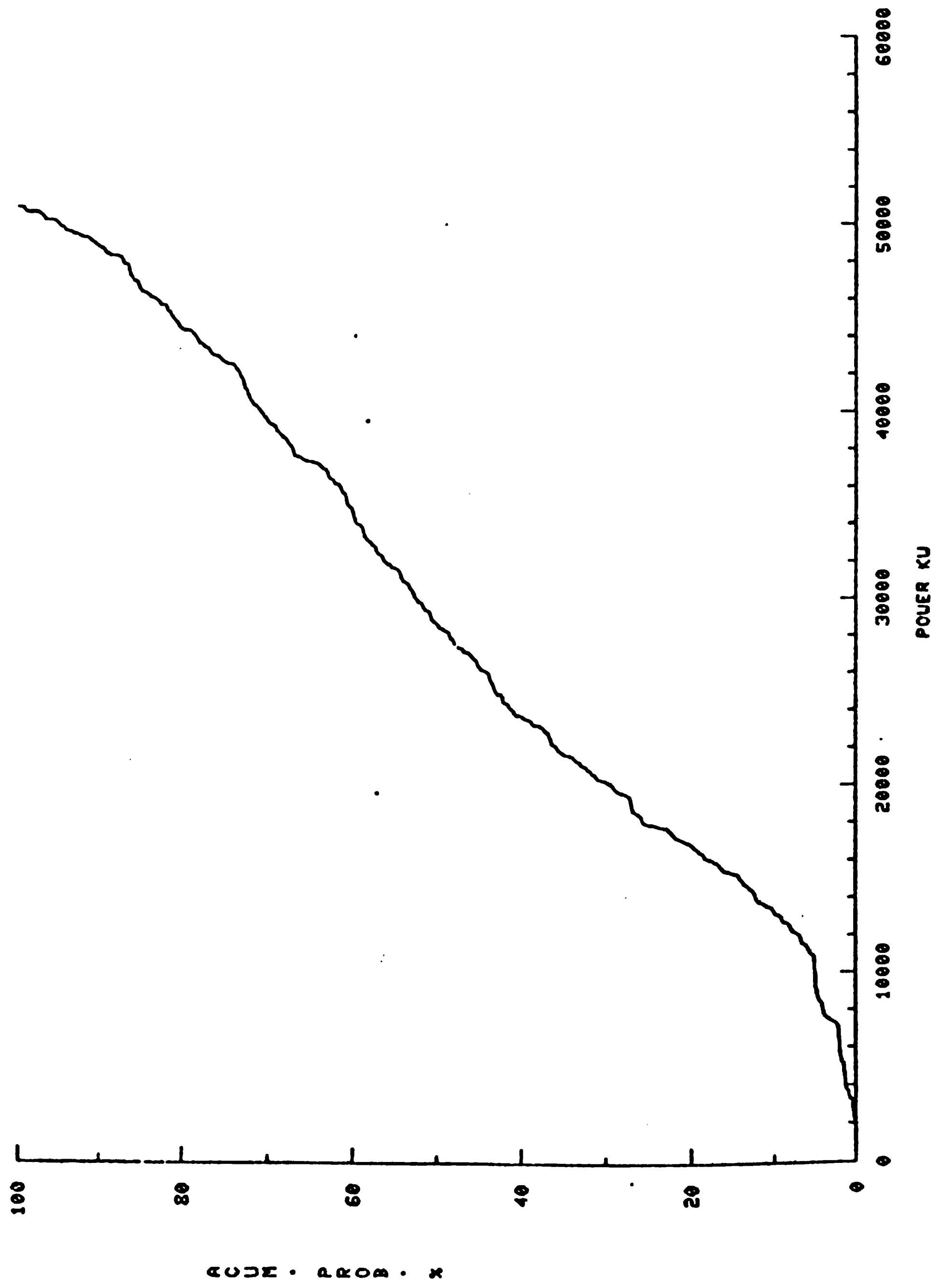

0
20
40
60
80
100
0
10000
20000
30000
40000
50000
60000
POWER KW
FEBRUARY


0
10000
20000
30000
40000
50000
60000
POUER KU
0
20
40
60
80
100

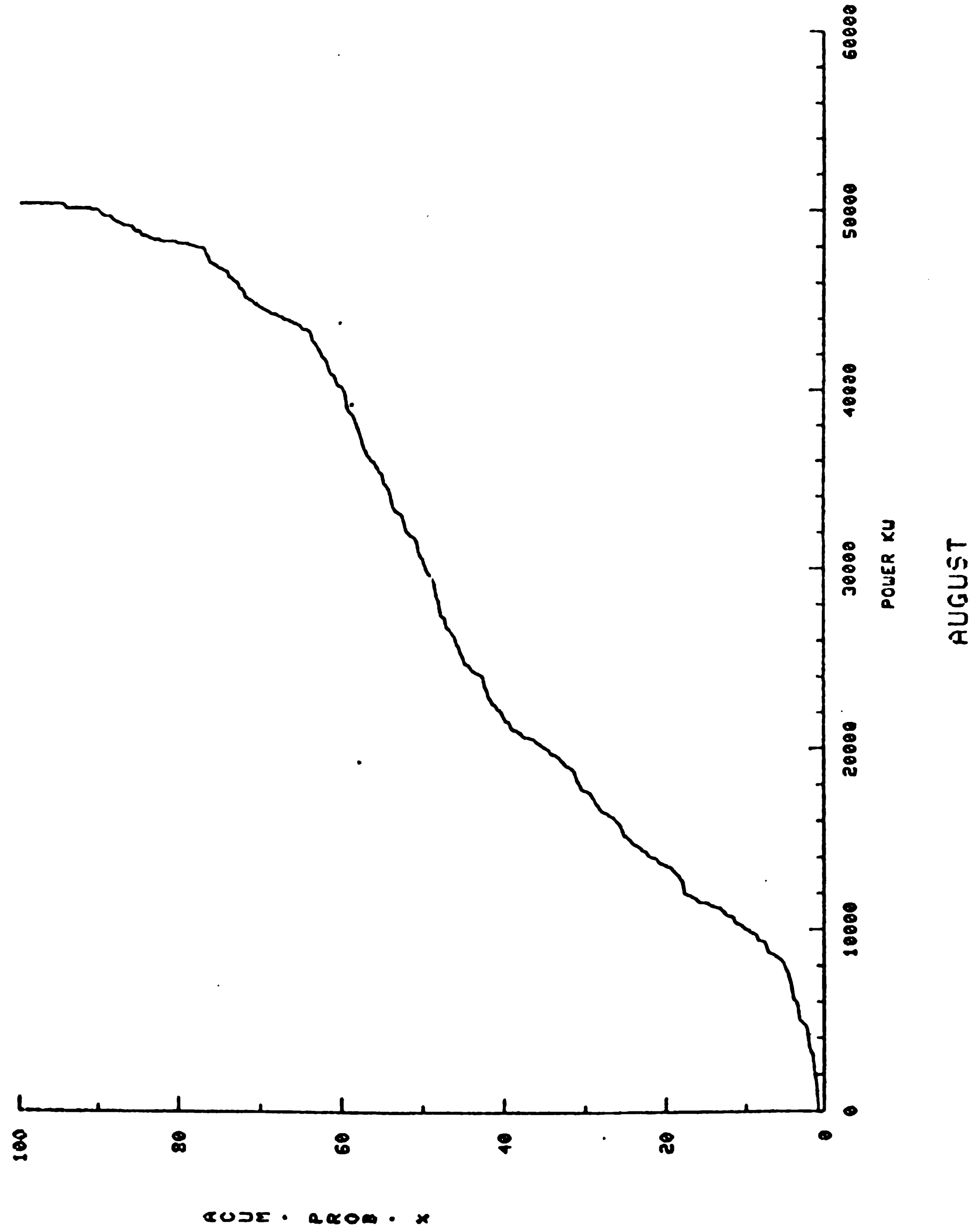
APRIL


0
10000
20000
30000
40000
50000
60000
POWER KW
100
80
60
40
20
0
MAY

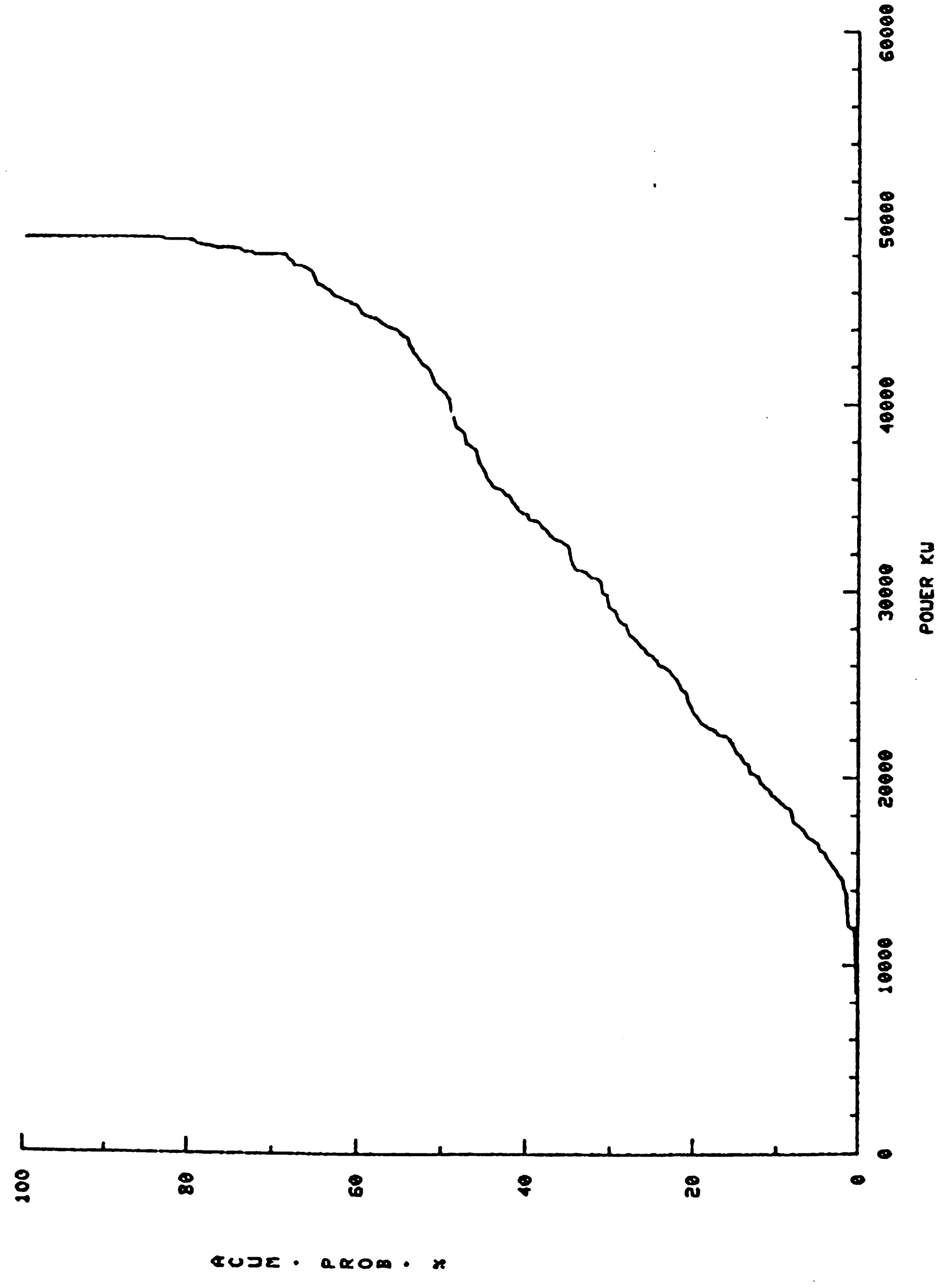

0
10000
20000
30000
40000
50000
60000
POWER KW
0
20
40
60
80
100
CUME. PROB. %
JUNE


% PROB. EXCD
100
80
60
40
20
0
10000
20000
30000
40000
50000
60000
POWER KW

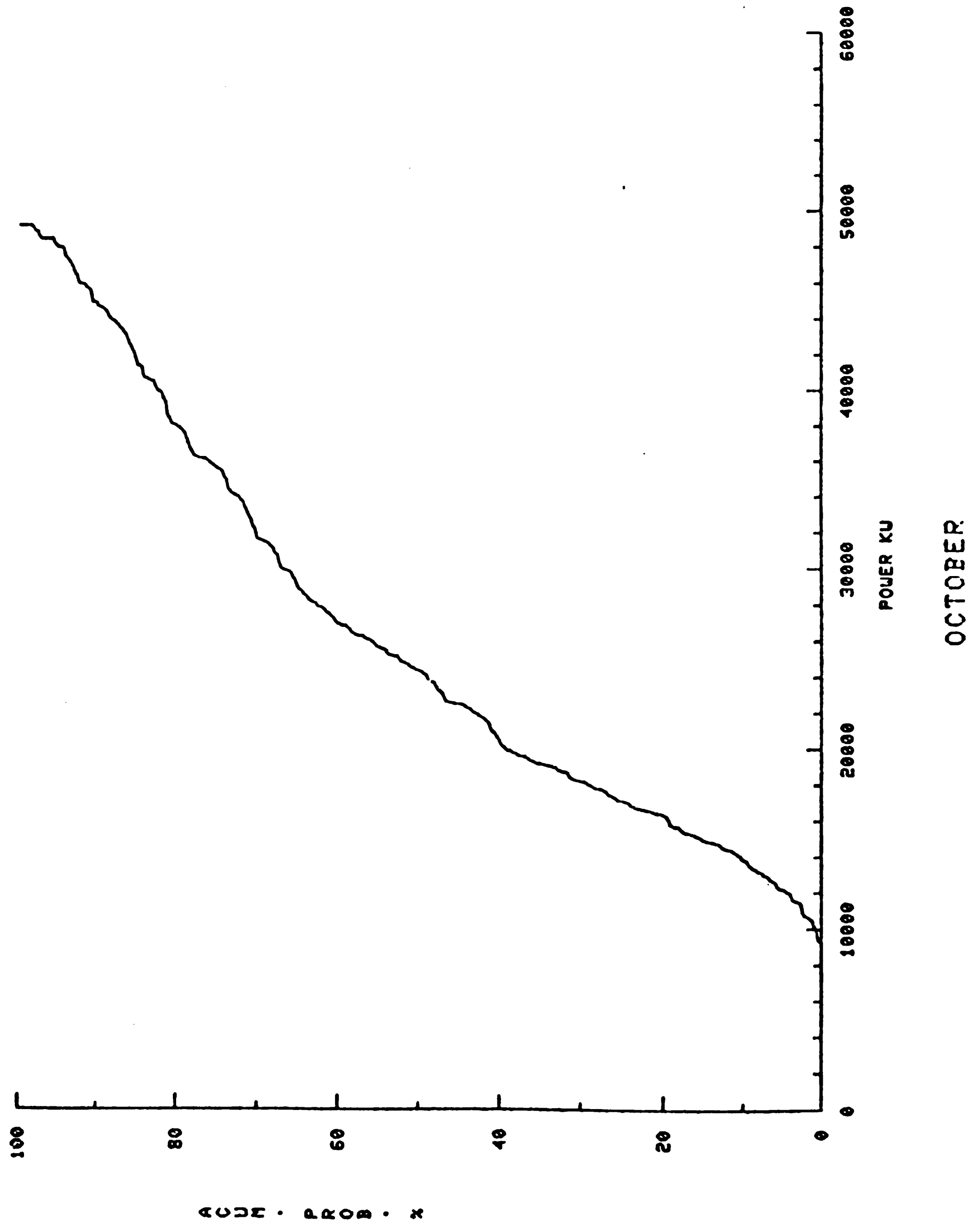
JULY

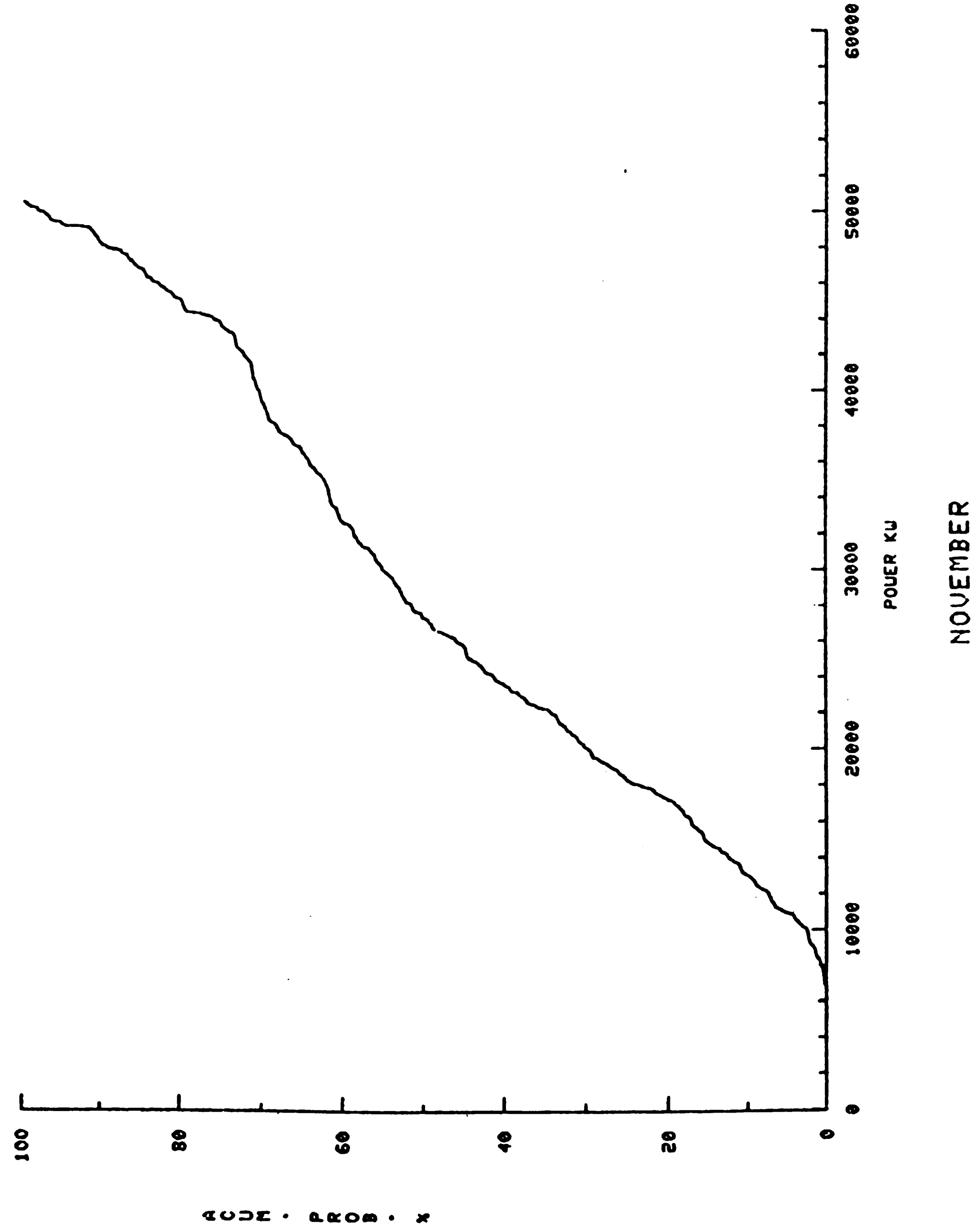


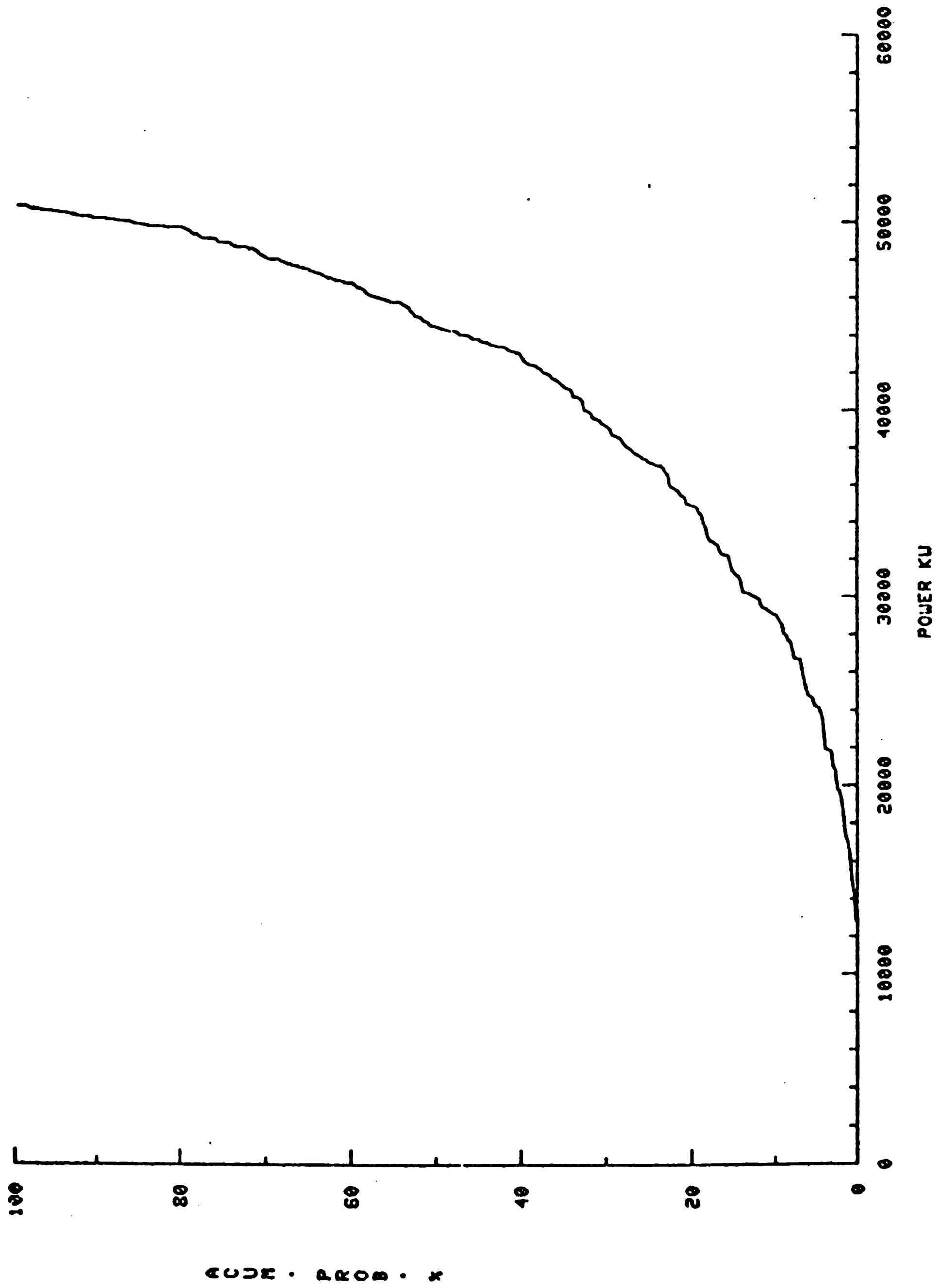
CUM. PROB. %
0
20
40
60
80
100
POWER KW
0
10000
20000
30000
40000
50000
60000
AUGUST


CUMU. PROB. %
100
80
60
40
20
0
0
10000
20000
30000
40000
50000
60000
POWER KW

SEPTEMBER


0
20
40
60
80
100
0
10000
20000
30000
40000
50000
60000
POWER KW
OCTOBER


0
20
40
60
80
100
0
10000
20000
30000
40000
50000
60000
POWER KW
NOVEMBER


POWER KW
0
10000
20000
30000
40000
50000
60000
CUM. PROB. %
0
20
40
60
80
100

DECEMBER

APPENDIX G

TABLE GIVING OPTIMAL DISCHARGE LOADING OF VALDESIA POWER PLANT TURBINES FOR DISCRETE HEAD-DISCHARGE COMBINATIONS

```
$NOFLOATCALLS
$STORAGE:2
C
C ######################################################################
C
C         Two Quantities Optimal Combinatorial Problem
C
C         IBM PC,    MS-FORTRAN V3.2        cSu      07/01, 1986
C
C ######################################################################
C
C
C **********************************************************************
C
      PROGRAM COMBN2
C
C     ******************************************************************
C
C         Find the best releasing policy thru 2 Francis turbines
C         with a certain total discharge under a specific head
C         NOTE: The policy that output from this program is
C               based on linearly interpolating the Power table
C               of a single turbine
C
C         RELS1 : Minimum total turbine discharge to be analyzed
C         RELS2 : Maximum total turbine discharge to be analyzed
C         HEAD1 : Minimum reservoir available head
C         HEAD2 : Maximum reservoir available head
C         DREL  : Total discharge increment of analysis
C         DHED  : Power head increment of analysis
C         TBQ1  : Minimum turbine capacity
C         TBQ2  : Maximum turbine capacity
C
C     ******************************************************************
C
      DIMENSION  HOT(2), QOT(99,2), TOT1(99,2), TOT2(99,2), POT(99,2)
C
      DATA  RELS1, RELS2 / 40.0, 90.0/,  HEAD1, HEAD2 / 131., 150./
      DATA  DREL / 1.0/, DHED / 0.5/
      DATA  TBQ1, TBQ2 / 20.0, 45.0/
      DATA  KOUT/ 2/
C
C
      DREL2 = DREL / 10.
      DHED2 = DHED / 10.
C
      OPEN (KOUT, FILE='KOUT.RLT', STATUS='NEW')
C
      IPR = 1
      HEAD = HEAD1
C
C **  Begin with new or initial Head, HEAD or HEAD1
C
  200 WRITE (*,910)  HEAD
```

```
      HOT(IPR) = HEAD

      ITR = 1
      RELS = RELS1
  300 WRITE (*,930)  RELS

C **  Begin with new or initial Total Discharge, RELS or RELS1
C
C **  For a certain total discharge, RELS, under a specific head, HEAD,
C **  find the maximum available power that can be generated
C
      QUPB = AMIN1 ( RELS, TBQ2 )
      TQ1 = 0.
      TQ2 = 0.
      POWO = 0.
      QP1 = TBQ1

C **  Find generated power of Turbine #1 with discharge QP1
C
  400 CALL SRFLN2 (POW1, HEAD, QP1)

C **  Find generated power of Turbine #2 with discharge QP2
C
      QP2 = RELS - QP1
      IF (QP2.LT.TBQ1)  THEN
          POW2 = 0.
          QP2 = 0.
      ELSE
          CALL SRFLN2 (POW2, HEAD, QP2)
          IF (QP2.GT.TBQ2)  QP2 = TBQ2
      ENDIF
      POWN = POW1 + POW2
C
      IF (POWN.GT.POWO)  THEN
          TQ1 = QP1
          TQ2 = QP2
          POWO = POWN
      ENDIF

C **  Check, to see whether Turbine #1 has reached full capacity
C
      IF ((QUPB-QP1) .LT. DREL2)  GOTO 500
      QP1 = QP1 + 0.5
      GOTO 400

C **  Check, to see whether all Total Discharge levels have been analyzed
C
  500 QOT(ITR,IPR) = RELS
      POT(ITR,IPR) = POWO
      TOT1(ITR,IPR) = TQ1
      TOT2(ITR,IPR) = TQ2

      IF ( (RELS2-RELS) .LT. DREL2 )  GOTO 600
      ITR = ITR + 1
```

```
      RELS = RELS + DREL
      GOTO 300

C **  Output the current optimal analysis results and
C **  Check, to see whether Head has reached the maximum level
C
  600 IF ( (HEAD2-HEAD) .LT. DHED2 )  GOTO 700
      IF (IPR.EQ.2)  THEN
          WRITE (KOUT,920)  (HOT(IP),IP=1,IPR)
          WRITE (KOUT,960)
          DO 650 IT = 1,ITR
          WRITE (KOUT,940)  (QOT(IT,IP), TOT1(IT,IP),
     *                       TOT2(IT,IP), POT(IT,IP), IP = 1,IPR)
  650     CONTINUE
          IPR = 0
      ENDIF
      IPR = IPR + 1
      HEAD = HEAD + DHED
      GOTO 200

  700 WRITE (KOUT,920)  (HOT(IP),IP=1,IPR)
      WRITE (KOUT,960)
      DO 750 IT = 1,ITR
      WRITE (KOUT,940)  (QOT(IT,IP), TOT1(IT,IP),
     *                   TOT2(IT,IP), POT(IT,IP), IP = 1,IPR)
  750 CONTINUE
      WRITE (*,950)
      STOP ' '
C
  910 FORMAT (/,' Analysis for Elevation =',F7.2,
     *          ' M,  Discharge is ....')
  920 FORMAT (//,' Elevation =',F7.2,' M',:,
     *        20X,' Elevation =',F7.2,' M',/)
  930 FORMAT (F5.1,\)
  940 FORMAT (F5.1,F10.1,F11.1,F9.2,:,6X,F5.1,F10.1,F11.1,F9.2,)
  950 FORMAT (//,' End of Analysis !')
  960 FORMAT (' Total  Turbine#1  Turbine#2  Power',6X,
     *        ' Total  Turbine#1  Turbine#2  Power',/,
     *        ' (CMS)    (CMS)      (CMS)     (MW)',6X,
     *        ' (CMS)    (CMS)      (CMS)     (MW)')
C
      END


C ********************************************************************
C
      SUBROUTINE SRFLN2 (PW, HDI, QPI)                              041786
C
C     ****************************************************************
C
C       LINEAR INTERPOLATION OF TABLE DATA
C
C       POWR, NH, NQ
C       THE POWER DATA SET OF RESERVOIR, POWR (NH*NQ MATRIX),
```

```
C       WITH H-AXIS ARRAY H  AND  Q-AXIS ARRAY Q
C       BOTH H AND Q ARRAY SHOULD BE IN ASSCENDING ORDER.                041786
