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RECON C5

DEPARTMENT OF WATER AFFAIRS
AND FORESTRY
Directorate of Project Planning

VAAL AUGMENTATION PLANNING STUDY

Orange Vaal Transfer Scheme

HYDROLOGY

AUGUST 1994

Orvaal Consult

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PD 000/00/3894
RECON C5

VAAL AUGMENTATION PLANNING STUDY

ORANGE VAAL TRANSFER SCHEME

HYDROLOGY

ORVAAL CONSORTIUM AUGUST 1994

Approved for Orvaal Consortium by:

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PREFACE

The Orange Vaal Transfer Study (OVTS) is one of three alternative augmentation schemes being investigated to further augment the Vaal River system after completion of the Lesotho Highlands Water Project (LHWP) Phases 1A and 1B. The other two schemes are the transfer of water from the Tugela River and also to develop the Lesotho Highlands Water Project's further phases.

A consortium, Orvaal Consult, was formed for this project. It consists of:

Van Wyk & Louw Inc
V3 Consulting Engineers
Chunnett Fourie & Partners
Willem van Riet Landscape Architects
Urban-Econ.

Various specialist sub-consultants are also retained for this study such as:

CSIR (Watertech)
Harza Engineering International Company
Murray & Roberts
Sigma Beta Consultants (Prof A Rooseboom)
B A Lund and Partners.

With the above number of professionals involved, it is essential to structure and manage the study properly in order to allow rapid progress by individuals and a minimum of repetition in the various reports.

With reference to the Structure For Reports shown at the end of this section, the following can be observed:

1. The study has three main reports, each forming the basis for the subsequent higher level report. The three main reports are:

    (a) Inception Report
    (b) Reconnaissance Report
    (c) Pre-feasibility Report.

    Each of the above reports have Supporting Reports (compiled by Orvaal Consult) and Primary Reference Reports, issued by the Department of Water Affairs and Forestry, the latter covering aspects of mutual interest for all three the studies.

The supporting reports also form a hierarchy with the purely technical reports normally at the lowest level. In subsequent levels of supporting reports, the information contained in the technical reports is used to compile dam reports followed by full development option reports.

The basic principle is that only the salient information concerning a technical issue is covered in a higher level report in order to render the latter self-contained. If more detailed information is required, the reader must refer back to a lower level report. The structure will enable the study to be optimally interlinked with all reports self-contained but without unnecessary repetition. Where feasible, only an executive summary of a lower level (or supporting) report will be used in a subsequent higher level report. By this token the Reconnaissance Report will consist mainly of the executive summaries of the individual development option reports (Supporting Reports Level A). It will then evaluate these options to develop the final (perhaps a phased combination) recommendation for an option to be investigated to Pre-feasibility level.

2. The contents and purpose of the main report, supporting reports and primary reference reports are shortly as follows:

(a) **Primary Reference Reports**

These reports (or documents) are of a general nature applicable to all reports (and all three studies). They are normally either prescriptive (eg the document on engineering economics and the sizing criteria) or informative.

(b) **Supporting Reports - Level C**

These are mostly technical reports that describe methodologies and factual background.

- Costing

  This report details the general methodologies for the costing of elements of development options. It does not detail or cost specific infrastructure, but gives, with reference to eg the costing models, instructions for measurements, use of shadow prices, and site specific unit rates. It also motivates changes from the primary reference report.

- Water demands

  This report is a comprehensive stand alone unit with all the relevant data on water demands. Where needed, other reports quote from this report.

- Sedimentation

This report describes the general sedimentation situation for the whole study area. It also describes the situations for specific locations such as dam sites and deals with potential problems along conveyance systems. Where required, findings/recommendations from this .eport are quoted in other (higher level) reports.

- Water quality

The Water Quality report covers the general study area and deals, in short, with site or scheme specific aspects. These findings are quoted where appropriate.

- Hydrology

The report on hydrology first details the virgin hydrology and then disaggregates the hydrology where required for the various development options.

- Floods

This report describes the methodologies for flood evaluation and details the flood analyses for specific dams. The results are quoted in the relevant dam reports.

- System yield

This report details the methodologies and describes the developed yield curves. However, the application of these curves are done in the individual dam reports.

- Environmental

The Environment report contains all the specific environmental evaluations prepared for the various options as well as any general environmental statements for the study area as a whole.

- GIS

The GIS report details the work done and the records available for future retrieval and use. It is considered a support system and is not cross-referenced in other reports.

- Hydropower

  A report on the hydropower potential identifies those schemes with no potential for hydropower and quantify the hydropower costs and benefits.

- Geology

  Geology forms an integral part of all the development options. All the specific geotechnical reports for the various elements of schemes are combined in a single comprehensive report. Abbreviated abstracts are included in the appropriate reports on the development option's elements (dams, tunnels, canals, etc).

- Social aspects

  The report on social aspects comprises a general status quo report on the study area. It evaluates the social impact of the individual development options and, where required, it identifies and discusses factors such as relocation costs for dam basins. Relevant abbreviated abstracts of this report are used in higher level reporting.

- Economic aspects

  This report is handled in the same manner as the report on Social Aspects.

(c) **Supporting Reports : Level B**

These reports are dam reports. They all utilize, and quote, from Level C reports and contain only the findings/recommendations of Level C reports with a minimum of the technical inputs or evaluations covered by those reports.

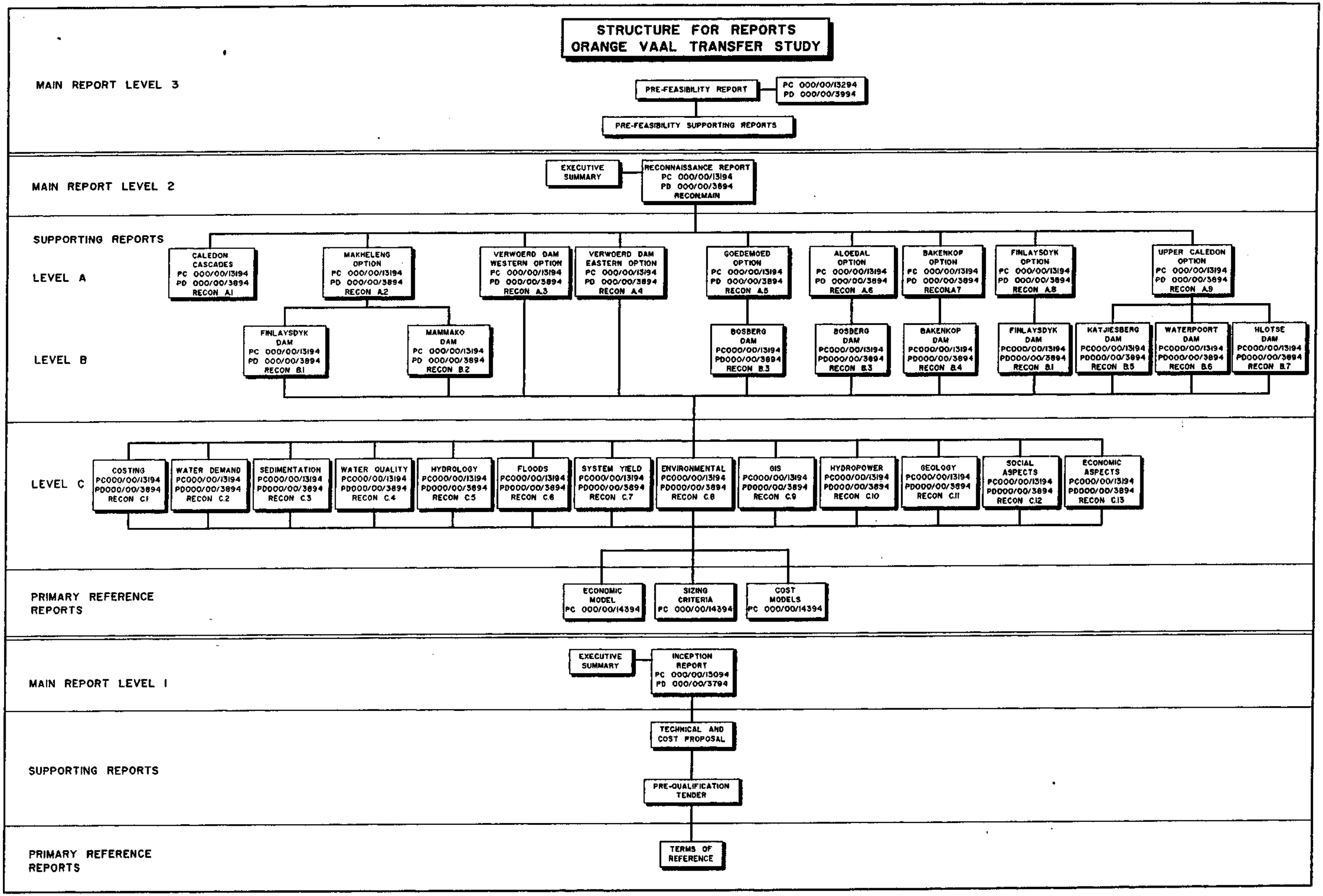
(d) **Supporting Reports : Level A**

The Level A reports are the actual Development Options. They combine the dam reports (Level B reports) with the conveyance system to constitute the full development option report. Where applicable these reports may also contain an economic evaluation of sub-options (smaller schemes or partial development of schemes).

(e) **Main Report : Level 2**

The Reconnaissance Main Report is the only Level 2 report. It serves to combine all the development options and to compare them on technical, economic and other merits (such as social and environmental aspects). The development of an optimal recommendation which may be a single development option or a combination of various options is the main objective of this report.

The report is kept as short as possible by avoiding repetition of technical inputs. The inputs are, a. far as possible, the executive summaries of the Support Reports Level A. These are fairly detailed and are sub-divided under sub-headings (where appropriate) to highlight aspects such as geology, hydrology and environment. The reader requiring more detail on specific elements is referred to an appropriate lower level report.


STRUCTURE FOR REPORTS
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BOSBERG DAM PC000/00/13194 PD000/00/3894 RECON B3
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HYDROLOGY : RUNOFF MODEL CALIBRATION AND SIMULATION

EXECUTIVE SUMMARY

The study area is shown in FIGURE 17 at the back of this report and is defined as the Caledon River catchment, the Makhaleng River catchment and the Orange River catchment between the Makhaleng River confluence and the PK Le Roux Dam. The portion of this area to be studied in more detail (hydrological model calibration) is shown in FIGURE 1 and will for the purpose of this report henceforth merely be referred to as the Caledon River (upstream of Welbedacht Dam) and the Makhaleng River catchments (upstream of gauge D1H006).

The purpose of this module of the study was to simulate natural monthly runoff sequences at all points of interest to this study and particularly at selected (key) sites in the upper Caledon River catchment and on the Makhaleng River in Lesotho. However, it was a specific requirement of this study that the existing simulated natural hydrology recently prepared by the Department, was not to be changed. The purpose of this investigation was therefore essentially to disaggregate the existing hydrology to obtain realistic simulated natural runoff sequences at the particular key sites.

Adequate simulated natural runoff sequences at key sites in the Orange River and the lower Caledon River can be obtained by simply disaggregating the existing runoff sequences on the basis of mean annual rainfall and catchment area because of the relative hydrological homogeneity of these catchments. However, since this is not the case in the Caledon River and the Makhaleng River catchments it was deemed necessary to base the disaggregation in these catchments on actual monthly runoff simulations. For this reason it was therefore necessary to perform complete hydrological investigations of these particular areas.

Because of some doubts about the accuracy of the isohyet maps compiled by the Department of Agricultural Engineering of the University of Natal for the mountainous areas of Lesotho, the consultant was instructed to only use the latter source for the RSA portion of the study area and to use the "old" 1:250 000 SA Isohyet maps for the Lesotho portion of the study area.

Due to a lack of evaporation stations in the Makhaleng River catchment, mean annual gross S-pan evaporation isolines that were recently prepared for the Department for the Caledon River catchment were extended into the Makhaleng River catchment by means of the evaporation maps contained in an earlier study by the RSA Water Research Commission.

Existing hydrometeorological records and patching of these records as part of previous studies were used as far as possible as input to this study, accepting that these records had been accurately and competently patched where necessary.

The WRSM90 hydrological model (based on the Pitman hydrological model) was used for the hydrological calibration of both the Caledon River and Makhaleng River catchments.

In the Caledon River catchment the natural monthly runoff for all the catchments up to the Jammersdrift gauging station (for which an accepted simulated natural runoff sequence exists), were simulated and were then used to disaggregate the existing simulated natural hydrology at Jammersdrift on a monthly basis in the same proportions as the simulated runoffs of the incremental catchments. For the Makhaleng River the runoff was simulated directly because a total recalibration of the larger incremental catchment within which the Makhaleng River catchment falls and for which the hydrology was already done, was not deemed necessary for the purpose of this study. However, should the Makhaleng option be considered during further stages of the study consideration should be given to further checks to be carried out on the Makhaleng River hydrology by using the observed records on the Orange River above and below the confluence of the Makhaleng River with the Orange River. For the possible new dam sites on the lower Caledon River and on the Orange River upstream of the Hendrik Verwoerd Dam the natural runoff simulations were obtained by merely adjusting the runoff simulations of some of the existing incremental catchments provided by the Department, on the basis of rainfall and catchment area, to suit the purpose of this study.

A summary of the areas, mean annual precipitations and mean annual runoffs for the various subcatchments shown in FIGURE 17, is given in TABLE 20.

This report does not at this (reconnaissance) stage include the generation of stochastic runoff sequences which will only be prepared once a final decision has been taken on the sites to be investigated to a pre-feasibility level.

HYDROLOGY : RUNOFF MODEL CALIBRATION AND SIMULATION

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FIGURES

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HYDROLOGY : RUNOFF MODEL CALIBRATION AND SIMULATION

1 INTRODUCTION

The Vaal Augmentation Planning Study was initiated in order to determine the best alternative to augment the water supply of the Vaal River Catchment by means of water transfers from the Orange River catchment as well as the Tugela River catchment.

Although the study area for this report is defined as the Caledon River catchment, the Makhaleng River catchment and the Orange River catchment between the Makhaleng River confluence and the PK le Roux Dam, reference to the study area in this report will mostly refer only to the catchments of the Caledon and Makhaleng River catchments.

Historic naturalised runoff sequences have recently being prepared by BKS [1,2] at certain key points throughout the upper Orange River and Caledon River catchments. For the purpose of this study naturalised runoff sequences are however also required at other points that do not coincide with these key points.

Because of the relative hydrological homogeneity of these catchments, naturalised runoff sequences at dam sites in the Orange River and the lower Caledon River can be obtained by simply disaggregating the latest (above) naturalised runoff sequences on the basis of rainfall and catchment area. However, since exactly the opposite is true for the Caledon River and lower Lesotho catchments, it was deemed necessary for the purpose of this study to base the disaggregation factors for the key points in the Caledon and Makhaleng Rivers on actual monthly runoff simulations of these catchments.

In view of the above the major part of this report will therefore be dedicated to the description of the hydrological investigations performed to attain more accurate hydrology for the Caledon and Makhaleng Rivers in particular.

2 GENERAL DESCRIPTION OF THE CATCHMENT

2.1 PHYSICAL CHARACTERISTICS

A general map of the study area (Caledon and Makheleng River catchments) is given in FIGURE 1 at the back of this appendix.

Topographically the study area is very diverse, with altitudes varying from about 2900 m.a.s.l. in the upper reaches of the Caledon River to about 1400 m.a.s.l. at Welbedacht Dam on the Caledon River. For the Makhaleng River altitudes vary from about 2800 m.a.s.l. in the Maluti mountain range to about 1400 m.a.s.l. at the confluence with the Senqu River (Orange River).

The Caledon River catchment is generally underlain by mudstone and sandstone in the flatter areas, and with basalt in the mountainous areas. The Makhaleng River region is mainly underlain by basalt.

The climatic conditions in the study area are generally associated with the topography. The isohyet map of the Caledon and Makhaleng River catchments is shown in FIGURE 1. The isohyets for the RSA portion of the Caledon and Makhaleng River catchments were compiled by the Department of Agricultural Engineering of the University of Natal (DAEUN), while the isohyets for the Lesotho portion of the Caledon and Makhaleng River catchments were obtained from the "old" 1 : 250 000 SA Isohyet maps. This therefore explains the discontinuity of the given isohyets in the Caledon River catchment and the Makhaleng River catchment and also implies that the Pitman model parameters will not be transferable across the boundaries. For the Lesotho portion the "old" maps were used on the basis of the WR90-project [3] where possible inaccuracies were identified in the new maps. The mean annual precipitation (MAP) for the Caledon and Makhaleng River catchments varies between a 1000 mm in the mountainous area to 500 mm in the low-lying areas at Welbedacht Dam and at the Makhaleng River confluence with the Orange River. The rainy season generally lasts from October to March, with the maximum rainfall usually occurring in January.

The isolines for gross Symons pan (S-pan) evaporation for the Caledon and Makhaleng River catchments are shown in FIGURE 1. These isolines were compiled by BKS [1] for the Caledon River catchment and were extrapolated into Lesotho after comparison with the evaporation maps from the Addendum to Surface Water Resources of South Africa [4]. Evaporation maps from the Addendum to Surface Water Resources [4] were employed in the WR90-project, as there is still some concern over the accuracy of the DAEUN evaporation maps for Lesotho. The gross S-pan evaporation for the Caledon and Makhaleng River catchments varies between 1300mm in the mountainous area to 1600mm in the low lying areas at Welbedacht Dam and at the Makhaleng River confluence with the Orange River.

The natural veld types encountered in the Caledon and Makhaleng River catchments essentially consist of different types of grassland, with alpine veld in the mountainous areas and highveld sourveld north-east of Clocolan and Themeda veld south of Clocolan in the lower lying areas.

2.2 CATCHMENT SUB-DIVISION

In order to disaggregate the runoff sequences for the Caledon and Makhaleng Rivers, it was necessary for calibration purposes to sub-divide the catchments used in the previous studies [1,2] into smaller catchments. Catchment sub-division was done on the basis of similar physiographic and hydrologic characteristics, as described in the previous paragraph, the hydrological zones as employed in the WR90-project [3], and the locations of streamflow gauging stations.

Based on the above criteria the Caledon River catchment was divided into three subcatchments as indicated on FIGURE 1. Subcatchment 1 essentially consists of the mountainous high rainfall portion in the east of the Caledon River catchment. The creation of subcatchments 2 and 3 was essentially based on the available river gauging stations at D2H020 (Pleasant View) and D2H001 (Jammerdrift) and on the rainfall characteristics.

On the basis of its hydrologic characteristics the Makhaleng River catchment was sub-divided into only two subcatchments. For the purpose of defining the upstream wetter subcatchment use were made of the hydrological zone borders employed in the WR90-project [3]. However, should the Makhaleng option be considered further, a more appropriate sub-division should be investigated.

TABLE 1 shows the basic subcatchment information used in the calibration process.

3 HISTORICAL DEVELOPMENT AND MODELLING OF WATER USE WITHIN THE CATCHMENT

3.1 GENERAL

The WRSM90 hydrological model [3] (based on the Pitman hydrological model) generates and is calibrated for monthly runoff and therefore the historical water use had to be established on a monthly basis.

Land use records for the Caledon River catchment were available from previous reports [1,2], while the observed runoff for the Makhaleng River was taken to be the natural runoff as there is no significant development in its catchment [2].

3.2 WATER USE BY IRRIGATION

The major water consumer within the catchment is irrigation, as described in more detail in supporting report RECON.C2. Two categories of irrigation exist in the Caledon and Makhaleng River catchments, namely irrigation from the main rivers (controllable) and diffuse irrigation from small tributaries. Controllable irrigation is supplied from the larger rivers with reliable flow which is often augmented by means of dams and is typically controlled as a Government Water Scheme or by an Irrigation Board. Diffuse irrigation is supplied from run-of-river or small farm dams. The reliability of water supply for diffuse irrigation can be low and irrigation is often supplemental to rainfall.

The total irrigated area upstream of D2H001 (Jammerdrift) is about 6000 ha. About 3445 ha of this area is situated along the Caledon River, with the rest being irrigated from small farm dams. The controllable irrigation of 800 ha from Armenia Dam, on a tributary of the Caledon River, is included in the irrigation for subcatchment 3. Pumped irrigation of 533 ha from Welbedacht Dam, taking place downstream of D2H001 (Jammerdrift), was excluded as the Jammerdrift record was used in the calibration process. A summary of the irrigation data for the subcatchments is given in TABLE 2. Subsequent to the completion of this investigation it was found on the basis of new information that the total irrigation area of 6013 ha (1987) was in fact closer to 8600 ha. The growth, which primarily took place in subcatchment 3, mainly occurred during the last five to six years. This only increased the mean historic irrigation demands from about 9.0 x $10^6 m^3/a$ to about 10.4 x $10^6 m^3/a$, compared to an observed runoff of about 1208 x $10^6 m^3/a$. The effect of this change on the calibration for the Caledon River catchment was therefore found to be insignificant and no further attempts were made to recalibrate.

For the purpose of calibrating the hydrological model, it was necessary to simulate the effect of irrigation on the observed runoff of the Caledon River catchment. Irrigation demands for the respective minor catchments were simulated employing the irrigation submodule of the WRSM90 simulation model, which uses as input irrigated crop areas, crop types and accompanying crop factors. Since irrigation water use have not had a very significant effect on the historic runoff no attempt was made at simulating the actual net effect [1] of irrigation. Irrigation information was gathered from the previous reports [1] prepared on the Caledon River catchment. The reports also gave the historic growth pattern of irrigation, the different crops irrigated, including their respective crop factors.

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1 The net effect of irrigation (ie reduction in runoff due to irrigation) is somewhat less than the field edge water requirement due to factors such as return seepage, enhanced rainfall runoff, etc.

3.3 WATER USE BY EXOTIC AFFORESTATION

From previous work done [1,2] it was concluded that there is no existing exotic afforestation in either catchment that needs to be simulated. No mention was made of possible future introduction of exotic afforestation and exotic afforestation as a possible future water user was therefore not simulated.

3.4 URBAN WATER USE

Water use for domestic, municipal, industrial, mining and stockwatering purposes within the catchment has generally been insignificant and has therefore not significantly affected the catchment runoff. The towns of Ficksburg, Clocolan and Maseru comprise the three major urban water users in the Caledon River catchment.

With a current net use of about 8.52×10^6 m^3/a compared to a natural MAR (mean annual runoff) of 1212×10^6 m^3/a it is evident that the urban water use is practically negligible for the purpose of the hydrological model calibration.

3.5 WATER TRANSFERS

Although water is transferred from the Caledon River catchment to adjacent catchments, the transfer takes place downstream of the gauging station D2H001 (Jammerdrift) and is therefore excluded from model calibration.

3.6 WATER USE FROM DAMS

Dams are not water consumers as such except for the evaporation loss that occurs from the increased water surface area. Dams can however significantly influence the downstream runoff records and are therefore of prime importance to modelling the runoffs from the various minor catchments.

In the case of the Makhaleng River catchment small dams were excluded from the hydrological model calibration as there are no significant small dams present.

For the Caledon River catchment however there are a significant number of small irrigation dams of which the effect had to be considered. The storage capacity of the small irrigation dams was derived from calculations using maximum surface water area as obtained from 1 : 50 000 topographic maps, employing an average depth of 2 m. Based on previous studies [5,6] and on discussions with hydrologists with experience in various other catchments in the country, it was accepted that an average depth of 2 m would be a good estimate for the calculation of small dam capacities in this study. It may be noted here that during the calibration process it was found that the calibration was very insensitive to this average depth. Although the calibration was insensitive to the size of the small dams due to the relatively late development of these dams, a sensitivity analysis of the above assumption of 2m average depth will again be done in the systems analysis. To include the effect of these small dams into the hydrological model, three dummy dams were created, one dummy dam for each of the three subcatchments with each dummy dam representing the cumulative storage capacity of all the small dams in that subcatchment. The area-capacity relationships used for the evaporation calculations is of the form : area = constant x $(\text{capacity})^b$, where only full supply areas and capacities of the dams were used to determine the constant and where the value of b was accepted as 0.66.

In order to simulate the effect of these small dams each subcatchment was divided into two portions. The first portion constituted the area from which the natural runoff was routed through the farm dams, while the second portion constituted the natural runoff which was unaffected by the irrigation and small dams and was taken to be available at the outflow of the subcatchment. The percentage split between these portions was judiciously based on inspection of 1 : 50 000 topographic maps indicating the irrigation areas. These dummy dams were all operated to supply the monthly irrigation water demand, as defined in the relevant supporting report, whenever there was water in the dam.

A summary of the full supply area and capacities of the small dams for the respective subcatchments is given in TABLE 3.

3.7 RIVER WATER LOSSES

It was noted that no river loss model was introduced into the previous runoff model calibration and thus has therefore been excluded from this study as well. Due to the relatively high runoff in the calibration catchments and the fact that there is no net reduction in natural monthly runoff in a downstream direction a river loss model is not necessary.

4 AVAILABILITY OF HYDROMETEOROLOGICAL RECORDS

4.1 RAINFALL

The rainfall records for 143 rainfall stations in and around the Caledon and Makhaleng River catchments were available from the previous hydrology reports [1,2] done on the Caledon River Catchment and the Lesotho Highlands. It was not the intention of this study to regenerate the basic hydrometeorological records and therefore the patched rainfall records from the previous reports were accepted as being ready for use in this study.

For the purpose of this study only the patched portion of the original observed period of record was used in the calibration process while all extensions of rainfall records were discarded. A summary of the rainfall records used is given in TABLE 4.

The rainfall gauging stations used to derive the monthly rainfall distribution for each subcatchment are given in TABLE 5 to TABLE 8 inclusive. The MAP's for the subcatchments in the RSA portion of the Caledon and Makhaleng River catchments were determined from the electronic rainfall data used in the WR90-project [3] (compiled by the DAEUN), while the MAP's for the Makhaleng River catchment were derived directly from the WR90-project data as compiled from the "old" isohyet maps.

4.2 EVAPORATION

Evaporation is of great importance in the estimation of irrigation water requirements, simulation of streamflow and reservoir operation programs. The mean annual S-pan evaporation isolines are shown in FIGURE 1. The given isolines for the Caledon River catchment were obtained from previous studies as part of the Orange River System Analysis [1,2] and were extended into the Makhaleng River catchment by inference from the S-pan evaporation maps of a previous WRC study [4] (which was also used in the WR90-study). This map was then used to determine the mean annual S-pan evaporation for each of the subcatchments. The values used, were also checked against the values used in the WR90-study. Mean annual evaporation used for determining irrigation water requirements were derived from the appropriate gauging stations at D2E002 (Wepener) and D2E008 (Ficksburg).

During the calibration process the monthly gross S-pan evaporation patterns from the evaporation stations available in each subcatchment were used. For the Caledon River evaporation patterns from evaporation stations D1E004, D2E006 and D2E008 were used, while for the Makhaleng River catchment the monthly S-pan evaporation patterns previously established for the incremental catchment to gauge D1H009 (Oranjedraai) [7] were used. Class A-pan monthly gross evaporation values were established on the basis of the monthly distribution pattern previously obtained [1].

The monthly Symons pan and Class A-pan evaporation applicable to the respective subcatchments are given in TABLE 9.

4.3 STREAMFLOW

For the Makhaleng River only one gauging station D1H006 (Maghaleen), near the Maghaleen border crossing, was available for use. Observations at the gauge commenced in 1947 and daily staff gauge readings were taken until 1972, at which time an automatic water level recorder was installed. Although gauge D1H006 (Maghaleen) has a record length of 46 years, it required a fair amount of patching, which is discussed in Section 5.3.

In the Caledon River catchment only three gauging stations equipped with automatic recorders were available for use. These are the weirs at D2H001 (Jammerdrift) and D2H020 (Pleasant View) on the Caledon River, and the weir at D2H012 (Caledonspoort) on the Little Caledon River in the upper reaches of the catchment.

The D2H012 (Caledonspoort) record samples only a very small portion (2%) of the flow at D2H001 (Jammerdrift) and is located on a tributary in the headwaters region of the catchment. The 20-year record also required considerable patching. For these reasons this record was not used for calibration.

The D2H020 (Pleasant View) record only commenced in 1982 and also contained quite a number of gaps. An investigation of the record quality indicated the gauging station to have consisted only of an automatic recorder and gauge plates. The problem however was that constant siltation and blocking of the inlet pipe, as well as an unstable river bed at the station resulted in a very poor record, which could not be used in the calibration process, as was also found from initial tests.

Calibration of the runoff models for the Caledon River catchment could therefore only be done against the D2H001 (Jammerdrift) record. This station has been in operation since April 1913 and has a reasonably reliable record with relatively few gaps. The station was closed in 1978 due to flooding after the completion of Welbedacht Dam. After the commissioning of Welbadacht Dam a combined flow record [1] for Jammerdrift and Welbedacht Dam was created by combining the two flow records on the basis that the contribution to the total runoff at Welbedacht Dam of the incremental area between the two stations is negligible. The combined flow record could then be used for calibration purposes. The Knellpoort Dam, situated in the catchment between the two stations, was only completed in 1988, which means that the combined record up to 1987 was unaffected by this development.

5 VERIFICATION OF THE RELIABILITY OF HYDROMETEOROLOGICAL RECORDS

5.1 GENERAL

Many of the basic records used in this study were available from previous work done on the catchment and the previously patched records were therefore essentially accepted as adequate and ready for use in this study [1,2].

5.2 CONDITION OF GAUGING STATIONS

Gauging station D1H006 (Maghaleen) was the only record available for use on the Makhaleng River. Although it was mentioned in the LHWP Feasibility Study [8] that the record prior to 1972, which consisted of daily readings, was unreliable, no other gauging station on the Makhaleng River was available for use. It was nevertheless decided that a simulation based on this record, if found to be produced by acceptable Pitman parameters, would be better than a mere disaggregation of the simulated runoff of a relatively large catchment on the basis of area and MAP only.

It was gathered from previous reports [1] that the combined record for Jammerdrift and Welbedacht Dam was accurate and reliable, with only 35 months of missing or faulty streamflow data.

5.3 PATCHING OF RECORDS

Patching of the observed record for the Makhaleng River was done by means of the WRSM90-model only. Incomplete data were patched iteratively during the calibration process so that the final patched value for each month is exactly the same as the simulated virgin runoff, noting that there has been no significant past water use from the catchment. TABLE 10 shows the patched record for gauge D1H006.

In the previous study [1] the combined flow record for Jammerdrift/Welbedacht Dam was patched using values generated by the HRU (1981). Only 35 months in the record of 68 years required patching and the previously patched record was accepted. TABLE 11 shows the combined patched record for Jammerdrift/Welbedacht Dam.

6 CATCHMENT HYDROLOGICAL MODEL CALIBRATION

6.1 GENERAL

As was previously mentioned, the WRSM90-model was used to simulate runoff sequences for the Makhaleng and Caledon Rivers. The WRSM90-model essentially simulates runoff from catchments in undeveloped conditions after suitable allowance for the effects of water usage within the catchment.

The model calibration for the Makhaleng and Caledon Rivers will be discussed separately, as different approaches were used. For both catchments the regional parameters as suggested in the WR90-project were used as initial values to calibrate the model. This resulted in an inadequate calibration with the observed flows not modelled within acceptable limits of variation. The regional parameters therefore had to be adapted in order to obtain an acceptable calibration. The changed parameters were however within acceptable limits from the WR90-parameters.

Note that the WRSM90-model parameters will not correspond across the boundary between the Caledon River catchment and the Makhaleng River catchment, as rainfall from different sources were used in the calibration process. Model parameters will therefore not be transferable between these catchments.

6.2 MODEL PARAMETERS

- Makhaleng River

The observed runoff in the Makhaleng River is essentially the virgin runoff, as the development and water use in this subcatchment is negligible. Model calibration was done against the flow record of river gauging station D1H006 (Maghaleen), with the flow record being patched iteratively during model calibration.

Calibration of the WRSM90-model for the Makhaleng subcatchment was done employing the two subcatchments as described before. The finally adopted model parameters are given in TABLE 12. Although the aim was to get a good overall fit, the assignment of the parameters was strongly influenced by the objective of obtaining a good correlation between the observed and simulated stage/gross yield curves.

- Caledon River

The calibration of the WRSM90-model for the Caledon region was done employing three minor catchments and calibrating against the Jammerdrift/Welbedacht Dam flow record. The finally adopted model parameters are given in TABLE 12.

6.3 MODEL VERIFICATION

6.3.1 General

The purpose of the calibration process was to disaggregate already available runoff sequences for further use at possible dam sites. It is therefore quite possible that with extra time spent on the calibration of the model a somewhat better fit could be obtained for both catchments. It was however felt that for the purpose of this study, the runoff as simulated was within acceptable limits of variation.

When reviewing the quality of the results that were obtained and that are dealt with in the subsequent sections, the following must be kept in mind :

- the quality of the runoff record at gauge D1H006 (Maghaleen);
- the physiographical diversity of the Caledon River catchment and the variability of the meteorological factors;
- the lack of streamflow data for the Caledon River catchment on which to calibrate the Pitman model.

6.3.2 Statistical Properties

A comparison of the most relevant statistical properties of the observed and simulated observed hydrographs for gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) is given in TABLES 13 and 14 respectively. From an examination of TABLES 13 and 14 the following observations were made :

- Makhaleng River

  The MAR's compare favourably, with the rest of the statistics indicating a reasonable comparison between the observed and simulated flows.

- Caledon River

  The statistics indicate a fairly good comparison between observed and simulated hydrographs, considering that only one gauging station was used in the calibration process.

6.3.3 Monthly Hydrographs

The observed and simulated hydrographs for gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) are shown in FIGURES 2 and 3 respectively. These hydrographs give an indication of the goodness-of-fit of the model. From an examination of these plots the following observations were made ;

- Makhaleng River

  Due to the general lack of recorded high flows it is difficult to assess the simulated peak runoffs.

- Caledon River

  The hydrographs suggest that the model underestimates the high flows.