C
C       PW, HD, QP
C       FIND THE INTERPOLATED VALUE "PW" FOR A SPECIFIC
C       COORDINATE (HD,QP) ON THE TABLE (MATRIX)
C       POWR : POWER, IN MW
C         HT : ELEVATION, IN M (A.S.L.)
C         QT : POWER RELEASE, IN CMS
C
C       TAKE AVERAGE POWER COEFFICIENT OF 2 CORRESPONDING POINTS
C       FIRST, THE VALUE IS INTERPOLATED OVER H AXIS FIRST.
C       THEN INTERPOLATE THE FINAL POWER COEFFICIENT FROM THESE
C       2 NEW POINTS (E1 & E2) OVER Q AXIS.
C
C       FOR POINTS OUTSIDE THE TABLE IS ASSIGNED VALUED WITH
C       ALL DATA WITH EITHER HEAD OR DISCHARGE SMALLER THAN THE          041786
C       MINIMUM H OR Q VALUE IS RETURNED WITH ZERO COEFFICIENT.          041786
C       IF BOTH HEAD AND DISCHARGE OF THE POINT ARE GREATER THAN         041786
C       THE MAXIMUM H AND Q VALUE, THEN POWR(NH,NQ) IS RETURNED.         041786
C       IN CASE QP IS LARGER THAN THE MAXIMUM QT(NQ), THEN QP IS         041786
C       TRUNCATED TO QT(NQ), OR QP=QT(NQ).                               041786
C       FOR HD IS LARGER THAN THE MAXIMUM HT(NH), THEN IH=NH IS          041786
C       RETURNED.
C
C                     0      | POWR(NH,IQ) | POWR(NH,NQ)
C               ------------+-------IQ-----+------------  HT(NH)
C                          IH2  X      X   |
C                           |   |      |   |                ^
C                     0    IH  E1--PW--E2  | POWR(IH,NQ)    | HD
C                           |   |      |   |                |
C                          IH1  X      X   |
C               ------------+--IQ1----IQ2-+------------  HT(1)
C                     0     |      0      |     0
C                         QT(1)   ----->  QT(NQ)
C                                  QP
C
C        KNOWN :  POWR(NH,NQ), HT(NH), QT(NQ)
C        INPUT :  HDI=HD,  QPI=QP
C       OUTPUT :  PW
C
C        IBM PC,   MS-FORTRAN V3.2          cSu             4/17/86
C
C     ******************************************************************
C
C
      DIMENSION  POWR(7,9), HT(7), QT(9)
C
C     TOTAL  63 (NH*NQ)  DATA POINTS ON THE TABLE
C
      DATA  NH, NQ/ 7, 9/
      DATA  QT/  20.0, 25.0, 30.0, 32.5, 35.0, 37.5, 40.0, 42.5, 45.0/
      DATA  HT/  130.75, 134.0, 137.0, 141.0, 144.0, 147.0, 150.0/
      DATA  POWR/  8.0,    8.3,    8.7,    9.0,    9.3,    9.9,   10.5,
```

```
     2                 10.7,    11.2,   11.8,   12.5,   13.0,   13.6,   14.4,
     3                 13.2,    14.1,   14.9,   16.0,   16.8,   17.4,   18.2,
     4                 14.5,    15.6,   16.4,   17.7,   18.5,   19.2,   20.0,
     5                 15.6,    16.8,   17.8,   19.2,   20.2,   20.9,   21.8,
     6                 16.6,    17.9,   19.1,   20.4,   21.6,   22.4,   23.5,
     7                 17.5,    18.9,   20.3,   21.7,   22.9,   23.8,   24.9,
     8                 17.7,    19.8,   21.3,   22.7,   24.0,   25.1,   26.0,
     9                 19.0,    20.5,   22.0,   23.5,   24.9,   26.1,   27.0/
C
      HD = HDI
      QP = QPI
C
      IF (HD.LT.HT(1) .OR. QP.LT.QT(1))  THEN                           041786
                                         PW = 0.                        041786
                                         RETURN                         041786
                                         ENDIF                          041786
C
C
      IH=0
      IQ=0
      IF (HD.GE.HT(NH))  IH = NH                                        041786
      IF (QP.GE.QT(NQ))  IQ = NQ                                        041786
      IF (QP.GT.QT(NQ))  QP = QT(NQ)                                    041786
C
      DO 200 I=1,NH-1                                                   041786
      IF (HD.EQ.HT(I))  THEN
                        IH = I
                        GO TO 300
                        ENDIF
      IF (HD.GT.HT(I))  IH1 = I
  200 CONTINUE
      IH2=IH1+1
C
  300 DO 400 I=1,NQ-1                                                   041786
      IF (QP.EQ.QT(I))  THEN
                        IQ = I
                        GO TO 500
                        ENDIF
      IF (QP.GT.QT(I))  IQ1=I
  400 CONTINUE
      IQ2=IQ1+1
C
C **  FOR POINT CLASSIFIED TO CORNER OR GRID POINT, JUST RETURN THE VALUE
C
  500 IF (IH.NE.0 .AND. IQ.NE.0) THEN
                               PW = POWR(IH,IQ)
                               RETURN
                               ENDIF
C
C **  PERFORM LINEAR INTERPOLATION ON A LINE
C **  FOR POINT SIT AT BOUNDARY OR GRID LINE
C
      IF (IH.NE.0)  THEN
         CALL TWOPLN
```

```
     1        (QP,QT(IQ1),QT(IQ2),POWR(IH,IQ1),POWR(IH,IQ2),PW)
                RETURN
                ENDIF
           IF (IQ.NE.0)  THEN
                CALL TWOPLN
     1        (HD,HT(IH1),HT(IH2),POWR(IH1,IQ),POWR(IH2,IQ),FW)
                RETURN
                ENDIF
C
C **  PERFORM LINEAR INTERPOLATION ON A THE TABLE
C
C **  FIRST, 2 LINEAR INTERPOLATIONS OVER H-AXIS FOR NEW PWI VALUE
C **   THEN, GET NEW VALUE OVER THE Q-AXIS DIRECTION
C
      CALL TWOPLN (HD,HT(IH1),HT(IH2),POWR(IH1,IQ1),POWR(IH2,IQ1),PW1)
      CALL TWOPLN (HD,HT(IH1),HT(IH2),POWR(IH1,IQ2),POWR(IH2,IQ2),PW2)
      CALL TWOPLN (QP,QT(IQ1),QT(IQ2),PW1,PW2,PW)
C
      RETURN
C
      END


C ***********************************************************************
C
       SUBROUTINE TWOPLN (X, X1, X2, Y1, Y2, Y)
C
C     ****************************************************************
C
C         LINEAR INTERPOLATION BETWEEN 2 POINTS
C
C         FOR VALUE X BETWEEN (X1,X2), LINEARLY INTERPOLATE THE
C         CORRESPONDING VALUE Y OF (X,Y) BETWEEN (X1,Y1) AND (X2,Y2)
C
C           - ---------*---------------*---------------*-------- +
C                  (X2,Y2)           (X,Y)           (X1,Y1)
C
C          INPUT:  X, X1, X2, Y1, Y2
C         OUTPUT:  Y
C
C     ****************************************************************
C
C
      IF (X1.EQ.X2) THEN
         IF (Y1.NE.Y2) STOP 'CAN''T INTERPOLATE LINE Y=C FOR 2 X''S !'
         Y = Y1
         RETURN
      END IF
C
      Y = Y2+(Y2-Y1)*(X-X2)/(X2-X1)
C
      RETURN
      END
```

Elevation = 131.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	17.61
41.0	41.0	.0	17.71
42.0	42.0	.0	17.81
43.0	43.0	.0	18.11
44.0	44.0	.0	18.61
45.0	45.0	.0	19.12
46.0	21.0	25.0	19.30
47.0	22.0	25.0	19.85
48.0	23.0	25.0	20.39
49.0	24.0	25.0	20.93
50.0	25.0	25.0	21.48
51.0	25.0	26.0	21.98
52.0	25.0	27.0	22.49
53.0	25.0	28.0	23.00
54.0	27.0	27.0	23.50
55.0	25.0	30.0	24.01
56.0	25.0	31.0	24.53
57.0	25.0	32.0	25.06
58.0	25.5	32.5	25.58
59.0	26.5	32.5	26.08
60.0	27.5	32.5	26.59
61.0	28.5	32.5	27.09
62.0	29.5	32.5	27.60
63.0	30.5	32.5	28.12
64.0	31.5	32.5	28.64
65.0	32.5	32.5	29.17
66.0	32.5	33.5	29.61
67.0	32.5	34.5	30.06
68.0	33.0	35.0	30.50
69.0	34.0	35.0	30.94
70.0	35.0	35.0	31.38
71.0	35.0	36.0	31.79
72.0	35.0	37.0	32.19
73.0	35.5	37.5	32.59
74.0	36.5	37.5	33.00
75.0	37.5	37.5	33.40
76.0	37.5	38.5	33.76
77.0	37.5	39.5	34.13
78.0	38.5	39.5	34.49
79.0	39.0	40.0	34.85
80.0	40.0	40.0	35.22
81.0	40.0	41.0	35.32
82.0	37.0	45.0	35.61
83.0	38.0	45.0	36.00
84.0	39.0	45.0	36.36
85.0	40.0	45.0	36.72
86.0	41.0	45.0	36.82
87.0	42.0	45.0	36.93
88.0	44.0	44.0	37.23
89.0	44.0	45.0	37.73
90.0	45.0	45.0	38.23

Elevation = 131.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	17.82
41.0	41.0	.0	17.97
42.0	42.0	.0	18.11
43.0	43.0	.0	18.42
44.0	44.0	.0	18.88
45.0	45.0	.0	19.35
46.0	22.5	23.5	19.43
47.0	22.0	25.0	19.98
48.0	23.0	25.0	20.53
49.0	24.0	25.0	21.08
50.0	25.0	25.0	21.63
51.0	25.0	26.0	22.15
52.0	25.0	27.0	22.67
53.0	25.0	28.0	23.19
54.0	25.0	29.0	23.70
55.0	25.0	30.0	24.22
56.0	25.0	31.0	24.76
57.0	25.0	32.0	25.30
58.0	25.5	32.5	25.83
59.0	26.5	32.5	26.35
60.0	27.5	32.5	26.87
61.0	28.5	32.5	27.38
62.0	29.5	32.5	27.90
63.0	30.5	32.5	28.43
64.0	31.5	32.5	28.97
65.0	32.5	32.5	29.51
66.0	32.5	33.5	29.96
67.0	32.5	34.5	30.41
68.0	33.0	35.0	30.86
69.0	34.5	34.5	31.30
70.0	35.0	35.0	31.75
71.0	35.0	36.0	32.16
72.0	35.0	37.0	32.57
73.0	35.5	37.5	32.98
74.0	36.5	37.5	33.39
75.0	37.5	37.5	33.80
76.0	38.0	38.0	34.17
77.0	37.5	39.5	34.54
78.0	38.0	40.0	34.91
79.0	39.0	40.0	35.28
80.0	40.0	40.0	35.65
81.0	40.0	41.0	35.79
82.0	37.0	45.0	36.04
83.0	38.0	45.0	36.43
84.0	39.0	45.0	36.80
85.0	40.0	45.0	37.17
86.0	41.0	45.0	37.31
87.0	42.0	45.0	37.46
88.0	43.0	45.0	37.76
89.0	44.0	45.0	38.23
90.0	45.0	45.0	38.69

NOTE: Flow less than 40 CMS should be released thru one single turbine

Elevation = 132.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	18.04
41.0	41.0	.0	18.23
42.0	42.0	.0	18.41
43.0	43.0	.0	18.72
44.0	44.0	.0	19.15
45.0	45.0	.0	19.58
46.0	45.0	.0	19.58
47.0	22.0	25.0	20.12
48.0	23.5	24.5	20.67
49.0	24.5	24.5	21.23
50.0	25.0	25.0	21.78
51.0	25.0	26.0	22.32
52.0	25.0	27.0	22.85
53.0	25.0	28.0	23.38
54.0	25.0	29.0	23.91
55.0	25.0	30.0	24.44
56.0	25.0	31.0	24.99
57.0	25.0	32.0	25.54
58.0	25.5	32.5	26.08
59.0	26.5	32.5	26.61
60.0	27.5	32.5	27.14
61.0	28.5	32.5	27.67
62.0	29.5	32.5	28.20
63.0	30.5	32.5	28.74
64.0	31.5	32.5	29.30
65.0	32.5	32.5	29.85
66.0	32.5	33.5	30.30
67.0	32.5	34.5	30.76
68.0	33.0	35.0	31.21
69.0	34.0	35.0	31.67
70.0	35.0	35.0	32.12
71.0	35.5	35.5	32.54
72.0	35.5	36.5	32.95
73.0	35.5	37.5	33.37
74.0	36.5	37.5	33.78
75.0	37.5	37.5	34.20
76.0	37.5	38.5	34.58
77.0	38.5	38.5	34.95
78.0	38.0	40.0	35.33
79.0	39.0	40.0	35.70
80.0	40.0	40.0	36.08
81.0	40.0	41.0	36.26
82.0	37.0	45.0	36.47
83.0	38.0	45.0	36.86
84.0	39.0	45.0	37.24
85.0	40.0	45.0	37.62
86.0	41.0	45.0	37.80
87.0	42.0	45.0	37.99
88.0	43.0	45.0	38.30
89.0	44.0	45.0	38.73
90.0	45.0	45.0	39.15

Elevation = 132.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	18.25
41.0	41.0	.0	18.48
42.0	42.0	.0	18.72
43.0	43.0	.0	19.03
44.0	44.0	.0	19.42
45.0	45.0	.0	19.81
46.0	45.0	.0	19.81
47.0	22.0	25.0	20.25
48.0	23.0	25.0	20.82
49.0	24.0	25.0	21.38
50.0	25.0	25.0	21.94
51.0	25.5	25.5	22.48
52.0	25.0	27.0	23.02
53.0	25.0	28.0	23.57
54.0	25.0	29.0	24.11
55.0	22.5	32.5	24.66
56.0	23.5	32.5	25.22
57.0	24.5	32.5	25.78
58.0	25.5	32.5	26.73
59.0	26.5	32.5	26.98
60.0	27.5	32.5	27.42
61.0	28.5	32.5	27.96
62.0	29.5	32.5	28.51
63.0	30.5	32.5	29.06
64.0	31.5	32.5	29.62
65.0	32.5	32.5	30.18
66.0	32.5	33.5	30.65
67.0	32.5	34.5	31.11
68.0	33.5	34.5	31.57
69.0	34.0	35.0	32.03
70.0	35.0	35.0	32.49
71.0	35.0	36.0	32.91
72.0	36.0	36.0	33.34
73.0	35.5	37.5	33.76
74.0	36.5	37.5	34.18
75.0	37.5	37.5	34.60
76.0	37.5	38.5	34.98
77.0	37.5	39.5	35.36
78.0	38.0	40.0	35.74
79.0	39.0	40.0	36.13
80.0	40.0	40.0	36.51
81.0	40.0	41.0	36.74
82.0	40.0	42.0	36.97
83.0	38.0	45.0	37.30
84.0	39.0	45.0	37.68
85.0	40.0	45.0	38.06
86.0	41.0	45.0	38.29
87.0	42.0	45.0	38.52
88.0	43.0	45.0	38.83
89.0	44.0	45.0	39.22
90.0	45.0	45.0	39.62

Elevation = 133.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	18.47
41.0	41.0	.0	18.74
42.0	42.0	.0	19.02
43.0	43.0	.0	19.33
44.0	44.0	.0	19.68
45.0	45.0	.0	20.04
46.0	45.0	.0	20.04
47.0	22.0	25.0	20.39
48.0	23.0	25.0	20.96
49.0	24.0	25.0	21.52
50.0	25.0	25.0	22.09
51.0	25.0	26.0	22.65
52.0	25.0	27.0	23.20
53.0	25.5	27.5	23.76
54.0	21.5	32.5	24.32
55.0	22.5	32.5	24.89
56.0	23.5	32.5	25.46
57.0	24.5	32.5	26.02
58.0	25.5	32.5	26.59
59.0	26.5	32.5	27.14
60.0	27.5	32.5	27.70
61.0	28.5	32.5	28.25
62.0	29.5	32.5	28.81
63.0	31.5	31.5	29.37
64.0	31.5	32.5	29.95
65.0	32.5	32.5	30.52
66.0	32.5	33.5	30.99
67.0	32.5	34.5	31.46
68.0	33.0	35.0	31.93
69.0	34.0	35.0	32.39
70.0	35.0	35.0	32.86
71.0	35.0	36.0	33.29
72.0	35.0	37.0	33.72
73.0	35.5	37.5	34.14
74.0	36.5	37.5	34.57
75.0	37.5	37.5	35.00
76.0	37.5	38.5	35.39
77.0	37.5	39.5	35.78
78.0	38.0	40.0	36.16
79.0	39.0	40.0	36.55
80.0	40.0	40.0	36.94
81.0	40.0	41.0	37.21
82.0	40.0	42.0	37.49
83.0	40.0	43.0	37.80
84.0	40.0	44.0	38.15
85.0	40.0	45.0	38.51
86.0	41.0	45.0	38.78
87.0	42.0	45.0	39.06
88.0	43.0	45.0	39.37
89.0	44.0	45.0	39.72
90.0	45.0	45.0	40.08

Elevation = 133.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	18.68
41.0	41.0	.0	19.00
42.0	42.0	.0	19.32
43.0	43.0	.0	19.64
44.0	44.0	.0	19.95
45.0	45.0	.0	20.27
46.0	45.0	.0	20.27
47.0	23.0	24.0	20.52
48.0	23.0	25.0	21.10
49.0	24.0	25.0	21.67
50.0	25.0	25.0	22.25
51.0	25.0	26.0	22.81
52.0	20.0	32.0	23.39
53.0	20.5	32.5	23.97
54.0	21.5	32.5	24.55
55.0	22.5	32.5	25.12
56.0	23.5	32.5	25.69
57.0	24.5	32.5	26.27
58.0	25.5	32.5	26.84
59.0	26.5	32.5	27.41
60.0	27.5	32.5	27.97
61.0	28.5	32.5	28.54
62.0	29.5	32.5	29.11
63.0	31.5	31.5	29.69
64.0	31.5	32.5	30.27
65.0	32.5	32.5	30.86
66.0	32.5	33.5	31.34
67.0	32.5	34.5	31.81
68.0	34.0	34.0	32.28
69.0	34.0	35.0	32.76
70.0	35.0	35.0	33.23
71.0	35.0	36.0	33.66
72.0	35.0	37.0	34.10
73.0	36.5	36.5	34.53
74.0	36.5	37.5	34.97
75.0	37.5	37.5	35.40
76.0	37.5	38.5	35.79
77.0	37.5	39.5	36.19
78.0	38.0	40.0	36.58
79.0	39.5	39.5	36.98
80.0	40.0	40.0	37.37
81.0	40.5	40.5	37.69
82.0	40.0	42.0	38.00
83.0	40.0	43.0	38.32
84.0	40.5	43.5	38.64
85.0	40.5	44.5	38.95
86.0	41.0	45.0	39.27
87.0	42.0	45.0	39.59
88.0	43.5	44.5	39.90
89.0	44.5	44.5	40.22
90.0	45.0	45.0	40.54

Elevation = 134.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	18.90
41.0	41.0	.0	19.26
42.0	42.0	.0	19.62
43.0	43.0	.0	19.94
44.0	44.0	.0	20.22
45.0	45.0	.0	20.50
46.0	45.0	.0	20.50
47.0	20.0	27.0	20.66
48.0	20.0	28.0	21.24
49.0	20.0	29.0	21.82
50.0	20.0	30.0	22.40
51.0	20.0	31.0	23.00
52.0	20.0	32.0	23.60
53.0	20.5	32.5	24.19
54.0	21.5	32.5	24.77
55.0	22.5	32.5	25.35
56.0	23.5	32.5	25.93
57.0	24.5	32.5	26.51
58.0	25.5	32.5	27.09
59.0	26.5	32.5	27.67
60.0	27.5	32.5	28.25
61.0	28.5	32.5	28.83
62.0	29.5	32.5	29.41
63.0	30.5	32.5	30.00
64.0	31.5	32.5	30.60
65.0	32.5	32.5	31.20
66.0	32.5	33.5	31.68
67.0	32.5	34.5	32.16
68.0	33.0	35.0	32.64
69.0	34.0	35.0	33.12
70.0	35.0	35.0	33.60
71.0	35.0	36.0	34.04
72.0	35.0	37.0	34.48
73.0	35.5	37.5	34.92
74.0	36.5	37.5	35.36
75.0	37.5	37.5	35.80
76.0	38.0	38.0	36.20
77.0	37.5	39.5	36.60
78.0	38.0	40.0	37.00
79.0	39.0	40.0	37.40
80.0	40.0	40.0	37.80
81.0	40.0	41.0	38.16
82.0	41.0	41.0	38.52
83.0	40.5	42.5	38.88
84.0	41.5	42.5	39.24
85.0	42.5	42.5	39.60
86.0	42.5	43.5	39.88
87.0	42.5	44.5	40.16
88.0	43.5	44.5	40.44
89.0	44.0	45.0	40.72
90.0	45.0	45.0	41.00

Elevation = 134.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.13
41.0	41.0	.0	19.50
42.0	42.0	.0	19.87
43.0	43.0	.0	20.19
44.0	44.0	.0	20.47
45.0	45.0	.0	20.75
46.0	45.0	.0	20.75
47.0	20.0	27.0	20.84
48.0	20.0	28.0	21.43
49.0	21.0	28.0	22.01
50.0	20.0	30.0	22.60
51.0	20.0	31.0	23.20
52.0	20.0	32.0	23.80
53.0	20.5	32.5	24.39
54.0	21.5	32.5	24.98
55.0	22.5	32.5	25.57
56.0	23.5	32.5	26.15
57.0	24.5	32.5	26.74
58.0	25.5	32.5	27.33
59.0	26.5	32.5	27.91
60.0	27.5	32.5	28.50
61.0	28.5	32.5	29.09
62.0	29.5	32.5	29.67
63.0	30.5	32.5	30.27
64.0	31.5	32.5	30.87
65.0	32.5	32.5	31.47
66.0	32.5	33.5	31.96
67.0	32.5	34.5	32.45
68.0	34.0	34.0	32.95
69.0	34.0	35.0	33.44
70.0	35.0	35.0	33.93
71.0	35.0	36.0	34.39
72.0	36.0	36.0	34.84
73.0	35.5	37.5	35.29
74.0	36.5	37.5	35.75
75.0	37.5	37.5	36.20
76.0	37.5	38.5	36.61
77.0	38.5	38.5	37.03
78.0	38.0	40.0	37.44
79.0	39.0	40.0	37.85
80.0	40.0	40.0	38.27
81.0	40.0	41.0	38.63
82.0	40.0	42.0	39.00
83.0	41.0	42.0	39.37
84.0	42.0	42.0	39.73
85.0	42.5	42.5	40.10
86.0	42.5	43.5	40.38
87.0	42.5	44.5	40.66
88.0	43.5	44.5	40.94
89.0	44.0	45.0	41.22
90.0	45.0	45.0	41.50

Elevation = 135.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.37
41.0	41.0	.0	19.74
42.0	42.0	.0	20.11
43.0	43.0	.0	20.44
44.0	44.0	.0	20.72
45.0	45.0	.0	21.00
46.0	45.0	.0	21.00
47.0	20.0	27.0	21.02
48.0	20.0	28.0	21.61
49.0	20.0	29.0	22.21
50.0	20.0	30.0	22.80
51.0	20.0	31.0	23.40
52.0	20.0	32.0	24.00
53.0	20.5	32.5	24.60
54.0	21.5	32.5	25.19
55.0	22.5	32.5	25.78
56.0	23.5	32.5	26.38
57.0	24.5	32.5	26.97
58.0	25.5	32.5	27.56
59.0	26.5	32.5	28.16
60.0	27.5	32.5	28.75
61.0	28.5	32.5	29.34
62.0	29.5	32.5	29.94
63.0	30.5	32.5	30.53
64.0	31.5	32.5	31.13
65.0	32.5	32.5	31.73
66.0	33.0	33.0	32.24
67.0	32.5	34.5	32.75
68.0	33.0	35.0	33.25
69.0	34.0	35.0	33.76
70.0	35.0	35.0	34.27
71.0	35.0	36.0	34.73
72.0	36.0	36.0	35.20
73.0	35.5	37.5	35.67
74.0	36.5	37.5	36.13
75.0	37.5	37.5	36.60
76.0	37.5	38.5	37.03
77.0	37.5	39.5	37.45
78.0	39.0	39.0	37.88
79.0	39.0	40.0	38.31
80.0	40.0	40.0	38.73
81.0	40.0	41.0	39.11
82.0	40.0	42.0	39.48
83.0	40.5	42.5	39.85
84.0	41.5	42.5	40.23
85.0	42.5	42.5	40.60
86.0	42.5	43.5	40.88
87.0	42.5	44.5	41.16
88.0	43.5	44.5	41.44
89.0	44.0	45.0	41.72
90.0	45.0	45.0	42.00