6.3.4 Annual Runoff

The observed and simulated annual runoff for gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) are shown in FIGURES 4 and 5 respectively. From an examination of these plots the following observations were made :

- Makhaleng River

  There is a fairly good relation between the observed and simulated annual runoffs.

- Caledon River

  There is a fairly good overall relation between the observed and simulated annual runoffs.

6.3.5 Mean Monthly Runoff

The comparison of observed and simulated mean monthly runoff for gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) is shown in FIGURES 6 and 7 respectively. From an examination of these plots the following observations were made :

- Makhaleng River

  The model apparently overestimates the March runoff, while it is underestimating the June and September runoffs. However, no plausible adjustment could be made to the model parameters to rectify these apparent problems.

- Caledon River

  Low flows are modelled fairly well, but the medium and higher flows are overestimated in October, December, January and April and underestimated in November.

6.3.6 Storage/Gross Yield Relationships

Storage/gross yield relationships for the gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) are shown in FIGURES 8 and 9 respectively. From an examination of these plots the following observations were made :

- Makhaleng River

  The graphs generally compare fairly well, with a slight overestimation for gross storage capacities between 280 and 560 million cubic metres.

- Caledon River

  The model slightly overestimates the gross yields for all gross storage capacities between 500 x 10^6 m^3 and 2000 x 10^6 m^3. For gross storage capacities in excess of 2000 x 10^6 m^3 the model overestimates gross yields by about 7 %.

6.3.7 Scatter Diagrams

Scatter diagrams for the gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) are shown in FIGURES 10 and 11 respectively. These diagrams reflect the goodness-of-fit of the model as summarised by the coefficient of efficiency, indicated on

FIGURES 10 and 11 respectively. The coefficient of efficiency is related to the better known correlation coefficient and is likewise a measure of goodness-of-fit. See ANNEXURE 1 for the relation between these two coefficients. From an examination of these plots the following observations were made :

- Makhaleng River

  The coefficient of efficiency (E) of 0.82 indicates a good fit, which is also supported by the scatter diagram.

- Caledon River

  The coefficient of efficiency (E) of 0.62 indicates a substandard fit, but it should be kept in mind that a single outlier can reduce the value of E considerably. The model seemingly underestimates the high flows.

6.3.8 Monthly Histograms

The histograms of monthly runoff for gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) are shown in FIGURES 12 and 13 respectively. These diagrams reflect how runoff of particular sizes are simulated. From an examination of these plots the following observations were made :

- Makhaleng River

  The model generally overestimates low flows and underestimates medium to high flows slightly.

- Caledon River

  The comparison is somewhat erratic for the very low flows but medium to high flows are modelled fairly well.

6.3.9 Cumulative Frequency Plot

The cumulative frequency plots for gauging stations D1H006 (Maghaleen) and D2H001 (Jammerdrift) are shown in FIGURES 14 and 15 respectively. These curves show the percentages of time various flows are equalled or exceeded. From an examination of these plots the following observations were made :

- Makhaleng River

  This curve generally confirms the findings based on the monthly histograms.

- Caledon River

  This curve generally confirms the findings based on the monthly histograms.

6.3.10 Mass Plot of Cumulative Runoff

As a final check on the simulated runoff for the Makhaleng River a mass plot of the cumulative runoff of the Makhaleng River versus the cumulative runoff of the remainder of the incremental catchment (ORAN.INC, BKS) was made and is shown in FIGURE 16.

From FIGURE 16 the prominent change in slope from about 1972 is quite evident. If the record before 1972 is accepted as correct, this would indicate that the runoff for the incremental catchment (ORAN.INC) is being overestimated for the period after 1972. The above problem was taken up with the Project Co-ordinating leader who confirmed that it is quite possible that incremental record ORAN.INC contained some runoff which was not very reliable. However, in view of the fact that all of the Lesotho hydrology is presently being investigated, it was decided to accept the previous hydrology [1,2] as accurate enough for the purpose of this study.

6.3.11 Rainfall/Runoff Relationships

From TABLE 12 it is quite evident that the runoff percentage (runoff expressed as a percentage of the rainfall) is considerably higher in the Makhaleng River catchment than in the Caledon River catchment. The seemingly high runoff of the Makhaleng River was then checked against some other subcatchments within Lesotho (WR90-project) and was found to be in order. From further enquiries about this matter, the explanation for the relatively high runoff was found to lie in the very significant difference in vegetation cover, with the ground cover in Lesotho apparently being very sparse.

7 SIMULATION OF FLOW DATA

7.1 GENERAL

Natural monthly runoff sequences were simulated for the period 1920/21 to 1987/88, as it was not required for the purpose of this study to extend the recently completed runoff simulations [9] to include the 1992/93 hydrological year.

For the Orange River catchment upstream of PK le Roux Dam long-term monthly runoff sequences have been simulated for all incremental catchments to be considered in the systems analysis. The system as used by BKS in the yield analysis up to PK le Roux Dam [9] will be used as basis and modified to incorporate possible new dams that need to be evaluated.

It is evident from the previous sections that for both the Makhaleng and Caledon Rivers the catchment hydrological model simulates the runoff within reasonable limits and was therefore accepted to be suitable for the generation of long-term monthly runoff sequences.

For the rest of the Orange River catchment long-term monthly runoff sequences at existing dams as well as possible new dams will be derived from the incremental runoff sequences used by BKS [9]. It has been accepted that any disaggregation of runoff within these incremental catchments will purely be made on the basis of MAP and areas for both reconnaissance and pre-feasibility stages. FIGURE 17 shows the incremental catchments to be used in the system analysis.

7.2 SIMULATION OF MONTHLY RUNOFF SEQUENCES FOR THE MAKHALENG RIVER

As mentioned before, the observed runoff for the Makhaleng River catchment is essentially the virgin runoff. This means that both the observed and simulated runoff effectively represents natural runoff.

Using the WRSM90 model with the calibrated parameters for the two subcatchments, runoff sequences were generated for the Makhaleng river at gauge D1H006 (Maghaleen). The natural simulated runoff sequences generated for subcatchments 4 and 5 are shown in TABLES 15 and 16 respectively.

The Mammako dam site on the Makhaleng River forms part of the Oranjedraai incremental catchment used by BKS [9]. This incremental catchment has been divided into two subcatchments, namely the Mammako dam site incremental catchment and the remainder of the BKS Oranjedraai incremental catchment [9]. The runoff sequence for the incremental catchment to the Mammako Dam site on the Makhaleng River has been derived from the simulation done at D1H006 (Maghaleen), by scaling the simulated runoff on the basis of MAP and area. The runoff for the rest of the Oranjedraai incremental catchment [9] has been taken to be the difference between the BKS Oranjedraai [9] runoff and the Mammako Dam runoff.

7.3 SIMULATION OF MONTHLY RUNOFF SEQUENCES FOR THE Caledon RIVER

The simulated natural runoff sequences at Jammerdrift was disaggregated to create natural runoff sequences for the three minor catchments in the Caledon River. Disaggregation was done on the basis of the previously simulated respective contributions of the three subcatchments to the total natural runoff at D2H001 (Jammerdrift) on a monthly basis. The natural simulated runoff sequences thus created are shown in TABLES 17 to 19 inclusive.

These disaggregated natural runoff sequences for subcatchments 1 and 2 were used to generate monthly runoff sequences at three possible dam sites in the upper reaches of the Caledon catchment. The three dam sites are :

- Hlotse Dam on the Hlotse River;
- Katjiesberg Dam on the Caledon River;
- Waterpoort Dam on the Meulspruit.

In order to generate the runoff sequences at the dam sites, the natural runoff sequences were disaggregated on the basis of MAP and catchment areas. The natural simulated runoff sequences for the three dam sites as well as the Jammerdrift/Welbadacht Dam gauging point, are shown in TABLES 21 to 24 inclusive and the respective incremental catchments are shown on FIGURE 17.

The MAR's at the dam sites had been estimated on two other occasions in the past. In the review on alternative proposals for the Caledon River [10], done by the Olivier Shand Consortium, their figures were compared to those obtained in 1985 by WLPU/BKS. TABLE 25 compares the previous estimates with those derived in this study.

7.4 SIMULATION OF MONTHLY RUNOFF SEQUENCES FOR OTHER DAMS

Apart from the incremental catchment to gauge D1H009 (Oranjedraai) which is affected by the Makhaleng River runoff, the other seven incremental subcatchments inside Lesotho, as employed by BKS [9], have been kept unchanged. The same holds for the Knellpoort Dam incremental catchment and the incremental catchment between the HF Verwoerd and PK le Roux Dams.

The Bosberg incremental catchment has been used as a node point in the modified system. The Morgenson dam site is located only a very short distance upstream of the Bosberg site and it has therefore been accepted to have the same runoff as Bosberg. For the purpose of this study the incremental catchments in the vicinity of the Bosberg dam site were all slightly adapted from those previously used by BKS, as shown in FIGURE 18. The available BKS runoff sequences for the relevant incremental catchments were consequently all adjusted (to fit the new incremental catchments) on the basis of MAP and area.

The runoff sequences for Finlaysdyk and Bakenkop Dam sites have been derived from the new Verwoerd Dam incremental catchment as described above, disaggregating runoff on the basis of MAP and area. No runoff sequences have however been simulated for these two dam sites, as the runoff sequence for the HF Verwoerd Dam incremental catchment will merely be scaled during the system analysis when modelling either one of the two possible dams, allocating a portion to the new dam being modelled and the remainder being available to HF Verwoerd Dam itself. TABLE 20 summarises the basic hydrological information for the respective incremental catchments, with FIGURE 17 showing the incremental catchments for the Upper Orange River catchment upstream of PK le Roux Dam. The runoff sequences for the respective incremental catchments are given in TABLES 26 to 32 inclusive.

8 SUMMARY AND CONCLUSIONS

The aim of this study was to generate natural monthly runoff sequences at all major points of interest to this study and particularly at selected points on the Makhaleng River in Lesotho and on the Caledon River upstream of the Welbedacht Dam.

Using isohyets from different sources for the Caledon River catchment and the Makhaleng River catchment respectively resulted in the isohyets not matching up (as indicated on FIGURE 1). This is as a result of the DAEUN isohyets which were used in the Caledon River catchment, being under suspicion in the mountainous areas of Lesotho. Isohyets from the "old" 1: 250 000 SA Isohyets maps were used for the Makhaleng River catchment.

Due to a lack of evaporation stations in the Makhaleng River catchment, the S-pan mean annual evaporation isolines as mapped by BKS for the Caledon River catchment in a previous study [1] were extended into the Makhaleng River catchment by means of the evaporation maps contained in an earlier study for the Water Research Commission [4].

Hydrometeorological records and simulations from previous studies were used as input to this study, accepting these records as having been accurately and competently patched where necessary.

The WRSM90 hydrological model (using the Pitman hydrological model as basis) was used for the hydrological calibration of both the Caledon River catchment and the Makhaleng River catchment. For the Makhaleng river a natural streamflow sequence was simulated directly. However, should the Makhaleng option be considered further it is suggested that some further checks be carried out on the Makhaleng River hydrology by making use of the observed records on the Orange River at D1H009 (Oranjedraai) and D1H031 (Seaka). For use in the systems analysis new incremental catchments were created at possible new dam sites, while some of the incremental catchments used by BKS [9] were changed slightly to suit the purposes of this study. For the key points in the Caledon River catchment simulated runoff sequences were derived by disaggregating the existing runoff at Welbedacht Dam by means of simulated runoff sequences (on a monthly basis) for three different hydrological zones within the catchment.

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TABLE 1

SUB-DIVISION OF UPPER CALEDON RIVER AND MAKHALENG RIVER CATCHMENTS

SUB- CATCHMENT	AREA (km^2)	MAP (mm)	OUTLET LOCATION
1	2774	906	Confluence of Caledon and Hlotse Rivers
2	5625	727	Gauge D2H020
3	5022	670	Gauge D2H001
4	2154	896	WR90-project quartenary catchment D15E
5	815	705	Gauge D1H006

TABLE 2

DISTRIBUTION OF IRRIGATION IN SUBCATCHMENTS

SUB-CATCHMENT(2)	IRRIGATION AREAS (ha)(1)			
	CALEDON RIVER	RSA TRIBUTARIES (3)	LESOTHO TRIBUTARIES (3)	TOTAL
1	0	0	60	60
2	2133	1321	142	3596
3	1312	900	145	2357
TOTAL	3445	2221	347	6013

NOTES :

(1) Crop areas during 1987 as used for calibration. Refer Section 3.2.
(2) See FIGURE 1
(3) Not controllable

GROWTH RATE OF IRRIGATION IN SUBCATCHMENTS

PERIOD	SUBCATCHMENT						TOTAL
	1		2		3		
	FARM DAMS	RIVER	FARM DAMS	RIVER	FARM DAMS	RIVER	
1920	0	0	0	0	0	0	0
1954	0	0	0	150	0	50	200
1960	0	0	0	150	600	50	800
1970	0	0	100	200	600	100	1000
1975	20	0	250	1100	650	580	2600
1980	25	0	440	1860	740	793	3858
1987	30	0	707	2919	965	1392	6013

TABLE 3

SMALL DAMS AREA/CAPACITY

SUBCATCHMENT	AREA (km^2)	CAPACITY (10^6 m^3)
1	0.32	0.65
2	5.81	12.37[(1)]
3	18.10	47.19[(1)]
TOTAL	24.23	60.21

NOTES :

(1) The area-capacity information for subcatchments 2 and 3 is a combination of capacities calculated from full supply areas using an average depth of 2 m for some dams and kwown full supply capacities for other farm dams in the same subcatchment.

TABLE 4

RAIN GAUGES SELECTED FOR ANALYSIS OF SUBCATCHMENT RAINFALL

UPPER CALEDON RIVER CATCHMENT

GAUGE NUMBER	GAUGE NAME	LAT	LONG	ALT (m)	MAP (mm)	PERIOD OF RECORD
263/373	Waterland	29°13'	27°13'	1641	639	1916-1987
263/567X	Convamore	29°27'	27°19'	1539	591	1917-1954
263/567Y					696	1955-1987
263/792	Leliehoek	29°12'	27°27'	1580	695	1919-1987
264/022Y	Botshabelo	29°22'	27°31'	1646	722	1957-1987
264/417	Roma	29°27'	27°44'	1646	802	1936-1985
295/539	Mequatlingsnek	28°59'	27°18'	1555	636	1923-1987
296/157	Sunny Hills	28°37'	27°36'	1675	742	1931-1987
296/682	Ficksburg-tnk	28°52'	27°53'	1585	733	1920-1987
297/388X	Lesotho Gauge	28°58'	28°13'	1900	983	1937-1961
297/388Y					758	1970-1985
297/436X	Butha-Buthe	28°46'	28°15'	1768	799	1930-1957
297/436Y					723	1958-1985
297/721	Clarens Pol	28°31'	28°25'	1676	724	1920-1987
298/244	Caledonia	28°34'	28°39'	1951	960	1920-1981
331/058	Overdene	28°28'	28°02'	1830	783	1920-1968

MAKHALENG RIVER CATCHMENT

GAUGE NUMBER	GAUGE NAME	LAT	LONG	ALT (m)	MAP (mm)	PERIOD OF RECORD
204/819	Mohale's Hoek	30°09'	27°28'	1600	745	1922-1989
233/439	Mafeteng	29°49'	27°15'	1610	713	1920-1989
233/747	Thabana-Morena	29°57'	27°25'	1680	717	1951-1989
234/008	Morija	29°38'	27°31'	1700	797	1965-1989
234/111	Malealea	29°51'	27°34'	1970	830	1954-1989
234/150	Mt Carmel	29°60'	27°35'	1750	782	1926-1989
264/417	Roma (Nul)	29°27'	27°44'	1650	812	1967-1989
264/715	Molimo Nthuse	29°25'	27°54'	2040	958	1963-1989
264/836	Thaba-Putsoa	29°26'	27°58'	2600	1041	1963-1989

TABLE 5

RAINFALL DISTRIBUTION FOR SUBCATCHMENT 1

RAINFALL AS PERCENT M.A.P.

YEAR	NO. OF GAUGES	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR
1920	2	7.15	7.29	7.65	13.99	10.81	12.25	7.89	0.56	0.26	0.00	0.02	4.08	71.86
1921	2	3.52	14.75	17.61	18.46	6.36	6.95	0.64	2.53	4.06	0.00	5.46	0.16	78.50
1922	2	11.41	21.66	15.12	14.86	15.81	4.36	8.28	4.75	9.86	3.28	2.03	0.91	112.14
1923	2	8.02	7.75	11.49	14.21	12.25	20.77	1.61	1.06	0.12	0.28	0.54	7.53	83.61
1924	2	14.54	22.05	19.35	9.00	9.51	30.92	17.14	3.13	1.84	0.15	0.13	4.78	132.54
1925	2	5.32	21.82	6.77	10.53	15.31	11.34	0.11	1.78	1.47	0.00	0.00	10.45	84.89
1926	2	14.97	13.79	19.90	8.72	14.18	7.86	3.91	0.14	0.00	6.17	0.39	0.02	89.85
1927	2	19.86	5.79	21.36	11.97	15.02	10.53	1.15	0.25	0.26	0.00	0.48	4.80	91.30
1928	2	9.26	6.54	13.56	10.93	12.59	12.28	2.92	3.99	10.59	2.82	2.01	19.89	106.17
1929	2	6.81	14.25	13.07	18.97	9.95	18.93	8.09	0.36	0.33	0.41	1.75	0.00	80.93
1930	3	3.86	6.11	10.25	21.44	7.80	10.33	15.66	0.18	0.00	4.07	0.02	0.00	79.75
1931	3	5.82	9.77	8.67	9.42	21.17	12.62	1.17	4.86	0.00	0.00	0.00	2.45	75.95
1932	3	3.03	14.47	14.07	3.54	13.22	12.51	3.73	1.97	1.44	0.25	0.00	1.57	69.71
1933	3	3.26	25.30	24.38	30.86	14.56	18.41	6.57	4.29	3.18	7.99	7.54	0.24	144.58
1934	3	12.29	28.23	22.27	10.28	10.86	15.35	6.54	4.86	0.82	0.00	1.00	1.80	113.72
1935	3	5.69	8.27	9.56	11.94	12.03	11.84	2.60	6.57	0.00	0.00	0.00	0.09	68.58
1936	3	11.38	28.93	12.39	26.08	17.67	13.85	2.40	0.19	0.00	0.19	0.11	1.17	114.45
1937	4	8.04	5.46	8.57	20.41	22.09	3.25	10.01	2.65	10.01	0.67	9.39	2.62	104.18
1938	4	12.29	4.49	11.32	17.63	19.51	4.62	2.95	7.22	0.56	4.57	3.93	3.55	92.64
1939	4	12.10	18.54	9.30	11.74	12.10	10.18	12.03	8.65	0.80	0.30	0.12	9.08	104.71
1940	4	2.26	12.54	16.66	13.85	15.75	6.97	10.84	0.28	0.15	2.38	0.00	7.10	88.79
1941	4	15.37	0.35	5.22	23.80	12.26	18.52	8.59	4.14	0.81	0.01	6.89	2.11	97.96
1942	4	11.41	13.56	21.48	21.29	6.12	12.94	11.06	10.68	0.80	7.95	3.48	2.46	123.02
1943	4	21.83	20.52	24.65	15.93	16.97	7.66	0.80	3.74	8.10	2.66	0.00	9.78	132.45
1944	4	10.90	13.26	3.92	7.30	14.29	21.57	5.07	3.56	0.00	0.04	0.00	0.18	80.11
1945	4	3.07	5.24	8.50	13.50	11.22	9.36	5.79	7.69	0.00	0.29	0.00	1.10	65.74
1946	4	19.91	14.51	9.34	11.55	14.32	13.39	11.00	0.83	0.79	0.95	0.11	7.12	103.93
1947	4	13.24	14.60	18.26	11.10	7.85	27.62	10.95	3.88	0.00	0.19	0.22	1.11	109.15
1948	4	8.93	7.02	4.95	18.22	9.78	11.91	7.22	1.79	1.06	0.74	0.27	2.45	74.24
1949	4	10.27	12.79	13.15	17.13	12.30	18.62	13.26	9.35	0.80	2.03	7.30	1.81	120.61
1950	4	7.09	7.19	19.79	17.31	10.80	7.05	9.13	6.00	1.57	0.21	2.46	3.27	91.66
1951	4	24.66	4.08	12.56	15.46	18.63	10.27	4.32	1.44	0.59	4.69	1.93	2.86	101.55
1952	4	7.03	13.20	13.62	7.18	22.94	11.34	10.40	2.69	0.34	0.00	1.40	1.44	91.59
1953	4	11.27	9.56	14.50	18.86	10.96	14.15	2.27	3.78	0.71	0.14	0.00	2.67	88.90
1954	4	3.48	12.56	7.45	20.94	22.13	7.24	6.50	4.36	0.93	0.76	0.00	0.84	98.99
1955	4	11.12	20.03	17.99	5.26	17.71	10.86	5.66	8.20	0.09	0.40	0.03	2.95	100.35
1956	4	19.83	18.47	30.75	14.66	10.36	13.40	6.41	0.88	4.00	3.72	4.97	25.80	151.06
1957	4	26.32	12.72	10.96	18.91	4.95	8.23	10.59	4.34	0.73	0.01	0.00	7.27	104.94
1958	4	5.84	13.22	14.44	10.47	5.73	4.54	13.42	16.59	1.35	5.88	0.01	0.37	91.87
1959	4	15.20	12.21	20.75	10.89	18.75	18.41	11.18	4.06	0.20	2.02	4.85	5.85	124.38
1960	4	12.23	19.01	20.26	20.14	9.08	11.69	15.00	9.54	5.82	1.61	1.53	4.53	130.45
1961	4	1.23	19.99	10.08	10.03	19.86	11.71	8.37	1.06	0.00	0.00	1.56	2.05	85.63
1962	3	5.27	14.76	5.30	30.34	10.34	15.83	13.44	4.52	3.76	3.73	0.70	0.55	108.54
1963	3	9.04	14.40	10.37	17.06	10.96	20.38	5.47	1.12	7.48	0.00	4.12	2.53	102.91
1964	3	20.96	8.10	15.85	16.98	4.85	4.59	12.20	0.03	2.81	2.80	1.75	2.26	93.21
1965	3	4.83	15.47	2.86	26.19	9.67	4.06	2.44	1.84	0.51	0.00	1.30	1.30	70.50
1966	3	6.27	10.09	14.01	33.17	22.33	13.47	11.40	7.87	0.00	0.00	0.96	3.16	122.74
1967	3	8.04	12.13	6.33	5.20	5.18	15.81	9.73	8.23	0.44	0.61	1.97	1.13	78.77
1968	3	6.27	9.04	14.02	8.52	8.53	16.95	7.91	10.39	1.33	0.07	0.81	1.13	82.96
1969	3	16.96	7.28	17.20	13.52	8.15	4.64	3.53	2.18	3.56	4.81	3.48	6.07	91.22
1970	4	7.87	6.61	26.29	19.76	12.12	11.71	9.66	7.64	0.15	2.02	0.92	0.66	105.53
1971	4	6.35	7.80	10.59	17.09	18.23	18.21	3.59	3.96	1.57	0.22	1.11	4.50	90.23
1972	4	9.06	14.65	2.85	8.76	19.19	7.53	6.17	0.73	0.10	1.93	12.56	5.27	80.64
1973	4	3.29	11.92	14.34	22.20	10.99	13.59	4.44	1.72	2.10	0.02	0.77	1.18	86.56
1974	4	5.44	32.51	9.36	19.03	18.73	14.83	4.88	1.52	0.61	1.86	1.57	10.44	119.76
1975	4	7.74	23.09	17.59	15.87	22.10	28.19	10.48	4.12	2.67	0.00	0.50	9.89	142.25
1976	4	18.71	20.16	11.23	21.34	8.58	20.18	3.35	1.46	0.01	0.00	0.02	6.96	111.99
1977	4	17.50	4.37	14.20	25.37	9.18	19.61	12.53	0.83	1.23	0.68	3.40	6.62	115.50
1978	4	7.97	3.86	25.72	9.10	12.84	7.22	2.13	5.50	1.13	6.62	17.74	6.36	106.17
1979	4	11.42	16.68	13.74	9.43	17.67	5.41	1.62	1.82	0.30	0.00	0.52	13.63	92.26
1980	4	2.56	16.36	8.74	31.41	16.75	15.82	7.19	1.30	3.72	0.00	7.90	2.12	113.90
1981	4	2.73	16.03	21.52	12.69	3.43	7.18	16.60	1.24	1.45	2.41	0.00	4.15	89.41
1982	3	15.73	13.57	6.78	7.16	9.30	9.34	7.00	0.60	1.89	2.51	0.00	2.73	76.61
1983	3	13.43	19.20	16.09	17.43	5.75	12.75	5.44	4.79	0.89	0.34	5.24	0.32	103.45
1984	3	11.78	7.69	11.47	10.63	14.44	5.72	2.86	0.00	0.00	0.05	0.00	0.35	64.98
1985	3	10.94	12.92	22.22	12.43	13.28	6.36	11.72	0.00	6.73	0.00	7.79	2.31	106.69
1986	1	16.72	19.42	8.71	12.16	11.82	9.19	6.15	0.97	0.00	0.48	6.71	27.57	121.89
1987	1	3.66	18.03	35.83	33.18	14.23	28.19	11.61	1.45	2.56	2.49	0.00	7.12	158.46
	AVERAGE	10.11	13.47	14.19	15.69	12.97	12.67	7.32	3.59	1.76	1.49	2.29	4.42	100.00
	ADJUSTED	10.11	13.47	14.20	15.69	12.97	12.67	7.33	3.59	1.76	1.49	2.29	4.42	100.00

DETAILS OF RAINFALL STATIONS USED

SECTOR	POSITION	MAP	PERIOD OF RECORD		LAT	LONG
296	244	860	1920	1961	28.34	28.39
297	436	799	1930	1957	28.46	28.15
297	436	723	1956	1965	28.46	28.15
297	386	983	1937	1961	28.58	28.13
297	386	756	1970	1985	28.58	28.13
297	721	724	1920	1987	28.31	28.25

TABLE 6

RAINFALL DISTRIBUTION FOR SUBCATCHMENT 2

RAINFALL AS PERCENT M.A.P.

YEAR	NO. OF GAUGES	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR
1920	3	9.85	6.85	7.03	15.96	18.81	22.39	8.36	1.74	0.25	0.00	0.07	5.85	96.56
1921	3	3.63	18.98	20.92	21.23	7.81	7.47	0.21	3.27	3.80	0.31	4.15	0.37	90.04
1922	3	10.09	21.10	13.75	15.10	12.42	7.82	8.13	4.15	7.27	3.17	2.55	0.37	105.92
1923	4	5.14	9.96	7.52	15.47	11.80	26.11	1.47	1.21	0.49	0.19	0.40	10.06	99.81
1924	4	12.93	22.92	22.24	11.36	11.66	32.06	16.43	5.39	0.78	0.27	0.02	4.12	140.19
1925	4	5.86	11.69	5.59	10.24	14.35	16.93	0.94	1.85	1.39	0.00	0.00	8.96	77.92
1926	4	13.60	12.86	15.57	11.91	12.86	16.85	2.13	0.12	0.00	5.08	2.11	0.07	92.96
1927	4	13.03	4.15	19.68	17.58	13.11	11.34	4.55	0.24	0.64	0.00	0.66	2.91	87.92
1928	4	10.13	10.70	13.66	14.95	8.00	16.12	2.86	5.30	8.49	2.46	2.46	18.05	113.23
1929	4	6.32	16.10	21.23	14.14	12.01	21.58	9.56	1.93	0.36	0.00	1.82	0.98	106.02
1930	4	3.66	4.85	8.70	20.90	11.66	11.74	20.94	0.14	0.04	6.31	0.11	0.00	87.85
1931	5	7.37	14.08	8.41	9.18	16.94	10.21	0.70	1.82	0.22	0.00	0.00	2.72	71.66
1932	5	2.90	10.34	13.90	2.08	8.88	11.13	4.36	1.29	1.09	0.53	0.00	1.20	57.88
1933	5	2.02	28.32	19.90	35.74	10.33	15.47	8.84	12.53	0.10	6.29	5.15	0.89	144.19
1934	5	11.57	24.94	18.21	11.36	10.06	14.81	7.07	3.75	1.43	0.00	1.49	1.82	104.50
1935	5	5.24	11.49	11.07	10.40	10.91	14.82	4.34	7.85	0.03	0.00	0.00	0.06	78.02
1936	5	10.76	27.83	12.66	26.23	20.06	13.37	3.32	0.51	0.00	0.80	0.27	3.47	119.09
1937	5	4.64	5.43	11.52	18.57	20.66	3.86	12.22	2.36	5.02	0.82	6.39	1.10	90.90
1938	5	13.79	4.25	9.99	23.35	20.53	5.61	1.59	5.26	0.08	8.47	6.51	1.85	98.27
1939	5	11.46	16.27	10.21	10.20	10.22	9.41	11.16	5.44	1.03	0.36	0.00	9.99	95.77
1940	5	1.31	12.43	15.23	17.84	16.77	6.56	12.02	0.00	0.01	2.16	0.23	4.58	89.14
1941	5	13.53	0.36	2.71	19.53	15.91	16.71	9.84	3.29	0.14	0.00	7.08	1.55	92.46
1942	5	10.31	14.32	20.14	19.56	4.95	10.82	14.94	13.07	0.00	11.44	6.37	1.89	127.91
1943	5	21.53	29.59	24.66	12.39	18.19	9.33	0.47	4.44	9.21	0.00	0.00	7.73	137.54
1944	5	12.46	10.71	4.11	6.53	13.41	21.12	2.84	3.61	0.00	0.08	0.00	0.00	78.86
1945	5	1.44	7.21	5.94	18.61	13.18	15.81	7.17	6.39	0.01	0.21	0.00	0.80	76.78
1946	5	17.89	12.25	11.03	14.05	12.99	14.62	14.47	1.92	0.52	0.83	0.00	6.49	106.86
1947	5	15.13	11.81	23.31	9.89	7.13	31.45	11.55	3.06	0.00	0.04	0.19	0.51	114.10
1948	5	7.89	6.42	2.56	16.96	6.59	9.90	3.49	2.84	1.95	1.12	0.13	2.76	61.59
1949	5	11.18	10.42	17.56	16.30	13.42	20.95	18.55	11.40	1.02	3.04	7.66	0.97	132.49
1950	5	5.40	6.91	19.22	17.78	10.76	8.61	11.21	3.88	1.31	0.86	2.45	1.91	90.11
1951	5	21.04	5.48	7.34	19.09	19.80	9.84	4.08	0.74	0.86	5.89	0.97	3.15	98.78
1952	5	6.19	14.09	14.55	5.83	24.72	10.33	11.61	2.58	0.21	0.00	1.12	1.02	92.26
1953	5	11.06	12.27	12.88	18.29	15.50	17.33	1.59	4.03	1.80	0.08	0.00	0.97	93.56
1954	5	1.76	10.68	10.91	24.09	22.30	6.70	9.08	2.72	1.54	1.51	0.00	0.55	91.85
1955	5	9.46	15.49	15.89	7.38	22.73	16.67	4.39	6.11	0.05	0.30	0.05	2.84	103.16
1956	5	19.85	11.50	32.93	14.14	13.70	10.01	8.73	0.85	4.03	4.32	5.07	26.32	151.44
1957	5	27.61	12.69	14.85	23.99	7.67	12.94	12.04	5.97	0.22	0.00	0.00	5.90	123.59
1958	5	4.94	14.44	18.29	9.79	6.12	6.86	15.61	13.59	0.83	6.10	0.00	1.95	98.62
1959	5	11.03	11.97	19.83	6.69	18.41	14.50	8.78	2.07	1.08	2.15	4.39	3.43	104.32
1960	5	9.22	13.23	16.56	17.89	3.95	14.27	15.05	7.49	7.29	1.78	1.94	1.97	110.82
1961	5	0.85	18.63	8.18	7.52	23.09	8.82	7.98	1.06	0.00	0.00	1.02	1.81	78.96
1962	5	5.62	17.92	6.67	23.84	10.19	13.39	15.40	5.63	2.42	3.04	0.29	0.80	105.22
1963	5	8.54	19.11	13.03	10.50	9.97	23.16	7.29	0.70	6.77	0.19	2.86	1.80	103.51
1964	5	20.77	7.79	14.80	17.53	4.85	2.72	13.26	0.34	3.01	3.07	1.69	1.73	91.56
1965	5	4.86	11.79	3.45	24.25	15.35	5.49	2.71	1.06	1.39	0.00	0.74	0.79	71.70
1966	5	6.01	10.09	15.51	31.41	26.44	14.27	15.54	8.05	0.53	0.09	0.91	2.03	130.79
1967	5	9.77	12.00	9.03	6.33	3.62	15.01	11.02	9.35	0.47	1.15	2.89	0.70	81.42
1968	5	7.11	5.80	16.17	6.72	10.86	18.89	7.52	10.89	1.34	0.01	1.33	1.36	88.03
1969	4	15.99	4.61	12.91	15.80	5.84	3.80	3.06	2.12	2.72	4.37	2.48	7.04	80.54
1970	4	9.47	7.56	24.59	16.51	11.94	6.63	9.07	5.89	0.00	1.41	0.36	0.69	94.15
1971	4	6.11	6.94	12.53	21.26	22.67	22.07	4.75	2.85	2.76	0.17	0.50	0.42	103.03
1972	4	10.46	13.70	4.28	6.37	18.96	7.66	8.31	0.09	0.29	1.95	10.72	5.91	88.88
1973	4	1.36	8.97	13.85	27.63	10.81	11.55	5.47	1.13	0.74	0.00	2.09	1.78	85.20
1974	4	3.04	30.69	7.80	24.69	16.67	15.59	5.07	2.86	0.78	1.96	1.49	10.19	122.43
1975	4	6.88	18.02	22.84	16.82	24.14	20.18	9.67	4.43	1.82	0.00	0.24	9.13	133.56
1976	4	17.67	13.82	9.54	18.06	8.65	18.01	2.98	1.28	0.10	0.00	0.16	11.12	101.41
1977	4	12.31	9.92	14.56	27.61	10.59	20.22	16.76	0.48	1.18	0.90	2.47	6.05	122.07
1978	4	7.86	2.93	21.66	13.13	7.04	5.42	4.78	5.90	0.31	7.31	14.07	4.00	94.44
1979	4	10.59	14.48	13.27	10.06	14.78	6.97	2.80	1.26	0.00	0.00	0.15	14.60	88.97
1980	4	1.82	15.13	9.61	29.75	19.19	10.65	7.23	1.82	3.51	0.00	9.29	1.59	109.38
1981	4	3.40	12.18	24.73	11.56	4.93	7.45	16.66	0.34	2.11	2.48	0.00	3.84	89.67
1982	4	17.15	14.60	7.65	5.58	6.01	7.15	7.04	1.64	2.55	5.06	0.00	1.63	76.05
1983	4	12.36	17.86	18.41	15.32	4.22	14.18	2.74	4.90	0.28	0.22	6.50	0.39	97.40
1984	4	15.07	13.43	10.52	12.69	19.49	7.28	3.59	0.19	1.17	0.00	0.00	0.48	83.90
1985	4	10.59	9.74	20.84	13.05	11.03	7.47	12.21	0.00	6.53	0.00	7.36	3.45	102.26
1986	4	18.22	18.69	9.11	5.68	14.01	13.89	9.33	0.46	0.00	1.53	9.19	28.79	128.01
1987	4	3.90	16.78	18.56	14.01	21.18	24.23	13.39	3.99	2.94	1.67	1.56	7.14	129.38
	AVERAGE	9.58	12.90	13.86	15.65	13.36	13.34	8.12	3.66	1.61	1.60	2.22	4.13	100.03
	ADJUSTED	9.57	12.90	13.86	15.64	13.36	13.34	8.11	3.66	1.61	1.60	2.22	4.13	100.00

DETAILS OF RAINFALL STATIONS USED

SECTOR	POSITION	MAP	PERIOD OF RECORD		LAT	LONG
297	721	724	1920	1987	28.31	28.25
296	682	733	1920	1987	28.52	27.53
331	58	783	1920	1968	28.28	28.02
296	157	742	1931	1987	28.37	27.36
295	539	636	1923	1987	28.59	27.18

TABLE 7

RAINFALL DISTRIBUTION FOR SUBCATCHMENT 3

RAINFALL AS PERCENT M.A.P.