Elevation = 135.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.60
41.0	41.0	.0	19.98
42.0	42.0	.0	20.36
43.0	43.0	.0	20.69
44.0	44.0	.0	20.97
45.0	45.0	.0	21.25
46.0	45.0	.0	21.25
47.0	45.0	.0	21.25
48.0	20.0	28.0	21.80
49.0	20.5	28.5	22.40
50.0	20.0	30.0	23.00
51.0	20.0	31.0	23.60
52.0	20.0	32.0	24.20
53.0	20.5	32.5	24.80
54.0	23.0	31.0	25.40
55.0	22.5	32.5	26.00
56.0	23.5	32.5	26.60
57.0	24.5	32.5	27.20
58.0	25.5	32.5	27.80
59.0	28.0	31.0	28.40
60.0	27.5	32.5	29.00
61.0	28.5	32.5	29.60
62.0	29.5	32.5	30.20
63.0	30.5	32.5	30.80
64.0	31.5	32.5	31.40
65.0	32.5	32.5	32.00
66.0	32.5	33.5	32.52
67.0	32.5	34.5	33.04
68.0	33.0	35.0	33.56
69.0	34.0	35.0	34.08
70.0	35.0	35.0	34.60
71.0	35.0	36.0	35.08
72.0	35.0	37.0	35.56
73.0	35.5	37.5	36.04
74.0	36.5	37.5	36.52
75.0	37.5	37.5	37.00
76.0	37.5	38.5	37.44
77.0	37.5	39.5	37.88
78.0	38.0	40.0	38.32
79.0	39.0	40.0	38.76
80.0	40.0	40.0	39.20
81.0	40.0	41.0	39.58
82.0	40.0	42.0	39.96
83.0	40.5	42.5	40.34
84.0	41.5	42.5	40.72
85.0	42.5	42.5	41.10
86.0	42.5	43.5	41.38
87.0	42.5	44.5	41.66
88.0	43.5	44.5	41.94
89.0	44.0	45.0	42.22
90.0	45.0	45.0	42.50

Elevation = 135.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.37
41.0	41.0	.0	19.74
42.0	42.0	.0	20.11
43.0	43.0	.0	20.44
44.0	44.0	.0	20.72
45.0	45.0	.0	21.00
46.0	45.0	.0	21.00
47.0	20.0	27.0	21.02
48.0	20.0	28.0	21.61
49.0	20.0	29.0	22.21
50.0	20.0	30.0	22.80
51.0	20.0	31.0	23.40
52.0	20.0	32.0	24.00
53.0	20.5	32.5	24.60
54.0	21.5	32.5	25.19
55.0	22.5	32.5	25.78
56.0	23.5	32.5	26.38
57.0	24.5	32.5	26.97
58.0	25.5	32.5	27.56
59.0	26.5	32.5	28.16
60.0	27.5	32.5	28.75
61.0	28.5	32.5	29.34
62.0	29.5	32.5	29.94
63.0	30.5	32.5	30.53
64.0	31.5	32.5	31.13
65.0	32.5	32.5	31.73
66.0	33.0	33.0	32.24
67.0	32.5	34.5	32.75
68.0	33.0	35.0	33.25
69.0	34.0	35.0	33.76
70.0	35.0	35.0	34.27
71.0	35.0	36.0	34.73
72.0	36.0	36.0	35.20
73.0	35.5	37.5	35.67
74.0	36.5	37.5	36.13
75.0	37.5	37.5	36.60
76.0	37.5	38.5	37.03
77.0	37.5	39.5	37.45
78.0	39.0	39.0	37.88
79.0	39.0	40.0	38.31
80.0	40.0	40.0	38.73
81.0	40.0	41.0	39.11
82.0	40.0	42.0	39.48
83.0	40.5	42.5	39.85
84.0	41.5	42.5	40.23
85.0	42.5	42.5	40.60
86.0	42.5	43.5	40.88
87.0	42.5	44.5	41.16
88.0	43.5	44.5	41.44
89.0	44.0	45.0	41.72
90.0	45.0	45.0	42.00

Elevation = 135.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.60
41.0	41.0	.0	19.98
42.0	42.0	.0	20.36
43.0	43.0	.0	20.69
44.0	44.0	.0	20.97
45.0	45.0	.0	21.25
46.0	45.0	.0	21.25
47.0	45.0	.0	21.25
48.0	20.0	28.0	21.80
49.0	20.5	28.5	22.40
50.0	20.0	30.0	23.00
51.0	20.0	31.0	23.60
52.0	20.0	32.0	24.20
53.0	20.5	32.5	24.80
54.0	23.0	31.0	25.40
55.0	22.5	32.5	26.00
56.0	23.5	32.5	26.60
57.0	24.5	32.5	27.20
58.0	25.5	32.5	27.80
59.0	28.0	31.0	28.40
60.0	27.5	32.5	29.00
61.0	28.5	32.5	29.60
62.0	29.5	32.5	30.20
63.0	30.5	32.5	30.80
64.0	31.5	32.5	31.40
65.0	32.5	32.5	32.00
66.0	32.5	33.5	32.52
67.0	32.5	34.5	33.04
68.0	33.0	35.0	33.56
69.0	34.0	35.0	34.08
70.0	35.0	35.0	34.60
71.0	35.0	36.0	35.08
72.0	35.0	37.0	35.56
73.0	35.5	37.5	36.04
74.0	36.5	37.5	36.52
75.0	37.5	37.5	37.00
76.0	37.5	38.5	37.44
77.0	37.5	39.5	37.88
78.0	38.0	40.0	38.32
79.0	39.0	40.0	38.76
80.0	40.0	40.0	39.20
81.0	40.0	41.0	39.58
82.0	40.0	42.0	39.96
83.0	40.5	42.5	40.34
84.0	41.5	42.5	40.72
85.0	42.5	42.5	41.10
86.0	42.5	43.5	41.38
87.0	42.5	44.5	41.66
88.0	43.5	44.5	41.94
89.0	44.0	45.0	42.22
90.0	45.0	45.0	42.50

Elevation = 136.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.83
41.0	41.0	.0	20.22
42.0	42.0	.0	20.61
43.0	43.0	.0	20.94
44.0	44.0	.0	21.22
45.0	45.0	.0	21.50
46.0	45.0	.0	21.50
47.0	45.0	.0	21.50
48.0	20.0	28.0	21.99
49.0	20.0	29.0	22.59
50.0	20.0	30.0	23.20
51.0	21.0	30.0	23.81
52.0	22.0	30.0	24.41
53.0	23.0	30.0	25.02
54.0	24.0	30.0	25.63
55.0	25.0	30.0	26.23
56.0	26.0	30.0	26.84
57.0	27.0	30.0	27.45
58.0	28.0	30.0	28.05
59.0	29.0	30.0	28.66
60.0	30.0	30.0	29.27
61.0	30.0	31.0	29.87
62.0	30.0	32.0	30.47
63.0	30.5	32.5	31.07
64.0	31.5	32.5	31.67
65.0	32.5	32.5	32.27
66.0	32.5	33.5	32.80
67.0	32.5	34.5	33.33
68.0	33.0	35.0	33.87
69.0	34.0	35.0	34.40
70.0	35.0	35.0	34.93
71.0	35.0	36.0	35.43
72.0	35.0	37.0	35.92
73.0	35.5	37.5	36.41
74.0	36.5	37.5	36.91
75.0	37.5	37.5	37.40
76.0	37.5	38.5	37.85
77.0	37.5	39.5	38.31
78.0	38.5	39.5	38.76
79.0	39.0	40.0	39.21
80.0	40.0	40.0	39.67
81.0	40.0	41.0	40.05
82.0	40.0	42.0	40.44
83.0	41.0	42.0	40.83
84.0	41.5	42.5	41.21
85.0	42.5	42.5	41.60
86.0	42.5	43.5	41.88
87.0	42.5	44.5	42.16
88.0	43.5	44.5	42.44
89.0	44.0	45.0	42.72
90.0	45.0	45.0	43.00

Elevation = 136.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	20.07
41.0	41.0	.0	20.46
42.0	42.0	.0	20.85
43.0	43.0	.0	21.19
44.0	44.0	.0	21.47
45.0	45.0	.0	21.75
46.0	45.0	.0	21.75
47.0	45.0	.0	21.75
48.0	20.0	28.0	22.17
49.0	20.0	29.0	22.79
50.0	20.0	30.0	23.40
51.0	21.0	30.0	24.01
52.0	22.0	30.0	24.63
53.0	23.0	30.0	25.24
54.0	24.0	30.0	25.85
55.0	25.0	30.0	26.47
56.0	26.0	30.0	27.08
57.0	27.0	30.0	27.69
58.0	28.0	30.0	28.31
59.0	29.5	29.5	28.92
60.0	30.0	30.0	29.53
61.0	30.0	31.0	30.13
62.0	30.0	32.0	30.73
63.0	30.5	32.5	31.33
64.0	31.5	32.5	31.93
65.0	32.5	32.5	32.53
66.0	32.5	33.5	33.08
67.0	32.5	34.5	33.63
68.0	33.0	35.0	34.17
69.0	34.0	35.0	34.72
70.0	35.0	35.0	35.27
71.0	35.5	35.5	35.77
72.0	35.0	37.0	36.28
73.0	35.5	37.5	36.79
74.0	36.5	37.5	37.29
75.0	37.5	37.5	37.80
76.0	37.5	38.5	38.27
77.0	38.5	38.5	38.73
78.0	38.0	40.0	39.20
79.0	39.0	40.0	39.67
80.0	40.0	40.0	40.13
81.0	40.0	41.0	40.53
82.0	40.0	42.0	40.92
83.0	40.5	42.5	41.31
84.0	41.5	42.5	41.71
85.0	42.5	42.5	42.10
86.0	42.5	43.5	42.38
87.0	42.5	44.5	42.66
88.0	43.5	44.5	42.94
89.0	44.0	45.0	43.22
90.0	45.0	45.0	43.50

Elevation = 136.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	19.83
41.0	41.0	.0	20.22
42.0	42.0	.0	20.61
43.0	43.0	.0	20.94
44.0	44.0	.0	21.22
45.0	45.0	.0	21.50
46.0	45.0	.0	21.50
47.0	45.0	.0	21.50
48.0	20.0	28.0	21.99
49.0	20.0	29.0	22.59
50.0	20.0	30.0	23.20
51.0	21.0	30.0	23.81
52.0	22.0	30.0	24.41
53.0	23.0	30.0	25.02
54.0	24.0	30.0	25.63
55.0	25.0	30.0	26.23
56.0	26.0	30.0	26.84
57.0	27.0	30.0	27.45
58.0	28.0	30.0	28.05
59.0	29.0	30.0	28.66
60.0	30.0	30.0	29.27
61.0	30.0	31.0	29.87
62.0	30.0	32.0	30.47
63.0	30.5	32.5	31.07
64.0	31.5	32.5	31.67
65.0	32.5	32.5	32.27
66.0	32.5	33.5	32.80
67.0	32.5	34.5	33.33
68.0	33.0	35.0	33.87
69.0	34.0	35.0	34.40
70.0	35.0	35.0	34.93
71.0	35.0	36.0	35.43
72.0	35.0	37.0	35.92
73.0	35.5	37.5	36.41
74.0	36.5	37.5	36.91
75.0	37.5	37.5	37.40
76.0	37.5	38.5	37.85
77.0	37.5	39.5	38.31
78.0	38.5	39.5	38.76
79.0	39.0	40.0	39.21
80.0	40.0	40.0	39.67
81.0	40.0	41.0	40.05
82.0	40.0	42.0	40.44
83.0	41.0	42.0	40.83
84.0	41.5	42.5	41.21
85.0	42.5	42.5	41.60
86.0	42.5	43.5	41.88
87.0	42.5	44.5	42.16
88.0	43.5	44.5	42.44
89.0	44.0	45.0	42.72
90.0	45.0	45.0	43.00

Elevation = 136.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	20.07
41.0	41.0	.0	20.46
42.0	42.0	.0	20.85
43.0	43.0	.0	21.19
44.0	44.0	.0	21.47
45.0	45.0	.0	21.75
46.0	45.0	.0	21.75
47.0	45.0	.0	21.75
48.0	20.0	28.0	22.17
49.0	20.0	29.0	22.79
50.0	20.0	30.0	23.40
51.0	21.0	30.0	24.01
52.0	22.0	30.0	24.63
53.0	23.0	30.0	25.24
54.0	24.0	30.0	25.85
55.0	25.0	30.0	26.47
56.0	26.0	30.0	27.08
57.0	27.0	30.0	27.69
58.0	28.0	30.0	28.31
59.0	29.5	29.5	28.92
60.0	30.0	30.0	29.53
61.0	30.0	31.0	30.13
62.0	30.0	32.0	30.73
63.0	30.5	32.5	31.33
64.0	31.5	32.5	31.93
65.0	32.5	32.5	32.53
66.0	32.5	33.5	33.08
67.0	32.5	34.5	33.63
68.0	33.0	35.0	34.17
69.0	34.0	35.0	34.72
70.0	35.0	35.0	35.27
71.0	35.5	35.5	35.77
72.0	35.0	37.0	36.28
73.0	35.5	37.5	36.79
74.0	36.5	37.5	37.29
75.0	37.5	37.5	37.80
76.0	37.5	38.5	38.27
77.0	38.5	38.5	38.73
78.0	38.0	40.0	39.20
79.0	39.0	40.0	39.67
80.0	40.0	40.0	40.13
81.0	40.0	41.0	40.53
82.0	40.0	42.0	40.92
83.0	40.5	42.5	41.31
84.0	41.5	42.5	41.71
85.0	42.5	42.5	42.10
86.0	42.5	43.5	42.38
87.0	42.5	44.5	42.66
88.0	43.5	44.5	42.94
89.0	44.0	45.0	43.22
90.0	45.0	45.0	43.50

Elevation = 137.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	20.30
41.0	41.0	.0	20.70
42.0	42.0	.0	21.10
43.0	43.0	.0	21.44
44.0	44.0	.0	21.72
45.0	45.0	.0	22.00
46.0	45.0	.0	22.00
47.0	45.0	.0	22.00
48.0	20.0	28.0	22.36
49.0	20.0	29.0	22.98
50.0	20.5	29.5	23.60
51.0	21.5	29.5	24.22
52.0	22.0	30.0	24.84
53.0	25.5	27.5	25.46
54.0	24.0	30.0	26.08
55.0	25.0	30.0	26.70
56.0	26.0	30.0	27.32
57.0	27.5	29.5	27.94
58.0	28.0	30.0	28.56
59.0	29.0	30.0	29.18
60.0	30.0	30.0	29.80
61.0	30.0	31.0	30.40
62.0	30.0	32.0	31.00
63.0	31.0	32.0	31.60
64.0	32.0	32.0	32.20
65.0	32.5	32.5	32.80
66.0	32.5	33.5	33.36
67.0	32.5	34.5	33.92
68.0	33.0	35.0	34.48
69.0	34.0	35.0	35.04
70.0	35.0	35.0	35.60
71.0	35.0	36.0	36.12
72.0	35.0	37.0	36.64
73.0	35.5	37.5	37.16
74.0	36.5	37.5	37.68
75.0	37.5	37.5	38.20
76.0	37.5	38.5	38.68
77.0	37.5	39.5	39.16
78.0	38.0	40.0	39.64
79.0	39.0	40.0	40.12
80.0	40.0	40.0	40.60
81.0	40.0	41.0	41.00
82.0	40.5	41.5	41.40
83.0	40.5	42.5	41.80
84.0	41.5	42.5	42.20
85.0	42.5	42.5	42.60
86.0	42.5	43.5	42.88
87.0	42.5	44.5	43.16
88.0	43.5	44.5	43.44
89.0	44.0	45.0	43.72
90.0	45.0	45.0	44.00

Elevation = 137.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	20.47
41.0	41.0	.0	20.87
42.0	42.0	.0	21.27
43.0	43.0	.0	21.62
44.0	44.0	.0	21.90
45.0	45.0	.0	22.19
46.0	45.0	.0	22.19
47.0	45.0	.0	22.19
48.0	20.0	28.0	22.51
49.0	20.0	29.0	23.15
50.0	20.0	30.0	23.77
51.0	21.0	30.0	24.40
52.0	22.0	30.0	25.03
53.0	23.5	29.5	25.67
54.0	24.5	29.5	26.30
55.0	25.0	30.0	26.92
56.0	26.0	30.0	27.56
57.0	27.0	30.0	28.18
58.0	28.0	30.0	28.81
59.0	29.0	30.0	29.44
60.0	30.0	30.0	30.07
61.0	30.0	31.0	30.68
62.0	31.0	31.0	31.30
63.0	30.5	32.5	31.90
64.0	31.5	32.5	32.51
65.0	32.5	32.5	33.13
66.0	32.5	33.5	33.69
67.0	32.5	34.5	34.25
68.0	33.0	35.0	34.82
69.0	34.0	35.0	35.38
70.0	35.0	35.0	35.95
71.0	35.0	36.0	36.46
72.0	35.0	37.0	36.98
73.0	36.0	37.0	37.50
74.0	36.5	37.5	38.01
75.0	37.5	37.5	38.53
76.0	37.5	38.5	39.01
77.0	38.0	39.0	39.50
78.0	38.0	40.0	39.98
79.0	39.0	40.0	40.46
80.0	40.0	40.0	40.95
81.0	40.0	41.0	41.35
82.0	40.5	41.5	41.75
83.0	40.5	42.5	42.15
84.0	41.5	42.5	42.55
85.0	42.5	42.5	42.95
86.0	42.5	43.5	43.23
87.0	42.5	44.5	43.52
88.0	43.0	45.0	43.81
89.0	44.0	45.0	44.09
90.0	45.0	45.0	44.38