YEAR	NO. OF GAUGES	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR
1920	3	10.63	5.56	4.19	8.66	15.10	14.87	8.59	4.98	0.03	0.00	0.00	2.83	73.47
1921	3	4.98	20.84	27.09	18.50	7.33	1.26	0.00	3.50	7.38	0.88	1.72	0.34	91.65
1922	3	7.21	13.24	9.38	18.21	17.81	5.78	7.55	3.48	8.05	2.51	1.87	0.06	91.16
1923	3	4.51	10.54	3.31	18.24	7.32	31.70	2.51	1.50	0.50	0.00	0.24	8.61	86.97
1924	3	11.74	22.00	15.66	15.04	17.69	37.56	18.24	7.97	0.42	0.07	0.65	5.36	152.42
1925	3	7.65	8.95	6.41	7.77	9.49	18.92	2.53	1.56	0.57	0.00	0.00	4.06	65.90
1926	3	9.57	11.31	10.81	11.45	9.23	28.37	0.83	0.46	0.00	1.19	5.34	1.12	89.70
1927	3	12.81	7.06	18.81	24.42	9.59	14.20	8.30	0.21	0.48	0.00	1.20	0.87	93.74
1928	3	10.15	13.92	8.18	14.71	8.28	17.85	2.78	6.84	7.17	4.85	1.84	18.98	109.33
1929	3	3.57	10.73	19.05	12.43	9.14	17.35	15.18	5.18	0.05	0.00	3.99	0.00	96.68
1930	3	5.34	4.98	8.71	16.39	15.92	10.94	21.36	0.01	0.03	7.29	0.00	0.00	91.98
1931	3	10.15	27.11	8.83	11.03	13.70	17.29	1.37	3.40	0.25	0.08	0.00	5.59	98.79
1932	3	4.29	7.31	9.07	4.02	3.97	10.74	4.82	1.77	1.12	0.98	0.36	0.55	48.80
1933	3	1.05	31.00	24.05	44.51	9.97	13.47	9.96	11.34	0.10	3.21	4.07	1.46	154.21
1934	3	12.19	18.66	11.08	8.80	11.99	17.82	9.97	4.92	3.27	0.33	4.73	1.55	108.02
1935	3	8.31	13.24	11.86	11.71	11.08	15.32	4.17	7.99	0.04	0.13	0.00	0.21	83.86
1936	4	12.77	23.89	14.85	27.48	20.61	12.51	3.04	2.41	0.14	1.82	0.10	2.69	122.49
1937	4	4.03	10.22	15.19	14.65	22.22	3.04	14.20	1.56	4.56	2.15	2.43	2.29	96.57
1938	4	14.10	6.31	14.83	21.49	20.08	5.54	1.48	5.83	0.29	3.25	6.52	3.00	102.70
1939	4	17.95	17.21	7.03	5.06	12.42	13.70	13.34	6.34	0.71	1.56	0.00	12.37	108.29
1940	4	2.85	15.27	15.21	14.09	22.75	7.93	13.02	0.34	0.02	2.67	1.36	3.92	99.52
1941	4	14.81	0.38	4.37	18.15	10.97	17.16	10.78	1.31	0.05	0.00	6.35	2.91	88.93
1942	4	15.25	19.36	18.30	15.88	5.93	10.11	21.79	12.44	0.01	9.00	12.35	0.91	139.03
1943	4	17.23	32.05	16.00	11.45	14.17	6.54	2.14	4.83	7.86	0.00	0.00	5.15	119.22
1944	4	8.30	9.67	2.10	10.75	12.63	18.19	1.08	4.29	0.12	0.23	0.00	0.00	67.35
1945	4	3.19	7.56	9.28	23.15	7.01	16.52	5.24	7.57	1.36	0.76	0.00	1.93	83.60
1946	4	14.40	4.87	9.63	11.64	17.43	7.13	8.91	2.96	0.94	0.94	0.00	6.33	85.17
1947	4	12.81	7.03	20.19	13.15	7.75	34.86	9.03	5.04	0.00	0.33	0.03	0.00	110.03
1948	4	4.22	2.80	2.89	17.16	9.91	11.66	2.45	4.08	1.05	0.74	0.16	3.20	60.35
1949	4	7.51	12.64	17.99	10.72	14.81	25.28	25.20	12.29	1.79	5.74	12.49	1.80	148.28
1950	4	3.44	7.64	19.76	19.75	9.65	14.14	8.41	1.95	1.82	0.20	1.09	2.64	90.49
1951	4	19.11	3.07	3.50	15.25	15.85	11.93	4.04	1.63	0.94	7.63	3.12	5.50	91.57
1952	4	4.35	18.93	14.30	10.37	28.19	10.46	16.63	2.84	1.12	0.00	2.12	1.09	108.39
1953	4	12.94	12.55	14.78	7.91	17.28	21.06	3.70	6.35	1.61	0.08	0.00	0.64	98.89
1954	4	1.92	8.70	8.77	34.81	20.89	9.91	9.70	3.82	1.81	1.96	0.70	0.39	103.17
1955	4	7.97	11.32	17.92	10.90	28.74	20.80	7.89	7.16	0.17	0.20	0.00	1.90	114.78
1956	4	12.64	7.36	29.71	19.46	13.41	11.27	6.94	0.96	4.64	2.28	7.00	18.83	134.51
1957	5	24.07	13.54	12.47	20.98	7.80	9.54	11.12	9.74	0.12	0.01	0.00	4.56	113.78
1958	5	4.92	20.62	14.35	11.39	10.80	11.85	13.78	6.74	0.02	7.01	0.00	1.00	102.28
1959	5	10.01	13.32	20.82	9.84	11.27	16.89	8.39	2.09	1.64	1.92	4.83	2.52	103.15
1960	5	10.94	17.28	13.20	10.32	5.14	17.62	13.41	5.13	9.31	1.45	2.17	0.24	106.21
1961	5	0.13	22.15	18.10	7.20	32.29	13.99	8.23	0.78	0.00	0.00	0.03	1.11	102.01
1962	5	4.55	24.76	8.34	25.37	10.86	18.25	16.02	5.26	2.53	3.69	0.70	0.48	120.79
1963	5	6.17	23.51	10.91	4.86	9.77	24.06	8.03	1.26	6.14	0.01	0.91	1.39	97.02
1964	5	20.39	7.70	14.08	10.88	4.30	3.62	11.90	1.07	2.96	4.04	2.38	1.23	84.25
1965	5	4.15	10.94	3.57	33.23	13.48	4.77	3.11	1.71	2.40	0.00	0.31	0.04	77.72
1966	5	5.25	6.17	14.86	27.08	14.22	11.13	20.92	8.16	0.59	0.37	1.28	0.49	112.34
1967	5	8.53	7.13	10.99	8.10	1.51	15.74	13.41	8.97	0.31	3.04	2.28	2.31	82.30
1968	5	6.03	4.13	17.50	3.72	18.26	21.18	11.20	8.49	0.78	0.00	3.03	1.70	94.01
1969	5	18.17	4.93	5.86	13.98	3.82	2.91	2.18	1.22	2.74	2.89	2.42	8.57	69.50
1970	5	9.19	10.80	22.36	18.76	11.78	8.14	6.58	9.04	0.05	2.71	0.06	0.53	99.00
1971	5	6.49	4.74	10.32	24.04	28.50	23.04	4.65	2.58	2.88	0.00	1.06	1.31	109.41
1972	5	8.49	7.76	2.36	4.02	22.06	8.02	6.86	0.83	0.12	1.08	9.79	5.84	75.22
1973	5	2.15	8.90	9.85	34.22	19.06	12.03	6.67	1.28	0.68	0.00	5.28	1.82	102.23
1974	5	1.26	21.08	11.86	21.06	23.62	15.44	5.90	1.23	2.23	1.97	0.20	9.11	114.96
1975	5	3.99	21.47	16.12	27.12	20.37	24.66	10.60	4.81	2.37	0.01	0.04	10.16	141.72
1976	5	20.10	5.80	11.20	18.17	15.73	21.53	3.77	1.38	0.45	0.35	0.33	13.18	112.99
1977	5	14.55	11.05	11.86	26.10	13.37	20.14	16.86	0.00	1.48	0.70	2.15	5.70	123.76
1978	5	4.55	5.69	24.48	9.71	16.46	3.22	8.86	3.06	0.51	7.61	9.83	2.52	96.52
1979	5	10.65	10.06	9.97	7.87	9.87	8.52	4.43	0.65	0.16	0.22	0.52	9.73	72.96
1980	5	0.95	17.74	9.86	27.60	18.80	14.18	6.59	4.59	3.15	0.00	13.00	0.21	116.64
1981	5	4.71	11.55	17.14	8.36	10.70	7.85	22.56	0.62	3.25	3.92	0.00	4.83	95.51
1982	5	16.26	14.73	8.59	4.70	6.05	5.56	4.80	2.71	2.74	7.67	0.06	1.84	73.72
1983	5	10.44	18.50	11.32	14.02	4.54	8.48	3.05	11.77	0.50	0.10	6.38	0.62	89.73
1984	5	9.22	13.43	5.23	12.98	15.05	7.36	4.29	0.39	4.22	0.00	0.00	0.43	72.60
1985	5	14.59	17.90	15.83	9.31	9.77	12.63	3.74	0.00	5.36	0.01	7.95	3.52	100.63
1986	4	17.30	18.56	7.70	3.19	13.67	10.91	10.71	0.16	0.00	2.19	6.81	24.91	116.15
1987	4	4.75	17.34	11.29	5.19	33.33	18.64	14.56	3.59	3.42	0.63	1.02	6.68	120.82
	AVERAGE	8.87	12.68	12.24	15.42	13.98	14.22	8.45	3.84	1.73	1.70	2.65	3.89	99.68
	ADJUSTED	8.90	12.72	12.28	15.47	14.02	14.27	8.48	3.86	1.74	1.71	2.66	3.90	100.00

DETAILS OF RAINFALL STATIONS USED

SECTOR	POSITION	MAP	PERIOD OF RECORD		LAT	LONG
263	373	639	1918	1987	29.13	27.13
263	792	691	1919	1987	29.12	27.27
264	417	802	1936	1985	29.27	27.44
263	567	591	1920	1954	29.27	27.19
263	567	696	1955	1987	29.27	27.19
264	22	722	1957	1987	29.22	27.31

TABLE 8

RAINFALL DISTRIBUTION FOR SUBCATCHMENTS 4 AND 5

RAINFALL AS PERCENT M.A.P.

YEAR	NO. OF GAUGES	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR
1920	1	5.36	8.53	2.40	15.80	19.97	16.13	9.85	3.34	1.04	0.00	0.04	1.32	83.28
1921	1	4.78	20.39	19.14	16.73	5.56	1.84	0.04	1.35	9.56	2.13	5.06	0.11	86.50
1922	2	5.42	21.54	4.13	23.32	31.33	6.04	10.06	10.78	4.46	3.56	0.93	0.26	121.84
1923	2	3.66	9.20	1.51	12.37	10.53	35.97	3.86	0.80	0.84	0.12	0.49	7.47	85.71
1924	2	9.16	19.11	16.35	15.16	17.36	32.00	20.21	15.69	0.07	0.18	1.20	3.23	149.73
1925	2	3.09	8.74	5.74	4.97	13.66	16.67	3.74	3.70	2.06	0.27	0.00	1.83	66.69
1926	3	6.16	11.95	9.55	8.58	6.99	32.30	1.72	0.67	0.00	2.03	1.50	1.06	92.73
1927	3	14.22	6.22	12.13	20.71	7.34	12.50	7.37	0.30	0.72	0.12	0.57	2.18	84.39
1928	3	8.79	11.86	12.83	15.01	6.33	15.81	0.94	4.22	6.85	8.94	2.48	20.89	111.91
1929	3	8.51	6.35	26.25	13.02	8.06	11.84	11.17	2.95	1.17	0.23	2.86	0.00	90.22
1930	3	9.04	8.89	4.78	18.18	13.03	18.11	19.86	0.05	0.00	9.51	0.14	0.00	97.43
1931	3	.2.32	17.27	6.82	13.03	18.69	9.26	0.36	0.73	0.87	0.89	0.00	6.75	86.36
1932	3	3.81	6.04	12.72	13.87	8.29	8.10	8.79	0.86	1.59	0.05	0.35	0.22 -	82.77
1933	3	1.55	19.63	28.45	22.97	8.00	13.77	6.79	5.07	2.18	2.09	3.01	0.40	111.91
1934	3	15.59	17.02	18.22	7.83	11.72	20.90	10.75	10.04	1.48	0.72	8.90	0.76	121.63
1935	3	6.75	10.63	10.92	12.74	13.97	12.85	3.55	8.49	1.34	1.31	0.00	2.02	84.37
1936	3	12.44	23.93	13.12	28.94	27.47	10.33	1.17	3.19	0.27	1.38	0.27	0.54	122.94
1937	3	2.18	3.43	12.69	14.98	21.94	4.42	16.60	1.61	4.55	1.19	3.84	1.57	89.00
1938	3	10.48	11.43	12.04	24.39	23.06	4.29	5.33	8.51	0.63	4.14	6.09	1.34	111.71
1939	3	17.37	13.03	8.07	6.67	11.90	16.80	10.63	7.78	0.14	0.96	0.80	13.11	106.67
1940	3	2.28	9.86	18.30	13.81	21.70	5.43	6.79	1.10	0.32	3.66	1.01	5.93	82.20
1941	3	13.09	2.84 .	4.39	19.15	21.20	22.06	8.14	1.05	0.86	0.00	5.54	6.35	104.43
1942	3	10.82	15.43	26.28	12.12	12.24	11.93	20.70	17.99	0.00	1.69	6.49	2.78	138.14
1943	3	11.99	20.66	24.69	10.44	14.62	12.37	1.95	6.20	4.46	0.00	0.00	8.23	115.62
1944	3	4.44	12.57	2.79	10.09	13.24	18.80	1.31	6.44	0.09	0.53	0.00	0.00	70.40
1945	3	2.32	7.56	10.57	16.19	11.63	16.47	8.36	9.28	0.77	0.95	0.00	2.57	86.69
1946	3	12.51	5.80	11.06	10.94	17.88	4.59	8.96	6.29	0.85	1.52	0.79	11.06	93.14
1947	3	12.78	10.77	24.14	12.04	17.09	25.98	7.91	4.33	0.00	0.31	0.84	0.00	116.01
1948	3	12.18	3.33	6.36	9.04	8.62	11.29	2.08	5.10	1.62	1.45	0.00	1.44	62.50
1949	3	6.49	14.80	11.11	13.24	10.71	25.98	23.76	9.03	1.30	5.73	11.39	3.27	136.81
1950	3	5.07	7.88	18.36	13.89	15.91	13.45	8.92	1.60	2.32	3.03	1.20	7.64	99.06
1951	4	17.22	2.30	3.20	14.13	13.66	5.82	7.56	1.31	3.20	10.51	3.78	8.77	91.48
1952	4	5.22	8.91	6.98	6.78	22.42	6.70	10.77	1.79	0.09	0.00	2.40	3.82	77.86
1953	4	11.24	10.05	14.00	9.52	14.39	23.61	5.83	6.22	0.27	2.35	0.00	2.36	99.83
1954	5	2.53	7.76	14.98	29.65	27.90	8.26	10.15	3.75	2.34	1.28	1.02	0.97	110.18
1955	5	8.94	15.96	14.66	5.83	30.56	22.12	6.79	3.91	1.30	0.89	0.00	2.98	114.08
1956	5	6.32	15.86	20.80	11.47	13.47	12.34	6.97	1.86	1.72	3.51	6.97	22.50	123.58
1957	5	20.85	12.20	9.68	28.40	9.58	8.75	7.98	10.39	0.30	0.18	0.00	3.28	111.58
1958	5	6.42	18.80	19.40	9.97	11.98	12.08	11.47	6.67	0.82	7.71	0.32	0.63	105.87
1959	5	4.38	7.67	24.39	13.19	16.51	13.04	11.33	3.72	3.47	2.39	8.51	3.02	111.62
1960	5	9.12	11.54	10.10	9.86	7.54	21.17	12.20	15.08	6.78	3.14	2.39	0.90	111.81
1961	5	0.49	22.01	19.30	10.43	25.37	13.44	9.43	1.09	0.25	0.42	0.18	0.76	103.18
1962	5	2.86	22.07	7.22	24.98	8.15	17.93	16.90	3.48	4.43	5.85	1.32	0.69	113.88
1963	7	9.79	24.80	12.40	6.48	9.77	20.95	6.95	2.92	5.51	0.00	0.98	2.86	103.29
1964	7	19.46	5.26	12.27	11.50	5.75	6.43	13.88	0.10	3.91	2.03	4.34	1.55	86.31
1965	8	4.86	9.82	5.97	36.32	16.01	5.13	4.42	1.94	2.44	0.00	0.77	0.23	87.50
1966	8	5.17	11.28	12.83	33.64	9.98	12.31	19.70	9.21	2.29	1.06	3.05	1.01	121.35
1967	9	11.19	9.84	6.05	5.93	2.91	15.08	12.58	8.79	1.12	2.24	1.01	2.97	79.69
1968	9	6.82	8.80	17.86	7.07	16.56	24.20	12.02	5.09	0.55	0.89	3.37	1.74	102.57
1969	9	16.44	3.42	9.00	10.36	6.31	3.53	1.82	1.90	3.83	1.71	4.29	9.07	70.68
1970	9	8.26	6.86	17.77	14.31	15.41	10.35	9.78	4.32	0.10	2.47	0.85	0.70	91.17
1971	9	8.41	6.43	12.02	23.31	23.36	20.65	5.46	3.60	3.26	0.14	0.80	1.32	108.80
1972	9	8.27	6.24	6.09	6.31	20.82	10.54	7.84	2.72	0.29	1.04	7.94	4.26	81.96
1973	9	2.55	8.60	10.60	24.97	27.04	16.77	3.28	2.89	0.82	0.01	5.52	0.80	103.84
1974	9	6.87	18.79	11.52	13.82	14.25	15.54	7.83	1.21	3.41	3.80	1.06	9.85	107.75
1975	9	4.45	18.86	16.51	28.26	14.64	20.86	11.14	4.21	2.98	0.18	0.18	13.03	135.30
1976	9	23.25	3.79	9.47	18.62	13.97	19.62	4.85	3.06	0.70	0.00	0.59	12.78	110.72
1977	9	15.27	7.69	11.57	17.22	9.12	21.65	13.98	0.82	1.19	0.46	3.01	6.98	108.97
1978	9	2.90	6.85	20.15	6.90	16.07	5.24	5.53	5.18	0.96	7.82	10.49	2.86	90.96
1979	9	13.35	10.50	8.56	7.48	12.15	4.83	3.65	0.90	0.37	0.23	1.48	5.65	69.06
1980	9	0.37	13.31	7.12	25.54	18.66	10.50	5.46	6.96	3.43	0.13	12.69	0.83	104.80
1981	9	4.62	13.72	13.90	7.90	9.20	9.70	22.29	0.60	4.39	4.16	0.05	4.25	94.78
1982	9	17.46	10.07	4.90	6.56	4.29	8.70	7.66	5.35	3.81	6.52	0.19	3.01	80.65
1983	9	8.06	16.44	14.55	12.84	3.78	11.06	4.32	6.77	1.08	0.34	9.80	0.37	96.43
1984	9	9.21	7.96	6.57	13.61	16.34	7.49	6.00	0.25	4.59	0.14	0.00	0.50	72.87
1985	9	15.55	10.36	15.23	15.09	9.31	10.30	3.69	0.85	6.18	0.12	6.53	4.63	97.85
1986	9	16.65	17.40	5.40	2.79	14.04	8.04	9.54	0.20	2.36	2.39	10.32	19.24	110.36
1987	9	7.09	15.36	11.52	6.73	31.34	22.28	16.60	3.78	2.31	3.09	1.87	11.14	133.10
	AVERAGE	8.73	11.62	12.31	14.55	14.56	14.04	8.67	4.40	2.07	1.97	2.71	4.21	99.85
	ADJUSTED	8.75	11.64	12.33	14.57	14.58	14.06	8.68	4.41	2.08	1.98	2.71	4.22	100.00

DETAILS OF RAINFALL STATIONS USED

SECTOR	POSITION	MAP	PERIOD OF RECORD		LAT	LONG
233	439	713	1920	1989	29.49	27.15
204	819	745	1922	1989	30.09	27.28
234	8	797	1985	1989	29.38	27.31
234	111	830	1954	1989	29.51	27.34
234	150	762	1926	1989	29.6	27.35
264	417	812	1967	1989	29.27	27.44
264	715	958	1963	1989	29.25	27.54
264	836	1041	1963	1989	29.26	27.58
233	747	717	1951	1989	29.57	27.25

TABLE 9

SUBCATCHMENT MEAN MONTHLY EVAPORATION (mm)

SUB-CATCH NO	PAN TYPE	AVERAGE EVAPORATION (mm)												ANNUAL
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
1	S	145	161	175	165	111	112	83	52	49	52	76	119	1300
	A	202	220	238	220	165	147	110	92	73	73	128	165	1833
2	S	151	161	183	158	132	118	89	75	66	66	93	124	1416
	A	216	235	255	235	176	156	118	98	79	78	137	176	1959
3	S	163	185	200	192	149	130	89	70	53	62	90	132	1515
	A	230	251	272	251	189	168	126	104	84	84	147	189	2095
4,5	S	156	165	187	184	147	127	91	72	57	65	91	128	1470

NOTES : See FIGURE 1 for gross S-pan isolines

TABLE 10

PATCHED NATURAL STREAMFLOW DATA FOR D1H006

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	65.58+	26.58+	202.32+	76.78+	93.66+	288.16+	108.48+	12.94+	3.66+	1.62+	3.22	2.73	885.73
1948	41.12+	14.21+	2.91+	5.07+	8.89	54.9	1.66	14.9	3.31	1.71	1.36	1.14	151.18
1949	1.45	25.0	31.0	22.1	98.9	185	395	154	32.2	61.7	92.66+	138	1237.01
1950	9.8	5.02	291	51.5	38.3	117	57.3	6.32	7.73	6.53	5.16	4.07	599.73
1951	250	52.3	3.63	12.8	66.0	15.7	6.12	4.56	3.89	14.0	12.6	38.8	480.4
1952	10.49+	28.4	31.6	14.1	44.0	22.2	97.3	18.0	6.24	2.26	2.06	3.31	279.96
1953	57.5	24.7	88.3	20.6	28.1	236.03+	41.3	23.1	11.0	6.01	4.62	5.49	546.75
1954	4.30	4.32	57.43+	271.02+	345.01+	95.52+	44.43+	19.12+	5.67+	3.93+	2.34+	1.12+	854.21
1955	10.01+	63.02+	73.96+	19.20+	308.31+	298.83+	157	32.0	17.3	10.9	6.10	5.69	1002.32
1956	5.12+	44.1	207	36.3	104	36.7	24.5	5.98	3.79	4.16	9.9	241.90+	723.45
1957	258.06+	78.96+	55.9	234.08+	52.4	29.0	57.0	76.6	31.8	13.1	8.51	5.73	901.14
1958	4.64	98.30+	33.1	38.6	78.7	47.9	75.13+	38.91+	24.8	39.2	19.5	6.98	505.76
1959	15.7	33.6	137	31.9	37.0	47.6	74.7	49.3	18.9	12.7	26.6	14.7	499.7
1960	19.0	53.3	44.1	41.6	35.9	64.6	143	77.5	120	25.5	16.7	7.76	648.96
1961	0.492	80.3	200	51.1	222.63+	63.4	30.4	9.9	2.31	0.795	4.60	2.99	668.917
1962	1.64	68.2	35.0	115	67.8+	123.52+	275	34.8	17.7	35.4	20.7	9.3	804.06
1963	11.2	119	86.9	22.4	33.9	43.5	114	13.8	13.0	10.2	6.51	5.23	479.64
1964	151.23+	39.3	35.5	24.0	11.3	5.47	53.9	7.13	9.7	8.56	6.62	6.94	359.65
1965	5.76	13.3	13.2	359.67+	213	23.3	11.6	9.9	4.83	4.07	3.28	2.57	664.48
1966	3.98	20.6	20.6	326.81+	190	45.11+	210.78+	115.93+	23.1	31.0	15.4	9.2	1012.51
1967	21.9	62.9	12.8	9.2	2.06	19.8	34.7	66.3	17.6	22.0	5.88	2.35+	277.49
1968	6.02	7.38	52.9	12.0	27.3	132	102	22.2	17.4	9.00	18.6	3.39	410.19
1969	102.39+	28.0	10.0	26.3	20.6	2.26	1.77+	2.35+	7.19+	5.95+	7.47+	38.7	252.92
1970	33.5	17.1	79.0	38.1	38.5	43.0	32.3	34.7	9.9	8.30	4.72	1.52	340.64
1971	4.16	4.39	12.9	98.8	239.81+	217	73.2	66.9	44.8	13.3	6.81	5.52	787.59
1972	17.9	13.3	6.72	0.311	144.47+	50.9	23.70+	11.6	4.93	3.69	26.9	10.2	314.621
1973	5.18	7.49+	13.37+	180.14+	309.81+	198	94.2	22.4	11.5	7.97	9.19+	4.08+	863.33
1974	5.41+	72.3	53.83+	41.9	86.1	166	47.20+	7.74+	7.34+	15.9	7.52	26.8	538.04
1975	24.6	75.8	93.9	307	247	172	122	72.4	42.9	22.6	12.7	27.6	1220.5
1976	253	115	27.0	82.56+	77.50	168.99+	56.34+	13.7	10.7	7.78	5.30	68.78+	886.65
1977	42.1	35.2	44.4	145	60.9	70.9	236	53.2	16.0	11.1	9.5	9.91+	734.21
1978	15.6	8.07	131	24.7	32.3	27.2	10.0	9.0	2.56	10.5	64.8	41.1	376.83
1979	104	27.76+	9.22+	15.1	23.2	15.6	6.24	2.18	2.34	2.08	2.04	4.56	214.32
1980	3.00	27.53+	48.2	185.79+	176.78+	130	47.3	28.7	52.5	14.6	72.0	47.7	834.1
1981	13.6	31.8	46.1	17.5	30.2	21.7	243.91+	33.6	18.8	15.8	7.80	6.55	487.36
1982	39.2	128	24.7	10.1	5.87	7.25	9.8	11.5	10.4	21.9	10.6	4.40	283.72
1983	6.36	33.2	56.6	64.8	11.8	10.3	7.56	44.7	6.60	3.94	7.60	11.6	265.06
1984	12.3	16.6	24.6	20.6	26.7	40.7	9.73+	5.87	12.3	3.46	1.41	0.608	174.878
1985	87.76+	56.8	104	68.6	36.3	30.8	7.32	4.40	14.1	4.74	8.42	23.6	446.84
1986	57.6	142	25.6	6.50	16.8	9.8	20.5	5.27	3.80	3.72	31.1	201.95+	524.64
1987	60.5	90.7	100	24.0	323.50+	369	110	35.2	24.1	22.8	9.9	72.0	1241.7
AVG	45.0	46.2	64.1	76.9	97.9	91.4	79.9	31.2	17.0	12.8	14.6	27.5	604.4
% TOT	7.44	7.64	10.60	12.73	16.20	15.12	13.21	5.16	2.82	2.12	2.42	4.55	100.00