Elevation = 138.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	20.65
41.0	41.0	.0	21.05
42.0	42.0	.0	21.45
43.0	43.0	.0	21.80
44.0	44.0	.0	22.08
45.0	45.0	.0	22.38
46.0	45.0	.0	22.38
47.0	45.0	.0	22.38
48.0	23.5	24.5	22.67
49.0	22.0	27.0	23.31
50.0	21.0	29.0	23.95
51.0	21.0	30.0	24.59
52.0	22.0	30.0	25.23
53.0	26.5	26.5	25.87
54.0	24.5	29.5	26.51
55.0	25.0	30.0	27.15
56.0	26.5	29.5	27.79
57.0	27.0	30.0	28.43
58.0	28.0	30.0	29.07
59.0	29.0	30.0	29.71
60.0	30.0	30.0	30.35
61.0	30.0	31.0	30.97
62.0	30.0	32.0	31.59
63.0	30.5	32.5	32.21
64.0	31.5	32.5	32.83
65.0	32.5	32.5	33.45
66.0	32.5	33.5	34.02
67.0	32.5	34.5	34.59
68.0	33.0	35.0	35.16
69.0	34.0	35.0	35.73
70.0	35.0	35.0	36.30
71.0	35.0	36.0	36.81
72.0	35.0	37.0	37.32
73.0	36.0	37.0	37.83
74.0	37.0	37.0	38.34
75.0	37.5	37.5	38.85
76.0	38.0	38.0	39.34
77.0	38.0	39.0	39.83
78.0	38.0	40.0	40.32
79.0	39.0	40.0	40.81
80.0	40.0	40.0	41.30
81.0	40.5	40.5	41.70
82.0	40.0	42.0	42.10
83.0	40.5	42.5	42.50
84.0	41.5	42.5	42.90
85.0	42.5	42.5	43.30
86.0	42.5	43.5	43.59
87.0	43.5	43.5	43.88
88.0	43.0	45.0	44.17
89.0	44.0	45.0	44.46
90.0	45.0	45.0	44.75

Elevation = 138.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	20.83
41.0	41.0	.0	21.23
42.0	42.0	.0	21.63
43.0	43.0	.0	21.97
44.0	44.0	.0	22.27
45.0	45.0	.0	22.56
46.0	45.0	.0	22.56
47.0	45.0	.0	22.56
48.0	20.0	28.0	22.83
49.0	20.0	29.0	23.48
50.0	20.0	30.0	24.13
51.0	21.5	29.5	24.78
52.0	22.0	30.0	25.42
53.0	23.0	30.0	26.08
54.0	24.0	30.0	26.73
55.0	25.0	30.0	27.38
56.0	26.5	29.5	28.03
57.0	27.0	30.0	28.67
58.0	28.0	30.0	29.33
59.0	29.0	30.0	29.98
60.0	30.0	30.0	30.63
61.0	30.0	31.0	31.26
62.0	30.0	32.0	31.89
63.0	30.5	32.5	32.51
64.0	31.5	32.5	33.15
65.0	32.5	32.5	33.78
66.0	32.5	33.5	34.35
67.0	32.5	34.5	34.93
68.0	33.0	35.0	35.50
69.0	34.0	35.0	36.08
70.0	35.0	35.0	36.65
71.0	35.5	35.5	37.16
72.0	35.5	36.5	37.66
73.0	35.5	37.5	38.17
74.0	36.5	37.5	38.67
75.0	37.5	37.5	39.17
76.0	37.5	38.5	39.67
77.0	37.5	39.5	40.17
78.0	38.5	39.5	40.66
79.0	39.5	39.5	41.16
80.0	40.0	40.0	41.65
81.0	40.0	41.0	42.05
82.0	40.5	41.5	42.45
83.0	40.5	42.5	42.85
84.0	41.5	42.5	43.25
85.0	42.5	42.5	43.65
86.0	42.5	43.5	43.94
87.0	42.5	44.5	44.24
88.0	43.5	44.5	44.54
89.0	44.0	45.0	44.83
90.0	45.0	45.0	45.13

Elevation = 139.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.00
41.0	41.0	.0	21.40
42.0	42.0	.0	21.80
43.0	43.0	.0	22.15
44.0	44.0	.0	22.45
45.0	45.0	.0	22.75
46.0	45.0	.0	22.75
47.0	45.0	.0	22.75
48.0	20.0	28.0	22.98
49.0	20.0	29.0	23.64
50.0	20.0	30.0	24.30
51.0	21.0	30.0	24.96
52.0	22.0	30.0	25.62
53.0	23.0	30.0	26.28
54.0	24.0	30.0	26.94
55.0	25.0	30.0	27.60
56.0	28.0	28.0	28.26
57.0	28.0	29.0	28.92
58.0	28.0	30.0	29.58
59.0	29.0	30.0	30.24
60.0	30.0	30.0	30.90
61.0	30.0	31.0	31.54
62.0	30.0	32.0	32.18
63.0	30.5	32.5	32.82
64.0	31.5	32.5	33.46
65.0	32.5	32.5	34.10
66.0	32.5	33.5	34.68
67.0	33.0	34.0	35.26
68.0	33.0	35.0	35.84
69.0	34.0	35.0	36.42
70.0	35.0	35.0	37.00
71.0	35.0	36.0	37.50
72.0	35.0	37.0	38.00
73.0	35.0	38.0	38.50
74.0	35.0	39.0	39.00
75.0	35.0	40.0	39.50
76.0	36.0	40.0	40.00
77.0	37.0	40.0	40.50
78.0	38.0	40.0	41.00
79.0	39.0	40.0	41.50
80.0	40.0	40.0	42.00
81.0	40.0	41.0	42.40
82.0	40.5	41.5	42.80
83.0	40.5	42.5	43.20
84.0	41.5	42.5	43.60
85.0	42.5	42.5	44.00
86.0	42.5	43.5	44.30
87.0	42.5	44.5	44.60
88.0	43.0	45.0	44.90
89.0	44.0	45.0	45.20
90.0	45.0	45.0	45.50

Elevation = 139.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.17
41.0	41.0	.0	21.57
42.0	42.0	.0	21.97
43.0	43.0	.0	22.33
44.0	44.0	.0	22.63
45.0	45.0	.0	22.94
46.0	45.0	.0	22.94
47.0	45.0	.0	22.94
48.0	20.5	27.5	23.14
49.0	20.0	29.0	23.81
50.0	22.5	27.5	24.48
51.0	21.0	30.0	25.15
52.0	24.5	27.5	25.82
53.0	23.0	30.0	26.49
54.0	26.5	27.5	27.16
55.0	25.0	30.0	27.83
56.0	26.0	30.0	28.49
57.0	27.0	30.0	29.17
58.0	28.0	30.0	29.83
59.0	29.0	30.0	30.50
60.0	30.0	30.0	31.17
61.0	30.0	31.0	31.92
62.0	30.0	32.0	32.47
63.0	30.5	32.5	33.13
64.0	31.5	32.5	33.78
65.0	32.5	32.5	34.42
66.0	32.5	33.5	35.01
67.0	32.5	34.5	35.60
68.0	33.0	35.0	36.18
69.0	34.0	35.0	36.76
70.0	35.0	35.0	37.35
71.0	35.0	36.0	37.85
72.0	35.0	37.0	38.34
73.0	35.0	38.0	38.84
74.0	35.0	39.0	39.35
75.0	35.0	40.0	39.85
76.0	36.0	40.0	40.35
77.0	37.0	40.0	40.84
78.0	38.0	40.0	41.34
79.0	39.0	40.0	41.85
80.0	40.0	40.0	42.35
81.0	40.0	41.0	42.75
82.0	40.5	41.5	43.15
83.0	40.5	42.5	43.55
84.0	41.5	42.5	43.95
85.0	42.5	42.5	44.35
86.0	42.5	43.5	44.65
87.0	42.5	44.5	44.96
88.0	43.0	45.0	45.26
89.0	44.0	45.0	45.57
90.0	45.0	45.0	45.88

Elevation = 139.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.00
41.0	41.0	.0	21.40
42.0	42.0	.0	21.80
43.0	43.0	.0	22.15
44.0	44.0	.0	22.45
45.0	45.0	.0	22.75
46.0	45.0	.0	22.75
47.0	45.0	.0	22.75
48.0	20.0	28.0	22.98
49.0	20.0	29.0	23.64
50.0	20.0	30.0	24.30
51.0	21.0	30.0	24.96
52.0	22.0	30.0	25.62
53.0	23.0	30.0	26.28
54.0	24.0	30.0	26.94
55.0	25.0	30.0	27.60
56.0	28.0	28.0	28.26
57.0	28.0	29.0	28.92
58.0	28.0	30.0	29.58
59.0	29.0	30.0	30.24
60.0	30.0	30.0	30.90
61.0	30.0	31.0	31.54
62.0	30.0	32.0	32.18
63.0	30.5	32.5	32.82
64.0	31.5	32.5	33.46
65.0	32.5	32.5	34.10
66.0	32.5	33.5	34.68
67.0	33.0	34.0	35.26
68.0	33.0	35.0	35.84
69.0	34.0	35.0	36.42
70.0	35.0	35.0	37.00
71.0	35.0	36.0	37.50
72.0	35.0	37.0	38.00
73.0	35.0	38.0	38.50
74.0	35.0	39.0	39.00
75.0	35.0	40.0	39.50
76.0	36.0	40.0	40.00
77.0	37.0	40.0	40.50
78.0	38.0	40.0	41.00
79.0	39.0	40.0	41.50
80.0	40.0	40.0	42.00
81.0	40.0	41.0	42.40
82.0	40.5	41.5	42.80
83.0	40.5	42.5	43.20
84.0	41.5	42.5	43.60
85.0	42.5	42.5	44.00
86.0	42.5	43.5	44.30
87.0	42.5	44.5	44.60
88.0	43.0	45.0	44.90
89.0	44.0	45.0	45.20
90.0	45.0	45.0	45.50

Elevation = 139.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.17
41.0	41.0	.0	21.57
42.0	42.0	.0	21.97
43.0	43.0	.0	22.33
44.0	44.0	.0	22.63
45.0	45.0	.0	22.94
46.0	45.0	.0	22.94
47.0	45.0	.0	22.94
48.0	20.5	27.5	23.14
49.0	20.0	29.0	23.81
50.0	22.5	27.5	24.48
51.0	21.0	30.0	25.15
52.0	24.5	27.5	25.82
53.0	23.0	30.0	26.49
54.0	26.5	27.5	27.16
55.0	25.0	30.0	27.83
56.0	26.0	30.0	28.49
57.0	27.0	30.0	29.17
58.0	28.0	30.0	29.83
59.0	29.0	30.0	30.50
60.0	30.0	30.0	31.17
61.0	30.0	31.0	31.82
62.0	30.0	32.0	32.47
63.0	30.5	32.5	33.13
64.0	31.5	32.5	33.78
65.0	32.5	32.5	34.42
66.0	32.5	33.5	35.01
67.0	32.5	34.5	35.60
68.0	33.0	35.0	36.18
69.0	34.0	35.0	36.76
70.0	35.0	35.0	37.35
71.0	35.0	36.0	37.85
72.0	35.0	37.0	38.34
73.0	35.0	38.0	38.84
74.0	35.0	39.0	39.35
75.0	35.0	40.0	39.85
76.0	36.0	40.0	40.35
77.0	37.0	40.0	40.84
78.0	38.0	40.0	41.34
79.0	39.0	40.0	41.85
80.0	40.0	40.0	42.35
81.0	40.0	41.0	42.75
82.0	40.5	41.5	43.15
83.0	40.5	42.5	43.55
84.0	41.5	42.5	43.95
85.0	42.5	42.5	44.35
86.0	42.5	43.5	44.65
87.0	42.5	44.5	44.96
88.0	43.0	45.0	45.26
89.0	44.0	45.0	45.57
90.0	45.0	45.0	45.88

Elevation = 140.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.35
41.0	41.0	.0	21.75
42.0	42.0	.0	22.15
43.0	43.0	.0	22.51
44.0	44.0	.0	22.82
45.0	45.0	.0	23.13
46.0	45.0	.0	23.13
47.0	45.0	.0	23.13
48.0	20.0	28.0	23.29
49.0	20.0	29.0	23.97
50.0	20.0	30.0	24.65
51.0	21.0	30.0	25.33
52.0	22.0	30.0	26.01
53.0	23.0	30.0	26.69
54.0	27.0	27.0	27.37
55.0	25.0	30.0	28.05
56.0	26.0	30.0	28.73
57.0	27.0	30.0	29.41
58.0	28.0	30.0	30.09
59.0	29.0	30.0	30.77
60.0	30.0	30.0	31.45
61.0	30.0	31.0	32.11
62.0	30.0	32.0	32.77
63.0	30.5	32.5	33.43
64.0	31.5	32.5	34.09
65.0	32.5	32.5	34.75
66.0	32.5	33.5	35.34
67.0	32.5	34.5	35.93
68.0	33.0	35.0	36.52
69.0	34.0	35.0	37.11
70.0	35.0	35.0	37.70
71.0	35.0	36.0	38.19
72.0	35.0	37.0	38.68
73.0	35.0	38.0	39.18
74.0	35.0	39.0	39.69
75.0	35.0	40.0	40.20
76.0	36.0	40.0	40.69
77.0	37.0	40.0	41.18
78.0	38.0	40.0	41.68
79.0	39.0	40.0	42.19
80.0	40.0	40.0	42.70
81.0	40.5	40.5	43.10
82.0	40.0	42.0	43.50
83.0	40.5	42.5	43.90
84.0	41.5	42.5	44.30
85.0	42.5	42.5	44.70
86.0	42.5	43.5	45.01
87.0	42.5	44.5	45.32
88.0	43.0	45.0	45.63
89.0	44.0	45.0	45.94
90.0	45.0	45.0	46.25

Elevation = 140.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.53
41.0	41.0	.0	21.93
42.0	42.0	.0	22.33
43.0	43.0	.0	22.68
44.0	44.0	.0	23.00
45.0	45.0	.0	23.31
46.0	45.0	.0	23.31
47.0	45.0	.0	23.31
48.0	20.0	28.0	23.44
49.0	23.5	25.5	24.14
50.0	20.0	30.0	24.83
51.0	23.5	27.5	25.52
52.0	23.0	29.0	26.21
53.0	23.0	30.0	26.90
54.0	25.0	29.0	27.59
55.0	25.0	30.0	28.28
56.0	26.0	30.0	28.97
57.0	27.0	30.0	29.66
58.0	28.0	30.0	30.35
59.0	29.0	30.0	31.03
60.0	30.0	30.0	31.73
61.0	30.0	31.0	32.40
62.0	30.5	31.5	33.07
63.0	30.5	32.5	33.74
64.0	31.5	32.5	34.40
65.0	32.5	32.5	35.08
66.0	32.5	33.5	35.67
67.0	33.5	33.5	36.27
68.0	33.0	35.0	36.86
69.0	34.0	35.0	37.46
70.0	35.0	35.0	38.05
71.0	35.0	36.0	38.54
72.0	35.5	36.5	39.02
73.0	35.0	38.0	39.52
74.0	35.0	39.0	40.04
75.0	35.0	40.0	40.55
76.0	36.0	40.0	41.04
77.0	37.0	40.0	41.52
78.0	38.5	39.5	42.02
79.0	39.0	40.0	42.54
80.0	40.0	40.0	43.05
81.0	40.0	41.0	43.45
82.0	40.5	41.5	43.85
83.0	40.5	42.5	44.25
84.0	41.5	42.5	44.65
85.0	42.5	42.5	45.05
86.0	42.5	43.5	45.37
87.0	42.5	44.5	45.68
88.0	43.0	45.0	46.00
89.0	44.0	45.0	46.31
90.0	45.0	45.0	46.63

Elevation = 141.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.70
41.0	41.0	.0	22.10
42.0	42.0	.0	22.50
43.0	43.0	.0	22.86
44.0	44.0	.0	23.18
45.0	45.0	.0	23.50
46.0	45.0	.0	23.50
47.0	45.0	.0	23.50
48.0	20.0	28.0	23.60
49.0	20.0	29.0	24.30
50.0	20.0	30.0	25.00
51.0	21.0	30.0	25.70
52.0	23.0	29.0	26.40
53.0	23.0	30.0	27.10
54.0	24.0	30.0	27.80
55.0	25.0	30.0	28.50
56.0	26.0	30.0	29.20
57.0	28.0	29.0	29.90
58.0	28.0	30.0	30.60
59.0	29.0	30.0	31.30
60.0	30.0	30.0	32.00
61.0	30.0	31.0	32.68
62.0	30.0	32.0	33.36
63.0	30.5	32.5	34.04
64.0	31.5	32.5	34.72
65.0	32.5	32.5	35.40
66.0	32.5	33.5	36.00
67.0	32.5	34.5	36.60
68.0	33.5	34.5	37.20
69.0	34.0	35.0	37.80
70.0	35.0	35.0	38.40
71.0	35.0	36.0	38.88
72.0	35.0	37.0	39.36
73.0	35.0	38.0	39.86
74.0	35.0	39.0	40.38
75.0	35.0	40.0	40.90
76.0	36.0	40.0	41.38
77.0	37.0	40.0	41.86
78.0	38.0	40.0	42.36
79.0	39.0	40.0	42.88
80.0	40.0	40.0	43.40
81.0	40.0	41.0	43.80
82.0	40.5	41.5	44.20
83.0	40.5	42.5	44.60
84.0	41.5	42.5	45.00
85.0	42.5	42.5	45.40
86.0	42.5	43.5	45.72
87.0	42.5	44.5	46.04
88.0	43.0	45.0	46.36
89.0	44.0	45.0	46.68
90.0	45.0	45.0	47.00