MEAN ANNUAL RUNOFF = 604.42 million cubic metres

STANDARD DEVIATION = 298.20 million cubic metres

+ PATCHED VALUE

TABLE 11

PATCHED STREAMFLOW DATA AT WELBEDACHT DAM (D2R004)/JAMMERDRIFT GAUGING WEIR (D2H001)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	49.70	18.74	5.91	109.50	178.21+	152.70	142.90	36.16	14.89+	3.06+	1.93+	6.03+	719.73
1921	4.94+	74.97	187.80	172.00	24.38	15.19	11.98	4.06	18.13	4.70	2.90	2.34	523.39
1922	30.17	138.80	49.79	144.20	330.50	68.76	74.31	58.11	74.36	58.15	24.27	21.40	1072.82
1923	8.04	71.74	28.97	54.85	122.20	353.40	50.43	16.75	9.85	5.68	3.01	40.25	765.17
1924	82.43	521.90	272.20	142.60	147.70	834.00	354.00	212.00	136.80	33.30	20.47	22.24	2779.64
1925	68.11	67.08	43.00	28.34	69.22	136.10	35.86	11.11	9.32	6.67	4.33	10.04	489.18
1926	21.81	133.80	97.77	86.71	77.31	202.80	53.33	10.65	5.66	6.18	12.66	3.77	712.45
1927	78.71	28.22	117.20	253.40	116.10	77.68	35.29	8.92	6.41	4.77	3.01	1.51	731.22
1928	52.21	54.27	93.64	103.30	35.75	143.80	40.88	18.41	48.78	56.99	13.63	152.90	814.56
1929	102.30	78.70	243.70	122.40	74.83	137.50	211.60	29.31	15.38	10.61	7.17	6.86	1040.36
1930	50.54	8.55	19.54	138.50	131.20	81.16	329.90	32.56	15.94	22.86	9.58	2.76	843.09
1931	24.68	184.00	20.09	79.96	126.20	114.50	29.28	10.34	6.34	3.95	3.06	8.52	610.92
1932	5.58	36.34	43.97	22.74	54.23	49.57	19.91	0.53	6.41	1.96	0.33	0.00	241.57
1933	0.00	381.30	382.80	1307.00	288.60	338.00	239.50	114.60	96.93	74.25	123.40	27.16	3373.54
1934	60.54	416.50	320.30	80.83	53.03	188.80	90.21	115.90	38.58	22.26	11.43	12.86	1411.24
1935	15.04	40.67	17.45	101.30	57.51	34.30	70.46	35.42	22.41	4.01	2.23	1.00	401.80
1936	41.77	357.00	158.20	405.90	444.60	160.10	95.10	32.87	13.84	7.46	4.03	3.85	1724.72
1937	8.67	15.68	26.36	49.26	272.00	77.13	54.20	31.35	20.54	19.31	20.32	36.18	631.00
1938	44.10	50.42	79.29	173.40	458.70	131.00	29.45	35.29	11.47	14.88	26.00	19.96	1073.96
1939	150.50	243.40	50.38	24.70	58.97	76.25	66.74	118.70	17.33	8.71	5.04	73.05	893.77
1940	29.85	144.50	102.20	121.90	368.90	90.73	76.81	25.52	6.69	6.76	3.79	11.24	988.89
1941	95.75	24.93	4.84	139.20	111.10	347.20	76.07	35.72	9.85	4.86	22.76	22.82	895.10
1942	73.03	131.50	380.70	231.10	96.24	99.80	103.60	281.60	57.36	114.80	106.60	166.10	1842.43
1943	330.40	826.40	754.40	366.40	338.90	175.70	43.03	23.45	88.11	28.77	14.73	41.24	3031.53
1944	112.50	88.05	39.49	14.92	42.80	237.90	47.37	33.60	16.58	7.25	3.88	3.67	648.01
1945	12.87	12.95	26.42	181.50	111.20	82.19	69.57	50.54	23.27	4.82	3.79	3.67	582.79
1946	132.80	93.49	67.17	72.00	138.10	49.67	89.27	101.50	7.47	4.55	3.79	21.16	780.97
1947	103.80	79.57	229.60	122.10	56.73	589.30	134.00	78.74	27.20	13.51	7.72	3.22	1445.49
1948	25.34	21.71	2.50	60.37	74.66	63.92	8.29	11.06	3.59	2.14	0.96	1.53	276.07
1949	5.53	181.10	164.40	120.70	133.80	415.20	573.10	361.00	73.13	78.83	144.30	76.59	2327.68
1950	46.78	21.14	168.30	355.40	122.00	87.43	72.42	43.23	27.23	15.66	7.32	8.09	975.00
1951	436.00	170.30	52.38	57.50	187.50	174.40	30.96	8.95	7.84	25.50	10.37	13.41	1175.11
1952	9.48	114.60	97.17	50.16	181.90	58.43	151.60	37.93	14.63	2.71	2.35	1.90	722.86
1953	94.39	88.15	219.60	129.60	115.20	367.60	119.50	81.18	57.26	36.70	1.93+	1.96+	1313.07
1954	1.48+	25.40+	56.98+	341.26+	761.24+	133.56+	70.09+	110.40	44.96	35.48	23.27	2.47	1606.59
1955	25.93	101.70	405.50	105.80	289.90	277.90	227.20	71.15	33.51	16.77	12.68	9.19	1577.23
1956	29.14	249.90	808.60	266.10	280.00	205.40	126.00	22.43	18.24	36.38	43.37	512.10	2597.66
1957	971.20	354.60	339.90	469.40	156.50	83.24	109.70	105.00	37.83	14.16	8.63	17.57	2667.73
1958	9.04	224.80	69.47	72.75	96.60	49.03	31.70	308.40	43.22	58.50	21.21	9.41	994.13
1959	48.06	123.60	237.80	90.88	152.50	161.30	182.90	53.77	16.59	15.55	24.34	15.07	1122.36
1960	60.20	75.30	89.50	178.00	80.90	112.00	208.00	99.10	187.00	36.20	26.80	12.10	1165.10
1961	4.59	120.00	204.00	38.70	495.00	148.00	43.90	24.70	11.60	9.15	6.77	5.48	1111.89
1962	9.32	92.50	21.80	237.00	145.00	198.00	423.00	70.80	26.60	35.80	18.60	7.23	1285.65
1963	7.05	124.00+	111.00	46.60	43.50	103.00	217.00	18.90	20.50	7.68	9.66	4.73	713.62
1964	192.00	99.10	74.50	77.00	37.70	0.92	36.70	10.00	8.13	4.58	4.58	4.69	549.90
1965	4.85	17.20	11.60	296.00	263.00	9.88	5.33	5.45	4.99	2.91	1.78	1.08	624.07
1966	2.13	40.80	75.20	162.00	663.00	103.00	280.00	79.00	116.00	25.10	13.10	7.95	1567.28
1967	15.40	94.20	34.30	12.70	6.09	41.80	61.10	100.00	16.60	11.50	6.08	5.93	405.70
1968	11.50	5.21	56.20	5.70	50.10	114.00	130.00	49.30	25.80	7.33	8.34	2.78	466.26
1969	68.70	27.10	42.40	39.50	50.90	5.12	0.00	0.00	0.45	2.83	1.54	17.00+	265.34
1970	79.50	44.50	160.00	168.00	117.00	47.10	187.00+	41.50	9.63	5.00	3.62	8.00+	809.36
1971	2.74	4.73	25.86	366.00+	417.00+	388.80	86.27	120.00+	17.00+	6.45	2.07	11.00+	1179.70
1972	19.90	43.16	16.00+	0.44	150.57	37.63	34.37	1.16	1.37	0.71	42.00+	25.00+	379.31
1973	18.23	20.13	118.15	482.09	540.98	163.25	91.67	21.71	11.60	7.19	9.59	5.23	1489.82
1974	1.60	223.93	130.79	163.04	409.57	516.46	53.73	30.20	14.04	17.08	13.14	7.05	1580.63
1975	29.74	204.12	274.36	975.78	1248.21	813.47	497.22	178.26	72.64	37.56	21.73	54.30	4407.39
1976	598.10	297.51	79.86	129.99	280.50	590.41	81.70	28.83	18.41	11.64	9.67	53.03	2179.65
1977	158.69	76.05	53.72	506.89	207.98	185.49	849.03	95.32	39.84	26.44	19.22	26.56	2245.23
1978	40.81	16.34	464.80	51.33	70.66	39.85	8.33	7.71	6.41	23.90	194.02	61.23	985.39
1979	181.35	144.70	118.83	45.30	92.33	57.62	12.83	1.16	4.00	4.46	3.62	21.02	687.22
1980	15.40	40.71	77.79	465.08	361.98	315.59	81.12	40.59	44.31	13.01	88.63	31.67	1575.88
1981	10.82	98.55	129.24	50.98	65.61	17.90	260.16	42.45	17.92	14.24	5.28	4.96	718.11
1982	63.07	269.99	46.23	8.93	24.61	12.69	12.43	7.83	6.66	20.52	5.31	1.33	479.60
1983	26.78	74.43	120.75	238.80	16.73	42.99	20.87	49.81	2.37	2.68	7.24	16.22	621.67
1984	12.89	71.96	53.73	42.58	93.72	97.26	16.26	0.00	12.11	1.21	0.00	0.00	401.72
1985	8.86	146.29	282.47	66.19	112.74	57.53	19.35	4.98	20.87	1.93	4.88	23.37	749.46
1986	97.83	537.08	50.54	11.95	29.05	28.53	77.91	5.03	0.76	0.71	38.19	316.26	1193.84
1987	154.42	175.95	312.04	102.40	909.13	1368.08	269.95	75.21	49.19	41.32	18.87	96.18	3572.78
AVG	79.3	135.1	143.0	175.6	204.7	187.3	124.2	58.6	29.0	18.7	19.9	32.7	1203.5
% TOT	6.59	11.22	11.86	14.50	16.85	15.57	10.25	4.80	2.41	1.56	1.67	2.72	100.00

MEAN ANNUAL RUNOFF = 1203.47 million cubic metres

STANDARD DEVIATION = 849.28 million cubic metres

+ PATCHED VALUE

TABLE 12

WRSM90 MODEL PARAMETERS

SUB-CATCH NUMBER	AREA (km^2)	MAP (mm)	MODEL PARAMETERS											Mean Annual Runoff		
			POW	SL	ST	FT	GW	ZMIN	ZMAX	PI	TL	GL	R	10^6 m^3	mm	% Rainfall
1	2774	906	3	0	145	14	5	999	999	1.0	.5	2	.5	472.4	170	18.8
2	5625	727	3	0	145	0	0	40	420	1.0	.5	2	.5	423.1	75	10.4
3	5022	670	3	0	145	0	0	40	420	1.0	.5	2	.5	321.3	64	9.6
4	2154	896	3	0	30	14	0	999	999	1.5	.25	0	.5	519.4	241	26.9
5	815	705	3	0	55	0	0	50	450	1.5	.25	0	.5	71.2	87	12.3

NOTES : See FIGURE 1 for respective subcatchments

TABLE 13

WRSM90 : Results for System MAKHALENG

CALIBRATION PARAMETERS

Runoff Submodel	4	5
POW - Power of soil moisture/subsurface flow eqn.	3.00	3.00
SL - Soil moisture state when subsurface flow=0	.00	.00
ST - Soil moisture capacity in mm	30.00	55.00
FT - Subsurface flow at soil moisture capacity	14.00	.00
GW - Maximum groundwater flow in mm/month	.00	.00
ZMIN - Minimum catchment absorption in mm/month	999.00	50.00
ZMAX - Maximum catchment absorption in mm/month	999.00	450.00
PI - Interception storage in mm	1.50	1.50
TL - Lag of flow (excluding groundwater)	.25	.25
GL - Lag of groundwater flow in months	.00	.00
R - Coeff. in evaporation/soil moisture eqn.	.50	.50

FLOW STATISTICS : ROUTE NO. 3 (FLOW AT GAUGE D1H006)

INDEX	UNITS	OBSERVED	SIMULATED
MEAN ANNUAL RUNOFF (M A R)	M**3*10**6	604.42	589.03
STANDARD DEVIATION OF ANNUAL FLOWS (S)	M**3*10**6	298.20	255.87
COEFFICIENT OF VARIABILITY (S/MAR)	PERCENT	49.34	43.44
COEFF. OF SKEWNESS	-	0.5015	0.0839
RANGE	PERCENT MAR	353.82	362.26
AUTOCORRELATION COEFF OF ANNUAL FLOWS	-	0.0419	0.0182
MEAN OF LOGS OF ANNUAL FLOWS	(M**3*10**6)	2.7237	2.7201
STD. DEV. OF LOGS OF ANNUAL FLOWS	-	0.2366	0.2275
INDEX OF SEASONAL VARIABILITY	PERCENT	26.20	28.04

CALIBRATION PERIOD : 1947/48 - 1987/88

TABLE 14

WRSM90 : Results for System CALEDON

CALIBRATION PARAMETERS

Runoff Submodel	1	2	3
POW - Power of soil moisture/subsurface flow eqn.	3.00	3.00	3.00
SL - Soil moisture state when subsurface flow=0	.00	.00	.00
ST - Soil moisture capacity in mm	145.00	145.00	145.00
FT - Subsurface flow at soil moisture capacity	14.00	.00	.00
GW - Maximum groundwater flow in mm/month	5.00	.00	.00
ZMIN - Minimum catchment absorption in mm/month	999.00	40.00	40.00
ZMAX - Maximum catchment absorption in mm/month	999.00	420.00	420.00
PI - Interception storage in mm	1.00	1.00	1.00
TL - Lag of flow (excluding groundwater)	.50	.50	.50
GL - Lag of groundwater flow in months	2.00	2.00	2.00
R - Coeff. in evaporation/soil moisture eqn.	.50	.50	.50

FLOW STATISTICS : ROUTE NO. 20 (FLOW AT D2R004/D2H001)

INDEX	UNITS	OBSERVED	SIMULATED
MEAN ANNUAL RUNOFF (M A R)	M**3*10**6	1208.08	1207.88
STANDARD DEVIATION OF ANNUAL FLOWS (S)	M**3*10**6	849.66	777.53
COEFFICIENT OF VARIABILITY (S/MAR)	PERCENT	70.33	64.37
COEFF. OF SKEWNESS	-	1.6777	1.3521
RANGE	PERCENT MAR	523.25	371.65
AUTOCORRELATION COEFF OF ANNUAL FLOWS	-	0.1495	-0.0498
MEAN OF LOGS OF ANNUAL FLOWS	(M**3*10**6)	2.9920	2.9984
STD. DEV. OF LOGS OF ANNUAL FLOWS	-	0.2799	0.2774
INDEX OF SEASONAL VARIABILITY	PERCENT	30.28	32.21

CALIBRATION PERIOD : 1920/21 - 1987/88

TABLE 15

NATURAL SIMULATED STREAMFLOW FOR SUBCATCHMENT 4

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	4.8	5.9	1.9	37.4	129.5	125.5	84.2	16.3	3.6	1.9	1.1	0.9	392.8
1921	2.7	109.8	141.7	86.8	19.3	1.1	0.3	1.0	58.5	23.6	9.9	3.7	456.1
1922	3.4	124.0	42.0	129.5	304.0	91.3	41.0	77.9	31.2	11.3	4.8	1.1	861.5
1923	1.5	4.6	1.5	9.4	14.9	341.9	116.9	2.7	1.9	1.7	1.3	9.9	508.3
1924	15.4	97.7	102.8	57.9	98.5	316.9	267.3	186.5	45.1	1.7	1.7	2.5	1192.2
1925	1.8	5.3	3.8	1.4	41.4	133.9	43.5	5.9	5.0	2.8	1.3	1.2	247.1
1926	4.5	16.5	13.1	6.1	4.8	292.6	98.9	1.7	1.2	3.4	3.1	1.4	447.2
1927	64.4	23.5	23.6	105.7	38.9	43.8	27.2	5.6	1.8	1.8	1.4	1.5	336.8
1928	10.1	17.8	38.7	43.0	13.7	82.6	28.1	7.3	30.3	33.3	11.8	169.1	483.8
1929	61.4	4.0	194.0	79.2	10.2	34.5	64.1	21.6	3.4	2.1	3.6	1.6	479.6
1930	10.4	8.8	3.2	45.6	49.6	97.4	190.3	55.3	1.1	56.6	20.6	0.9	539.7
1931	41.7	85.6	27.1	15.5	106.0	45.1	4.4	1.0	1.6	2.0	1.3	8.0	339.2
1932	4.4	2.4	29.9	30.9	12.8	9.6	12.3	4.9	3.0	2.2	1.3	0.7	114.4
1933	0.5	99.1	229.9	191.7	47.3	59.2	28.9	11.8	6.9	5.1	5.1	2.0	687.6
1934	80.8	95.7	92.9	25.7	23.9	153.3	97.4	71.7	21.6	2.9	40.0	14.2	720.1
1935	5.5	10.4	16.8	16.8	49.1	59.5	17.8	35.9	14.5	3.4	1.7	1.3	232.7
1936	43.7	167.6	85.4	209.5	278.3	92.9	8.3	4.7	2.9	2.9	1.9	0.8	898.8
1937	0.7	0.6	28.9	41.7	152.2	49.3	121.5	42.6	9.3	6.2	6.2	2.9	462.1
1938	24.7	19.1	25.8	150.2	203.7	54.1	6.4	17.9	7.5	10.9	36.6	12.4	569.1
1939	103.2	57.9	13.1	3.4	22.6	99.2	77.7	43.6	11.1	2.4	1.7	68.3	504.0
1940	23.6	7.2	97.3	51.2	145.0	49.4	28.2	10.8	1.7	8.2	4.8	6.7	434.0
1941	54.0	17.7	2.5	79.9	158.8	205.1	75.3	8.9	2.2	1.7	9.3	10.7	625.9
1942	25.2	57.7	211.0	74.4	29.2	44.7	186.5	218.0	55.3	3.4	16.3	7.3	929.0
1943	39.1	125.4	212.3	64.5	54.7	58.8	15.2	12.1	13.3	5.3	1.5	14.8	616.8
1944	7.2	22.1	7.5	5.5	38.6	132.8	41.3	14.1	6.3	1.9	1.2	0.6	279.2
1945	0.7	3.5	12.0	71.9	45.2	97.7	54.1	53.9	17.6	2.6	1.5	1.7	362.4
1946	44.7	16.5	15.5	11.6	93.7	32.7	38.7	26.7	7.0	3.3	2.2	43.8	336.6
1947	63.0	25.2	170.7	65.3	85.2	238.2	89.6	12.9	3.7	1.6	1.4	0.7	757.5
1948	40.1	13.9	2.9	4.8	7.6	31.0	11.1	8.2	5.8	3.7	1.8	1.1	131.9
1949	5.0	42.2	29.1	21.7	18.7	214.8	286.6	116.7	17.7	20.3	80.7	27.5	880.9
1950	3.8	4.7	96.6	52.9	74.8	76.5	44.7	11.1	4.1	6.8	4.0	10.5	390.3
1951	105.8	34.6	1.2	22.9	49.3	17.6	15.6	6.7	6.8	80.9	32.4	23.6	397.3
1952	10.4	6.4	8.6	4.0	149.4	54.7	49.7	18.4	1.9	1.2	2.7	3.6	311.0
1953	31.0	17.5	46.5	19.3	51.4	196.9	67.1	15.6	6.2	4.8	2.6	1.6	460.5
1954	1.2	3.8	54.8	226.2	283.4	79.7	44.0	19.0	5.7	3.9	2.3	1.1	725.1
1955	9.8	59.5	70.4	18.4	254.2	247.4	64.3	9.1	4.4	2.8	1.5	2.0	743.6
1956	5.1	54.2	143.3	50.0	42.3	54.0	23.3	5.6	3.3	7.5	24.3	198.2	611.0
1957	213.2	67.8	14.3	195.5	72.8	12.2	22.6	66.1	21.8	1.8	1.1	2.2	691.3
1958	5.4	88.9	137.7	41.6	24.7	45.4	69.5	37.1	8.2	38.0	14.3	1.1	512.0
1959	2.2	4.1	171.3	72.9	80.3	74.0	71.6	23.7	8.0	6.9	38.0	14.5	567.5
1960	12.0	15.5	13.2	8.3	6.2	150.3	118.3	142.5	93.5	24.8	5.7	1.9	590.2
1961	0.4	128.0	150.2	42.0	188.6	115.8	50.7	12.6	1.7	1.6	1.3	0.8	691.6
1962	1.1	129.3	47.0	151.2	52.7	108.7	161.9	47.0	10.5	24.6	9.7	1.4	744.9
1963	17.0	169.5	81.0	10.3	9.2	149.5	58.7	7.0	15.4	6.8	1.9	2.1	528.6
1964	130.2	44.7	24.8	16.2	5.0	5.2	85.0	29.1	7.9	6.9	7.9	3.4	366.2
1965	2.7	7.3	4.6	292.4	167.2	26.1	5.0	3.6	4.4	2.7	1.6	0.8	518.4
1966	3.0	10.7	31.8	267.9	95.7	43.9	175.1	100.0	19.7	3.8	4.4	2.1	758.0
1967	29.2	16.7	4.9	2.0	1.2	73.1	95.1	63.8	16.0	4.6	2.9	2.4	311.8
1968	6.0	4.2	89.9	31.7	75.7	213.0	127.5	30.1	4.9	2.3	4.6	2.6	592.4
1969	91.7	31.1	5.1	7.6	4.8	2.2	1.8	2.4	7.2	6.0	7.5	26.6	193.9
1970	16.9	5.7	89.0	54.2	70.1	42.4	43.8	18.7	3.7	4.8	3.1	1.1	353.5
1971	4.7	3.8	22.5	136.8	202.8	196.6	54.4	7.0	7.3	3.7	1.7	1.1	642.4
1972	8.6	4.9	3.2	2.2	126.2	65.5	23.5	8.6	2.5	2.4	28.9	13.3	289.7
1973	2.2	5.0	12.6	153.7	256.4	163.8	34.4	3.9	2.7	1.7	9.2	4.1	649.9
1974	5.4	91.4	49.7	26.2	54.9	95.1	44.1	7.7	7.3	10.6	5.0	30.1	427.4
1975	12.2	91.0	103.6	215.5	117.1	163.1	102.1	24.1	7.4	3.6	1.4	67.0	907.9
1976	201.6	60.6	8.0	76.0	69.7	144.7	48.5	5.6	3.0	1.7	1.3	64.2	684.8
1977	99.9	29.9	21.3	63.8	26.4	157.8	140.9	31.3	2.5	2.2	3.9	9.9	589.6
1978	4.2	3.0	118.0	40.9	70.6	26.2	7.2	10.7	5.3	42.1	76.7	23.3	428.1
1979	55.0	26.5	8.9	4.3	25.3	10.6	3.6	2.2	1.6	1.6	2.0	6.0	147.6
1980	2.2	25.9	12.4	158.0	153.7	57.5	14.2	23.1	13.6	4.1	86.7	29.8	581.3
1981	2.6	31.4	53.0	17.0	8.4	17.6	200.1	66.6	10.3	13.3	5.1	3.7	429.0
1982	105.8	42.5	4.0	3.8	2.2	9.3	19.0	14.5	11.0	31.5	11.4	2.4	257.5
1983	8.6	64.7	71.0	29.8	5.2	25.9	12.7	19.7	8.7	2.3	38.3	13.6	300.2
1984	11.9	7.8	4.4	20.4	79.3	30.7	9.7	3.7	10.5	5.7	1.5	0.7	186.4
1985	80.2	34.9	61.0	52.7	18.8	23.8	10.3	2.3	18.5	8.3	15.5	9.3	335.6
1986	121.3	113.5	26.4	0.8	45.0	22.6	36.4	12.5	3.8	5.5	60.1	168.3	616.1
1987	56.0	51.5	36.2	8.3	265.2	253.2	177.6	46.4	5.7	7.2	4.7	45.7	957.5
AVG	33.4	42.4	55.5	63.8	82.0	96.2	65.8	30.3	11.3	9.1	11.8	17.9	519.4

TABLE 16

NATURAL SIMULATED STREAMFLOW FOR SUBCATCHMENT 5

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.0	0.2	0.1	3.1	18.7	16.9	4.0	0.1	0.0	0.0	0.0	0.0	43.0
1921	0.0	14.6	19.8	9.2	1.4	0.0	0.0	0.0	5.7	1.9	0.0	0.0	52.7
1922	0.0	18.4	6.1	19.8	67.4	20.3	0.4	9.4	3.1	0.0	0.0	0.0	144.9
1923	0.0	0.1	0.0	1.1	0.9	83.9	27.9	0.0	0.0	0.0	0.0	0.1	114.1
1924	0.3	11.5	10.2	4.9	10.3	73.3	61.7	40.9	9.4	0.0	0.0	0.0	222.4
1925	0.0	0.2	0.1	0.0	1.6	20.6	6.7	0.0	0.0	0.0	0.0	0.0	29.3
1926	0.0	1.0	0.6	0.3	0.1	68.8	22.9	0.0	0.0	0.0	0.0	0.0	93.7
1927	4.0	1.3	1.1	12.8	4.2	1.2	0.5	0.0	0.0	0.0	0.0	0.0	25.0
1928	0.2	1.0	1.7	3.2	[illegible]	8.2	2.7	0.0	0.0	0.0	0.0	34.9	52.9
1929	11.7	0.0	38.1	14.1	0.6	0.9	4.4	1.4	0.0	0.0	0.0	0.0	71.1
1930	0.2	0.3	0.1	3.7	2.7	11.1	38.8	11.7	0.0	8.6	2.2	0.0	77.3
1931	1.1	6.8	2.2	1.5	13.6	4.6	0.1	0.0	0.0	0.0	0.0	0.0	29.9
1932	0.0	0.0	1.3	2.4	0.8	0.2	0.1	0.0	0.0	0.0	0.0	0.0	4.8
1933	0.0	11.7	45.8	34.2	6.6	2.9	1.0	0.0	0.0	0.0	0.0	0.0	102.3
1934	7.7	8.4	7.9	2.1	0.9	27.8	12.5	7.6	2.2	0.0	0.2	0.1	77.2
1935	0.0	0.6	0.8	1.5	2.4	1.9	0.4	0.2	0.1	0.0	0.0	0.0	7.9
1936	1.2	28.8	11.0	41.3	60.0	16.0	0.2	0.0	0.0	0.0	0.0	0.0	158.3
1937	0.0	0.0	1.3	3.1	25.4	8.2	19.5	6.5	0.0	0.0	0.0	0.0	63.9
1938	0.5	1.0	1.3	24.9	37.2	9.7	0.0	0.0	0.0	0.0	0.1	0.0	74.7
1939	13.7	6.0	0.6	0.1	1.0	12.2	6.8	1.0	0.0	0.0	0.0	5.6	46.9
1940	1.9	0.4	11.4	5.6	24.1	7.8	0.2	0.1	0.0	0.0	0.0	0.0	51.4
1941	2.1	0.7	0.0	7.2	25.0	40.2	11.0	0.0	0.0	0.0	0.0	0.0	86.2
1942	0.5	3.2	42.3	14.8	1.4	1.3	39.3	50.0	12.3	0.0	0.0	0.0	165.2
1943	1.0	17.2	41.1	12.3	2.6	1.9	0.4	0.0	0.0	0.0	0.0	0.1	76.6
1944	0.0	1.2	0.4	0.4	1.7	20.6	6.7	0.0	0.0	0.0	0.0	0.0	31.1
1945	0.0	0.1	0.6	6.1	2.8	11.8	4.0	3.7	1.2	0.0	0.0	0.0	30.2
1946	1.2	0.4	0.7	0.8	10.5	3.4	0.4	0.2	0.0	0.0	0.0	0.7	18.2
1947	2.6	1.4	31.7	11.5	8.5	50.0	15.9	0.0	0.0	0.0	0.0	0.0	121.4
1948	1.1	0.4	0.0	0.2	0.3	0.8	0.3	0.0	0.0	0.0	0.0	0.0	3.0
1949	0.0	2.4	1.5	1.8	1.1	46.3	66.8	20.9	1.3	0.0	12.0	4.0	158.1
1950	0.0	0.1	11.2	5.5	5.6	4.6	1.2	0.1	0.0	0.0	0.0	0.1	28.3
1951	15.1	5.0	0.0	2.1	2.5	0.6	0.1	0.0	0.0	11.3	3.8	0.2	40.7
1952	0.1	0.2	0.3	0.1	24.5	8.2	1.7	0.6	0.0	0.0	0.0	0.0	35.6
1953	0.7	0.7	2.1	1.0	2.4	39.1	12.8	0.0	0.0	0.0	0.0	0.0	58.8
1954	0.0	0.1	2.6	44.9	61.6	15.6	0.5	0.1	0.0	0.0	0.0	0.0	125.6
1955	0.2	3.6	3.6	0.8	54.1	51.4	11.2	0.0	0.0	0.0	0.0	0.0	124.9
1956	0.0	3.2	21.7	7.7	2.0	1.7	0.4	0.0	0.0	0.0	0.0	43.7	80.4
1957	44.8	11.2	0.7	38.6	13.1	0.3	0.2	6.9	2.3	0.0	0.0	0.0	118.0
1958	0.0	9.4	18.9	5.7	1.1	1.4	5.6	1.8	0.0	0.9	0.3	0.0	45.0
1959	0.0	0.1	31.6	12.0	7.1	4.1	5.4	1.6	0.0	0.0	0.2	0.1	62.1
1960	0.2	0.9	0.7	0.5	0.2	26.4	16.6	27.9	15.9	2.5	0.0	0.0	91.8
1961	0.0	19.1	21.9	5.7	36.0	15.1	1.3	0.1	0.0	0.0	0.0	0.0	99.3
1962	0.0	19.7	6.6	25.9	8.6	14.9	29.8	8.3	0.0	0.0	0.0	0.0	113.8
1963	0.4	30.9	11.4	0.4	0.4	26.3	8.8	0.0	0.0	0.0	0.0	0.0	78.6
1964	21.0	7.0	1.1	1.2	0.3	0.0	10.1	3.4	0.0	0.0	0.0	0.0	44.1
1965	0.0	0.3	0.1	67.2	28.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	98.2
1966	0.0	0.7	1.5	58.9	19.9	1.3	35.7	15.9	1.4	0.0	0.0	0.0	135.3
1967	0.7	0.6	0.1	0.0	0.0	5.4	10.6	5.5	0.9	0.0	0.0	0.0	23.8
1968	0.0	0.0	9.4	3.2	6.0	42.5	20.9	2.5	0.0	0.0	0.0	0.0	84.5
1969	10.7	3.6	0.1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	15.2
1970	0.2	0.1	9.2	5.3	4.5	1.7	0.5	0.1	0.0	0.0	0.0	0.0	21.7
1971	0.0	0.0	1.0	21.1	37.0	37.6	9.2	0.0	0.0	0.0	0.0	0.0	105.9
1972	0.1	0.1	0.0	0.0	18.2	6.6	0.3	0.0	0.0	0.0	0.1	0.0	25.5
1973	0.0	0.2	0.6	26.5	53.4	28.2	4.5	0.0	0.0	0.0	0.0	0.0	113.3
1974	0.0	10.0	4.1	2.2	2.8	9.8	3.1	0.0	0.0	0.0	0.0	0.4	32.4
1975	0.1	9.9	10.1	41.0	15.3	29.2	13.9	1.5	0.0	0.0	0.0	5.2	126.3
1976	40.6	13.0	0.3	6.6	4.1	24.3	7.9	0.0	0.0	0.0	0.0	4.6	101.4
1977	11.1	3.3	0.9	5.0	1.8	29.6	23.7	4.6	0.0	0.0	0.0	0.0	80.1
1978	0.0	0.0	16.6	5.6	4.6	1.5	0.0	0.0	0.0	1.1	9.8	3.1	42.5
1979	2.2	1.3	0.3	0.1	1.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	5.4
1980	0.0	1.6	0.6	27.8	23.1	5.1	0.2	0.0	0.0	0.0	11.9	4.0	74.2
1981	0.0	1.8	2.5	0.7	0.3	0.4	43.9	14.6	0.0	0.0	0.0	0.0	64.2
1982	14.6	5.3	0.1	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	20.7
1983	0.1	4.0	3.7	2.1	0.5	0.7	0.2	0.0	0.0	0.0	0.2	0.1	11.5
1984	0.3	0.2	0.1	1.9	6.8	2.1	0.0	0.0	0.0	0.0	0.0	0.0	11.3
1985	7.5	3.0	3.0	3.7	1.2	0.6	0.2	0.0	0.0	0.0	0.0	0.0	19.2
1986	19.1	13.2	2.3	0.0	2.0	0.8	0.4	0.1	0.0	0.0	5.3	33.7	76.8
1987	10.7	3.0	1.8	0.3	58.3	53.4	35.3	8.0	0.0	0.0	0.0	0.7	171.5
AVG	3.7	4.8	7.1	9.9	12.4	15.7	9.9	3.8	0.8	0.4	0.7	2.1	71.2

TABLE 17

NATURAL SIMULATED (DISAGGREGATED) STREAMFLOW FOR SUBCATCHMENT 1

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	14.9	8.3	4.7	19.6	16.0	10.2	16.2	30.0	14.6	3.1	1.9	5.8	145.5
1921	4.7	5.6	13.6	16.6	4.2	12.2	10.8	4.1	16.7	4.3	2.9	2.3	97.9
1922	18.0	61.6	22.3	45.8	131.6	38.7	62.1	51.4	72.1	56.6	24.3	21.4	606.2
1923	8.0	36.3	13.2	8.8	24.3	75.2	11.5	16.8	9.9	5.7	3.0	21.0	233.6
1924	30.5	176.5	87.1	44.3	42.9	188.7	92.1	84.4	133.7	33.3	20.5	22.2	956.1
1925	61.3	57.3	37.5	20.7	31.0	31.1	7.5	11.2	9.4	6.7	4.4	7.0	284.9
1926	12.6	75.1	55.9	46.8	33.3	21.7	4.7	10.7	5.7	6.1	12.4	3.8	288.8
1927	48.6	18.1	38.9	44.4	23.8	41.1	18.2	8.8	6.5	4.8	3.1	1.6	257.8
1928	19.6	9.9	16.1	13.5	8.1	38.1	10.9	17.8	44.2	53.1	13.7	82.7	327.7
1929	57.5	37.4	36.7	18.4	29.7	50.8	79.9	17.6	15.4	10.7	7.3	7.0	368.2
1930	49.9	8.3	8.6	31.9	29.8	24.0	72.7	7.9	16.0	21.9	9.1	2.9	282.9
1931	15.1	7.3	0.8	27.5	67.1	60.2	16.1	10.4	6.4	4.0	3.1	8.6	226.6
1932	5.6	19.0	13.2	7.6	41.3	26.6	12.2	0.6	6.5	2.0	0.4	0.1	135.1
1933	0.2	64.5	92.3	291.2	66.3	249.8	165.1	57.3	44.0	73.1	121.7	27.2	1252.7
1934	32.5	163.4	163.8	55.7	34.2	90.9	46.1	102.1	38.6	22.3	11.5	12.9	794.3
1935	12.6	9.3	2.8	21.0	17.6	8.7	21.4	30.0	19.0	4.1	2.3	1.2	150.0
1936	11.7	116.2	54.4	109.8	129.7	72.2	70.4	33.0	13.9	7.6	4.1	4.1	627.0
1937	8.7	9.3	3.9	11.6	104.5	34.5	30.5	18.0	20.6	19.4	20.1	35.6	314.7
1938	17.1	17.6	28.9	11.7	103.8	56.1	29.2	34.9	11.4	14.6	24.3	18.9	368.5
1939	38.2	95.6	25.8	16.0	29.8	32.7	37.6	92.9	17.3	8.8	5.2	35.4	435.3
1940	13.6	36.9	17.5	18.4	81.7	28.3	41.0	13.6	6.8	6.9	3.9	11.6	280.3
1941	41.2	11.4	5.1	39.6	31.5	148.2	37.7	29.2	10.0	5.0	21.2	21.1	401.2
1942	25.5	21.9	116.7	94.7	46.7	74.4	30.8	79.7	21.7	86.1	42.3	64.2	704.6
1943	136.2	176.6	171.1	155.3	163.4	97.8	37.3	23.5	71.7	24.0	14.9	37.6	1129.4
1944	60.5	44.6	26.9	9.1	11.0	101.3	23.7	33.8	16.7	7.4	4.1	3.9	342.9
1945	13.2	9.1	11.9	5.9	6.3	13.4	14.4	41.1	20.2	5.0	4.0	3.9	148.3
1946	51.1	44.8	44.5	23.5	32.7	20.1	41.9	48.4	7.6	4.7	4.0	19.7	343.1
1947	27.1	35.2	57.2	23.0	30.0	136.8	35.7	58.5	27.3	13.7	7.9	3.5	455.9
1948	21.4	17.0	2.6	7.0	11.9	38.1	6.0	11.3	3.8	2.3	1.2	1.9	124.4
1949	2.7	59.3	25.0	23.3	43.4	116.9	112.3	70.1	31.5	78.6	78.9	39.2	681.2
1950	46.5	18.6	30.8	63.4	32.2	40.6	31.7	30.7	27.4	15.8	7.6	8.7	354.1
1951	190.0	78.6	50.1	12.2	83.3	86.7	23.0	9.1	8.0	23.5	9.7	13.9	568.3
1952	9.3	21.8	14.6	11.8	41.2	15.0	79.5	20.7	14.6	2.9	2.6	2.2	236.3
1953	30.2	18.7	44.3	29.9	23.3	82.4	36.5	80.1	56.3	38.9	2.2	2.3	443.0
1954	1.9	11.0	16.9	23.0	148.8	57.3	54.9	90.0	45.2	35.7	23.5	2.8	511.0
1955	16.0	63.6	198.2	41.0	37.9	31.5	49.2	62.7	30.6	17.0	12.9	9.7	570.3
1956	11.4	131.4	244.7	68.6	98.2	118.6	98.5	20.1	18.4	36.5	42.1	186.6	1075.1
1957	308.7	116.1	183.3	96.0	30.8	46.8	45.9	60.1	33.1	14.4	8.9	17.7	961.7
1958	9.1	27.9	6.7	11.4	40.7	21.5	7.2	160.7	28.6	57.3	20.8	9.8	401.6
1959	29.9	50.2	72.8	30.4	82.0	93.4	130.6	50.7	16.9	15.8	24.7	16.0	613.3
1960	41.5	45.2	51.8	95.2	47.9	45.2	98.2	72.2	178.0	33.6	27.3	12.5	746.7
1961	5.1	25.5	40.8	14.4	83.3	26.8	29.7	22.4	11.8	9.4	7.1	5.9	284.3
1962	9.6	5.2	1.4	75.0	49.2	110.0	170.3	28.5	26.6	36.1	18.9	7.7	538.6
1963	6.4	11.0	9.9	18.3	26.2	33.7	75.6	17.9	19.9	7.6	10.1	5.2	241.7
1964	65.5	36.0	30.3	21.2	13.8	1.3	15.4	4.5	8.4	4.9	5.0	5.2	211.4
1965	5.4	7.7	5.4	46.2	42.6	3.9	5.5	5.7	5.3	3.2	2.1	1.6	134.7
1966	2.6	17.7	10.7	44.0	210.6	43.9	94.7	25.4	110.0	25.3	13.6	8.4	606.8
1967	10.3	37.4	13.2	6.2	5.2	9.2	17.6	64.7	14.7	11.8	6.7	6.4	203.5
1968	10.7	4.8	7.1	0.8	10.2	24.5	37.4	39.4	22.7	7.6	9.0	3.3	177.4
1969	14.9	6.7	23.8	10.3	14.3	5.4	0.4	0.3	0.8	3.2	2.2	14.2	96.5
1970	47.8	22.3	44.7	55.3	57.8	33.0	184.5	37.0	9.4	5.4	4.1	8.0	489.2
1971	3.5	4.5	7.4	18.6	46.2	75.6	23.1	119.6	17.0	6.8	2.6	11.0	336.0
1972	11.8	15.9	7.0	1.3	37.0	10.5	29.3	1.4	1.8	1.3	30.6	18.9	166.7
1973	18.8	16.0	43.1	63.3	74.9	72.2	67.8	21.6	12.1	7.7	10.6	6.1	414.1
1974	2.9	75.7	47.1	31.0	97.4	213.4	32.4	30.4	14.7	17.7	13.8	5.6	582.2
1975	19.4	95.4	94.4	147.5	322.2	327.7	243.8	162.5	73.3	38.1	22.5	40.5	1587.1
1976	250.9	171.6	65.9	55.4	106.6	255.0	39.6	29.4	19.0	12.2	10.5	16.6	1032.8
1977	76.1	44.2	17.3	108.1	49.5	75.2	264.4	28.4	40.7	27.1	21.0	28.8	780.8
1978	36.8	15.8	122.2	14.1	25.8	19.3	8.5	7.5	6.9	21.5	141.6	49.6	469.6
1979	145.0	96.4	73.6	24.4	57.8	38.1	12.4	1.9	4.7	5.2	4.7	6.1	470.2
1980	5.3	10.7	18.8	122.9	108.2	169.4	66.9	40.3	45.3	13.8	51.6	18.5	671.6
1981	13.3	45.0	35.7	15.6	39.8	13.6	82.9	15.0	18.9	15.3	6.5	10.2	311.8
1982	14.5	68.1	19.9	9.8	24.0	12.1	12.1	8.2	7.9	19.5	5.9	3.5	205.5
1983	13.0	32.4	51.7	95.7	9.3	23.6	11.4	38.5	2.4	3.6	9.0	17.1	307.7
1984	5.0	12.5	13.5	11.8	12.3	17.4	15.7	1.0	13.4	2.2	1.4	2.6	108.7
1985	2.2	20.7	94.3	27.3	59.4	34.0	11.8	4.1	21.3	2.8	6.6	26.4	310.8
1986	31.8	198.1	25.5	13.0	13.3	8.8	30.3	4.0	1.8	2.2	32.7	94.8	456.4
1987	50.6	92.2	212.0	89.5	412.0	447.1	123.6	43.3	50.7	43.0	21.6	94.3	1679.8
AVG	35.8	47.7	47.8	42.4	60.3	68.9	52.0	36.9	26.1	18.2	16.6	19.5	472.4

TABLE 18

NATURAL SIMULATED (DISAGGREGATED) STREAMFLOW FOR SUBCATCHMENT 2

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	17.8	5.7	1.1	88.9	135.9	122.9	113.6	3.6	0.0	0.0	0.0	0.3	489.8
1921	0.2	29.0	69.4	81.8	15.8	2.4	1.2	0.0	0.0	0.0	0.0	0.0	200.0
1922	10.9	68.9	24.6	63.2	82.4	9.1	9.7	4.8	2.0	1.3	0.0	0.0	277.0
1923	0.1	19.9	9.7	26.3	61.1	139.1	19.0	0.0	0.0	0.0	0.0	14.9	290.2
1924	37.2	228.1	134.5	74.0	28.7	310.2	131.5	65.7	0.5	0.0	0.0	0.0	1010.4
1925	2.0	8.7	5.1	6.4	34.1	62.3	14.2	0.0	0.0	0.0	0.0	3.1	136.1
1926	8.3	47.1	34.4	32.0	33.5	46.4	9.8	0.0	0.0	0.1	0.2	0.0	211.7
1927	19.3	6.3	56.7	101.6	35.5	21.9	6.6	0.0	0.0	0.0	0.0	0.0	248.0
1928	20.1	19.2	51.2	65.9	17.5	55.0	15.3	0.2	3.4	3.1	0.0	45.9	296.8
1929	29.5	36.9	151.3	72.0	34.2	66.8	93.2	2.2	0.0	0.0	0.0	0.0	486.1
1930	0.0	0.1	5.5	82.1	68.8	24.6	160.6	15.4	0.0	0.2	0.1	0.0	357.4
1931	2.6	24.2	2.8	24.5	42.7	28.6	2.1	0.0	0.0	0.0	0.0	0.0	127.6
1932	0.0	15.7	28.1	13.8	13.0	16.5	5.1	0.0	0.0	0.0	0.0	0.0	92.2
1933	0.0	165.7	141.8	460.3	103.8	62.8	51.4	46.3	45.5	1.2	1.8	0.1	1080.7
1934	15.8	181.4	127.1	22.0	11.7	43.5	19.2	3.3	0.0	0.0	0.0	0.0	423.9
1935	0.3	14.0	7.5	42.4	21.8	14.6	27.6	3.4	2.2	0.0	0.0	0.0	133.6
1936	13.3	162.1	69.2	161.2	176.8	53.8	16.6	0.0	0.0	0.0	0.0	0.0	654.9
1937	0.1	0.4	7.0	22.2	98.2	23.2	11.0	7.1	0.1	0.1	0.4	0.8	170.5
1938	16.0	19.2	11.9	99.4	227.3	46.3	0.3	0.3	0.1	0.2	1.3	0.8	423.1
1939	24.1	61.7	14.5	8.4	16.9	14.1	10.1	11.2	0.1	0.0	0.0	14.8	175.9
1940	6.4	44.1	44.8	73.8	142.1	21.2	18.6	6.4	0.0	0.0	0.0	0.1	357.5
1941	29.7	7.5	0.0	66.1	57.3	149.9	26.6	3.3	0.0	0.0	1.4	1.6	343.2
1942	11.6	34.8	157.1	105.4	38.5	17.5	21.0	87.4	21.3	23.8	13.2	1.6	533.1
1943	149.2	401.0	379.7	179.8	120.1	61.6	4.2	0.0	12.9	3.9	0.0	3.9	1316.2
1944	47.9	36.4	9.2	2.2	19.3	96.7	17.1	0.0	0.0	0.0	0.0	0.0	228.9
1945	0.0	2.4	4.7	71.6	49.5	45.2	31.6	7.6	2.4	0.0	0.0	0.0	215.0
1946	63.6	39.7	20.4	37.2	52.2	16.6	45.9	51.2	0.0	0.0	0.0	1.3	328.2
1947	57.5	35.6	124.1	67.0	9.3	235.2	53.0	18.8	0.0	0.0	0.0	0.0	600.4
1948	4.4	5.0	0.2	31.9	36.0	7.4	0.8	0.0	0.0	0.0	0.0	0.0	85.6
1949	3.2	73.7	77.6	66.8	65.2	146.9	203.1	122.2	19.7	0.0	4.9	2.9	788.2
1950	0.6	1.7	79.3	159.2	47.4	17.5	17.2	11.0	0.0	0.0	0.0	0.0	333.9
1951	166.5	62.3	2.6	35.7	94.3	61.3	3.2	0.0	0.0	0.6	0.3	0.0	426.8
1952	0.5	40.9	43.0	22.0	68.7	21.7	25.0	4.8	0.0	0.0	0.0	0.0	226.6
1953	29.2	36.7	91.4	74.7	63.0	130.8	36.0	0.0	0.0	0.0	0.0	0.0	461.9
1954	0.0	12.0	32.9	114.1	271.5	49.8	6.4	11.3	0.0	0.0	0.0	0.0	498.0
1955	8.3	32.5	127.8	30.7	104.2	103.7	75.6	4.8	2.4	0.0	0.0	0.0	489.9
1956	16.4	106.6	362.2	118.3	75.0	51.4	15.9	2.1	0.0	0.1	0.4	271.7	1020.2
1957	491.1	160.7	103.6	261.9	87.2	30.3	49.3	26.7	0.6	0.0	0.0	0.7	1212.0
1958	0.5	57.5	33.4	46.3	18.8	2.9	15.8	131.5	14.8	0.6	0.3	0.0	322.4
1959	13.6	42.6	91.1	33.4	61.8	48.9	25.7	2.2	0.0	0.0	0.0	0.0	319.3
1960	8.5	11.4	22.4	72.0	31.0	27.4	62.0	20.6	5.7	1.0	0.0	0.0	262.0
1961	0.0	42.8	64.2	3.2	148.3	41.8	3.6	1.5	0.0	0.0	0.0	0.0	305.4
1962	0.4	29.2	7.0	88.4	52.3	31.6	99.9	18.2	0.2	0.0	0.0	0.0	327.2
1963	1.4	49.1	47.3	23.6	14.1	39.3	79.6	0.7	0.6	0.3	0.0	0.0	255.9
1964	78.0	39.2	29.5	45.4	22.2	0.0	15.2	4.1	0.0	0.0	0.0	0.0	233.6
1965	0.0	7.1	4.6	94.3	90.5	4.5	0.1	0.0	0.0	0.0	0.0	0.0	201.2
1966	0.2	19.7	44.3	79.2	347.4	55.1	98.8	26.5	3.8	0.0	0.0	0.0	675.2
1967	4.6	51.0	15.9	2.7	0.4	18.5	22.7	16.8	1.4	0.0	0.0	0.0	134.2
1968	1.4	0.9	26.9	3.0	9.9	40.4	45.5	5.9	2.8	0.0	0.0	0.0	136.7
1969	26.6	10.3	19.3	23.4	26.0	0.1	0.0	0.0	0.0	0.0	0.0	1.1	106.8
1970	19.1	10.4	75.7	73.5	35.7	8.8	16.2	3.0	0.1	0.0	0.0	0.0	242.4
1971	0.2	0.9	15.7	180.3	169.2	163.4	38.9	0.3	0.0	0.0	0.0	0.0	568.8
1972	8.2	26.4	8.6	0.1	53.8	13.1	4.9	0.2	0.0	0.0	8.1	4.3	127.6
1973	0.4	3.9	62.6	196.0	195.0	23.2	13.8	0.2	0.0	0.0	0.0	0.0	495.0
1974	0.0	121.6	68.0	92.3	181.3	139.9	14.0	0.1	0.0	0.0	0.0	2.6	619.8
1975	8.8	50.0	119.5	408.6	467.5	298.2	130.1	8.6	0.1	0.0	0.0	8.0	1499.4
1976	170.1	72.9	13.9	41.8	81.4	130.5	19.0	0.0	0.0	0.0	0.0	16.9	546.6
1977	38.0	14.8	28.0	255.6	97.5	66.3	369.4	43.0	0.0	0.0	0.0	0.9	913.5
1978	6.3	2.4	171.6	20.9	17.7	1.0	0.1	0.2	0.2	1.8	49.1	14.9	286.3
1979	24.2	41.1	42.6	20.1	32.3	17.5	0.5	0.0	0.0	0.0	0.0	16.2	194.4
1980	11.3	15.9	30.1	215.1	159.0	64.2	5.6	1.1	0.0	0.0	10.6	4.2	537.3
1981	0.0	39.0	81.2	32.5	17.1	1.2	57.0	8.9	0.0	0.0	0.0	0.0	237.0
1982	34.4	130.6	17.7	1.4	1.6	1.6	1.8	0.6	0.0	0.2	0.1	0.0	190.0
1983	16.9	28.4	54.1	120.8	6.3	20.0	10.0	0.2	0.0	0.0	0.5	1.0	258.2
1984	13.1	50.6	30.5	24.0	63.3	64.9	1.4	0.0	0.0	0.0	0.0	0.0	247.8
1985	3.8	24.6	121.7	36.0	45.6	11.4	5.7	1.8	0.7	0.1	0.5	1.9	253.7
1986	46.0	221.5	19.4	1.8	12.1	15.6	35.9	0.9	0.0	0.0	6.6	152.2	512.2
1987	73.0	51.6	80.0	16.6	161.6	485.0	115.5	20.3	0.0	0.0	0.0	5.4	1008.9
AVG	28.1	51.7	59.7	78.2	77.7	63.1	39.4	12.3	2.1	0.6	1.5	8.7	423.1

TABLE 19

NATURAL SIMULATED (DISAGGREGATED) STREAMFLOW FOR SUBCATCHMENT 3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	17.0	4.8	0.1	1.0	26.3	19.6	13.1	2.6	0.1	0.0	0.0	0.0	84.5
1921	0.0	40.4	104.6	73.6	4.3	0.6	0.0	0.0	1.4	0.4	0.0	0.0	225.6
1922	1.3	8.1	2.9	35.2	116.4	21.0	2.5	1.9	0.4	0.2	0.0	0.0	189.9
1923	0.0	15.6	6.1	19.8	36.8	139.0	19.9	0.0	0.0	0.0	0.0	4.4	241.8
1924	14.8	117.4	50.7	24.4	76.1	335.1	130.5	61.9	2.7	0.0	0.0	0.1	813.6
1925	4.9	1.1	0.4	1.3	4.2	42.7	14.1	0.0	0.0	0.0	0.0	0.0	68.9
1926	1.0	11.7	7.7	8.0	10.6	134.8	38.8	0.0	0.0	0.0	0.1	0.0	212.7
1927	10.9	3.8	21.7	107.5	56.9	14.8	10.6	0.2	0.0	0.0	0.0	0.0	226.4
1928	12.6	25.4	26.5	24.0	10.2	50.7	14.7	0.5	1.3	0.8	0.0	24.3	191.0
1929	15.4	4.6	55.9	32.2	10.9	16.0	36.6	9.5	0.0	0.0	0.0	0.0	185.3
1930	0.7	0.2	5.6	24.7	32.6	32.6	96.6	9.4	0.0	0.9	0.5	0.0	203.8
1931	7.2	152.7	16.6	28.1	16.5	25.8	11.1	0.0	0.0	0.0	0.0	0.2	258.2
1932	0.1	1.8	3.0	1.4	0.0	6.5	2.7	0.0	0.0	0.0	0.0	0.0	15.6
1933	0.0	151.2	149.0	555.7	118.6	25.6	23.0	11.1	7.5	0.0	0.0	0.0	1041.7
1934	12.5	51.9	29.7	3.4	7.3	54.4	25.1	10.6	0.1	0.0	0.0	0.0	194.9
1935	2.4	17.7	7.4	38.2	18.3	11.1	21.8	2.2	1.4	0.0	0.0	0.0	120.1
1936	17.1	79.0	35.0	135.0	136.2	34.3	8.2	0.0	0.0	0.0	0.0	0.0	444.9
1937	0.0	6.2	15.9	15.8	69.5	19.5	12.9	8.3	0.0	0.0	0.0	0.0	148.1
1938	11.3	13.9	38.9	62.6	127.8	28.8	0.1	6.3	0.1	0.0	0.5	0.5	284.8
1939	88.5	86.4	10.4	0.5	12.4	29.7	19.1	14.8	0.1	0.0	0.0	23.1	285.0
1940	10.1	63.9	40.4	30.1	145.2	41.4	17.3	5.7	0.0	0.0	0.0	0.0	354.0
1941	25.2	6.4	0.0	33.8	22.6	49.2	12.0	3.4	0.0	0.0	0.4	0.5	153.5
1942	36.3	75.2	107.4	31.5	11.2	8.1	52.0	114.6	14.5	5.1	51.3	100.6	607.7
1943	45.4	249.2	204.0	31.7	35.7	16.5	1.7	0.0	3.6	1.1	0.0	0.1	589.0
1944	4.6	7.5	3.7	3.9	12.9	40.0	6.8	0.0	0.0	0.0	0.0	0.0	79.3
1945	0.0	1.8	10.1	104.4	65.7	23.8	23.8	2.0	0.8	0.0	0.0	0.0	222.4
1946	18.5	9.4	2.8	11.7	53.5	13.2	1.6	2.1	0.0	0.0	0.0	0.6	113.4
1947	19.6	9.3	48.8	32.6	17.6	217.4	45.6	1.7	0.0	0.0	0.0	0.0	392.6
1948	0.0	0.0	0.0	22.0	27.1	18.7	1.7	0.0	0.0	0.0	0.0	0.0	69.5
1949	0.3	48.7	62.4	31.0	25.5	149.6	257.9	168.8	22.2	0.4	60.8	34.8	862.3
1950	0.0	1.3	58.7	133.4	42.6	29.7	23.7	1.8	0.0	0.0	0.0	0.0	291.3
1951	79.9	29.8	0.0	10.1	30.2	26.7	5.0	0.0	0.0	1.6	0.7	0.1	184.1
1952	0.1	52.6	40.4	18.7	72.3	22.0	47.3	12.7	0.0	0.0	0.0	0.0	264.0
1953	35.5	33.3	84.7	25.6	29.2	154.7	47.2	1.3	1.1	0.0	0.0	0.0	412.6
1954	0.0	2.9	7.8	204.6	341.1	26.8	9.1	9.4	0.0	0.0	0.0	0.0	601.8
1955	2.2	6.3	80.2	34.7	148.0	143.0	102.7	3.9	0.7	0.0	0.0	0.0	521.7
1956	2.0	12.6	202.3	80.0	107.2	35.7	11.8	0.4	0.0	0.0	1.3	54.1	507.5
1957	171.9	78.7	54.1	112.1	38.8	6.5	14.8	18.4	4.4	0.0	0.0	0.0	499.5
1958	0.1	140.2	30.4	15.8	37.4	24.9	8.9	16.4	0.1	0.8	0.4	0.0	275.4
1959	5.6	31.8	74.8	27.7	9.2	19.3	28.9	1.1	0.0	0.0	0.0	0.0	196.5
1960	11.2	19.7	16.4	11.5	2.3	39.7	48.0	6.6	5.5	1.9	0.0	0.0	162.8
1961	0.0	52.5	100.1	21.6	263.7	77.7	10.9	1.0	0.0	0.0	0.0	0.0	527.6
1962	0.0	58.9	14.0	74.3	44.0	56.7	153.0	24.4	0.1	0.0	0.0	0.0	425.3
1963	0.1	64.7	54.8	5.2	3.6	30.3	62.1	0.6	0.2	0.1	0.0	0.0	221.7
1964	49.3	24.7	15.9	11.2	2.0	0.0	6.3	1.7	0.0	0.0	0.0	0.0	111.1
1965	0.0	3.3	2.2	156.2	130.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0	293.7
1966	0.0	4.4	21.5	39.4	105.5	4.4	86.7	27.3	2.4	0.0	0.0	0.0	291.7
1967	1.5	6.6	6.1	4.3	0.9	14.5	21.1	18.6	0.7	0.0	0.0	0.0	74.8
1968	0.3	0.1	23.6	2.6	30.7	49.4	47.4	4.4	0.5	0.0	0.0	0.0	159.0
1969	28.2	10.9	0.2	6.8	11.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	58.9
1970	14.1	12.7	40.8	40.5	24.1	5.9	6.2	1.9	0.5	0.0	0.0	0.0	146.8
1971	0.1	0.2	4.2	167.2	201.6	150.2	24.7	0.1	0.0	0.0	0.0	0.0	548.4
1972	1.9	2.5	0.4	0.0	60.6	14.6	0.9	0.0	0.0	0.0	3.4	1.8	86.2
1973	0.2	2.3	14.5	224.1	272.1	68.7	10.8	0.5	0.0	0.0	0.1	0.1	593.3
1974	0.0	28.5	17.6	41.9	131.8	164.0	8.2	0.2	0.0	0.0	0.0	0.9	393.1
1975	2.9	61.2	63.4	421.8	459.6	188.1	124.1	8.0	0.1	0.0	0.0	8.0	1337.2
1976	179.3	55.2	3.2	35.7	94.2	205.7	23.8	0.0	0.0	0.0	0.0	21.7	618.9
1977	48.0	19.6	11.8	146.0	62.6	44.8	215.9	24.6	0.0	0.0	0.0	0.3	573.5
1978	0.5	0.2	174.9	18.9	28.9	20.8	0.9	1.0	0.0	1.3	4.6	1.1	253.1
1979	16.8	10.9	6.9	3.8	4.4	3.2	0.9	0.0	0.0	0.0	0.0	1.8	48.9
1980	1.3	18.9	33.6	130.0	96.6	63.5	10.1	0.4	0.0	0.0	28.0	11.1	393.4
1981	0.0	20.2	17.7	6.2	10.2	4.7	120.8	19.3	0.0	0.0	0.0	0.0	199.3
1982	18.7	76.9	11.5	0.3	0.6	0.4	0.1	0.0	0.0	1.7	0.6	0.0	110.8
1983	5.3	18.9	22.1	26.8	2.9	1.4	0.7	12.3	0.9	0.0	0.2	0.5	92.0
1984	1.1	15.4	14.5	11.7	20.9	17.0	0.9	0.0	0.0	0.0	0.0	0.0	81.3
1985	8.8	107.8	73.6	8.3	10.1	14.5	3.8	0.0	0.1	0.0	0.4	1.7	229.1
1986	25.3	123.3	10.7	0.4	7.0	6.4	13.6	1.1	0.0	0.0	1.4	71.0	260.2
1987	34.2	38.5	28.9	1.2	336.2	437.1	31.9	13.4	0.0	0.0	0.0	2.5	923.9
AVG	16.5	37.0	36.9	55.9	67.3	55.8	33.2	9.8	1.1	0.2	2.3	5.4	321.3

TABLE 20

BASIC HYDROLOGICAL DATA FOR SUBCATCHMENTS

Refer FIGURE 17

SUBCATCHMENT	FILE NAME	SOURCE DATA	AREA (km^2)	MAP (mm)	MAR (10^6 m^3)
KATJIESBERG DAM	KATJE.INC	0.248 * (WELB.INC)[1]	2400	845	296.9
HLOTSE DAM	HLOTS.INC	0.158 * (WELB.INC)[1]	960	944	189.0
WATERPOORT DAM	WATER.INC	0.067 * (WELB.INC)[1]	1082	700	80.4
KNELLPOORT DAM	KNEL.INC	KNEL.INC[1]	776	519	20.8
AREA FROM THE KATJIESBERG, HLOTSE, WATERPOORT AND KNELLPOORT DAMS TO WELBEDACHT DAM	WELBB.INC	0.527 * (WELB.INC)[1]	10027	691	629.8
WELBEDACHT DAM TO FINLAYSDYK DAM	FIN.INC	0.117 * HFDAM.INC[2]	1785	550	47.3
WELBEDACHT DAM TO BAKENKOP DAM	BAK.INC	0.288 * HFDAM.INC[2]	4692	516	116.4
LESOTHO[3]			15164	749	2637.2
MAKHALENG RIVER CATCHMENT TO THE MAMMAKO DAM SITE (UPSTREAM OF RIVER GAUGING STATION D1H006)	MAMKO.INC	[4]	2491	875	510.8
ORANJEDRAAI INCREMENTAL CATCHMENT AS USED BY BKS, BUT EXCLUDING MAKHALENG RIVER CATCHMENT UPSTREAM OF MAMMAKO DAM SITE	ORANB.INC	ORAN.INC[1] - MAMKO.INC [4]	7097	733	934.3
ORANJEDRAAI TO BOSBERG DAM SITE	BOS.INC	0.73 * (ALIW.INC)[1]	2537	616	166.8
AREA BETWEEN HF VERWOERD DAM AND WELBEDACHT DAM ON CALEDON RIVER AND BOSBERG DAM SITE ON ORANGE RIVER, EXCLUDING KRAAI RIVER CATCHMENT	HFDAM.INC	1.02 * (VERW.INC + HFDU.INC)[1]	14045	456	404.0
TOTAL KRAAI RIVER CATCHMENT TO THE CONFLUENCE WITH THE ORANGE RIVER AT ALIWAL NORTH	KRAAI.INC	1.08 * (ROOD.INC)[1]	9478	647	731.1
AREA BETWEEN HF VERWOERD DAM AND PK le ROUX DAM	PKDU.INC	PKDU.INC[1]	19093	337	147.0

(1) BKS files as used in the Yield Analysis up to PK le Roux Dam

(2) Calculated in this report, using BKS files as basis for calculations

(3) The LESOTHO catchment mentioned refers to the existing seven incremental subcatchments inside Lesotho u/s of the Oranjedraai incremental subcatchment as used by BKS [9]. These incremental subcatchments will be used unchanged.

(4) Based on flows simulated at D1H006 (Maghaleen)

TABLE 21

NATURAL SIMULATED STREAMFLOW FOR HLOTSE DAM

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	6.0	3.3	1.9	7.8	6.4	4.1	6.5	12.0	5.9	1.2	0.8	2.3	58.2
1921	1.9	2.2	5.4	6.6	1.7	4.9	4.3	1.6	6.7	1.7	1.2	0.9	39.2
1922	7.2	24.7	8.9	18.3	52.6	15.5	24.9	20.6	28.6	22.6	9.7	8.6	242.5
1923	3.2	14.5	5.3	3.5	9.7	30.1	4.6	6.7	3.9	2.3	1.2	8.4	93.5
1924	12.2	70.6	34.8	17.7	17.2	75.5	36.8	33.7	53.5	13.3	8.2	8.9	382.5
1925	24.5	22.9	15.0	8.3	12.4	12.4	3.0	4.5	3.7	2.7	1.7	2.8	113.9
1926	5.0	30.0	22.3	18.7	13.3	8.7	1.9	4.3	2.3	2.5	5.0	1.5	115.5
1927	19.4	7.3	15.6	17.7	9.5	16.4	7.3	3.5	2.6	1.9	1.2	0.6	103.1
1928	7.8	3.9	6.4	5.[illegible]	3.2	15.3	4.4	7.1	17.7	21.3	5.5	33.1	131.1
1929	23.0	14.9	14.7	7.4	11.9	20.3	31.9	7.0	6.2	4.3	2.9	2.8	147.3
1930	19.9	3.3	3.5	12.7	11.9	9.6	29.1	3.2	6.4	8.7	3.6	1.1	113.2
1931	6.1	2.9	0.3	11.0	26.8	24.1	6.4	4.2	2.6	1.6	1.3	3.4	90.7
1932	2.2	7.6	5.3	3.0	16.5	10.6	4.9	0.2	2.6	0.8	0.2	0.0	54.1
1933	0.1	25.8	36.9	116.5	26.5	99.9	66.0	22.9	17.6	29.3	48.7	10.9	501.1
1934	13.0	73.4	65.5	22.3	13.7	36.4	16.4	40.8	15.4	8.9	4.6	5.2	317.7
1935	5.0	3.7	1.1	8.4	7.0	3.5	8.5	12.0	7.6	1.6	0.9	0.5	60.0
1936	4.7	46.5	21.7	43.9	51.9	28.9	28.2	13.2	5.6	3.0	1.7	1.6	250.8
1937	3.5	3.7	1.5	4.6	41.8	13.8	12.2	6.4	8.2	7.7	8.0	14.2	125.9
1938	6.8	7.0	11.6	4.7	41.5	22.4	11.7	13.9	4.6	5.9	9.7	7.5	147.4
1939	15.3	38.3	10.3	6.4	11.9	13.1	15.0	37.1	6.9	3.5	2.1	14.2	174.1
1940	5.4	14.8	7.0	7.4	32.7	11.3	16.4	5.4	2.7	2.8	1.6	4.6	112.1
1941	16.5	4.5	2.0	15.9	12.6	59.3	15.1	11.7	4.0	2.0	8.5	8.4	160.5
1942	10.2	8.8	46.7	37.9	16.7	29.8	12.3	31.9	8.7	34.4	16.9	25.7	281.9
1943	54.5	70.6	68.4	62.1	73.3	39.1	14.9	9.4	28.7	9.6	6.0	15.0	451.8
1944	24.2	17.8	10.8	3.7	4.4	40.5	9.5	13.5	6.7	3.0	1.6	1.6	137.2
1945	5.3	3.7	4.8	2.4	2.5	5.4	5.8	16.4	8.1	2.0	1.6	1.6	59.3
1946	20.5	17.9	17.8	9.4	13.1	6.0	16.8	19.4	3.1	1.9	1.6	7.9	137.2
1947	10.9	14.1	22.9	9.2	12.0	54.7	14.3	23.4	10.9	5.5	3.2	1.4	182.3
1948	6.5	6.8	1.1	2.8	4.8	15.2	2.4	4.5	1.5	0.9	0.5	0.8	49.8
1949	1.1	23.7	10.0	9.3	17.4	46.7	44.9	28.1	12.6	31.5	31.5	15.7	272.5
1950	18.6	7.4	12.3	25.3	12.9	16.2	12.7	12.3	11.0	6.3	3.0	3.5	141.6
1951	76.0	31.4	20.0	4.9	25.3	34.7	9.2	3.6	3.2	9.4	3.9	5.5	227.3
1952	3.7	8.7	5.8	4.7	16.5	6.0	31.8	8.3	5.9	1.2	1.1	0.9	94.5
1953	12.1	7.5	17.7	12.0	9.3	32.9	14.6	32.0	22.5	14.8	0.9	0.9	177.2
1954	0.7	4.4	6.7	9.2	59.5	22.9	22.0	36.0	18.1	14.3	9.4	1.1	204.4
1955	6.4	25.4	79.3	16.4	15.2	12.6	19.7	25.1	12.2	6.8	5.2	3.9	228.1
1956	4.6	52.5	97.9	27.4	39.3	47.4	39.4	8.1	7.4	14.6	16.8	74.6	430.0
1957	123.5	46.5	73.3	38.4	12.3	18.7	18.4	24.0	13.2	5.7	3.6	7.1	384.7
1958	3.6	11.2	2.7	4.5	16.3	8.6	2.9	64.3	11.4	22.9	8.3	3.9	160.7
1959	12.0	20.1	29.1	12.2	32.8	37.4	52.2	20.3	6.7	6.3	9.9	6.4	245.3
1960	16.6	18.1	20.7	38.1	19.2	18.1	39.3	28.9	70.4	13.4	10.9	5.0	298.7
1961	2.1	10.2	16.3	5.8	33.3	11.5	11.9	8.9	4.7	3.8	2.8	2.4	113.7
1962	3.8	2.1	0.6	30.0	19.7	44.0	68.1	11.4	10.7	14.4	7.6	3.1	215.5
1963	2.6	4.4	3.9	7.3	10.5	13.5	30.3	7.1	8.0	3.0	4.0	2.1	96.7
1964	26.2	14.4	12.1	8.5	5.5	0.5	6.2	1.8	3.4	1.9	2.0	2.1	84.6
1965	2.1	3.1	2.2	18.5	17.1	1.6	2.2	2.3	2.1	1.3	0.8	0.6	53.9
1966	1.0	7.1	4.3	17.6	84.2	17.5	37.9	10.2	44.0	10.1	5.4	3.4	242.7
1967	4.1	15.0	5.3	2.5	2.1	3.7	7.0	25.9	5.9	4.7	2.7	2.6	81.4
1968	4.3	1.9	2.8	0.3	4.1	9.8	15.0	15.8	9.1	3.0	3.6	1.3	71.0
1969	6.0	2.7	9.5	4.1	5.7	2.2	0.2	0.1	0.3	1.3	0.9	5.7	38.6
1970	19.1	8.9	17.9	22.1	23.1	13.2	65.8	14.8	3.8	2.2	1.6	3.2	195.7
1971	1.4	1.8	3.0	7.4	18.5	30.2	9.3	47.9	6.8	2.7	1.0	4.4	134.4
1972	4.7	6.3	2.8	0.5	14.8	4.2	11.7	0.6	0.7	0.5	12.2	7.6	66.7
1973	7.5	6.4	17.3	25.3	30.0	28.9	27.1	8.6	4.8	3.1	4.2	2.5	165.6
1974	1.2	30.3	18.8	12.4	39.0	85.4	13.0	12.2	5.9	7.1	5.5	2.2	232.9
1975	7.8	38.1	37.8	59.0	128.9	131.1	97.5	65.0	29.3	15.2	9.0	16.2	634.8
1976	100.4	68.6	26.3	22.2	42.6	102.0	15.9	11.8	7.6	4.9	4.2	6.6	413.1
1977	30.4	17.7	6.9	43.2	19.8	30.1	105.8	11.3	16.3	10.8	8.4	11.5	312.3
1978	14.7	6.3	48.9	5.6	10.3	7.7	3.4	3.0	2.8	8.6	56.6	19.8	187.8
1979	58.0	38.6	29.4	9.8	23.1	15.2	4.9	0.8	1.9	2.1	1.9	2.4	188.1
1980	2.1	4.3	7.5	49.2	43.3	67.8	26.8	16.1	18.1	5.5	20.6	7.4	268.6
1981	5.3	18.0	14.3	6.2	15.9	5.4	33.2	6.0	7.5	6.1	2.6	4.1	124.7
1982	5.8	27.2	8.0	3.9	9.6	4.8	4.8	3.3	3.1	7.8	2.4	1.4	82.2
1983	5.2	13.0	20.7	38.3	3.7	9.4	4.6	15.4	0.9	1.4	3.6	6.9	123.1
1984	2.0	5.0	5.4	4.7	4.9	6.9	6.3	0.4	5.3	0.9	0.6	1.0	43.5
1985	0.9	8.3	37.7	10.9	23.8	13.6	4.7	1.7	8.5	1.1	2.6	10.6	124.3
1986	12.7	79.2	10.2	5.2	5.3	3.5	12.1	1.6	0.7	0.9	13.1	37.9	182.6
1987	20.2	36.9	84.8	35.8	164.8	178.8	49.4	17.3	20.3	17.2	8.6	37.7	671.9
AVG	14.3	19.1	19.1	17.0	24.1	27.6	20.8	14.7	10.4	7.3	6.7	7.8	189.0