Elevation = 141.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	21.90
41.0	41.0	.0	22.31
42.0	42.0	.0	22.71
43.0	43.0	.0	23.08
44.0	44.0	.0	23.41
45.0	45.0	.0	23.73
46.0	45.0	.0	23.73
47.0	45.0	.0	23.73
48.0	20.0	28.0	23.76
49.0	20.0	29.0	24.47
50.0	20.0	30.0	25.18
51.0	21.0	30.0	25.89
52.0	22.0	30.0	26.60
53.0	23.0	30.0	27.30
54.0	24.0	30.0	28.01
55.0	25.0	30.0	28.72
56.0	26.0	30.0	29.43
57.0	27.5	29.5	30.14
58.0	28.0	30.0	30.85
59.0	29.0	30.0	31.56
60.0	30.0	30.0	32.27
61.0	30.0	31.0	32.95
62.0	30.0	32.0	33.63
63.0	30.5	32.5	34.31
64.0	31.5	32.5	34.99
65.0	32.5	32.5	35.67
66.0	33.0	33.0	36.28
67.0	32.5	34.5	36.89
68.0	33.0	35.0	37.51
69.0	34.0	35.0	38.12
70.0	35.0	35.0	38.73
71.0	35.0	36.0	39.23
72.0	35.0	37.0	39.72
73.0	35.0	38.0	40.23
74.0	35.0	39.0	40.75
75.0	35.0	40.0	41.27
76.0	36.0	40.0	41.76
77.0	37.0	40.0	42.25
78.0	38.0	40.0	42.76
79.0	39.0	40.0	43.28
80.0	40.0	40.0	43.80
81.0	40.0	41.0	44.21
82.0	40.0	42.0	44.61
83.0	40.5	42.5	45.02
84.0	41.5	42.5	45.43
85.0	42.5	42.5	45.83
86.0	42.5	43.5	46.16
87.0	43.0	44.0	46.49
88.0	43.0	45.0	46.81
89.0	44.0	45.0	47.14
90.0	45.0	45.0	47.47

Elevation = 142.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.10
41.0	41.0	.0	22.51
42.0	42.0	.0	22.93
43.0	43.0	.0	23.30
44.0	44.0	.0	23.63
45.0	45.0	.0	23.97
46.0	45.0	.0	23.97
47.0	45.0	.0	23.97
48.0	45.0	.0	23.97
49.0	20.0	29.0	24.65
50.0	20.0	30.0	25.37
51.0	21.0	30.0	26.08
52.0	22.0	30.0	26.79
53.0	23.0	30.0	27.51
54.0	24.0	30.0	28.22
55.0	25.0	30.0	28.93
56.0	26.0	30.0	29.65
57.0	27.0	30.0	30.37
58.0	28.0	30.0	31.09
59.0	29.5	29.5	31.81
60.0	30.0	30.0	32.53
61.0	30.0	31.0	33.21
62.0	30.0	32.0	33.89
63.0	30.5	32.5	34.57
64.0	31.5	32.5	35.25
65.0	32.5	32.5	35.93
66.0	32.5	33.5	36.56
67.0	32.5	34.5	37.19
68.0	33.0	35.0	37.81
69.0	34.0	35.0	38.44
70.0	35.0	35.0	39.07
71.0	35.0	36.0	39.57
72.0	35.0	37.0	40.08
73.0	35.0	38.0	40.59
74.0	35.0	39.0	41.11
75.0	35.0	40.0	41.63
76.0	36.0	40.0	42.14
77.0	37.0	40.0	42.65
78.0	38.0	40.0	43.16
79.0	39.0	40.0	43.68
80.0	40.0	40.0	44.20
81.0	40.0	41.0	44.61
82.0	41.0	41.0	45.03
83.0	40.5	42.5	45.44
84.0	41.5	42.5	45.85
85.0	42.5	42.5	46.27
86.0	42.5	43.5	46.60
87.0	42.5	44.5	46.93
88.0	43.5	44.5	47.27
89.0	44.5	44.5	47.60
90.0	45.0	45.0	47.93

Elevation = 142.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.30
41.0	41.0	.0	22.72
42.0	42.0	.0	23.14
43.0	43.0	.0	23.52
44.0	44.0	.0	23.86
45.0	45.0	.0	24.20
46.0	45.0	.0	24.20
47.0	45.0	.0	24.20
48.0	45.0	.0	24.20
49.0	20.0	29.0	24.82
50.0	20.0	30.0	25.55
51.0	21.0	30.0	26.27
52.0	22.0	30.0	26.99
53.0	23.0	30.0	27.71
54.0	24.0	30.0	28.43
55.0	25.0	30.0	29.15
56.0	26.5	29.5	29.98
57.0	27.0	30.0	30.61
58.0	28.0	30.0	31.34
59.0	29.0	30.0	32.07
60.0	30.0	30.0	32.80
61.0	30.0	31.0	33.48
62.0	30.0	32.0	34.16
63.0	30.5	32.5	34.84
64.0	31.5	32.5	35.52
65.0	32.5	32.5	36.20
66.0	32.5	33.5	36.84
67.0	32.5	34.5	37.48
68.0	33.0	35.0	38.12
69.0	34.0	35.0	38.76
70.0	35.0	35.0	39.40
71.0	35.0	36.0	39.92
72.0	35.0	37.0	40.44
73.0	35.0	38.0	40.96
74.0	35.5	38.5	41.48
75.0	35.0	40.0	42.00
76.0	36.0	40.0	42.52
77.0	37.0	40.0	43.04
78.0	38.0	40.0	43.56
79.0	39.0	40.0	44.08
80.0	40.0	40.0	44.60
81.0	40.5	40.5	45.02
82.0	40.5	41.5	45.44
83.0	40.5	42.5	45.86
84.0	41.5	42.5	46.28
85.0	42.5	42.5	46.70
86.0	42.5	43.5	47.04
87.0	42.5	44.5	47.38
88.0	43.0	45.0	47.72
89.0	44.0	45.0	48.06
90.0	45.0	45.0	48.40

Elevation = 143.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.50
41.0	41.0	.0	22.93
42.0	42.0	.0	23.35
43.0	43.0	.0	23.74
44.0	44.0	.0	24.09
45.0	45.0	.0	24.43
46.0	45.0	.0	24.43
47.0	45.0	.0	24.43
48.0	45.0	.0	24.43
49.0	20.0	29.0	24.99
50.0	20.0	30.0	25.73
51.0	21.0	30.0	26.46
52.0	22.0	30.0	27.19
53.0	23.0	30.0	27.91
54.0	24.0	30.0	28.64
55.0	25.0	30.0	29.37
56.0	26.0	30.0	30.11
57.0	28.0	29.0	30.85
58.0	28.0	30.0	31.59
59.0	29.0	30.0	32.33
60.0	30.0	30.0	33.07
61.0	30.0	31.0	33.75
62.0	30.0	32.0	34.43
63.0	30.5	32.5	35.11
64.0	31.5	32.5	35.79
65.0	32.5	32.5	36.47
66.0	32.5	33.5	37.12
67.0	32.5	34.5	37.77
68.0	33.0	35.0	38.43
69.0	34.0	35.0	39.08
70.0	35.0	35.0	39.73
71.0	35.0	36.0	40.27
72.0	35.0	37.0	40.80
73.0	35.5	37.5	41.33
74.0	36.5	37.5	41.87
75.0	37.5	37.5	42.40
76.0	37.5	38.5	42.92
77.0	37.5	39.5	43.44
78.0	38.0	40.0	43.96
79.0	39.0	40.0	44.48
80.0	40.0	40.0	45.00
81.0	40.0	41.0	45.43
82.0	40.0	42.0	45.85
83.0	41.5	41.5	46.28
84.0	41.5	42.5	46.71
85.0	42.5	42.5	47.13
86.0	42.5	43.5	47.48
87.0	42.5	44.5	47.83
	43.0	45.0	48.17
	44.5	44.5	48.52
	45.0	46.0	48.87

Elevation = 143.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.70
41.0	41.0	.0	23.13
42.0	42.0	.0	23.57
43.0	43.0	.0	23.96
44.0	44.0	.0	24.31
45.0	45.0	.0	24.67
46.0	45.0	.0	24.67
47.0	45.0	.0	24.67
48.0	45.0	.0	24.67
49.0	20.0	29.0	25.17
50.0	20.0	30.0	25.92
51.0	21.0	30.0	26.65
52.0	22.0	30.0	27.38
53.0	23.0	30.0	28.12
54.0	24.0	30.0	28.85
55.0	25.0	30.0	29.58
56.0	26.0	30.0	[illegible]
57.0	27.0	30.0	31.08
58.0	28.0	30.0	31.83
59.0	29.0	30.0	32.58
60.0	30.0	30.0	33.33
61.0	30.0	31.0	34.01
62.0	30.0	32.0	34.69
63.0	30.5	32.5	35.37
64.0	31.5	32.5	36.05
65.0	32.5	32.5	36.73
66.0	32.5	33.5	37.40
67.0	33.5	33.5	38.07
68.0	33.0	35.0	38.73
69.0	34.0	35.0	39.40
70.0	35.0	35.0	40.07
71.0	35.0	36.0	40.61
72.0	35.0	37.0	41.16
73.0	36.5	36.5	41.71
74.0	36.5	37.5	42.25
75.0	37.5	37.5	42.80
76.0	37.5	38.5	43.32
77.0	37.5	39.5	43.84
78.0	38.0	40.0	44.36
79.0	39.0	40.0	44.88
80.0	40.0	40.0	45.40
81.0	40.0	41.0	45.83
82.0	40.5	41.5	46.27
83.0	40.5	42.5	46.70
84.0	41.5	42.5	47.13
85.0	42.5	42.5	47.57
86.0	42.5	43.5	47.92
87.0	42.5	44.5	48.27
88.0	44.0	44.0	48.63
89.0	44.0	45.0	48.98
90.0	45.0	45.0	49.33

Elevation = 144.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.90
41.0	41.0	.0	23.34
42.0	42.0	.0	23.78
43.0	43.0	.0	24.18
44.0	44.0	.0	24.54
45.0	45.0	.0	24.90
46.0	45.0	.0	24.90
47.0	45.0	.0	24.90
48.0	45.0	.0	24.90
49.0	20.0	29.0	25.34
50.0	20.0	30.0	26.10
51.0	21.0	30.0	26.84
52.0	22.0	30.0	27.58
53.0	23.0	30.0	28.32
54.0	24.0	30.0	29.06
55.0	25.0	30.0	29.80
56.0	26.0	30.0	30.56
57.0	27.0	30.0	31.32
58.0	28.5	29.5	32.08
59.0	29.5	29.5	32.84
60.0	30.0	30.0	33.60
61.0	30.0	31.0	34.28
62.0	30.0	32.0	34.96
63.0	30.0	33.0	35.64
64.0	30.0	34.0	36.32
65.0	30.0	35.0	37.00
66.0	31.0	35.0	37.68
67.0	32.0	35.0	38.36
68.0	33.0	35.0	39.04
69.0	34.0	35.0	39.72
70.0	35.0	35.0	40.40
71.0	35.5	35.5	40.96
72.0	35.5	36.5	41.52
73.0	35.5	37.5	42.08
74.0	36.5	37.5	42.64
75.0	37.5	37.5	43.20
76.0	37.5	38.5	43.72
77.0	38.5	38.5	44.24
78.0	38.0	40.0	44.76
79.0	39.0	40.0	45.28
80.0	40.0	40.0	45.80
81.0	40.0	41.0	46.24
82.0	40.0	42.0	46.68
83.0	41.0	42.0	47.12
84.0	42.0	42.0	47.56
85.0	42.5	42.5	48.00
86.0	42.5	43.5	48.36
87.0	42.5	44.5	48.72
88.0	43.0	45.0	49.08
89.0	44.0	45.0	49.44
90.0	45.0	45.0	49.80

Elevation = 144.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.05
41.0	41.0	.0	23.50
42.0	42.0	.0	23.96
43.0	43.0	.0	24.37
44.0	44.0	.0	24.73
45.0	45.0	.0	25.10
46.0	45.0	.0	25.10
47.0	45.0	.0	25.10
48.0	45.0	.0	25.10
49.0	20.0	29.0	25.54
50.0	20.0	30.0	26.30
51.0	21.0	30.0	27.04
52.0	22.0	30.0	27.78
53.0	23.0	30.0	28.52
54.0	24.0	30.0	29.26
55.0	25.0	30.0	30.00
56.0	26.0	30.0	30.76
57.0	27.0	30.0	31.52
58.0	28.0	30.0	32.28
59.0	29.0	30.0	33.04
60.0	30.0	30.0	33.80
61.0	30.5	30.5	34.49
62.0	30.0	32.0	35.17
63.0	30.5	32.5	35.86
64.0	31.5	32.5	36.55
65.0	32.5	32.5	37.23
66.0	32.5	33.5	37.91
67.0	32.5	34.5	38.59
68.0	33.0	35.0	39.27
69.0	34.0	35.0	39.95
70.0	35.0	35.0	40.63
71.0	35.0	36.0	41.20
72.0	35.0	37.0	41.77
73.0	35.5	37.5	42.33
74.0	36.5	37.5	42.90
75.0	37.5	37.5	43.47
76.0	37.5	38.5	43.99
77.0	37.5	39.5	44.52
78.0	38.5	39.5	45.05
79.0	39.0	40.0	45.57
80.0	40.0	40.0	46.10
81.0	40.0	41.0	46.55
82.0	40.0	42.0	47.01
83.0	40.5	42.5	47.46
84.0	41.5	42.5	47.91
85.0	42.5	42.5	48.37
86.0	42.5	43.5	48.73
87.0	42.5	44.5	49.10
88.0	43.0	45.0	49.47
89.0	44.0	45.0	49.83
90.0	45.0	45.0	50.20

Elevation = 145.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.20
41.0	41.0	.0	23.67
42.0	42.0	.0	24.13
43.0	43.0	.0	24.55
44.0	44.0	.0	24.93
45.0	45.0	.0	25.30
46.0	45.0	.0	25.30
47.0	45.0	.0	25.30
48.0	45.0	.0	25.30
49.0	20.0	29.0	25.74
50.0	20.0	30.0	26.50
51.0	21.0	30.0	27.24
52.0	22.0	30.0	27.98
53.0	23.0	30.0	28.72
54.0	24.0	30.0	29.46
55.0	25.0	30.0	30.20
56.0	26.5	29.5	30.96
57.0	27.0	30.0	31.72
58.0	28.0	30.0	32.48
59.0	29.5	29.5	33.24
60.0	30.0	30.0	34.00
61.0	30.0	31.0	34.69
62.0	30.0	32.0	35.39
63.0	30.5	32.5	36.08
64.0	31.5	32.5	36.77
65.0	32.5	32.5	37.47
66.0	32.5	33.5	38.15
67.0	32.5	34.5	38.83
68.0	33.0	35.0	39.51
69.0	34.0	35.0	40.19
70.0	35.0	35.0	40.87
71.0	35.0	36.0	41.44
72.0	35.0	37.0	42.01
73.0	35.5	37.5	42.59
74.0	36.5	37.5	43.16
75.0	37.5	37.5	43.73
76.0	37.5	38.5	44.27
77.0	37.5	39.5	44.80
78.0	38.0	40.0	45.33
79.0	39.0	40.0	45.87
80.0	40.0	40.0	46.40
81.0	40.0	41.0	46.87
82.0	40.0	42.0	47.33
83.0	40.5	42.5	47.80
84.0	41.5	42.5	48.27
85.0	42.5	42.5	48.73
86.0	42.5	43.5	49.11
87.0	42.5	44.5	49.48
88.0	43.0	45.0	49.85
89.0	44.0	45.0	50.23
90.0	45.0	45.0	50.60

Elevation = 145.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.35
41.0	41.0	.0	23.83
42.0	42.0	.0	24.31
43.0	43.0	.0	24.74
44.0	44.0	.0	25.12
45.0	45.0	.0	25.50
46.0	45.0	.0	25.50
47.0	45.0	.0	25.50
48.0	45.0	.0	25.50
49.0	20.0	29.0	25.94
50.0	20.0	30.0	26.70
51.0	21.0	30.0	27.44
52.0	22.0	30.0	28.18
53.0	23.0	30.0	28.92
54.0	24.0	30.0	29.66
55.0	25.5	29.5	30.40
56.0	26.5	29.5	31.16
57.0	27.0	30.0	31.92
58.0	28.5	29.5	32.68
59.0	29.5	29.5	33.44
60.0	30.0	30.0	34.20
61.0	30.0	31.0	34.90
62.0	30.0	32.0	35.60
63.0	30.5	32.5	36.30
64.0	31.5	32.5	37.00
65.0	32.5	32.5	37.70
66.0	32.5	33.5	38.38
67.0	33.5	33.5	39.06
68.0	33.0	35.0	39.74
69.0	34.0	35.0	40.42
70.0	35.0	35.0	41.10
71.0	35.0	36.0	41.68
72.0	35.5	36.5	42.26
73.0	35.5	37.5	42.84
74.0	36.5	37.5	43.42
75.0	37.5	37.5	44.00
76.0	37.5	38.5	44.54
77.0	38.0	39.0	45.08
78.0	38.0	40.0	45.62
79.0	39.0	40.0	46.16
80.0	40.0	40.0	46.70
81.0	40.0	41.0	47.18
82.0	40.0	42.0	47.66
83.0	40.5	42.5	48.14
84.0	41.5	42.5	48.62
85.0	42.5	42.5	49.10
86.0	42.5	43.5	49.48
87.0	42.5	44.5	49.86
88.0	43.0	45.0	50.24
89.0	44.0	45.0	50.62
90.0	45.0	45.0	51.00

Elevation = 146.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.50
41.0	41.0	.0	23.99
42.0	42.0	.0	24.49
43.0	43.0	.0	24.93
44.0	44.0	.0	25.31
45.0	45.0	.0	25.70
46.0	45.0	.0	25.70
47.0	45.0	.0	25.70
48.0	45.0	.0	25.70
49.0	20.0	29.0	26.14
50.0	20.0	30.0	26.90
51.0	21.0	30.0	27.64
52.0	22.0	30.0	28.38
53.0	23.0	30.0	29.12
54.0	24.0	30.0	29.86
55.0	25.5	29.5	30.60
56.0	26.5	29.5	31.36
57.0	27.0	30.0	32.12
58.0	28.0	30.0	32.88
59.0	29.0	30.0	33.64
60.0	30.0	30.0	34.40
61.0	30.0	31.0	35.11
62.0	30.0	32.0	35.81
63.0	30.5	32.5	36.52
64.0	31.5	32.5	37.23
65.0	32.5	32.5	37.93
66.0	32.5	33.5	38.61
67.0	32.5	34.5	39.29
68.0	33.0	35.0	39.97
69.0	34.0	35.0	40.65
70.0	35.0	35.0	41.33
71.0	35.0	36.0	41.92
72.0	35.0	37.0	42.51
73.0	36.5	36.5	43.09
74.0	36.5	37.5	43.68
75.0	37.5	37.5	44.27
76.0	37.5	38.5	44.81
77.0	37.5	39.5	45.36
78.0	38.5	39.5	45.91
79.0	39.5	39.5	46.45
80.0	40.0	40.0	47.00
81.0	40.0	41.0	47.49
82.0	40.0	42.0	47.99
83.0	41.0	42.0	48.48
84.0	41.5	42.5	48.97
85.0	42.5	42.5	49.47
86.0	42.5	43.5	49.85
87.0	42.5	44.5	50.24
88.0	43.5	44.5	50.63
89.0	44.0	45.0	51.01
90.0	45.0	45.0	51.40