TABLE 22

NATURAL SIMULATED STREAMFLOW FOR WATERPOORT DAM

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	3.4	1.1	0.2	16.9	25.8	23.4	21.6	0.7	0.0	0.0	0.0	0.0	93.1
1921	0.0	5.5	13.2	15.5	3.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	38.0
1922	2.1	13.1	4.7	12.0	15.7	1.7	1.8	0.9	0.4	0.3	0.0	0.0	52.6
1923	0.0	3.8	1.8	5.0	11.6	26.4	3.6	0.0	0.0	0.0	0.0	2.8	55.1
1924	7.1	43.3	25.6	14.1	5.5	58.9	25.0	12.5	0.1	0.0	0.0	0.0	192.0
1925	0.4	1.7	1.0	1.2	6.5	11.8	2.7	0.0	0.0	0.0	0.0	0.6	25.9
1926	1.6	9.0	6.5	6.1	6.4	8.8	1.9	0.0	0.0	0.0	0.0	0.0	40.2
1927	3.7	1.2	10.8	19.3	6.7	4.2	1.2	0.0	0.0	0.0	0.0	0.0	47.1
1928	3.8	3.6	9.7	12.5	3.3	10.5	2.9	0.0	0.8	0.6	0.0	8.7	56.4
1929	5.6	7.0	28.7	13.7	6.5	13.1	17.7	0.4	0.0	0.0	0.0	0.0	92.7
1930	0.0	0.0	1.0	15.6	13.1	4.7	30.5	2.9	0.0	0.0	0.0	0.0	67.9
1931	0.5	4.6	0.5	4.7	8.1	5.4	0.4	0.0	0.0	0.0	0.0	0.0	24.3
1932	0.0	3.0	5.3	2.6	2.5	3.1	1.0	0.0	0.0	0.0	0.0	0.0	17.5
1933	0.0	31.5	26.9	87.5	19.7	11.9	9.8	8.8	8.6	0.2	0.4	0.0	205.3
1934	3.0	34.5	24.1	4.2	2.2	8.3	3.6	0.6	0.0	0.0	0.0	0.0	80.5
1935	0.1	2.7	1.4	8.1	4.1	2.8	5.2	0.6	0.4	0.0	0.0	0.0	25.4
1936	2.5	30.8	13.1	30.6	34.0	10.2	3.2	0.0	0.0	0.0	0.0	0.0	124.4
1937	0.0	0.1	1.3	4.2	18.6	4.4	2.1	1.4	0.0	0.0	0.1	0.1	32.4
1938	3.0	3.7	2.3	18.9	43.2	8.6	0.1	0.1	0.0	0.0	0.3	0.2	80.4
1939	4.6	11.7	2.8	1.6	3.2	2.7	1.9	2.1	0.0	0.0	0.0	2.8	33.4
1940	1.2	8.4	8.5	14.0	27.0	4.0	3.5	1.2	0.0	0.0	0.0	0.0	67.9
1941	5.6	1.4	0.0	12.6	10.9	28.5	5.0	0.6	0.0	0.0	0.3	0.3	65.2
1942	2.2	6.6	29.8	20.0	7.3	3.3	4.0	16.6	4.1	4.5	2.5	0.3	101.3
1943	28.3	76.2	72.1	34.2	22.8	11.7	0.8	0.0	2.5	0.7	0.0	0.7	250.1
1944	9.1	6.9	1.8	0.4	3.7	18.4	3.3	0.0	0.0	0.0	0.0	0.0	43.5
1945	0.0	0.5	0.9	13.6	9.4	8.6	6.0	1.4	0.5	0.0	0.0	0.0	40.9
1946	12.1	7.5	3.9	7.1	9.9	3.2	8.7	9.7	0.0	0.0	0.0	0.3	62.3
1947	10.9	6.8	23.6	12.7	1.8	44.7	10.1	3.6	0.0	0.0	0.0	0.0	114.1
1948	0.8	0.9	0.0	6.1	6.8	1.4	0.2	0.0	0.0	0.0	0.0	0.0	16.3
1949	0.6	14.0	14.7	12.7	12.4	28.3	38.6	23.2	3.7	0.0	0.9	0.5	149.6
1950	0.1	0.3	15.1	30.2	9.0	3.3	3.3	2.1	0.0	0.0	0.0	0.0	63.4
1951	31.6	11.8	0.5	6.8	17.9	11.6	0.6	0.0	0.0	0.1	0.1	0.0	81.1
1952	0.1	7.8	8.2	4.2	13.1	4.1	4.8	0.9	0.0	0.0	0.0	0.0	43.1
1953	5.6	7.0	17.4	14.2	12.0	24.8	6.8	0.0	0.0	0.0	0.0	0.0	87.8
1954	0.0	2.3	6.2	21.7	51.6	9.5	1.2	2.1	0.0	0.0	0.0	0.0	94.6
1955	1.6	6.2	24.3	5.8	19.8	19.7	14.4	0.9	0.5	0.0	0.0	0.0	93.1
1956	3.1	20.3	68.8	22.5	14.3	9.8	3.0	0.4	0.0	0.0	0.1	51.6	193.8
1957	93.3	30.5	19.7	49.8	16.6	5.8	9.4	5.1	0.1	0.0	0.0	0.1	230.3
1958	0.1	10.9	6.3	8.8	3.6	0.6	3.0	25.0	2.8	0.1	0.1	0.0	61.3
1959	2.6	8.1	17.3	6.3	11.7	9.3	4.9	0.4	0.0	0.0	0.0	0.0	60.7
1960	1.6	2.2	4.2	13.7	5.9	5.2	11.8	3.9	1.1	0.2	0.0	0.0	49.8
1961	0.0	8.1	12.2	0.6	28.2	8.0	0.7	0.3	0.0	0.0	0.0	0.0	58.0
1962	0.1	5.6	1.3	16.8	9.9	6.0	19.0	3.5	0.0	0.0	0.0	0.0	62.2
1963	0.3	9.3	9.0	4.5	2.7	7.5	15.1	0.1	0.1	0.0	0.0	0.0	48.6
1964	14.8	7.4	5.6	8.6	4.2	0.0	2.9	0.8	0.0	0.0	0.0	0.0	44.4
1965	0.0	1.4	0.9	17.9	17.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	38.2
1966	0.0	3.7	8.4	15.1	66.0	10.5	18.8	5.0	0.7	0.0	0.0	0.0	128.3
1967	0.9	9.7	3.0	0.5	0.1	3.5	4.3	3.2	0.3	0.0	0.0	0.0	25.5
1968	0.3	0.2	5.1	0.6	1.9	7.7	8.7	1.1	0.5	0.0	0.0	0.0	26.0
1969	5.1	1.9	3.7	4.4	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.2	20.3
1970	3.6	2.0	14.4	14.0	6.8	1.7	3.1	0.6	0.0	0.0	0.0	0.0	46.1
1971	0.0	0.2	3.0	34.3	32.1	31.0	7.4	0.1	0.0	0.0	0.0	0.0	108.1
1972	1.6	5.0	1.6	0.0	10.2	2.5	0.9	0.0	0.0	0.0	1.5	0.8	24.2
1973	0.1	0.7	11.9	37.2	37.0	4.4	2.8	0.0	0.0	0.0	0.0	0.0	94.1
1974	0.0	23.1	12.9	17.5	34.4	26.6	2.7	0.0	0.0	0.0	0.0	0.5	117.8
1975	1.7	9.5	22.7	77.6	88.8	56.7	24.7	1.6	0.0	0.0	0.0	1.5	284.9
1976	32.3	13.8	2.6	8.0	15.5	24.8	3.6	0.0	0.0	0.0	0.0	3.2	103.9
1977	7.2	2.8	5.3	48.6	18.5	12.6	70.2	8.2	0.0	0.0	0.0	0.2	173.6
1978	1.2	0.5	32.6	4.0	3.4	0.2	0.0	0.0	0.0	0.3	9.3	2.8	54.4
1979	4.6	7.8	8.1	3.8	6.1	3.3	0.1	0.0	0.0	0.0	0.0	3.1	36.9
1980	2.1	3.0	5.7	40.9	30.2	16.0	1.1	0.2	0.0	0.0	2.0	0.8	102.1
1981	0.0	7.4	15.4	6.2	3.2	0.2	10.8	1.7	0.0	0.0	0.0	0.0	45.0
1982	6.5	24.8	3.4	0.3	0.3	0.3	0.3	0.1	0.0	0.0	0.0	0.0	36.1
1983	3.2	5.4	10.3	23.0	1.2	3.8	1.9	0.0	0.0	0.0	0.1	0.2	49.1
1984	2.5	9.6	5.8	4.6	12.0	12.3	0.3	0.0	0.0	0.0	0.0	0.0	47.1
1985	0.7	4.7	23.1	6.8	8.7	2.2	1.1	0.3	0.1	0.0	0.1	0.4	48.2
1986	8.7	42.1	3.7	0.3	2.3	3.0	6.8	0.2	0.0	0.0	1.3	28.9	97.3
1987	13.9	9.8	15.2	3.1	30.7	92.1	21.9	3.9	0.0	0.0	0.0	1.0	191.7
AVG	5.3	9.8	11.3	14.9	14.8	12.0	7.5	2.3	0.4	0.1	0.3	1.7	80.4

TABLE 23

NATURAL SIMULATED STREAMFLOW FOR KATJIESBERG DAM

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	10.5	4.8	2.2	29.8	39.9	34.3	34.5	13.1	6.1	1.3	0.8	2.4	179.5
1921	2.0	9.4	22.5	26.8	5.6	5.6	4.7	1.7	6.8	1.8	1.2	1.0	89.1
1922	10.0	42.2	15.2	34.2	74.0	18.1	27.8	22.2	30.0	23.5	9.9	8.8	315.6
1923	3.3	19.7	7.8	10.0	24.9	64.9	9.4	6.9	4.0	2.3	1.2	12.2	166.6
1924	21.6	128.1	68.6	36.3	24.6	153.2	69.9	50.6	54.8	13.6	8.4	9.1	638.6
1925	25.5	25.6	16.6	10.0	21.0	28.0	6.6	4.6	3.8	2.7	1.8	3.6	149.8
1926	7.2	42.3	31.3	27.0	21.8	20.2	4.4	4.4	2.3	2.5	5.1	1.5	170.0
1927	24.6	9.0	29.8	43.0	18.4	22.2	9.1	3.6	2.6	2.0	1.3	0.6	166.2
1928	12.9	8.7	19.1	21.7	7.6	29.1	8.2	7.3	18.9	22.5	5.6	45.1	206.7
1929	30.7	24.3	52.1	25.2	20.6	37.6	55.5	7.7	6.3	4.4	3.0	2.8	270.2
1930	20.4	3.4	4.9	33.1	29.1	15.8	69.1	7.0	6.5	9.0	3.7	1.2	203.3
1931	6.8	8.9	1.0	17.3	37.9	31.8	7.1	4.3	2.6	1.6	1.3	3.5	124.0
1932	2.3	11.6	12.3	6.5	20.1	14.9	6.2	0.2	2.7	0.8	0.2	0.0	77.9
1933	0.1	67.0	72.5	231.9	52.5	117.5	80.1	34.8	29.2	30.2	50.2	11.1	777.1
1934	17.2	119.5	98.1	28.1	16.9	47.9	23.6	42.6	15.8	9.1	4.7	5.3	428.7
1935	5.2	7.3	3.0	19.0	12.5	7.2	15.5	13.1	8.3	1.7	1.0	0.5	94.1
1936	8.0	87.2	39.2	84.4	96.9	42.7	32.9	13.5	5.7	3.1	1.7	1.7	416.9
1937	3.6	3.9	3.3	10.2	66.8	19.8	15.2	8.3	8.4	7.9	8.3	14.7	170.5
1938	10.9	11.9	14.8	29.1	98.1	34.3	12.0	14.3	4.7	6.1	10.3	7.9	254.4
1939	21.5	54.2	14.1	8.6	16.3	16.8	17.9	40.7	7.1	3.6	2.1	18.1	221.1
1940	7.1	25.9	18.1	25.6	68.3	16.6	21.3	7.1	2.8	2.8	1.6	4.7	202.2
1941	24.1	6.5	2.1	32.4	26.9	97.4	21.9	12.7	4.1	2.0	9.0	9.0	248.2
1942	13.3	17.5	86.2	64.5	28.5	34.7	17.7	54.0	14.1	41.0	20.5	26.6	418.8
1943	92.3	170.4	163.0	107.5	104.4	55.1	16.3	9.6	32.5	10.7	6.1	16.3	784.4
1944	36.5	27.2	13.3	4.3	9.2	65.1	13.9	13.8	6.8	3.0	1.7	1.6	196.3
1945	5.4	4.3	6.0	20.0	14.7	16.5	13.6	18.7	8.8	2.0	1.6	1.6	113.3
1946	36.5	28.0	23.2	18.7	26.2	12.3	28.4	32.3	3.1	1.9	1.6	8.4	220.7
1947	25.2	23.1	53.8	25.8	14.6	113.6	27.6	28.5	11.2	5.6	3.2	1.4	333.6
1948	9.8	8.2	1.1	10.7	13.7	17.4	2.6	4.6	1.6	0.9	0.5	0.8	71.9
1949	1.9	42.3	29.2	25.9	33.7	84.3	95.7	58.6	17.7	32.2	33.5	16.7	471.7
1950	19.2	8.0	32.0	64.9	24.8	20.9	17.2	15.2	11.2	6.5	3.1	3.6	226.6
1951	118.5	47.4	21.1	13.8	49.0	50.5	10.2	3.7	3.3	9.8	4.1	5.7	337.0
1952	3.9	18.9	16.5	10.2	33.7	11.4	38.6	9.6	6.1	1.2	1.1	0.9	152.2
1953	19.5	16.7	40.5	30.5	25.0	65.7	23.7	32.8	23.0	15.1	0.9	0.9	294.3
1954	0.6	7.5	14.9	37.4	127.4	35.6	24.0	39.6	18.5	14.6	9.6	1.1	331.0
1955	8.6	34.0	112.4	24.3	41.0	38.3	38.6	26.8	13.1	6.9	5.3	3.9	353.3
1956	8.7	79.8	188.6	57.0	58.6	61.1	44.2	8.8	7.5	14.9	17.3	142.9	689.7
1957	246.6	86.9	100.3	103.4	34.0	26.6	30.8	31.1	13.7	5.9	3.6	7.4	690.3
1958	3.8	25.5	10.9	16.0	21.3	9.5	6.8	97.9	15.3	23.6	8.6	4.0	243.3
1959	15.6	31.0	52.1	20.6	48.7	50.2	59.7	21.3	6.9	6.5	10.1	6.5	329.1
1960	19.1	21.3	26.7	56.6	27.2	25.2	55.4	34.6	73.4	14.0	11.2	5.1	369.6
1961	2.1	20.9	32.4	6.7	70.4	22.0	13.0	9.5	4.8	3.8	2.9	2.4	191.1
1962	4.0	9.3	2.3	52.3	32.9	52.7	94.1	16.1	10.9	14.8	7.7	3.1	300.5
1963	3.0	16.5	15.6	13.3	14.2	23.4	50.4	7.5	8.3	3.2	4.1	2.1	161.6
1964	45.9	24.3	19.6	19.8	11.1	0.5	10.0	2.8	3.4	2.0	2.0	2.1	143.7
1965	2.2	4.9	3.4	42.0	39.7	2.7	2.3	2.3	2.2	1.3	0.9	0.6	104.4
1966	1.1	12.0	15.2	37.4	171.2	31.4	62.9	16.9	45.9	10.4	5.5	3.5	413.6
1967	5.4	27.8	9.3	3.2	2.2	8.3	12.7	30.6	8.4	4.8	2.7	2.6	118.1
1968	4.7	2.2	9.5	1.0	6.6	19.9	26.5	17.5	10.0	3.1	3.7	1.4	106.1
1969	12.6	5.2	14.5	9.9	12.2	2.3	0.2	0.1	0.3	1.3	0.9	6.1	65.6
1970	24.2	11.7	36.8	40.6	32.4	15.6	71.3	15.9	3.9	2.2	1.7	3.3	259.5
1971	1.5	2.0	6.9	51.8	60.4	70.9	19.0	49.0	7.0	2.8	1.0	4.5	276.8
1972	6.9	13.0	5.0	0.6	28.3	7.5	13.2	0.6	0.7	0.5	14.5	8.8	99.5
1973	7.8	7.5	33.0	73.9	78.4	35.2	31.1	8.9	4.9	3.1	4.3	2.5	290.6
1974	1.2	60.8	35.9	35.3	84.3	121.6	16.7	12.5	6.0	7.3	5.7	2.9	390.0
1975	10.1	51.2	67.9	160.4	246.3	207.1	131.6	68.5	30.0	15.6	9.2	18.5	1016.5
1976	144.3	88.0	30.3	32.9	63.5	136.3	20.9	12.0	7.8	5.0	4.3	10.9	556.3
1977	40.4	21.7	14.0	106.8	44.2	47.0	198.6	22.1	16.7	11.1	8.6	12.0	543.1
1978	16.6	7.0	92.0	10.9	14.9	8.1	3.5	3.1	2.9	9.2	69.8	23.9	262.2
1979	65.2	49.5	40.5	14.9	31.5	19.9	5.2	0.8	1.9	2.1	1.9	6.5	240.0
1980	4.9	8.3	15.1	103.0	83.2	89.9	28.7	16.7	18.5	5.6	23.7	8.6	406.3
1981	5.4	28.0	34.5	14.4	20.5	5.9	47.9	8.3	7.7	6.3	2.7	4.2	185.6
1982	14.4	59.9	12.5	4.4	10.2	5.3	5.4	3.5	3.2	8.0	2.4	1.4	130.6
1983	9.5	20.2	34.4	68.7	5.3	14.6	7.1	15.8	1.0	1.5	3.8	7.3	189.1
1984	5.2	17.5	13.0	10.7	20.5	23.0	6.8	0.4	5.5	0.9	0.6	1.1	105.2
1985	1.8	14.5	66.4	20.0	35.5	16.7	6.2	2.1	8.9	1.2	2.8	11.3	189.3
1986	24.3	135.3	15.2	5.8	8.4	7.4	21.2	1.9	0.7	0.9	15.0	76.1	312.2
1987	38.6	50.4	106.3	40.7	208.1	301.7	78.8	22.7	20.7	17.6	8.8	39.9	934.2
AVG	21.5	32.2	34.2	36.5	43.7	43.6	30.9	18.1	11.2	7.6	7.2	10.1	296.9

TABLE 24

NATURAL DISAGGREGATED STREAMFLOW RECORD AT JAMMERDRIFT

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	29.9	9.6	1.6	55.0	106.1	91.0	80.4	10.3	2.9	0.6	0.4	1.2	389.0
1921	1.1	57.8	146.7	123.0	14.1	4.3	2.7	0.8	4.6	1.2	0.6	0.4	357.3
1922	10.9	58.9	21.1	79.7	188.2	33.5	19.8	14.5	15.2	11.8	4.6	4.1	462.2
1923	1.6	33.8	14.1	36.3	75.9	232.0	32.9	3.2	1.9	1.1	0.6	16.9	450.3
1924	41.6	280.0	143.3	74.6	100.5	546.4	222.3	115.2	28.5	6.4	3.9	4.4	1567.1
1925	17.8	17.0	10.5	8.9	29.4	83.9	23.6	2.1	1.8	1.3	0.8	3.1	200.2
1926	8.1	52.6	37.8	35.1	35.9	165.1	45.2	2.0	1.1	1.2	2.6	0.8	387.5
1927	31.1	10.9	61.2	173.4	81.5	35.0	17.8	1.9	1.2	0.9	0.6	0.3	415.7
1928	27.8	38.1	58.5	63.9	21.7	89.1	25.5	4.0	11.6	12.7	2.6	66.1	421.4
1929	43.1	32.6	148.4	76.3	36.0	66.5	106.5	14.2	3.0	2.0	1.4	1.3	531.4
1930	10.3	1.9	10.3	77.2	77.2	51.1	201.3	19.6	3.1	5.1	2.2	0.5	459.9
1931	11.5	167.8	18.4	47.2	53.5	53.5	15.4	2.0	1.2	0.8	0.6	1.8	373.6
1932	1.2	14.3	21.3	10.7	15.2	21.0	7.9	0.1	1.2	0.4	0.1	0.0	93.5
1933	0.0	257.2	246.7	871.3	190.0	108.7	83.6	48.2	41.6	14.7	24.3	5.3	1891.6
1934	27.6	189.4	132.8	26.4	20.4	96.4	44.7	32.0	7.4	4.3	2.2	2.5	586.2
1935	5.0	27.3	12.2	66.1	34.0	21.0	41.3	9.8	6.2	0.8	0.4	0.2	224.2
1936	26.8	192.7	84.5	247.1	262.0	78.4	31.0	6.3	2.7	1.4	0.8	0.8	934.6
1937	1.7	8.2	20.6	30.5	144.9	39.2	24.9	15.4	4.0	3.7	4.1	7.2	304.5
1938	23.7	28.1	51.1	121.0	276.0	65.7	5.9	7.1	2.3	2.9	6.0	4.6	594.3
1939	109.4	139.5	23.5	8.3	27.7	43.9	32.0	38.9	3.4	1.7	1.0	38.2	467.6
1940	16.3	95.9	69.0	75.3	241.1	58.8	35.7	11.9	1.3	1.3	0.8	2.2	609.5
1941	49.9	12.7	1.0	78.8	60.9	162.2	34.2	10.8	1.9	1.0	5.2	5.4	424.0
1942	47.7	99.1	218.4	109.1	41.9	32.2	69.7	179.2	30.7	35.0	66.9	113.7	1043.5
1943	155.7	509.4	451.2	163.0	138.6	70.0	11.2	4.6	24.6	7.8	2.8	9.5	1548.4
1944	43.2	36.6	14.0	6.9	25.8	114.0	21.0	6.5	3.2	1.4	0.8	0.7	274.1
1945	2.5	4.9	15.1	146.0	84.8	51.9	44.4	14.2	6.0	0.9	0.8	0.7	372.3
1946	64.2	40.3	22.8	37.2	89.2	26.4	35.6	40.2	1.5	0.9	0.8	5.1	364.3
1947	57.3	36.1	129.9	74.8	28.6	376.5	82.3	23.5	5.3	2.6	1.5	0.7	819.0
1948	6.6	6.1	0.6	41.4	49.7	30.2	3.3	2.2	0.7	0.4	0.2	0.4	141.7
1949	2.6	101.7	111.0	73.2	70.6	256.1	394.1	251.3	39.3	15.4	78.6	43.9	1437.7
1950	9.2	5.8	109.4	235.5	75.6	47.3	39.5	13.9	5.2	3.0	1.5	1.7	547.6
1951	210.3	80.0	11.1	32.7	95.6	77.9	11.2	1.7	1.5	6.4	2.7	2.8	533.8
1952	2.2	79.8	67.4	31.4	118.9	37.1	76.6	19.3	2.8	0.6	0.5	0.4	437.2
1953	57.9	57.6	144.8	73.5	69.3	244.3	74.5	16.6	11.9	7.0	0.4	0.4	758.2
1954	0.4	11.8	29.6	273.5	523.0	65.8	23.2	32.9	8.6	6.8	4.5	0.5	980.7
1955	10.0	36.8	190.3	59.8	214.1	207.5	154.8	18.6	7.9	3.2	2.5	1.8	907.4
1956	13.5	97.9	453.7	160.0	168.3	87.4	39.6	5.4	3.5	7.1	9.5	243.3	1289.2
1957	508.3	191.6	147.6	278.4	93.9	32.5	51.4	45.0	11.0	2.7	1.7	3.8	1368.0
1958	2.1	178.0	50.5	44.1	55.8	30.7	19.2	121.4	13.9	12.1	4.5	1.9	534.2
1959	18.9	65.5	140.2	52.4	59.7	64.8	66.4	12.0	3.2	3.0	4.8	3.1	494.0
1960	23.9	34.7	38.9	70.4	29.0	63.9	101.8	32.0	42.3	8.9	5.2	2.4	453.4
1961	1.0	81.6	144.2	26.2	363.4	106.9	18.6	6.2	2.3	1.8	1.3	1.1	754.5
1962	2.1	76.4	18.2	138.6	82.9	95.6	242.0	40.1	5.2	6.9	3.6	1.5	713.0
1963	2.1	94.5	83.4	22.0	16.6	58.9	121.5	4.4	4.3	1.7	1.9	1.0	412.5
1964	105.9	53.7	38.4	40.9	17.2	0.2	17.9	4.8	1.6	0.9	1.0	1.0	283.5
1965	1.0	8.8	5.8	218.2	189.6	5.1	1.1	1.1	1.0	0.6	0.4	0.3	433.1
1966	0.7	18.9	48.6	92.6	342.0	43.9	160.6	47.2	25.6	4.8	2.6	1.6	789.1
1967	6.2	42.7	17.6	7.1	2.2	26.7	37.3	40.6	4.3	2.3	1.3	1.2	189.5
1968	3.1	1.6	40.1	4.4	38.2	76.9	80.3	15.2	6.5	1.5	1.7	0.6	270.2
1969	46.1	17.9	15.7	22.0	28.5	1.1	0.1	0.1	0.2	0.6	0.4	5.1	137.6
1970	34.0	22.9	92.1	92.5	55.3	17.1	46.8	10.7	2.3	1.0	0.8	1.5	377.1
1971	0.9	1.6	14.5	272.6	306.0	257.0	51.2	23.1	3.2	1.3	0.5	2.1	933.9
1972	8.8	20.5	6.6	0.3	98.0	24.0	9.2	0.4	0.3	0.2	13.8	7.8	190.1
1973	4.0	7.5	58.1	346.9	396.5	95.6	31.6	4.7	2.3	1.5	2.1	1.2	952.0
1974	0.6	111.7	65.0	100.0	252.8	283.9	22.2	6.0	2.8	3.4	2.6	3.4	854.4
1975	11.6	107.7	149.0	680.9	785.2	419.1	244.2	43.9	14.1	7.3	4.3	20.3	2487.5
1976	323.4	129.2	23.7	69.9	160.5	328.1	42.1	5.6	3.6	2.3	2.0	34.4	1125.0
1977	84.0	36.4	30.9	311.0	127.1	96.6	475.1	54.3	7.8	5.2	4.0	6.3	1238.7
1978	11.1	4.6	295.2	33.4	43.8	25.0	2.6	2.6	1.4	6.4	59.4	19.0	504.5
1979	58.2	52.6	45.1	19.8	33.7	20.3	3.6	0.4	0.9	1.0	0.9	12.2	248.5
1980	8.7	30.0	54.2	275.1	207.1	143.4	26.0	8.7	8.7	2.6	43.8	16.9	825.2
1981	2.6	50.8	70.4	27.6	27.4	8.0	168.8	27.3	3.6	2.9	1.2	2.0	392.7
1982	40.9	163.7	25.3	3.0	6.1	3.6	3.5	1.9	1.5	5.5	1.8	0.7	257.5
1983	17.3	41.2	62.5	113.4	8.2	17.2	8.5	19.7	1.3	0.7	2.2	4.4	296.7
1984	9.4	46.4	34.3	27.5	59.0	57.0	4.6	0.2	2.6	0.4	0.3	0.5	242.1
1985	11.4	125.6	160.3	33.9	47.2	27.4	9.2	1.8	4.6	0.6	1.9	7.8	431.7
1986	57.3	286.3	26.5	3.9	16.4	17.0	39.7	2.4	0.3	0.4	11.4	175.1	636.8
1987	85.0	85.3	114.6	27.6	506.2	796.5	120.8	33.1	9.7	8.2	4.1	23.5	1814.8
AVG	39.3	75.3	79.7	108.2	122.7	104.6	65.3	23.8	7.3	4.0	6.3	14.1	650.6

TABLE 25

COMPARISON OF MAR's FOR THE THREE POSSIBLE DAMS IN THE UPPER CALEDON RIVER CATCHMENT

POSSIBLE DAM	MEAN ANNUAL RUNOFF (million cubic metres)		
	CFP (1)	SAFPROD Report (2)	OS (3)
HLOTSE	189	165	165
KATJIESBERG	297	328	317
WATERPOORT	80	76	76

NOTES :

(1) Chunnett, Fourie and Partners
(2) Southern Africa Project Development group
(3) Olivier Shand Consortium

TABLE 26

NATURAL INCREMENTAL RUNOFF FROM THE RIETSPRUIT TO D2R006 (KNELLPOORT DAM)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.0	0.0	0.0	0.0	1.7	2.3	0.9	0.1	0.0	0.0	0.0	0.0	5.0
1921	0.0	1.1	1.5	0.6	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	3.3
1922	0.0	4.2	1.4	15.2	25.9	6.9	0.0	0.0	0.0	0.0	0.0	0.0	53.7
1923	0.0	0.2	0.1	0.4	0.2	17.3	5.8	0.0	0.0	0.0	0.0	0.2	24.1
1924	0.1	0.4	2.5	1.8	4.0	50.5	31.0	23.3	6.1	0.0	0.0	0.0	119.6
1925	0.0	0.0	0.1	0.1	0.2	1.6	0.5	0.0	0.0	0.0	0.0	0.0	2.5
1926	0.0	0.4	0.2	0.1	0.1	26.1	8.7	0.0	0.0	0.0	0.0	0.0	35.6
1927	2.0	0.7	0.1	1.8	0.6	0.6	0.2	0.0	0.0	0.0	0.0	0.0	6.0
1928	0.0	0.3	0.1	2.6	0.9	1.0	0.3	0.0	0.2	0.1	0.0	1.1	6.6
1929	0.4	0.2	9.4	3.5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	13.8
1930	0.0	0.0	0.0	1.4	1.7	0.7	2.0	0.6	0.0	0.1	0.0	0.0	6.6
1931	0.1	2.8	0.9	0.1	0.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	4.7
1932	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.4
1933	0.0	3.0	4.2	16.5	5.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0	29.5
1934	1.1	2.0	1.3	0.3	0.4	3.3	1.1	0.0	0.0	0.0	0.0	0.0	9.5
1935	0.0	0.4	0.4	0.1	0.3	1.9	0.6	0.0	0.0	0.0	0.0	0.0	3.7
1936	0.5	7.6	3.0	4.1	6.3	1.8	0.1	0.0	0.0	0.0	0.0	0.0	23.3
1937	0.0	0.0	0.1	3.2	1.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	4.8
1938	0.0	0.6	0.2	5.7	3.7	0.6	0.0	0.0	0.0	0.0	0.1	0.0	11.0
1939	0.7	3.2	1.0	0.0	1.3	2.5	0.7	0.0	0.0	0.0	0.0	0.5	9.7
1940	0.2	2.8	2.3	2.0	7.4	2.3	0.0	0.0	0.0	0.0	0.0	0.0	17.0
1941	0.2	0.1	0.0	0.6	0.2	0.6	0.3	0.0	0.0	0.0	0.0	0.0	2.0
1942	0.3	0.2	2.3	0.8	0.0	0.0	27.7	11.5	0.8	0.0	0.7	0.2	44.6
1943	0.7	6.2	6.2	2.2	0.9	0.2	0.0	0.0	0.0	0.0	0.0	1.0	17.5
1944	0.3	0.0	0.0	0.0	0.9	3.5	1.1	0.0	0.0	0.0	0.0	0.0	5.9
1945	0.0	0.0	0.0	5.5	1.9	0.7	0.3	0.1	0.0	0.0	0.0	0.0	8.4
1946	0.0	0.0	0.0	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.9
1947	0.8	0.3	3.1	4.3	1.4	59.8	20.1	0.1	0.0	0.0	0.0	0.0	89.7
1948	0.0	0.0	0.0	0.0	0.0	1.1	0.4	0.0	0.0	0.0	0.0	0.0	1.6
1949	0.0	0.2	0.1	0.0	0.0	12.8	29.8	10.0	0.5	0.0	0.2	0.1	53.4
1950	0.0	0.1	1.5	1.2	0.5	0.6	0.2	0.0	0.0	0.0	0.0	0.0	3.9
1951	0.5	0.2	0.0	0.4	5.1	1.7	0.0	0.0	0.0	0.4	0.2	0.1	8.6
1952	0.0	0.4	0.2	0.0	10.6	3.5	0.6	0.2	0.0	0.0	0.0	0.0	15.5
1953	0.2	0.1	0.2	0.1	1.3	5.4	1.6	0.0	0.0	0.0	0.0	0.0	8.9
1954	0.0	0.0	0.4	14.3	16.4	4.0	0.1	0.0	0.0	0.0	0.0	0.0	35.2
1955	0.0	1.6	0.9	0.1	22.9	37.6	10.0	0.0	0.0	0.0	0.0	0.0	73.2
1956	0.0	0.3	1.8	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.3	3.6	6.8
1957	7.8	2.3	0.1	3.3	1.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	14.8
1958	0.0	2.9	3.3	1.9	0.5	0.1	0.5	0.2	0.0	0.0	0.0	0.0	9.2
1959	0.0	0.1	6.4	2.2	0.9	2.6	0.9	0.0	0.0	0.0	0.0	0.0	13.1
1960	0.5	0.2	0.2	0.1	0.0	6.1	2.3	0.1	0.0	0.0	0.0	0.0	9.5
1961	0.0	1.1	2.6	0.8	3.3	1.2	0.9	0.3	0.0	0.0	0.0	0.0	10.3
1962	0.0	2.0	0.7	19.6	6.6	1.4	1.0	0.2	0.0	0.0	0.0	0.0	31.4
1963	0.0	5.3	1.8	0.0	0.1	3.1	1.0	0.0	0.1	0.0	0.0	0.0	11.4
1964	0.6	0.2	1.2	0.7	0.1	0.0	0.6	0.2	0.0	0.0	0.0	0.0	3.6
1965	0.0	0.2	0.1	32.3	10.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	43.5
1966	0.0	0.0	1.4	10.7	3.6	0.9	7.8	2.7	0.1	0.0	0.0	0.0	27.0
1967	0.1	0.1	0.0	0.0	0.0	3.1	5.6	1.5	0.0	0.0	0.0	0.0	10.4
1968	0.0	0.0	0.4	0.1	2.7	2.1	0.6	0.1	0.0	0.0	0.0	0.0	6.0
1969	1.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.0
1970	0.1	0.0	0.4	0.8	1.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	3.8
1971	0.0	0.0	0.0	5.3	10.1	16.8	4.7	0.0	0.0	0.0	0.0	0.0	36.9
1972	0.1	0.0	0.0	0.0	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1
1973	0.0	0.0	0.4	21.4	20.4	5.4	0.4	0.0	0.0	0.0	0.0	0.0	47.9
1974	0.0	0.7	0.7	0.3	1.5	0.7	0.1	0.0	0.0	0.0	0.0	0.0	4.1
1975	0.0	0.6	4.9	9.2	4.6	22.1	7.3	0.1	0.0	0.0	0.0	0.0	48.7
1976	2.0	0.7	0.1	0.5	1.1	1.4	0.4	0.0	0.0	0.0	0.0	0.7	6.8
1977	0.5	0.1	0.1	0.2	0.1	3.0	1.8	0.3	0.0	0.0	0.0	0.0	5.9
1978	0.0	0.0	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	1.5	0.5	3.0
1979	0.2	0.1	0.1	0.0	6.7	2.3	0.0	0.0	0.0	0.0	0.0	0.1	9.4
1980	0.0	0.5	0.3	8.5	11.6	3.4	0.2	0.0	0.0	0.0	1.5	0.5	26.5
1981	0.0	0.5	3.3	1.0	0.1	0.2	2.4	0.8	0.0	0.0	0.0	0.0	8.3
1982	0.6	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	1.9
1983	0.0	0.7	1.4	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.8
1984	0.6	0.6	0.1	0.1	0.7	0.7	0.2	0.0	0.0	0.0	0.0	0.0	2.9
1985	2.3	0.9	1.8	0.7	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	6.2
1986	2.2	3.3	0.9	0.0	2.2	0.8	0.1	0.0	0.0	0.0	0.0	13.5	22.8
1987	4.5	3.4	1.2	0.0	113.4	67.5	24.0	4.7	0.0	0.0	0.0	0.6	219.1
AVG	0.5	1.0	1.2	3.1	4.8	5.9	3.0	0.8	0.1	0.0	0.1	0.3	20.8