Elevation = 146.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.65
41.0	41.0	.0	24.16
42.0	42.0	.0	24.66
43.0	43.0	.0	25.11
44.0	44.0	.0	25.51
45.0	45.0	.0	25.90
46.0	45.0	.0	25.90
47.0	45.0	.0	25.90
48.0	45.0	.0	25.90
49.0	20.0	29.0	26.34
50.0	20.0	30.0	27.10
51.0	21.0	30.0	27.84
52.0	22.0	30.0	28.58
53.0	23.0	30.0	29.32
54.0	24.0	30.0	30.06
55.0	25.0	30.0	30.80
56.0	26.0	30.0	31.56
57.0	27.0	30.0	32.32
58.0	28.5	29.5	33.08
59.0	29.5	29.5	33.84
60.0	30.0	30.0	34.60
61.0	30.0	31.0	35.31
62.0	30.0	32.0	36.03
63.0	31.5	31.5	36.74
64.0	31.5	32.5	37.45
65.0	32.5	32.5	38.17
66.0	32.5	33.5	38.85
67.0	33.5	33.5	39.53
68.0	33.0	35.0	40.21
69.0	34.0	35.0	40.89
70.0	35.0	35.0	41.57
71.0	35.0	36.0	42.16
72.0	35.0	37.0	42.75
73.0	35.5	37.5	43.35
74.0	36.5	37.5	43.94
75.0	37.5	37.5	44.53
76.0	37.5	38.5	45.09
77.0	37.5	39.5	45.64
78.0	38.0	40.0	46.19
79.0	39.0	40.0	46.75
80.0	40.0	40.0	47.30
81.0	40.0	41.0	47.81
82.0	41.0	41.0	48.31
83.0	40.5	42.5	48.82
84.0	41.5	42.5	49.33
85.0	42.5	42.5	49.83
86.0	42.5	43.5	50.23
87.0	42.5	44.5	50.62
88.0	43.0	45.0	51.01
89.0	44.0	45.0	51.41
90.0	45.0	45.0	51.80

Elevation = 142.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.10
41.0	41.0	.0	22.51
42.0	42.0	.0	22.93
43.0	43.0	.0	23.30
44.0	44.0	.0	23.63
45.0	45.0	.0	23.97
46.0	45.0	.0	23.97
47.0	45.0	.0	23.97
48.0	45.0	.0	23.97
49.0	20.0	29.0	24.65
50.0	20.0	30.0	25.37
51.0	21.0	30.0	26.08
52.0	22.0	30.0	26.79
53.0	23.0	30.0	27.51
54.0	24.0	30.0	28.22
55.0	25.0	30.0	28.93
56.0	26.0	30.0	29.65
57.0	27.0	30.0	30.37
58.0	28.0	30.0	31.09
59.0	29.5	29.5	31.81
60.0	30.0	30.0	32.53
61.0	30.0	31.0	33.21
62.0	30.0	32.0	33.89
63.0	30.5	32.5	34.57
64.0	31.5	32.5	35.25
65.0	32.5	32.5	35.93
66.0	32.5	33.5	36.56
67.0	32.5	34.5	37.19
68.0	33.0	35.0	37.81
69.0	34.0	35.0	38.44
70.0	35.0	35.0	39.07
71.0	35.0	36.0	39.57
72.0	35.0	37.0	40.08
73.0	35.0	38.0	40.59
74.0	35.0	39.0	41.11
75.0	35.0	40.0	41.63
76.0	36.0	40.0	42.14
77.0	37.0	40.0	42.65
78.0	38.0	40.0	43.16
79.0	39.0	40.0	43.68
80.0	40.0	40.0	44.20
81.0	40.0	41.0	44.61
82.0	41.0	41.0	45.03
83.0	40.5	42.5	45.44
84.0	41.5	42.5	45.85
85.0	42.5	42.5	46.27
86.0	42.5	43.5	46.60
87.0	42.5	44.5	46.93
88.0	43.5	44.5	47.27
89.0	44.5	44.5	47.60
90.0	45.0	45.0	47.93

Elevation = 142.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.30
41.0	41.0	.0	22.72
42.0	42.0	.0	23.14
43.0	43.0	.0	23.52
44.0	44.0	.0	23.86
45.0	45.0	.0	24.20
46.0	45.0	.0	24.20
47.0	45.0	.0	24.20
48.0	45.0	.0	24.20
49.0	20.0	29.0	24.82
50.0	20.0	30.0	25.55
51.0	21.0	30.0	26.27
52.0	22.0	30.0	26.99
53.0	23.0	30.0	27.71
54.0	24.0	30.0	28.43
55.0	25.0	30.0	29.15
56.0	26.5	29.5	29.88
57.0	27.0	30.0	30.61
58.0	28.0	30.0	31.34
59.0	29.0	30.0	32.07
60.0	30.0	30.0	32.80
61.0	30.0	31.0	33.48
62.0	30.0	32.0	34.16
63.0	30.5	32.5	34.84
64.0	31.5	32.5	35.52
65.0	32.5	32.5	36.20
66.0	32.5	33.5	36.84
67.0	32.5	34.5	37.48
68.0	33.0	35.0	38.12
69.0	34.0	35.0	38.76
70.0	35.0	35.0	39.40
71.0	35.0	36.0	39.92
72.0	35.0	37.0	40.44
73.0	35.0	38.0	40.96
74.0	35.5	38.5	41.48
75.0	35.0	40.0	42.00
76.0	36.0	40.0	42.52
77.0	37.0	40.0	43.04
78.0	38.0	40.0	43.56
79.0	39.0	40.0	44.08
80.0	40.0	40.0	44.60
81.0	40.5	40.5	45.02
82.0	40.5	41.5	45.44
83.0	40.5	42.5	45.86
84.0	41.5	42.5	46.28
85.0	42.5	42.5	46.70
86.0	42.5	43.5	47.04
87.0	42.5	44.5	47.38
88.0	43.0	45.0	47.72
89.0	44.0	45.0	48.06
90.0	45.0	45.0	48.40

Elevation = 143.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.50
41.0	41.0	.0	22.93
42.0	42.0	.0	23.35
43.0	43.0	.0	23.74
44.0	44.0	.0	24.09
45.0	45.0	.0	24.43
46.0	45.0	.0	24.43
47.0	45.0	.0	24.43
48.0	45.0	.0	24.43
49.0	20.0	29.0	24.99
50.0	20.0	30.0	25.73
51.0	21.0	30.0	26.46
52.0	22.0	30.0	27.19
53.0	23.0	30.0	27.91
54.0	24.0	30.0	28.64
55.0	25.0	30.0	29.37
56.0	26.0	30.0	30.11
57.0	28.0	29.0	30.85
58.0	28.0	30.0	31.59
59.0	29.0	30.0	32.33
60.0	30.0	30.0	33.07
61.0	30.0	31.0	33.75
62.0	30.0	32.0	34.43
63.0	30.5	32.5	35.11
64.0	31.5	32.5	35.79
65.0	32.5	32.5	36.47
66.0	32.5	33.5	37.12
67.0	32.5	34.5	37.77
68.0	33.0	35.0	38.43
69.0	34.0	35.0	39.08
70.0	35.0	35.0	39.73
71.0	35.0	36.0	40.27
72.0	35.0	37.0	40.80
73.0	35.5	37.5	41.33
74.0	36.5	37.5	41.87
75.0	37.5	37.5	42.40
76.0	37.5	38.5	42.92
77.0	37.5	39.5	43.44
78.0	38.0	40.0	43.96
79.0	39.0	40.0	44.48
80.0	40.0	40.0	45.00
81.0	40.0	41.0	45.43
82.0	40.0	42.0	45.85
83.0	41.5	41.5	46.28
84.0	41.5	42.5	46.71
85.0	42.5	42.5	47.13
86.0	42.5	43.5	47.48
87.0	42.5	44.5	47.83
88.0	43.0	45.0	48.17
89.0	44.5	44.5	48.52
90.0	45.0	45.0	48.87

Elevation = 143.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.70
41.0	41.0	.0	23.13
42.0	42.0	.0	23.57
43.0	43.0	.0	23.96
44.0	44.0	.0	24.31
45.0	45.0	.0	24.67
46.0	45.0	.0	24.67
47.0	45.0	.0	24.67
48.0	45.0	.0	24.67
49.0	20.0	29.0	25.17
50.0	20.0	30.0	25.92
51.0	21.0	30.0	26.65
52.0	22.0	30.0	27.38
53.0	23.0	30.0	28.12
54.0	24.0	30.0	28.85
55.0	25.0	30.0	29.58
56.0	26.0	30.0	30.33
57.0	27.0	30.0	31.08
58.0	28.0	30.0	31.83
59.0	29.0	30.0	32.58
60.0	30.0	30.0	33.33
61.0	30.0	31.0	34.01
62.0	30.0	32.0	34.69
63.0	30.5	32.5	35.37
64.0	31.5	32.5	36.05
65.0	32.5	32.5	36.73
66.0	32.5	33.5	37.40
67.0	33.5	33.5	38.07
68.0	33.0	35.0	38.73
69.0	34.0	35.0	39.40
70.0	35.0	35.0	40.07
71.0	35.0	36.0	40.61
72.0	35.0	37.0	41.16
73.0	36.5	36.5	41.71
74.0	36.5	37.5	42.25
75.0	37.5	37.5	42.80
76.0	37.5	38.5	43.32
77.0	37.5	39.5	43.84
78.0	38.0	40.0	44.36
79.0	39.0	40.0	44.88
80.0	40.0	40.0	45.40
81.0	40.0	41.0	45.83
82.0	40.5	41.5	46.27
83.0	40.5	42.5	46.70
84.0	41.5	42.5	47.13
85.0	42.5	42.5	47.57
86.0	42.5	43.5	47.92
87.0	42.5	44.5	48.27
88.0	44.0	44.0	48.63
89.0	44.0	45.0	48.98
90.0	45.0	45.0	49.33

Elevation = 144.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	22.90
41.0	41.0	.0	23.34
42.0	42.0	.0	23.78
43.0	43.0	.0	24.18
44.0	44.0	.0	24.54
45.0	45.0	.0	24.90
46.0	45.0	.0	24.90
47.0	45.0	.0	24.90
48.0	45.0	.0	24.90
49.0	20.0	29.0	25.34
50.0	20.0	30.0	26.10
51.0	21.0	30.0	26.84
52.0	22.0	30.0	27.58
53.0	23.0	30.0	28.32
54.0	24.0	30.0	29.06
55.0	25.0	30.0	29.80
56.0	26.0	30.0	30.56
57.0	27.0	30.0	31.32
58.0	28.5	29.5	32.08
59.0	29.5	29.5	32.84
60.0	30.0	30.0	33.60
61.0	30.0	31.0	34.28
62.0	30.0	32.0	34.96
63.0	30.0	33.0	35.64
64.0	30.0	34.0	36.32
65.0	30.0	35.0	37.00
66.0	31.0	35.0	37.68
67.0	32.0	35.0	38.36
68.0	33.0	35.0	39.04
69.0	34.0	35.0	39.72
70.0	35.0	35.0	40.40
71.0	35.5	35.5	40.96
72.0	35.5	36.5	41.52
73.0	35.5	37.5	42.08
74.0	36.5	37.5	42.64
75.0	37.5	37.5	43.20
76.0	37.5	38.5	43.72
77.0	38.5	38.5	44.24
78.0	38.0	40.0	44.76
79.0	39.0	40.0	45.28
80.0	40.0	40.0	45.80
81.0	40.0	41.0	46.24
82.0	40.0	42.0	46.68
83.0	41.0	42.0	47.12
84.0	42.0	42.0	47.56
85.0	42.5	42.5	48.00
86.0	42.5	43.5	48.36
87.0	42.5	44.5	48.72
88.0	43.0	45.0	49.08
89.0	44.0	45.0	49.44
90.0	45.0	45.0	49.80

Elevation = 144.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.05
41.0	41.0	.0	23.50
42.0	42.0	.0	23.96
43.0	43.0	.0	24.37
44.0	44.0	.0	24.73
45.0	45.0	.0	25.10
46.0	45.0	.0	25.10
47.0	45.0	.0	25.10
48.0	45.0	.0	25.10
49.0	20.0	29.0	25.54
50.0	20.0	30.0	26.30
51.0	21.0	30.0	27.04
52.0	22.0	30.0	27.78
53.0	23.0	30.0	28.52
54.0	24.0	30.0	29.26
55.0	25.0	30.0	30.00
56.0	26.0	30.0	30.76
57.0	27.0	30.0	31.52
58.0	28.0	30.0	32.28
59.0	29.0	30.0	33.04
60.0	30.0	30.0	33.80
61.0	30.5	30.5	34.49
62.0	30.0	32.0	35.17
63.0	30.5	32.5	35.86
64.0	31.5	32.5	36.55
65.0	32.5	32.5	37.23
66.0	32.5	33.5	37.91
67.0	32.5	34.5	38.59
68.0	33.0	35.0	39.27
69.0	34.0	35.0	39.95
70.0	35.0	35.0	40.63
71.0	35.0	36.0	41.20
72.0	35.0	37.0	41.77
73.0	35.5	37.5	42.33
74.0	36.5	37.5	42.90
75.0	37.5	37.5	43.47
76.0	37.5	38.5	43.99
77.0	37.5	39.5	44.52
78.0	38.5	39.5	45.05
79.0	39.0	40.0	45.57
80.0	40.0	40.0	46.10
81.0	40.0	41.0	46.55
82.0	40.0	42.0	47.01
83.0	40.5	42.5	47.46
84.0	41.5	42.5	47.91
85.0	42.5	42.5	48.37
86.0	42.5	43.5	48.73
87.0	42.5	44.5	49.10
88.0	43.0	45.0	49.47
89.0	44.0	45.0	49.83
90.0	45.0	45.0	50.20

Elevation = 145.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.20
41.0	41.0	.0	23.67
42.0	42.0	.0	24.13
43.0	43.0	.0	24.55
44.0	44.0	.0	24.93
45.0	45.0	.0	25.30
46.0	45.0	.0	25.30
47.0	45.0	.0	25.30
48.0	45.0	.0	25.30
49.0	20.0	29.0	25.74
50.0	20.0	30.0	26.50
51.0	21.0	30.0	27.24
52.0	22.0	30.0	27.98
53.0	23.0	30.0	28.72
54.0	24.0	30.0	29.46
55.0	25.0	30.0	30.20
56.0	26.5	29.5	30.96
57.0	27.0	30.0	31.72
58.0	28.0	30.0	32.48
59.0	29.5	29.5	33.24
60.0	30.0	30.0	34.00
61.0	30.0	31.0	34.69
62.0	30.0	32.0	35.39
63.0	30.5	32.5	36.08
64.0	31.5	32.5	36.77
65.0	32.5	32.5	37.47
66.0	32.5	33.5	38.15
67.0	32.5	34.5	38.83
68.0	33.0	35.0	39.51
69.0	34.0	35.0	40.19
70.0	35.0	35.0	40.87
71.0	35.0	36.0	41.44
72.0	35.0	37.0	42.01
73.0	35.5	37.5	42.59
74.0	36.5	37.5	43.16
75.0	37.5	37.5	43.73
76.0	37.5	38.5	44.27
77.0	37.5	39.5	44.80
78.0	38.0	40.0	45.33
79.0	39.0	40.0	45.87
80.0	40.0	40.0	46.40
81.0	40.0	41.0	46.87
82.0	40.0	42.0	47.33
83.0	40.5	42.5	47.80
84.0	41.5	42.5	48.27
85.0	42.5	42.5	48.73
86.0	42.5	43.5	49.11
87.0	42.5	44.5	49.48
88.0	43.0	45.0	49.85
89.0	44.0	45.0	50.23
90.0	45.0	45.0	50.60

Elevation = 145.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.35
41.0	41.0	.0	23.83
42.0	42.0	.0	24.31
43.0	43.0	.0	24.74
44.0	44.0	.0	25.12
45.0	45.0	.0	25.50
46.0	45.0	.0	25.50
47.0	45.0	.0	25.50
48.0	45.0	.0	25.50
49.0	20.0	29.0	25.94
50.0	20.0	30.0	26.70
51.0	21.0	30.0	27.44
52.0	22.0	30.0	28.18
53.0	23.0	30.0	28.92
54.0	24.0	30.0	29.66
55.0	25.5	29.5	30.40
56.0	26.5	29.5	31.16
57.0	27.0	30.0	31.92
58.0	28.5	29.5	32.66
59.0	29.5	29.5	33.44
60.0	30.0	30.0	34.20
61.0	30.0	31.0	34.90
62.0	30.0	32.0	35.60
63.0	30.5	32.5	36.30
64.0	31.5	32.5	37.00
65.0	32.5	32.5	37.70
66.0	32.5	33.5	38.38
67.0	33.5	33.5	39.06
68.0	33.0	35.0	39.74
69.0	34.0	35.0	40.42
70.0	35.0	35.0	41.10
71.0	35.0	36.0	41.68
72.0	35.5	36.5	42.26
73.0	35.5	37.5	42.84
74.0	36.5	37.5	43.42
75.0	37.5	37.5	44.00
76.0	37.5	38.5	44.54
77.0	38.0	39.0	45.08
78.0	38.0	40.0	45.62
79.0	39.0	40.0	46.16
80.0	40.0	40.0	46.70
81.0	40.0	41.0	47.18
82.0	40.0	42.0	47.66
83.0	40.5	42.5	48.14
84.0	41.5	42.5	48.62
85.0	42.5	42.5	49.10
86.0	42.5	43.5	49.48
87.0	42.5	44.5	49.86
88.0	43.0	45.0	50.24
89.0	44.0	45.0	50.62
90.0	45.0	45.0	51.00