TABLE 27

NATURAL INCREMENTAL RUNOFF FROM THE LOWER CALEDON RIVER (DOWNSTREAM OF WELBEDACHT DAM) AND ORANGE RIVER (DOWNSTREAM OF BOSBERG DAM SITE) TO D3R002 (HF VERWOERD DAM)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.0	0.1	0.1	2.9	45.8	137.8	65.6	8.4	0.1	0.0	0.0	0.0	260.8
1921	1.0	30.4	75.1	22.4	0.6	0.1	0.0	0.0	0.4	0.1	1.0	0.3	131.3
1922	0.0	87.6	29.8	176.5	146.3	35.2	3.1	1.6	1.2	0.3	0.0	0.0	481.6
1923	0.0	5.3	1.6	15.8	6.0	581.6	194.3	0.2	0.0	0.0	0.0	2.7	807.7
1924	1.8	9.6	86.2	58.7	139.3	1139.5	472.6	66.6	10.3	0:0	0.0	0.0	1984.7
1925	0.0	12.5	4.9	0.3	1.8	58.6	19.7	0.1	0.0	0.0	0.0	0.0	97.9
1926	0.2	14.0	8.8	1.9	0.9	133.1	44.3	0.0	0.0	0.0	0.0	0.0	203.0
1927	6.0	2.0	16.4	61.5	19.1	9.9	4.5	0.4	0.0	0.0	0.0	1.4	121.4
1928	2.4	19.7	7.4	35.5	11.7	31.3	10.4	0.8	2.1	1.0	0.3	121.1	243.8
1929	40.6	0.9	101.9	85.5	20.8	9.7	4.0	0.4	0.0	0.0	1.2	0.4	265.4
1930	4.0	1.6	0.1	20.3	11.4	17.9	25.5	6.7	0.0	9.7	3.3	0.0	100.4
1931	6.5	26.3	23.7	5.7	33.1	11.6	0.2	0.0	0.0	0.0	0.0	11.9	118.7
1932	4.0	0.3	0.3	0.6	0.2	8.2	4.7	0.7	0.0	0.0	0.0	0.0	18.9
1933	0.0	47.9	177.8	316.7	106.5	53.5	18.3	1.1	0.1	0.0	0.0	0.0	721.9
1934	23.9	33.0	36.2	9.6	4.2	71.0	26.6	10.4	3.1	0.0	0.6	0.2	218.8
1935	0.0	8.0	3.8	0.4	2.1	26.0	8.5	8.9	3.0	0.0	0.0	0.2	60.9
1936	22.7	160.2	53.2	48.7	65.0	17.9	0.5	0.1	0.0	0.0	0.0	0.0	368.4
1937	0.0	0.0	19.8	20.6	67.8	21.4	1.2	0.4	1.7	0.6	0.0	0.0	133.4
1938	15.1	19.2	14.9	157.1	204.3	51.2	0.4	0.2	0.0	0.0	8.3	2.8	473.3
1939	4.6	2.6	0.4	1.2	20.4	168.1	57.8	1.9	0.2	0.0	0.0	8.5	265.7
1940	2.9	21.8	19.6	34.7	151.2	47.1	9.6	3.2	0.0	0.0	0.2	0.1	290.4
1941	0.7	0.2	0.0	14.2	11.0	45.8	24.1	3.2	0.0	0.0	2.3	0.8	102.4
1942	22.5	15.2	50.3	17.6	1.1	10.3	291.6	124.1	9.4	0.0	8.9	3.0	553.9
1943	2.2	176.5	157.5	45.3	13.2	20.2	5.7	0.2	0.4	0.1	0.0	29.1	450.4
1944	12.7	1.0	0.0	0.3	4.8	15.3	5.5	0.4	0.0	0.0	0.0	0.0	40.1
1945	0.0	0.9	2.4	85.4	62.0	30.9	17.7	39.5	11.9	0.0	0.0	0.0	250.7
1946	23.9	8.0	0.2	1.5	28.2	9.4	5.0	3.1	0.5	0.0	0.0	11.4	91.1
1947	17.6	5.5	64.7	58.4	46.5	508.8	181.7	5.3	0.0	0.0	0.0	0.0	888.5
1948	0.4	0.1	0.0	0.3	1.4	13.8	4.5	2.3	0.8	0.0	0.0	0.0	23.6
1949	0.0	5.2	7.3	3.7	28.3	168.5	116.9	78.4	19.0	0.0	0.8	0.7	428.8
1950	1.5	0.9	60.8	32.7	7.3	17.0	6.0	0.2	0.0	0.0	0.0	0.4	126.9
1951	7.9	2.6	0.0	2.8	47.0	15.4	3.6	1.2	0.0	25.1	8.4	4.3	118.2
1952	1.6	0.9	5.2	1.8	93.0	31.7	29.2	9.6	0.0	0.0	0.0	0.0	173.0
1953	3.1	33.7	39.9	11.3	38.1	354.2	114.7	0.5	0.1	0.0	0.0	0.0	595.6
1954	0.0	2.4	2.0	203.2	228.1	61.5	9.0	2.1	0.0	0.0	0.0	0.0	508.1
1955	1.1	14.6	12.4	4.2	23.2	164.3	55.6	1.3	0.1	0.0	0.0	0.2	276.9
1956	4.3	17.2	55.7	32.4	10.0	21.2	6.5	0.0	0.4	0.1	6.0	26.9	180.5
1957	37.7	14.4	10.8	174.6	57.6	2.6	1.1	38.4	12.8	0.0	0.0	0.2	350.3
1958	1.4	22.2	53.7	30.4	31.9	11.8	13.5	9.6	1.8	0.4	0.1	0.0	176.6
1959	0.0	5.5	62.4	28.3	10.1	15.4	7.1	1.4	0.1	0.0	3.3	1.1	134.8
1960	10.2	9.4	25.5	12.7	1.8	168.3	60.6	7.9	3.4	0.8	0.2	0.0	300.8
1961	0.0	45.5	66.8	17.7	218.7	79.5	6.8	1.5	0.0	0.0	0.0	0.0	436.5
1962	0.0	88.6	36.3	447.3	150.3	197.5	84.2	6.2	0.0	0.2	0.1	0.0	1010.5
1963	11.5	127.5	43.9	0.9	0.4	3.1	5.4	1.5	0.9	0.3	0.0	0.0	195.2
1964	17.9	6.0	8.8	12.7	4.1	1.6	45.6	15.1	0.1	0.4	0.1	0.0	112.2
1965	0.1	3.5	1.1	132.0	84.8	13.6	0.0	0.0	0.0	0.0	0.0	0.0	235.1
1966	0.3	6.3	17.4	212.3	100.5	52.0	224.3	99.9	9.9	0.0	0.0	0.0	722.7
1967	4.3	3.1	0.6	0.0	0.0	39.1	34.2	7.9	0.3	0.0	0.0	0.0	89.3
1968	0.7	0.2	18.9	6.5	23.2	71.0	38.9	6.0	0.0	0.0	0.0	0.0	165.4
1969	29.8	10.0	0.0	0.3	0.8	0.2	0.0	0.0	0.8	0.4	2.9	2.3	47.5
1970	1.7	0.4	39.1	61.4	42.6	27.7	67.7	37.2	1.0	0.1	0.0	4.1	282.9
1971	7.2	2.4	5.5	37.2	460.7	338.8	60.8	32.5	0.0	0.0	0.0	1.0	966.2
1972	6.7	2.5	4.1	0.0	25.0	9.3	3.5	1.4	0.1	0.0	0.5	0.2	53.4
1973	0.0	2.9	64.0	402.7	603.1	1017.0	333.6	156.6	63.8	0.0	424.1	16.2	3083.9
1974	0.2	47.1	16.3	10.2	25.4	21.3	16.1	3.8	2.0	0.8	0.0	1.6	144.9
1975	0.5	14.6	76.1	154.0	203.5	793.5	173.9	82.4	1.3	0.0	0.0	8.2	1508.0
1976	38.2	13.0	1.2	18.3	16.2	37.0	12.7	0.6	0.1	0.0	0.0	16.8	153.9
1977	23.2	7.0	22.7	27.1	17.6	72.8	75.6	11.5	0.0	0.0	0.0	3.2	260.6
1978	1.1	0.0	52.8	20.1	16.0	5.0	0.4	5.4	1.7	0.8	7.7	2.5	113.4
1979	7.5	6.4	1.5	11.1	55.0	31.1	0.8	0.0	0.0	0.0	0.0	1.3	114.6
1980	0.4	7.6	4.2	58.9	130.4	54.4	5.8	11.5	4.4	0.2	78.1	26.0	381.9
1981	0.5	4.5	12.3	3.8	3.1	15.7	37.5	10.5	2.2	3.6	0.9	0.3	94.8
1982	5.9	41.2	13.4	0.5	0.1	3.7	2.4	1.3	0.5	15.2	6.8	0.6	91.6
1983	2.1	18.6	47.2	31.5	0.1	5.5	3.7	1.7	0.4	0.0	8.3	2.8	121.7
1984	11.6	10.1	2.1	7.3	70.8	35.6	4.3	0.0	0.6	0.2	0.0	0.0	142.5
1985	53.3	41.4	150.9	103.8	23.5	16.1	5.7	0.3	0.0	0.0	0.9	0.4	396.2
1986	75.6	50.0	8.3	0.0	20.3	8.0	1.4	0.3	0.7	0.6	0.2	115.6	280.9
1987	38.6	48.0	16.0	0.4	2131.0	764.9	54.1	12.2	0.2	0.0	0.0	59.8	3125.2
AVG	9.2	21.3	29.8	53.2	91.6	118.1	47.8	13.9	2.6	0.9	8.5	7.2	404.0

TABLE 28

NATURAL RUNOFF AT MAMMAKO DAM SITE

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	4.1	5.2	1.7	35.0	128.2	123.2	59.0	14.2	3.1	1.6	1.0	0.8	377.0
1921	2.3	107.3	139.7	83.1	17.9	0.9	0.3	0.9	53.9	22.0	8.6	3.2	440.1
1922	2.9	123.2	41.7	129.1	321.3	96.5	35.8	75.5	29.6	9.8	4.1	1.0	870.5
1923	1.3	4.1	1.4	9.1	13.6	368.4	125.3	2.3	1.7	1.5	1.2	8.7	538.4
1924	13.6	94.5	97.7	54.3	92.3	337.5	284.6	196.7	47.1	1.5	1.5	2.2	1223.6
1925	1.6	4.8	3.4	1.2	37.3	133.6	43.4	5.1	4.4	2.4	1.1	1.0	239.1
1926	3.9	15.1	11.6	5.5	4.3	312.6	105.4	1.4	1.0	2.9	2.6	1.2	467.9
1927	59.1	21.5	21.3	102.5	35.6	39.0	23.9	4.8	1.4	1.3	1.2	1.3	312.9
1928	8.9	16.3	33.3	39.9	12.6	78.6	26.7	6.3	26.3	28.8	10.2	176.5	464.2
1929	63.2	3.5	200.8	80.7	9.4	30.6	59.3	19.9	3.0	1.8	3.1	1.4	476.4
1930	9.2	7.8	2.8	42.6	45.2	93.9	198.1	58.0	0.9	54.6	19.7	0.8	533.7
1931	37.0	79.9	25.3	14.6	103.5	43.0	3.9	0.9	1.3	1.7	1.2	6.9	319.2
1932	3.6	2.1	27.0	28.8	11.7	8.4	10.7	4.3	2.6	1.9	1.1	0.6	103.1
1933	0.4	95.8	238.5	195.4	46.8	53.7	25.8	10.2	6.0	4.4	4.4	1.7	683.3
1934	76.6	90.0	87.2	24.0	21.5	158.6	95.1	68.6	20.5	2.5	34.8	12.3	689.7
1935	4.8	9.4	15.2	15.8	44.6	53.1	15.8	31.2	12.6	2.9	1.5	1.2	208.1
1936	38.6	169.8	83.3	216.9	292.6	94.2	7.3	4.1	2.5	2.5	1.6	0.7	914.4
1937	0.6	0.5	26.1	38.7	153.6	49.7	122.0	42.5	8.1	5.3	5.4	2.5	455.0
1938	21.8	17.3	23.4	151.4	208.4	55.1	5.5	15.5	6.5	9.4	31.8	10.7	556.9
1939	101.1	55.2	11.8	3.0	20.4	96.3	73.0	38.6	9.6	2.1	1.5	63.9	476.6
1940	22.1	6.6	94.0	49.2	146.2	49.4	24.6	9.4	1.5	7.1	4.1	5.8	419.9
1941	48.5	15.9	2.1	75.4	159.0	212.1	74.6	7.7	1.9	1.4	8.0	9.3	615.9
1942	22.2	52.7	219.1	77.1	26.5	39.8	195.3	231.8	58.5	3.0	14.1	6.3	946.5
1943	34.6	123.4	219.1	66.4	49.5	52.5	13.5	10.5	11.5	4.6	1.3	12.9	599.8
1944	6.3	20.2	6.9	5.2	34.9	132.6	41.5	12.2	5.4	1.7	1.1	0.5	268.4
1945	0.6	3.1	10.9	67.5	41.5	94.7	50.2	49.8	16.3	2.3	1.3	1.4	339.6
1946	39.7	14.7	14.0	10.9	90.1	31.3	33.8	23.3	6.1	2.9	1.9	38.4	306.9
1947	56.7	23.0	175.0	66.4	81.0	249.3	91.2	11.2	3.2	1.4	1.2	0.6	760.2
1948	35.6	12.3	2.5	4.4	6.8	27.5	9.8	7.1	5.0	3.2	1.6	0.9	116.6
1949	4.3	38.6	26.5	20.3	17.1	225.9	305.7	119.1	16.4	17.6	80.2	27.2	898.7
1950	3.2	4.2	93.2	50.5	69.5	70.1	39.7	9.6	3.5	5.9	3.4	9.1	362.1
1951	104.6	34.2	1.0	21.6	44.8	15.7	13.6	5.8	5.9	79.8	31.3	20.5	378.8
1952	9.1	5.7	7.7	3.5	150.4	54.4	44.5	16.4	1.6	1.1	2.3	3.1	299.8
1953	27.4	15.7	42.1	17.6	46.5	204.2	69.1	13.5	5.4	4.2	2.2	1.4	449.2
1954	1.0	3.4	49.7	234.4	298.4	82.6	38.4	16.5	4.9	3.4	2.0	1.0	735.9
1955	8.7	54.5	64.0	16.6	266.7	258.5	65.2	7.9	3.8	2.4	1.3	1.7	751.2
1956	4.4	49.6	142.7	49.9	38.2	48.2	20.5	4.8	2.9	6.5	21.1	209.2	598.1
1957	223.2	68.3	13.0	202.5	74.3	10.8	19.7	63.1	20.8	1.6	1.0	1.9	700.1
1958	4.7	85.0	135.5	40.9	22.4	40.5	65.0	33.7	7.1	33.6	12.6	1.0	481.8
1959	1.9	3.7	175.5	73.5	75.6	87.6	66.7	21.8	6.9	6.0	33.0	12.6	544.6
1960	10.6	14.2	12.0	7.6	5.5	152.8	115.0	147.4	94.6	23.6	4.9	1.6	589.9
1961	0.4	127.2	148.9	41.2	192.6	113.3	45.0	11.0	1.4	1.4	1.1	0.7	684.1
1962	0.9	128.9	46.4	153.2	53.1	106.9	165.8	47.8	9.0	21.2	8.4	1.2	742.7
1963	15.1	173.4	80.0	9.3	8.3	152.1	58.4	6.1	13.3	5.9	1.6	1.8	525.2
1964	130.8	44.7	22.4	15.0	4.6	4.5	82.2	28.1	6.8	6.0	6.8	2.9	354.9
1965	2.4	6.5	4.1	311.1	169.3	24.3	4.3	3.1	3.8	2.3	1.4	0.7	533.3
1966	2.6	9.9	28.8	282.7	100.0	39.0	182.3	100.3	18.2	3.3	3.8	1.8	772.7
1967	25.9	15.0	4.3	1.7	1.1	67.9	91.5	60.0	14.6	4.0	2.5	2.0	290.3
1968	5.2	3.7	85.9	30.2	70.7	221.0	128.3	28.2	4.3	2.0	4.0	2.2	585.5
1969	88.6	29.9	4.5	7.0	4.3	1.9	1.5	2.0	6.2	5.1	6.5	23.2	180.9
1970	14.8	5.0	84.9	51.5	64.6	38.2	38.3	16.2	3.2	4.2	2.7	0.9	324.5
1971	4.1	3.3	20.3	136.6	207.4	202.5	55.0	6.1	6.3	3.2	1.5	1.0	647.3
1972	7.5	4.3	2.8	1.9	125.0	62.4	20.5	7.5	2.2	2.1	25.1	11.5	272.6
1973	1.9	4.5	11.6	155.8	268.0	166.1	33.6	3.4	2.4	1.5	7.9	3.5	660.1
1974	4.7	87.6	46.6	24.5	49.8	90.7	40.8	6.7	6.3	9.2	4.3	26.4	397.7
1975	10.7	87.2	98.3	221.9	114.5	166.3	100.3	22.2	6.4	3.1	1.2	62.5	894.5
1976	209.6	63.7	7.2	71.4	63.9	146.2	48.7	4.8	2.6	1.4	1.1	59.5	680.0
1977	96.0	28.7	19.1	59.5	24.4	162.1	142.4	31.1	2.1	1.9	3.4	8.6	579.3
1978	3.6	2.6	116.4	40.2	65.1	24.0	6.2	9.2	4.6	37.4	74.8	22.9	407.0
1979	49.5	24.0	8.0	3.8	22.8	9.5	3.1	1.9	1.3	1.3	1.7	5.2	132.3
1980	1.9	23.8	11.2	160.7	152.9	54.2	12.4	20.0	11.8	3.5	85.3	29.2	566.9
1981	2.2	28.7	48.1	15.3	7.5	15.6	211.0	70.4	8.9	11.5	4.4	3.2	426.6
1982	104.2	41.4	3.6	3.5	2.0	8.2	16.6	12.6	9.5	27.3	9.9	2.0	240.6
1983	7.5	59.4	64.6	27.6	4.9	23.0	11.2	17.1	7.5	2.0	33.3	11.8	269.7
1984	10.5	6.9	3.8	19.2	74.5	28.4	8.4	3.2	9.1	5.0	1.3	0.6	171.0
1985	75.9	32.8	55.4	48.8	17.3	21.1	9.0	2.0	16.0	7.1	13.5	8.0	306.9
1986	121.4	109.6	24.8	0.7	40.7	20.2	31.8	10.9	3.3	4.8	56.5	174.7	599.3
1987	57.7	47.1	32.8	7.4	279.8	265.2	184.2	47.1	4.9	6.2	4.0	40.1	976.6
AVG	32.1	40.8	54.2	63.7	81.7	96.8	65.5	29.4	10.5	8.2	10.8	17.3	510.8

TABLE 29

NATURAL RUNOFF FROM ORANGE RIVER FOR INCREMENTAL CATCHMENT TO D1H009 (ORANJEDRAAI), EXCLUDING RUNOFF FROM MAMMAKO DAM INCREMENTAL CATCHMENT

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	26.1	37.7	38.5	8.1	20.9	114.5	52.0	21.6	14.4	8.6	5.2	20.3	368.0
1921	39.2	36.7	155.5	73.5	65.9	35.0	7.7	14.3	-13.9	7.6	26.9	17.2	465.5
1922	42.4	131.5	64.0	124.6	292.1	122.8	4.1	-36.8	14.2	58.5	29.7	11.0	858.0
1923	12.7	32.0	32.3	123.2	142.2	198.1	69.1	12.5	7.9	6.5	6.7	32.9	676.0
1924	37.7	46.4	177.7	110.2	147.6	486.4	277.3	71.9	27.3	15.0	8.2	21.1	1427.0
1925	27.9	55.0	53.9	141.4	65.1	144.0	56.9	9.7	12.9	11.1	6.2	23.7	609.7
1926	66.6	76.3	116.9	70.8	106.7	360.3	123.5	11.0	5.6	7.4	9.3	9.5	964.1
1927	57.6	44.4	151.6	285.8	137.0	71.0	22.0	7.3	5.5	4.6	10.0	9.7	806.6
1928	41.5	65.5	74.6	111.1	73.7	145.2	51.7	11.7	13.6	22.2	22.0	172.1	804.9
1929	79.7	70.0	117.9	143.4	84.1	71.9	19.3	11.8	12.1	8.9	17.8	11.6	648.7
1930	28.7	21.2	40.1	133.4	129.4	98.0	203.4	74.8	10.9	65.5	34.7	7.8	847.7
1931	29.5	66.6	63.8	60.8	154.8	95.1	22.5	7.1	5.5	5.6	4.4	14.0	530.0
1932	15.1	44.4	67.6	46.9	47.4	37.8	21.1	9.9	5.4	7.0	6.1	4.4	313.3
1933	4.4	289.6	383.6	545.5	236.7	102.6	45.8	24.0	14.9	12.3	10.4	7.8	1677.8
1934	39.7	131.6	163.8	97.2	81.4	81.6	38.6	11.9	22.5	16.5	4.1	8.6	697.5
1935	15.3	30.6	39.0	91.1	178.0	114.8	38.8	97.4	42.4	13.0	7.8	4.2	672.4
1936	31.9	352.6	150.1	279.3	354.9	236.3	59.2	6.9	5.7	5.7	4.9	4.0	1491.5
1937	8.7	13.7	94.2	135.3	192.7	72.1	31.3	25.5	25.2	23.0	21.1	13.0	655.7
1938	67.2	86.8	201.4	210.8	253.3	88.9	10.7	11.8	11.9	7.7	-0.2	26.5	978.6
1939	40.6	64.9	72.2	75.1	169.8	117.1	46.0	130.8	57.8	14.2	7.9	86.5	903.0
1940	51.0	49.7	129.3	167.6	179.4	86.3	36.7	17.1	7.9	4.7	7.1	9.5	746.1
1941	10.0	9.4	8.4	199.1	225.3	162.5	118.7	41.1	10.1	5.5	8.8	13.1	811.9
1942	53.9	155.3	310.8	185.4	45.0	72.2	202.0	187.7	61.6	19.9	158.0	61.8	1513.6
1943	164.0	377.8	278.8	108.9	100.8	99.0	32.0	10.4	30.4	20.6	8.1	44.2	1275.0
1944	47.4	39.7	14.1	83.5	164.4	245.1	79.5	6.1	8.3	6.6	4.4	3.9	705.0
1945	7.6	14.5	35.6	129.8	114.8	60.9	26.4	19.9	17.7	11.3	6.3	5.5	452.4
1946	21.6	71.6	97.5	75.9	99.4	63.8	8.8	-0.5	15.0	12.1	6.2	16.8	488.2
1947	41.8	90.6	116.4	267.4	145.0	252.6	69.9	14.5	10.0	6.5	4.1	2.7	1041.5
1948	1.6	8.2	35.3	153.7	119.3	132.3	56.0	20.2	12.5	8.9	6.5	7.4	561.8
1949	16.6	104.3	176.2	104.7	163.6	359.1	243.5	64.8	22.9	15.4	162.3	69.6	1503.3
1950	20.2	28.7	141.0	147.5	87.7	43.6	27.7	17.2	12.4	7.9	11.6	19.9	565.5
1951	87.4	35.6	9.1	195.4	260.7	104.2	25.5	12.3	10.6	-37.5	4.1	21.6	729.0
1952	21.6	64.8	91.6	78.1	130.7	67.5	33.2	22.2	12.0	6.9	5.9	17.3	552.0
1953	87.9	73.1	41.5	58.6	133.5	106.4	43.0	42.1	24.2	9.2	5.6	7.8	632.9
1954	16.2	24.5	25.3	382.9	329.1	117.4	33.3	19.1	16.3	11.0	6.4	4.0	987.6
1955	26.2	73.1	146.1	72.6	228.8	300.3	107.8	29.6	15.3	8.5	5.3	4.1	1017.8
1956	20.4	59.7	353.9	283.3	144.8	106.8	39.4	11.4	7.4	6.5	11.7	280.3	1325.6
1957	314.6	153.9	144.6	245.4	102.5	48.4	62.1	14.3	12.4	10.2	5.1	3.3	1116.8
1958	6.8	97.2	223.6	115.8	102.3	49.9	108.8	171.1	59.0	9.8	15.2	7.6	969.0
1959	33.6	87.6	174.1	123.0	87.3	127.5	41.9	22.6	16.6	10.4	-5.4	16.2	735.4
1960	103.6	71.9	147.2	-0.7	89.5	67.3	38.6	131.4	293.4	13.0	9.8	24.1	989.1
1961	7.9	-2.1	23.7	-10.1	199.9	-76.7	-40.3	279.3	63.2	27.7	12.6	5.7	490.8
1962	13.1	-122.5	-17.4	267.2	86.8	445.5	828.2	54.7	55.0	125.3	141.2	72.8	1949.9
1963	38.6	121.5	84.4	92.7	46.4	13.8	265.2	48.5	-10.6	65.2	84.7	90.7	941.0
1964	344.9	165.1	30.7	74.8	32.7	14.7	-74.8	-1.2	22.7	54.9	62.5	213.1	939.9
1965	171.7	26.1	21.0	-73.7	403.9	-21.3	41.6	30.9	17.4	8.2	0.3	4.9	631.1
1966	10.2	12.1	-11.6	-278.3	379.5	168.6	713.0	84.2	374.7	116.9	53.0	18.7	1641.0
1967	-4.9	116.5	17.3	21.7	18.0	-65.8	-52.6	126.4	53.3	66.4	28.6	53.9	378.5
1968	7.5	12.8	75.6	22.1	44.9	6.9	57.8	-1.4	40.6	25.2	29.5	7.1	328.6
1969	-41.1	30.0	67.4	0.4	39.7	11.4	1.6	-0.3	-2.6	-1.8	13.7	40.3	158.6
1970	26.6	93.2	9.8	90.3	176.0	44.4	153.4	144.8	37.9	18.1	11.5	10.1	816.2
1971	-1.4	43.4	-13.6	-49.6	287.4	490.6	165.7	228.2	65.0	36.1	19.7	26.9	1298.1
1972	38.1	-2.3	46.5	-1.3	-120.1	46.9	75.0	37.3	28.7	12.4	-20.4	16.4	161.2
1973	-0.7	-3.6	8.7	1.3	823.4	375.6	229.3	227.3	61.9	8.0	59.8	81.6	1872.9
1974	15.4	189.9	123.3	-14.8	164.1	452.7	61.7	62.5	33.7	67.9	43.8	-25.1	1195.0
1975	204.1	-47.3	361.9	423.9	620.5	392.6	193.3	279.0	293.5	116.8	33.7	-61.7	2810.2
1976	724.3	471.4	77.1	-67.2	346.5	532.8	73.6	79.7	33.7	24.9	12.0	-8.1	2300.7
1977	71.5	98.3	42.7	182.8	181.8	-151.8	417.2	100.0	44.2	21.3	12.7	-1.6	1019.1
1978	130.5	46.4	130.9	-5.0	-57.3	95.5	23.8	7.2	9.3	-24.8	134.0	151.0	641.3
1979	284.9	13.1	63.6	62.7	-12.8	80.6	49.2	12.1	5.6	4.6	4.2	-1.9	566.1
1980	71.2	-23.4	205.8	-137.4	-123.6	200.4	60.3	113.3	267.5	41.0	62.5	203.9	941.4
1981	66.1	7.0	188.6	25.2	161.6	75.5	98.5	94.0	25.1	20.3	14.3	13.4	789.5
1982	-99.9	553.9	54.3	0.6	12.3	-6.5	7.6	26.8	39.9	30.9	37.2	15.4	672.6
1983	-5.5	-55.6	258.7	237.8	11.4	-6.4	55.8	113.3	13.9	8.6	-18.9	62.6	675.6
1984	-1.5	58.4	67.4	1.6	38.1	233.0	105.2	12.3	15.4	1.8	-0.7	-0.1	530.9
1985	-70.2	184.9	349.4	3.1	126.4	78.8	6.9	24.2	19.7	3.5	-10.2	157.8	874.3
1986	-92.7	686.3	7.0	38.6	-8.2	7.4	99.5	15.6	4.8	2.8	-54.8	218.8	925.2
1987	593.3	331.6	136.3	13.6	-127.9	851.6	91.9	30.0	67.8	67.0	167.7	646.4	2869.2
AVG	64.3	94.3	108.4	102.5	143.2	143.5	93.9	53.5	39.1	21.1	23.9	46.5	934.3