Elevation = 146.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.50
41.0	41.0	.0	23.99
42.0	42.0	.0	24.49
43.0	43.0	.0	24.93
44.0	44.0	.0	25.31
45.0	45.0	.0	25.70
46.0	45.0	.0	25.70
47.0	45.0	.0	25.70
48.0	45.0	.0	25.70
49.0	20.0	29.0	26.14
50.0	20.0	30.0	26.90
51.0	21.0	30.0	27.64
52.0	22.0	30.0	28.38
53.0	23.0	30.0	29.12
54.0	24.0	30.0	29.86
55.0	25.5	29.5	30.60
56.0	26.5	29.5	31.36
57.0	27.0	30.0	32.12
58.0	28.0	30.0	32.88
59.0	29.0	30.0	33.64
60.0	30.0	30.0	34.40
61.0	30.0	31.0	35.11
62.0	30.0	32.0	35.81
63.0	30.5	32.5	36.52
64.0	31.5	32.5	37.23
65.0	32.5	32.5	37.93
66.0	32.5	33.5	38.61
67.0	32.5	34.5	39.29
68.0	33.0	35.0	39.97
69.0	34.0	35.0	40.65
70.0	35.0	35.0	41.33
71.0	35.0	36.0	41.92
72.0	35.0	37.0	42.51
73.0	36.5	36.5	43.09
74.0	36.5	37.5	43.68
75.0	37.5	37.5	44.27
76.0	37.5	38.5	44.81
77.0	37.5	39.5	45.36
78.0	38.5	39.5	45.91
79.0	39.5	39.5	46.45
80.0	40.0	40.0	47.00
81.0	40.0	41.0	47.49
82.0	40.0	42.0	47.99
83.0	41.0	42.0	48.48
84.0	41.5	42.5	48.97
85.0	42.5	42.5	49.47
86.0	42.5	43.5	49.85
87.0	42.5	44.5	50.24
88.0	43.5	44.5	50.63
89.0	44.0	45.0	51.01
90.0	45.0	45.0	51.40

Elevation = 146.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.65
41.0	41.0	.0	24.16
42.0	42.0	.0	24.66
43.0	43.0	.0	25.11
44.0	44.0	.0	25.51
45.0	45.0	.0	25.90
46.0	45.0	.0	25.90
47.0	45.0	.0	25.90
48.0	45.0	.0	25.90
49.0	20.0	29.0	26.34
50.0	20.0	30.0	27.10
51.0	21.0	30.0	27.84
52.0	22.0	30.0	28.58
53.0	23.0	30.0	29.32
54.0	24.0	30.0	30.06
55.0	25.0	30.0	30.80
56.0	26.0	30.0	31.56
57.0	27.0	30.0	32.32
58.0	28.5	29.5	33.08
59.0	29.5	29.5	33.84
60.0	30.0	30.0	34.60
61.0	30.0	31.0	35.31
62.0	30.0	32.0	36.03
63.0	31.5	31.5	36.74
64.0	31.5	32.5	37.45
65.0	32.5	32.5	38.17
66.0	32.5	33.5	38.85
67.0	33.5	33.5	39.53
68.0	33.0	35.0	40.21
69.0	34.0	35.0	40.89
70.0	35.0	35.0	41.57
71.0	35.0	36.0	42.16
72.0	35.0	37.0	42.75
73.0	35.5	37.5	43.35
74.0	36.5	37.5	43.94
75.0	37.5	37.5	44.53
76.0	37.5	38.5	45.09
77.0	37.5	39.5	45.64
78.0	38.0	40.0	46.19
79.0	39.0	40.0	46.75
80.0	40.0	40.0	47.30
81.0	40.0	41.0	47.81
82.0	41.0	41.0	48.31
83.0	40.5	42.5	48.82
84.0	41.5	42.5	49.33
85.0	42.5	42.5	49.83
86.0	42.5	43.5	50.23
87.0	42.5	44.5	50.62
88.0	43.0	45.0	51.01
89.0	44.0	45.0	51.41
90.0	45.0	45.0	51.80

Elevation = 147.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.80
41.0	41.0	.0	24.32
42.0	42.0	.0	24.84
43.0	43.0	.0	25.30
44.0	44.0	.0	25.70
45.0	45.0	.0	26.10
46.0	45.0	.0	26.10
47.0	45.0	.0	26.10
48.0	45.0	.0	26.10
49.0	20.0	29.0	26.54
50.0	20.0	30.0	27.30
51.0	21.0	30.0	28.04
52.0	22.0	30.0	28.78
53.0	23.0	30.0	29.52
54.0	24.0	30.0	30.26
55.0	25.0	30.0	31.00
56.0	26.0	30.0	31.76
57.0	27.0	30.0	32.52
58.0	28.0	30.0	33.28
59.0	29.0	30.0	34.04
60.0	30.0	30.0	34.80
61.0	30.0	31.0	35.52
62.0	31.0	31.0	36.24
63.0	30.5	32.5	36.96
64.0	31.5	32.5	37.68
65.0	32.5	32.5	38.40
66.0	32.5	33.5	39.08
67.0	32.5	34.5	39.76
68.0	33.0	35.0	40.44
69.0	34.0	35.0	41.12
70.0	35.0	35.0	41.80
71.0	35.0	36.0	42.40
72.0	35.0	37.0	43.00
73.0	35.5	37.5	43.60
74.0	37.0	37.0	44.20
75.0	37.5	37.5	44.80
76.0	37.5	38.5	45.36
77.0	37.5	39.5	45.92
78.0	38.0	40.0	46.48
79.0	39.0	40.0	47.04
80.0	40.0	40.0	47.60
81.0	40.0	41.0	48.12
82.0	40.0	42.0	48.64
83.0	40.5	42.5	49.16
84.0	41.5	42.5	49.68
85.0	42.5	42.5	50.20
86.0	43.0	43.0	50.60
87.0	42.5	44.5	51.00
88.0	43.0	45.0	51.40
89.0	44.0	45.0	51.80
90.0	45.0	45.0	52.20

Elevation = 147.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	23.98
41.0	41.0	.0	24.49
42.0	42.0	.0	25.00
43.0	43.0	.0	25.45
44.0	44.0	.0	25.85
45.0	45.0	.0	26.25
46.0	45.0	.0	26.25
47.0	45.0	.0	26.25
48.0	45.0	.0	26.25
49.0	20.0	29.0	26.77
50.0	20.0	30.0	27.53
51.0	21.0	30.0	28.28
52.0	22.0	30.0	29.03
53.0	23.0	30.0	29.77
54.0	24.0	30.0	30.52
55.0	25.0	30.0	31.27
56.0	26.0	30.0	32.03
57.0	27.0	30.0	32.79
58.0	28.5	29.5	33.55
59.0	29.5	29.5	34.31
60.0	30.0	30.0	35.07
61.0	30.0	31.0	35.79
62.0	30.0	32.0	36.51
63.0	30.5	32.5	37.23
64.0	31.5	32.5	37.95
65.0	32.5	32.5	38.67
66.0	32.5	33.5	39.35
67.0	32.5	34.5	40.04
68.0	33.5	34.5	40.73
69.0	34.5	34.5	41.41
70.0	35.0	35.0	42.10
71.0	35.0	36.0	42.71
72.0	35.5	36.5	43.33
73.0	35.5	37.5	43.94
74.0	36.5	37.5	44.55
75.0	37.5	37.5	45.17
76.0	37.5	38.5	45.73
77.0	37.5	39.5	46.29
78.0	38.0	40.0	46.85
79.0	39.0	40.0	47.41
80.0	40.0	40.0	47.97
81.0	40.0	41.0	48.47
82.0	40.5	41.5	48.98
83.0	40.5	42.5	49.49
84.0	41.5	42.5	49.99
85.0	42.5	42.5	50.50
86.0	42.5	43.5	50.90
87.0	43.0	44.0	51.30
88.0	43.0	45.0	51.70
89.0	44.0	45.0	52.10
90.0	45.0	45.0	52.50

Elevation = 148.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	24.17
41.0	41.0	.0	24.66
42.0	42.0	.0	25.15
43.0	43.0	.0	25.60
44.0	44.0	.0	26.00
45.0	45.0	.0	26.40
46.0	45.0	.0	26.40
47.0	45.0	.0	26.40
48.0	45.0	.0	26.40
49.0	20.0	29.0	27.01
50.0	20.0	30.0	27.77
51.0	21.0	30.0	28.52
52.0	22.0	30.0	29.27
53.0	23.0	30.0	30.03
54.0	24.0	30.0	30.78
55.0	25.0	30.0	31.53
56.0	26.0	30.0	32.29
57.0	27.0	30.0	33.05
58.0	28.0	30.0	33.81
59.0	29.0	30.0	34.57
60.0	30.0	30.0	35.33
61.0	30.0	31.0	36.05
62.0	31.0	31.0	36.77
63.0	30.5	32.5	37.49
64.0	31.5	32.5	38.21
65.0	32.5	32.5	38.93
66.0	32.5	33.5	39.63
67.0	32.5	34.5	40.32
68.0	33.0	35.0	41.01
69.0	34.0	35.0	41.71
70.0	35.0	35.0	42.40
71.0	35.0	36.0	43.03
72.0	35.0	37.0	43.65
73.0	35.5	37.5	44.28
74.0	36.5	37.5	44.91
75.0	37.5	37.5	45.53
76.0	38.0	38.0	46.09
77.0	38.0	39.0	46.65
78.0	38.0	40.0	47.21
79.0	39.0	40.0	47.77
80.0	40.0	40.0	48.33
81.0	40.0	41.0	48.83
82.0	40.0	42.0	49.32
83.0	40.5	42.5	49.81
84.0	42.0	42.0	50.31
85.0	42.5	42.5	50.80
86.0	43.0	43.0	51.20
87.0	42.5	44.5	51.60
88.0	43.0	45.0	52.00
89.0	44.0	45.0	52.40
90.0	45.0	45.0	52.80

Elevation = 148.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	24.35
41.0	41.0	.0	24.83
42.0	42.0	.0	25.31
43.0	43.0	.0	25.75
44.0	44.0	.0	26.15
45.0	45.0	.0	26.55
46.0	45.0	.0	26.55
47.0	45.0	.0	26.55
48.0	45.0	.0	26.55
49.0	20.5	28.5	27.24
50.0	20.0	30.0	28.00
51.0	21.5	29.5	28.76
52.0	22.0	30.0	29.52
53.0	23.0	30.0	30.28
54.0	24.5	29.5	31.04
55.0	25.0	30.0	31.80
56.0	26.0	30.0	32.56
57.0	27.0	30.0	33.32
58.0	28.5	29.5	34.08
59.0	29.5	29.5	34.84
60.0	30.0	30.0	35.60
61.0	30.0	31.0	36.32
62.0	30.0	32.0	37.04
63.0	30.5	32.5	37.76
64.0	31.5	32.5	38.48
65.0	32.5	32.5	39.20
66.0	32.5	33.5	39.90
67.0	32.5	34.5	40.60
68.0	33.0	35.0	41.30
69.0	34.0	35.0	42.00
70.0	35.0	35.0	42.70
71.0	35.0	36.0	43.34
72.0	35.0	37.0	43.98
73.0	36.0	37.0	44.62
74.0	36.5	37.5	45.26
75.0	37.5	37.5	45.90
76.0	37.5	38.5	46.46
77.0	37.5	39.5	47.02
78.0	38.5	39.5	47.58
79.0	39.0	40.0	48.14
80.0	40.0	40.0	48.70
81.0	40.0	41.0	49.18
82.0	40.0	42.0	49.66
83.0	40.5	42.5	50.14
84.0	41.5	42.5	50.62
85.0	42.5	42.5	51.10
86.0	42.5	43.5	51.50
87.0	43.0	44.0	51.90
88.0	43.0	45.0	52.30
89.0	44.0	45.0	52.70
90.0	45.0	45.0	53.10

Elevation = 149.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	24.53
41.0	41.0	.0	25.00
42.0	42.0	.0	25.47
43.0	43.0	.0	25.90
44.0	44.0	.0	26.30
45.0	45.0	.0	26.70
46.0	45.0	.0	26.70
47.0	45.0	.0	26.70
48.0	23.0	25.0	26.73
49.0	24.0	25.0	27.50
50.0	25.0	25.0	28.27
51.0	25.0	26.0	29.03
52.0	25.0	27.0	29.79
53.0	25.0	28.0	30.55
54.0	25.0	29.0	31.31
55.0	26.5	28.5	32.07
56.0	26.0	30.0	32.83
57.0	27.0	30.0	33.59
58.0	28.0	30.0	34.35
59.0	29.0	30.0	35.11
60.0	30.0	30.0	35.87
61.0	30.0	31.0	36.59
62.0	30.5	31.5	37.31
63.0	30.5	32.5	38.03
64.0	31.5	32.5	38.75
65.0	32.5	32.5	39.47
66.0	32.5	33.5	40.17
67.0	32.5	34.5	40.88
68.0	33.5	34.5	41.59
69.0	34.0	35.0	42.29
70.0	35.0	35.0	43.00
71.0	35.0	36.0	43.65
72.0	35.0	37.0	44.31
73.0	35.5	37.5	44.96
74.0	36.5	37.5	45.61
75.0	37.5	37.5	46.27
76.0	37.5	38.5	46.83
77.0	37.5	39.5	47.39
78.0	38.0	40.0	47.95
79.0	39.0	40.0	48.51
80.0	40.0	40.0	49.07
81.0	40.0	41.0	49.53
82.0	40.0	42.0	50.00
83.0	40.5	42.5	50.47
84.0	41.5	42.5	50.93
85.0	42.5	42.5	51.40
86.0	42.5	43.5	51.80
87.0	43.0	44.0	52.20
88.0	43.0	45.0	52.60
89.0	44.0	45.0	53.00
90.0	45.0	45.0	53.40

Elevation = 149.50 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	24.72
41.0	41.0	.0	25.17
42.0	42.0	.0	25.62
43.0	43.0	.0	26.05
44.0	44.0	.0	26.45
45.0	45.0	.0	26.85
46.0	45.0	.0	26.85
47.0	45.0	.0	26.85
48.0	23.5	24.5	26.99
49.0	24.5	24.5	27.76
50.0	25.0	25.0	28.53
51.0	25.0	26.0	29.29
52.0	25.0	27.0	30.05
53.0	25.5	27.5	30.81
54.0	25.0	29.0	31.57
55.0	25.0	30.0	32.33
56.0	26.0	30.0	33.09
57.0	27.5	29.5	33.85
58.0	28.0	30.0	34.61
59.0	29.0	30.0	35.37
60.0	30.0	30.0	36.13
61.0	30.5	30.5	36.85
62.0	30.0	32.0	37.57
63.0	30.5	32.5	38.29
64.0	31.5	32.5	39.01
65.0	32.5	32.5	39.73
66.0	32.5	33.5	40.45
67.0	32.5	34.5	41.16
68.0	33.0	35.0	41.87
69.0	34.0	35.0	42.59
70.0	35.0	35.0	43.30
71.0	35.0	36.0	43.97
72.0	35.0	37.0	44.63
73.0	35.5	37.5	45.30
74.0	36.5	37.5	45.97
75.0	37.5	37.5	46.63
76.0	37.5	38.5	47.19
77.0	37.5	39.5	47.75
78.0	38.0	40.0	48.31
79.0	39.0	40.0	48.87
80.0	40.0	40.0	49.43
81.0	40.5	40.5	49.89
82.0	40.5	41.5	50.34
83.0	40.5	42.5	50.79
84.0	41.5	42.5	51.25
85.0	42.5	42.5	51.70
86.0	43.0	43.0	52.10
87.0	42.5	44.5	52.50
88.0	43.0	45.0	52.90
89.0	44.0	45.0	53.30
90.0	45.0	45.0	53.70

Elevation = 150.00 M

Total (CMS)	Turbine#1 (CMS)	Turbine#2 (CMS)	Power (MW)
40.0	40.0	.0	24.90
41.0	41.0	.0	25.34
42.0	42.0	.0	25.78
43.0	43.0	.0	26.20
44.0	44.0	.0	26.60
45.0	45.0	.0	27.00
46.0	45.0	.0	27.00
47.0	45.0	.0	27.00
48.0	23.0	25.0	27.24
49.0	24.0	25.0	28.02
50.0	25.0	25.0	28.80
51.0	25.0	26.0	29.56
52.0	25.0	27.0	30.32
53.0	25.0	28.0	31.08
54.0	25.0	29.0	31.84
55.0	26.5	28.5	32.60
56.0	26.0	30.0	33.36
57.0	27.0	30.0	34.12
58.0	28.0	30.0	34.88
59.0	29.0	30.0	35.64
60.0	30.0	30.0	36.40
61.0	30.0	31.0	37.12
62.0	30.5	31.5	37.84
63.0	30.0	33.0	38.56
64.0	30.0	34.0	39.28
65.0	30.0	35.0	40.00
66.0	31.0	35.0	40.72
67.0	33.0	34.0	41.44
68.0	33.0	35.0	42.16
69.0	34.0	35.0	42.88
70.0	35.0	35.0	43.60
71.0	35.0	36.0	44.28
72.0	35.0	37.0	44.96
73.0	35.5	37.5	45.64
74.0	36.5	37.5	46.32
75.0	37.5	37.5	47.00
76.0	38.0	38.0	47.56
77.0	38.0	39.0	48.12
78.0	38.0	40.0	48.68
79.0	39.0	40.0	49.24
80.0	40.0	40.0	49.80
81.0	40.0	41.0	50.24
82.0	40.0	42.0	50.68
83.0	41.0	42.0	51.12
84.0	42.0	42.0	51.56
85.0	42.5	42.5	52.00
86.0	42.5	43.5	52.40
87.0	43.0	44.0	52.80
88.0	43.0	45.0	53.20
89.0	44.0	45.0	53.60
90.0	45.0	45.0	54.00

FECHA DE DEVOLUCION