TABLE 30

NATURAL INCREMENTAL RUNOFF FROM ORANJEDRAAI (ORANGE RIVER) TO BOSBERG DAM

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.2	1.0	0.2	3.9	19.5	49.3	24.9	7.1	2.9	1.9	1.4	0.9	115.1
1921	3.1	4.4	51.6	20.0	2.0	0.6	0.3	0.4	3.3	5.2	6.3	3.6	100.7
1922	1.5	42.8	15.0	88.7	112.9	31.9	6.1	6.8	9.3	8.6	4.6	1.8	329.8
1923	0.8	32.6	11.4	9.8	4.2	195.7	70.1	3.7	2.1	1.7	1.6	3.0	336.8
1924	4.0	8.0	35.3	23.3	44.9	301.8	211.3	82.6	20.6	4.4	2.5	1.5	740.2
1925	0.7	7.3	4.9	0.9	8.3	44.2	18.1	3.5	2.2	1.8	1.3	1.0	94.2
1926	1.4	2.5	3.9	1.4	1.1	96.9	35.1	2.0	1.2	1.7	2.0	1.2	150.3
1927	4.7	2.5	22.1	19.4	6.4	15.6	8.0	2.4	3.6	3.6	2.3	1.6	92.3
1928	4.3	24.3	15.1	9.0	2.6	13.0	5.9	.8	7.2	8.4	6.7	84.8	185.0
1929	31.4	3.5	20.8	17.9	4.6	4.0	5.2	4.5	3.2	2.2	3.0	2.1	102.3
1930	2.4	1.0	0.5	4.0	5.0	10.7	16.8	8.1	2.6	17.6	10.7	2.6	81.9
1931	9.1	9.0	8.7	3.2	7.6	4.4	1.4	0.9	1.0	1.5	1.5	6.9	55.2
1932	3.7	0.8	0.4	0.6	0.6	2.5	3.3	2.4	1.8	1.8	1.6	1.0	20.6
1933	0.5	69.3	99.1	105.4	31.4	17.1	9.0	4.7	3.3	2.6	2.3	1.2	346.1
1934	10.8	16.4	9.5	2.2	3.4	33.1	15.8	12.3	8.0	3.3	5.6	3.8	124.3
1935	2.2	3.6	2.0	1.0	4.7	10.8	6.7	10.2	7.5	4.3	2.5	1.4	56.8
1936	5.7	32.2	13.6	11.8	15.9	7.5	2.1	2.2	2.4	2.3	1.9	1.1	98.5
1937	0.9	0.4	5.3	8.6	32.6	12.3	4.5	3.7	5.1	4.9	3.5	1.9	83.6
1938	10.5	19.8	11.4	22.0	76.3	24.8	2.3	3.3	2.8	3.2	6.0	4.1	186.5
1939	8.1	5.3	1.2	0.1	10.4	52.2	24.7	8.1	4.7	2.9	2.0	7.3	126.9
1940	3.8	5.1	13.2	9.4	24.4	8.7	5.1	4.0	2.3	2.6	2.7	3.3	84.4
1941	5.1	1.9	0.2	13.0	12.0	20.3	12.2	4.7	2.3	1.7	5.8	4.2	83.3
1942	6.8	4.7	40.2	13.8	0.5	6.3	113.3	100.1	26.2	3.6	4.7	3.2	323.5
1943	3.6	90.2	67.2	14.8	2.0	15.6	7.2	4.6	5.5	4.0	2.0	16.4	233.0
1944	9.3	1.7	0.2	0.3	2.1	14.5	7.9	4.3	3.2	2.1	1.4	0.9	47.9
1945	0.7	1.2	2.3	26.5	12.6	7.3	8.6	17.0	10.5	4.1	1.9	1.1	94.0
1946	13.5	5.5	1.4	0.6	4.9	2.1	5.6	6.7	4.5	3.0	2.0	7.9	57.7
1947	8.6	4.5	18.6	19.5	17.4	60.8	28.1	6.8	3.0	1.9	1.4	0.9	171.2
1948	1.7	0.8	0.2	0.1	0.2	14.3	7.1	5.5	5.0	3.5	2.2	1.3	41.8
1949	0.9	3.4	10.9	6.4	4.0	32.3	34.3	20.1	10.3	6.1	6.9	5.0	140.5
1950	2.8	1.3	19.0	23.7	6.6	13.0	7.9	3.6	3.4	3.1	2.1	2.4	89.0
1951	9.8	3.9	0.3	1.7	5.3	2.6	3.3	3.9	4.3	14.2	10.2	7.3	66.7
1952	4.4	1.6	1.2	0.6	17.9	6.9	11.3	7.4	2.9	1.8	2.3	2.4	60.6
1953	6.6	22.8	14.5	3.1	12.3	185.3	64.8	4.9	3.4	2.3	1.6	1.1	322.7
1954	0.6	4.5	2.3	156.2	92.4	19.7	20.8	11.7	5.0	3.6	2.3	1.2	320.2
1955	4.6	7.9	15.4	5.0	5.4	29.5	23.1	10.9	5.2	3.1	1.9	1.5	113.4
1956	4.3	6.2	34.3	43.9	17.0	19.6	8.6	2.6	2.7	2.8	6.7	19.2	168.1
1957	21.6	32.3	12.0	40.3	13.8	2.2	4.2	16.7	10.7	3.8	1.7	1.2	160.7
1958	1.4	7.9	20.8	12.5	15.8	8.1	14.1	10.7	5.0	7.6	5.7	2.0	111.4
1959	1.6	3.1	22.8	10.2	10.3	8.6	5.5	5.7	5.5	4.6	5.8	4.0	87.6
1960	7.0	14.5	22.4	9.6	1.8	49.7	26.8	11.7	11.6	9.7	6.0	2.5	173.2
1961	0.7	25.8	18.0	3.9	144.2	55.3	8.0	4.2	2.3	1.8	1.4	0.9	266.6
1962	1.0	43.7	18.0	77.4	27.5	54.2	28.0	7.1	3.7	5.0	4.4	2.0	272.0
1963	4.4	49.6	20.3	1.5	0.6	15.6	9.3	3.7	3.4	2.9	2.0	1.2	114.4
1964	21.9	8.4	4.1	5.4	1.8	0.9	11.4	7.0	4.6	5.0	3.3	1.8	75.5
1965	1.3	4.8	1.6	69.5	32.9	4.1	1.2	1.2	2.0	2.3	1.7	1.1	123.7
1966	0.9	3.9	2.9	75.0	30.3	15.3	84.0	69.0	20.6	5.2	2.9	1.6	311.4
1967	4.4	4.1	1.0	0.2	0.1	8.3	7.8	5.8	3.9	2.7	1.9	1.5	41.6
1968	1.8	1.0	6.8	2.4	23.7	111.1	40.0	5.0	3.0	2.1	2.0	1.7	200.6
1969	10.4	4.2	0.4	1.5	0.7	0.3	0.4	0.8	2.6	4.0	6.0	8.0	39.3
1970	5.2	1.1	31.3	15.2	12.4	15.9	72.7	40.2	7.8	2.3	4.6	6.0	214.7
1971	2.2	2.0	5.0	52.4	102.5	75.1	24.0	14.6	2.8	2.2	1.7	3.0	287.5
1972	10.1	4.8	3.9	0.0	6.3	4.3	3.6	3.9	2.9	2.0	1.8	2.4	45.9
1973	3.8	2.0	17.3	123.4	150.2	182.1	44.0	36.5	22.0	3.6	109.2	5.8	700.0
1974	2.5	29.2	12.9	4.9	7.7	6.3	7.2	4.3	5.0	2.4	4.3	6.6	93.3
1975	3.3	8.5	24.0	56.1	59.4	135.0	29.2	17.8	6.2	3.6	2.0	4.8	349.9
1976	39.1	14.9	9.1	19.0	9.1	20.5	10.2	4.3	3.5	2.6	1.6	8.9	142.6
1977	15.1	5.1	15.9	16.2	8.9	7.7	52.7	16.0	2.9	1.9	2.2	5.7	152.4
1978	3.5	0.8	20.9	7.8	10.7	4.2	1.0	2.3	1.5	7.2	9.5	5.0	74.3
1979	7.7	3.2	3.0	2.3	8.4	9.5	2.7	2.1	1.6	1.7	1.8	2.5	46.5
1980	1.4	5.0	1.8	26.8	26.1	9.0	2.8	6.1	6.7	4.4	54.3	21.3	165.6
1981	3.4	2.9	8.3	3.0	3.5	6.8	21.9	19.6	8.4	7.4	5.2	2.7	95.0
1982	6.9	28.7	9.3	0.3	0.1	1.6	1.9	2.5	1.6	4.5	2.3	4.1	63.7
1983	2.3	8.3	9.7	11.5	0.2	2.1	2.8	8.3	3.7	3.3	5.8	3.7	62.6
1984	7.3	8.9	3.6	7.1	25.6	13.4	3.6	1.7	4.8	4.7	2.4	1.1	84.0
1985	18.9	12.2	33.7	35.5	12.2	10.8	5.5	2.0	2.1	2.3	3.9	3.4	142.5
1986	25.5	26.0	6.4	0.2	13.9	7.8	6.0	3.7	2.4	3.0	3.6	94.1	192.5
1987	35.5	11.6	3.7	0.9	315.8	125.9	61.0	24.6	5.4	3.7	2.6	16.7	607.1
AVG	6.9	12.2	13.9	20.3	25.1	34.7	21.1	11.1	5.4	3.9	5.7	6.5	166.8

TABLE 31

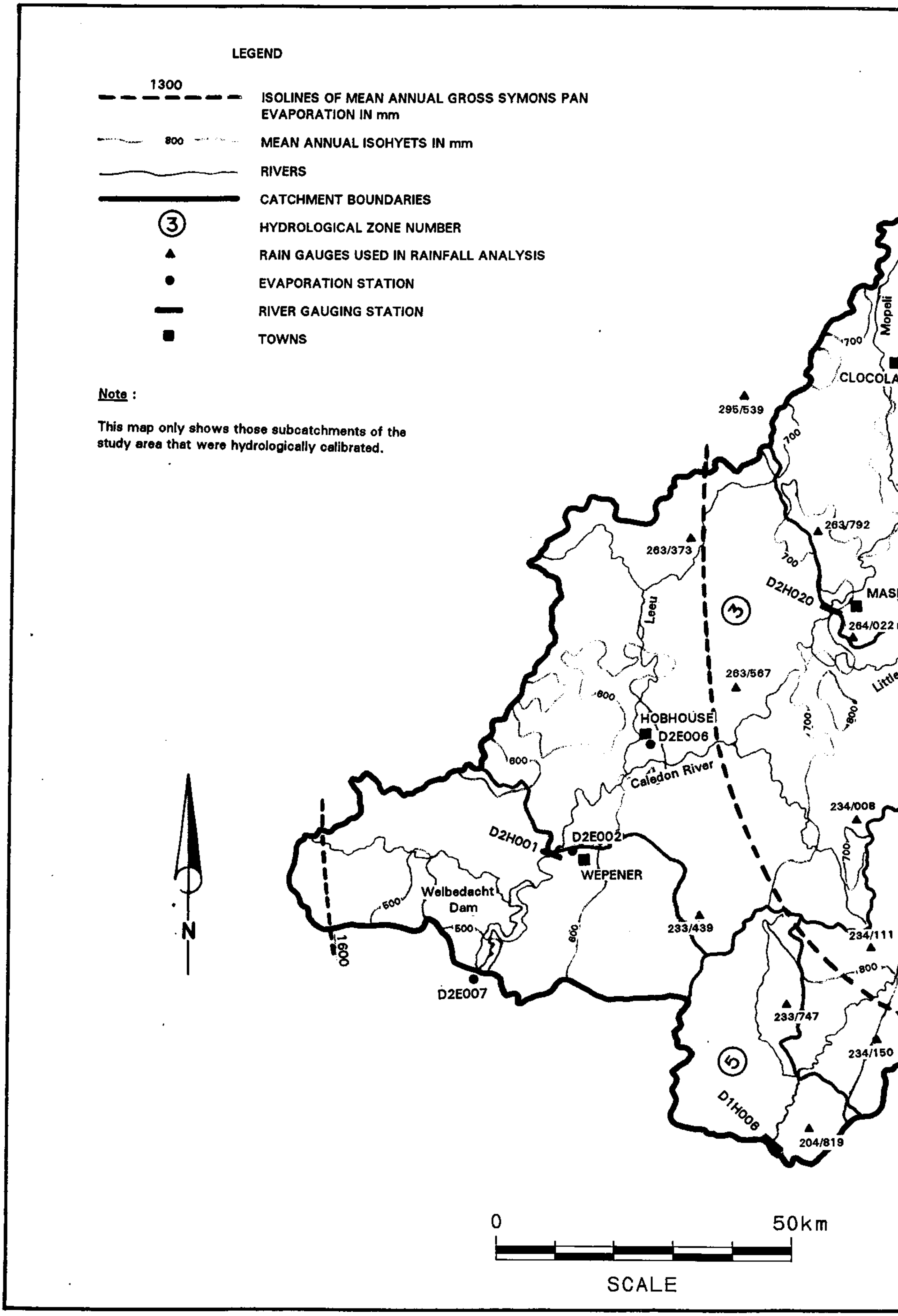
NATURAL INCREMENTAL RUNOFF FOR THE KRAAI RIVER CATCHMENT TO THE CONFLUENCE WITH THE ORANGE RIVER AT ALIWAL NORTH

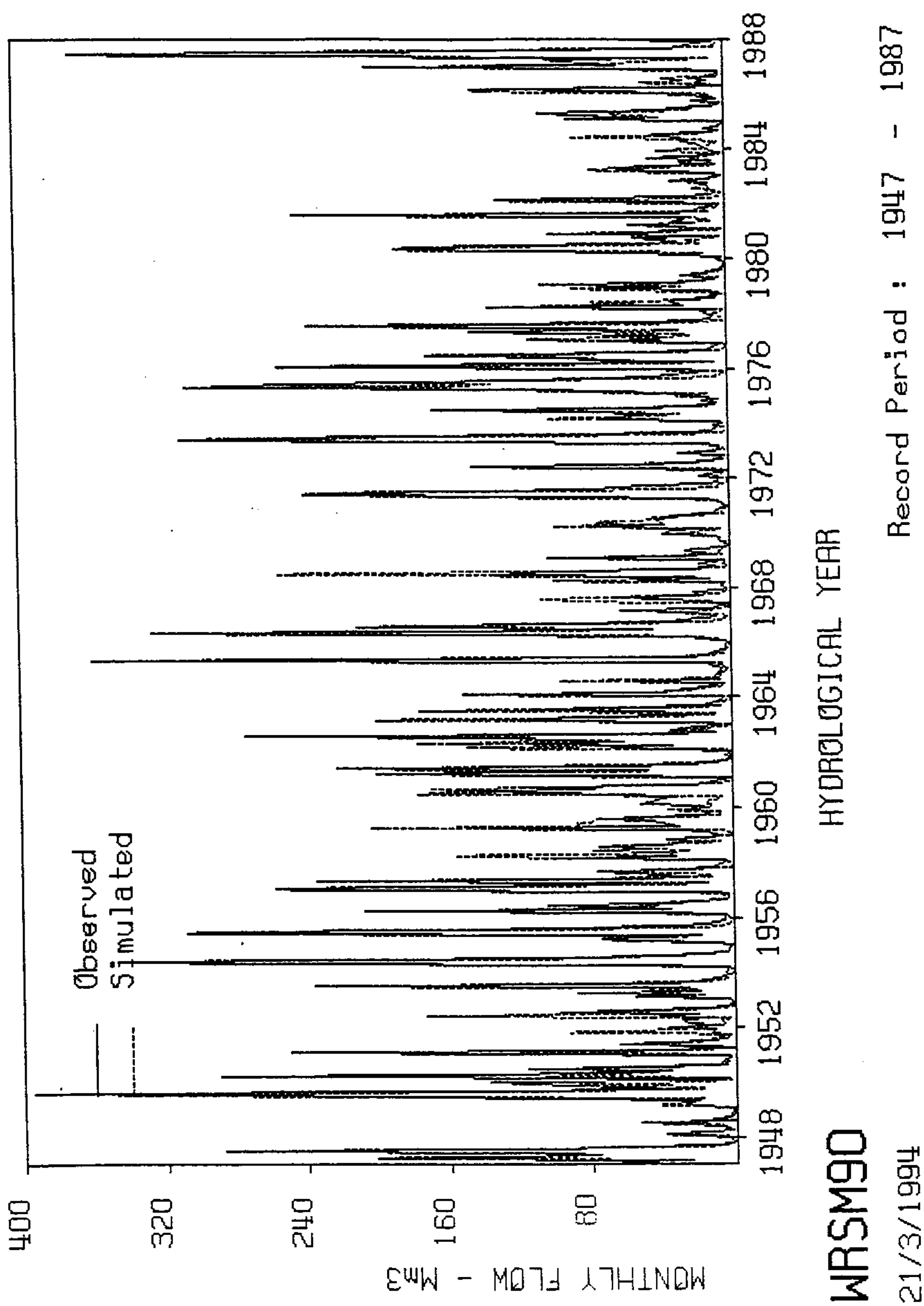
YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	5.8	3.9	2.4	5.3	122.9	155.7	160.5	55.0	12.7	8.3	5.2	3.7	541.3
1921	14.7	23.4	76.1	43.1	13.1	4.8	2.6	3.6	38.1	49.2	38.4	17.2	324.5
1922	10.5	89.2	34.3	402.6	357.8	106.3	26.5	47.2	124.3	64.2	21.3	8.3	1294.6
1923	4.5	82.2	29.4	10.4	17.7	823.9	285.2	10.9	6.1	7.4	7.5	11.7	1298.9
1924	9.0	47.7	131.2	70.3	56.9	879.9	810.7	274.5	55.7	21.2	13.4	7.4	2378.0
1925	5.1	18.4	21.0	16.0	15.8	193.8	75.3	11.5	9.9	8.6	5.7	6.9	387.9
1926	7.0	26.6	15.5	9.0	10.4	319.7	115.6	8.5	5.8	7.2	8.4	5.7	539.6
1927	12.4	12.2	156.4	134.5	45.5	39.9	20.0	7.2	4.8	5.1	5.6	10.0	453.6
1928	17.7	178.4	100.0	61.3	16.7	72.3	31.4	16.6	31.7	49.3	29.3	560.6	1165.4
1929	201.8	17.2	117.3	94.5	27.0	53.2	41.0	20.8	12.9	8.8	101.5	43.5	739.5
1930	15.7	5.9	10.1	50.8	58.6	104.6	79.8	28.3	8.2	260.3	101.8	8.0	732.3
1931	37.8	43.1	83.3	28.8	41.6	21.6	6.4	5.1	5.9	8.4	6.9	34.4	323.3
1932	17.5	7.4	4.6	2.3	3.4	43.6	29.1	11.2	7.7	7.5	7.3	5.6	147.2
1933	2.6	261.3	358.9	355.0	102.0	113.5	67.2	29.3	15.3	16.7	12.4	5.2	1359.4
1934	44.2	103.9	98.5	30.4	20.0	107.9	59.4	77.3	38.8	12.1	28.4	17.4	638.3
1935	7.3	34.5	14.3	4.1	21.6	26.4	19.0	27.1	20.4	20.0	13.3	7.5	215.5
1936	27.7	183.2	94.5	159.8	68.9	22.5	9.7	14.6	13.2	11.6	10.0	5.2	620.9
1937	5.6	3.5	56.4	36.9	193.6	71.9	37.0	24.9	19.0	18.0	15.1	8.3	490.3
1938	57.0	63.3	51.9	80.7	237.6	77.0	9.1	17.2	14.1	15.7	21.9	21.5	667.2
1939	45.5	20.5	3.7	1.5	79.7	234.7	94.5	51.5	30.6	13.6	8.0	37.4	621.1
1940	18.3	37.1	43.0	85.5	244.3	81.7	48.6	31.8	13.6	11.0	10.7	8.8	634.4
1941	25.5	9.6	0.6	103.6	100.0	122.6	51.4	15.1	9.8	7.3	33.2	28.2	507.0
1942	54.5	75.0	191.9	61.4	4.1	23.1	230.7	230.5	70.6	14.0	25.7	17.5	998.8
1943	15.0	447.5	232.3	44.0	15.2	178.4	69.0	21.2	23.9	16.0	7.5	111.6	1181.6
1944	54.7	8.1	0.8	1.9	40.2	71.3	33.3	18.2	13.1	8.1	5.1	3.0	257.7
1945	3.5	8.0	28.4	138.1	53.9	33.5	50.3	257.1	98.8	13.2	6.4	4.1	693.4
1946	35.2	20.7	7.0	9.2	38.1	18.5	15.9	21.7	17.0	14.6	12.3	21.2	231.4
1947	23.3	41.1	134.1	85.1	168.5	358.5	147.6	30.2	11.2	7.0	5.2	3.1	1014.8
1948	6.7	3.3	0.9	1.5	4.3	43.4	22.3	17.8	16.0	11.4	7.3	4.4	139.1
1949	3.2	7.9	19.4	9.1	55.5	169.2	274.9	113.2	32.3	23.9	34.3	23.6	766.5
1950	11.7	9.3	252.4	139.3	22.4	43.6	25.2	13.5	19.0	16.9	10.5	12.9	576.7
1951	47.2	17.5	1.0	17.4	76.5	30.6	18.1	15.3	13.8	28.9	24.0	46.2	336.4
1952	27.5	10.5	18.3	7.7	97.2	38.6	171.2	76.5	14.9	7.5	7.5	10.4	487.7
1953	31.3	88.1	46.3	10.6	50.2	403.7	147.7	18.5	12.3	9.2	6.1	3.9	827.8
1954	2.4	22.7	10.4	143.8	221.9	74.5	63.3	36.4	20.1	14.4	8.3	4.4	622.4
1955	12.3	46.6	29.1	10.7	39.0	129.4	151.9	63.5	20.8	12.5	7.6	10.6	534.0
1956	20.0	20.2	178.0	103.0	37.1	39.8	17.9	7.9	8.7	9.8	29.0	130.6	602.1
1957	99.3	57.2	18.7	284.9	98.7	20.7	26.8	253.6	97.9	11.1	5.4	5.0	981.3
1958	4.8	37.9	198.0	70.7	104.1	52.5	263.6	204.6	54.7	40.9	27.5	8.7	1068.1
1959	8.8	53.3	88.4	63.8	37.0	32.4	29.0	27.5	21.8	14.3	19.4	15.0	410.6
1960	31.4	103.0	48.1	22.6	9.7	256.7	118.4	66.7	56.7	37.5	29.7	13.6	794.0
1961	3.3	84.3	59.8	45.5	431.5	206.3	41.6	15.2	8.5	6.6	5.5	3.7	912.1
1962	3.3	98.9	101.1	251.6	85.1	503.3	193.3	18.4	12.1	37.6	29.1	9.7	1343.6
1963	39.4	99.8	55.5	10.6	2.4	34.2	34.2	18.0	18.8	15.2	7.9	4.7	340.8
1964	72.5	27.4	31.3	42.3	16.8	6.7	138.1	59.2	18.3	19.3	12.2	5.9	449.9
1965	58.1	76.2	7.9	64.2	154.1	9.4	2.7	2.3	3.2	1.3	0.7	1.4	379.6
1966	2.3	23.6	15.0	61.9	138.6	79.2	264.0	175.5	284.8	44.6	22.5	12.4	1124.3
1967	7.9	14.4	4.1	2.7	3.6	7.7	9.5	14.4	3.9	5.4	2.0	26.8	102.5
1968	11.7	11.0	39.8	7.8	17.2	189.7	85.4	16.9	11.6	6.4	9.0	4.7	411.4
1969	27.7	19.1	5.4	12.4	15.4	1.4	0.3	3.3	0.3	0.9	11.1	32.7	129.9
1970	142.9	9.5	210.7	47.5	77.2	55.8	168.1	99.3	15.8	7.8	3.4	14.3	852.4
1971	21.1	33.1	18.3	116.5	380.4	99.1	22.7	59.7	14.3	11.2	5.2	9.2	790.8
1972	26.1	35.0	13.0	1.6	33.4	21.0	25.1	7.6	3.7	1.4	3.9	2.3	174.2
1973	8.6	11.6	14.7	433.2	488.9	589.4	232.8	276.4	118.5	48.5	266.5	72.4	2561.5
1974	30.1	104.8	99.2	19.1	59.3	134.8	27.8	17.8	14.5	55.8	13.3	33.3	609.7
1975	25.5	26.3	162.2	293.3	379.7	648.0	432.1	270.7	97.5	49.0	21.8	39.5	2445.6
1976	672.4	287.7	63.5	20.1	57.0	98.2	21.2	24.9	8.7	8.0	4.2	44.1	1310.1
1977	58.5	32.7	35.5	81.3	26.8	37.4	310.9	51.8	16.5	10.6	8.3	73.0	743.3
1978	73.2	29.7	244.9	33.1	48.4	24.0	3.9	4.7	4.3	11.7	38.9	41.2	557.9
1979	105.6	29.1	51.0	19.1	32.5	70.5	10.5	2.3	1.6	1.4	1.9	6.3	331.8
1980	14.1	7.6	17.6	43.7	124.0	98.8	12.8	22.2	126.9	9.5	101.2	107.0	685.3
1981	42.3	23.9	61.7	14.1	10.4	35.5	64.3	40.9	29.8	37.1	24.1	14.5	398.4
1982	13.7	238.8	24.8	4.8	1.2	1.8	2.7	9.5	14.7	35.4	24.2	11.9	383.6
1983	19.5	16.0	34.5	83.3	6.4	15.2	30.5	35.5	5.0	4.3	5.7	14.7	270.7
1984	10.2	35.7	16.8	23.6	177.1	125.2	13.1	2.9	3.9	4.3	1.0	1.6	415.2
1985	20.7	179.3	194.7	81.1	76.3	41.7	7.9	3.6	4.0	2.1	2.7	18.8	633.1
1986	76.6	285.6	30.3	8.4	13.2	27.9	43.1	6.2	3.7	2.6	7.9	142.6	648.0
1987	355.4	78.1	21.9	14.3	581.6	357.7	209.3	71.4	69.3	32.4	14.8	250.6	2056.9
AVG	44.6	63.1	68.3	71.4	95.2	135.7	93.8	53.2	30.0	20.8	21.1	34.0	731.1

TABLE 32

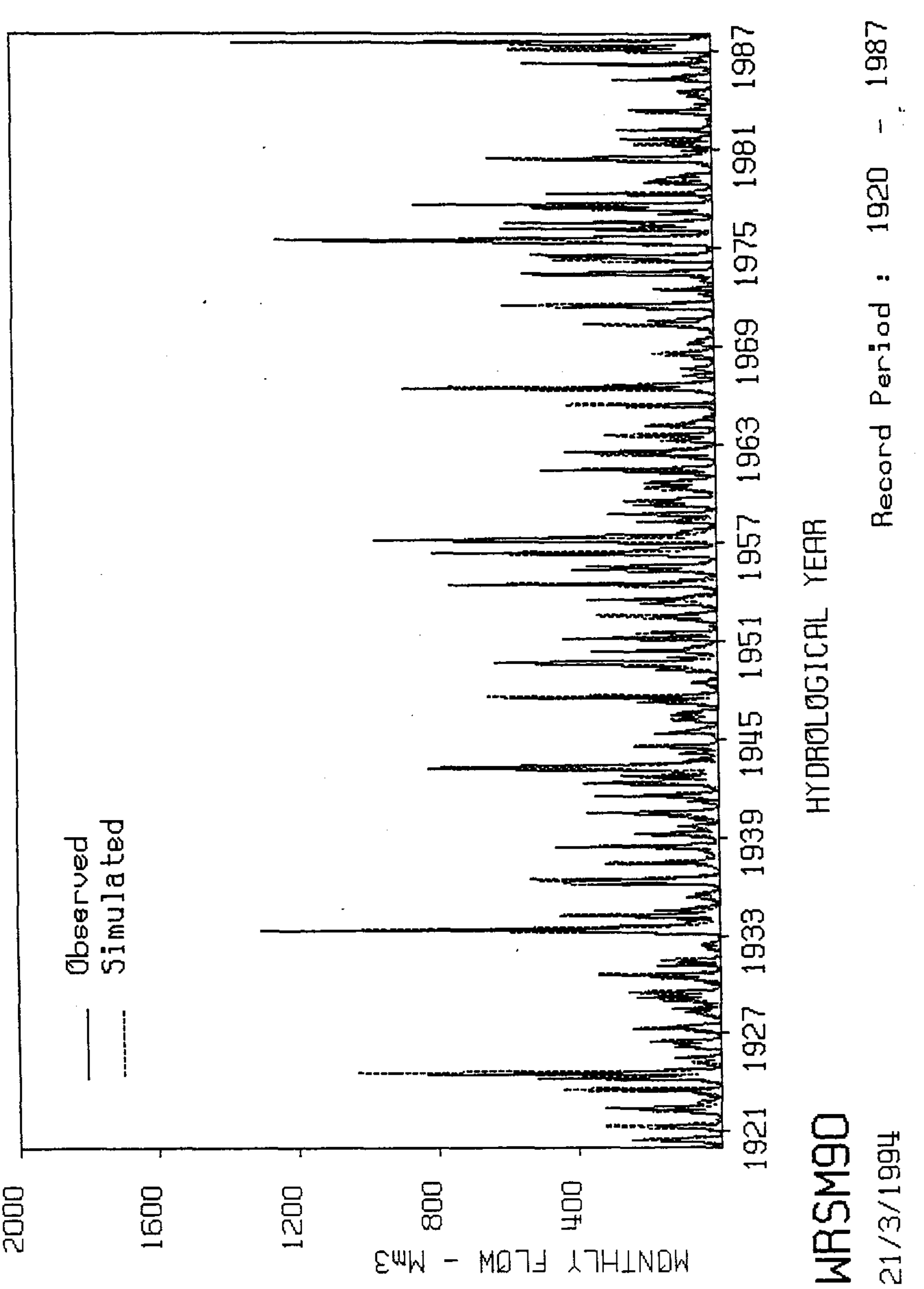
NATURAL INCREMENTAL RUNOFF FROM THE ORANGE RIVER BETWEEN HF VERWOERD DAM AND PK le ROUX DAM

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.0	0.0	0.0	0.0	13.3	117.4	70.2	10.8	0.0	0.0	0.0	0.0	211.8
1921	0.7	5.1	2.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2
1922	0.0	13.6	4.5	0.3	81.8	28.0	0.3	0.1	0.0	0.0	0.0	0.0	128.8
1923	0.0	0.5	0.2	0.2	0.2	448.3	149.5	0.0	0.0	0.0	0.0	0.0	598.8
1924	0.0	1.8	18.8	6.4	5.9	317.3	161.9	36.3	5.8	0.0	0.0	0.0	554.3
1925	0.0	0.3	0.1	0.0	0.0	12.8	4.3	0.0	0.0	0.0	0.0	0.0	17.5
1926	0.0	2.4	0.8	0.0	0.0	17.6	5.9	0.0	0.0	0.0	0.0	0.0	26.6
1927	6.1	2.0	0.7	5.8	1.9	8.8	3.2	0.1	0.0	0.0	0.0	1.1	29.6
1928	0.5	0.1	0.0	0.9	0.3	34.4	11.5	0.0	0.0	0.0	0.0	52.4	100.2
1929	17.6	0.0	10.6	12.9	5.7	2.5	0.5	0.0	0.0	0.0	0.2	0.1	50.1
1930	0.6	0.9	0.2	21.3	7.3	5.1	2.4	0.3	0.0	0.1	0.0	0.0	38.2
1931	0.2	3.5	12.2	3.7	5.2	1.8	0.0	0.0	0.0	0.0	0.0	4.4	31.0
1932	1.5	0.0	0.0	0.0	0.0	0.7	0.4	0.1	0.0	0.0	0.0	0.0	2.6
1933	0.0	4.3	5.3	55.3	30.3	15.3	5.3	0.5	0.0	0.0	0.0	0.0	116.3
1934	1.9	8.6	4.4	1.2	3.1	19.5	7.6	14.7	4.7	0.0	0.0	0.0	65.7
1935	0.0	0.2	0.1	0.0	0.2	10.1	3.4	3.1	1.0	0.0	0.0	0.0	18.1
1936	1.0	22.8	7.4	2.1	2.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	36.1
1937	0:0	0.0	8.0	4.2	28.7	9.4	0.0	0.0	0.2	0.1	0.0	0.0	50.6
1938	1.6	1.6	0.4	34.6	59.7	16.1	0.1	0.1	0.0	0.0	14.5	4.8	133.4
1939	1.7	0.6	0.0	0.0	1.9	129.9	43.2	0.0	0.0	0.0	0.0	0.7	178.0
1940	0.2	1.7	0.6	9.9	192.3	63.0	14.2	4.7	0.0	0.0	0.1	0.0	286.8
1941	0.0	0.0	0.0	0.6	4.5	11.6	3.4	0.0	0.0	0.0	0.0	0.1	20.2
1942	21.9	8.8	7.5	2.3	0.3	9.2	82.7	27.2	0.2	0.0	4.7	1.6	166.4
1943	0.1	78.5	30.2	1.5	2.1	39.2	12.9	0.0	0.0	0.0	0.0	0.9	165.3
1944	0.7	0.1	0.0	0.5	0.2	6.3	2.1	0.0	0.0	0.0	0.0	0.0	9.9
1945	0.0	0.0	0.0	1.5	2.5	3.7	4.0	72.2	23.7	0.0	0.0	0.0	107.5
1946	5.4	1.9	0.0	0.0	1.6	0.6	0.0	0.0	0.0	0.0	0.0	1.0	10.5
1947	0.5	0.1	4.2	2.1	105.9	245.5	83.7	4.5	0.0	0.0	0.0	0.0	446.5
1948	0.0	0.0	0.0	0.0	0.0	1.6	0.5	0.8	0.3	0.0	0.0	0.0	3.2
1949	0.0	0.0	0.1	0.1	47.7	88.3	71.4	26.1	3.4	0.0	0.0	0.8	237.9
1950	0.3	0.2	18.0	7.1	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	26.6
1951	0.0	0.0	0.0	0.0	64.6	21.6	0.4	0.1	0.0	3.3	1.1	0.0	91.1
1952	0.0	0.4	0.4	0.1	33.4	11.1	16.9	5.6	0.0	0.0	0.0	0.0	68.1
1953	0.0	33.0	18.1	2.4	0.0	102.1	34.4	0.1	0.0	0.0	0.0	0.0	190.1
1954	0.0	0.0	0.0	6.1	72.5	24.1	3.2	1.0	0.0	0.0	0.0	0.0	106.9
1955	0.0	7.6	4.9	3.7	1.1	41.5	14.5	0.2	0.0	0.0	0.0	0.0	73.5
1956	0.3	0.9	17.4	5.9	3.8	9.0	2.6	0.0	1.2	0.4	0.8	0.7	42.8
1957	1.1	0.3	8.1	75.9	24.4	0.0	0.0	11.6	3.9	0.0	0.0	0.2	125.4
1958	0.1	0.3	19.1	7.7	3.8	1.1	0.8	7.0	2.2	0.0	0.0	0.0	42.2
1959	0.0	0.0	2.9	1.0	1.0	10.6	3.7	0.1	0.0	0.0	1.4	0.5	21.1
1960	0.7	0.7	0.5	0.9	0.3	144.1	48.4	0.9	0.8	0.9	0.2	0.0	198.3
1961	0.0	8.0	5.6	1.0	19.9	7.7	0.4	0.0	0.0	0.0	0.0	0.0	42.7
1962	0.0	51.0	17.0	368.9	123.0	50.0	27.0	3.5	0.0	0.0	0.0	0.0	640.2
1963	1.3	24.3	8.4	0.2	0.0	0.0	2.3	0.8	0.2	0.1	0.0	0.0	37.4
1964	0.1	0.0	3.7	6.8	1.9	0.4	17.7	5.9	0.0	9.5	3.2	0.0	49.1
1965	0.0	0.4	0.1	3.5	2.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	7.1
1966	0.0	0.0	0.4	42.4	33.9	18.2	37.0	14.5	1.2	0.0	0.0	0.0	147.6
1967	0.1	0.1	0.0	0.0	0.0	35.5	16.4	1.6	0.0	0.0	0.0	0.0	53.7
1968	0.1	0.1	5.7	1.9	8.1	7.9	21.5	6.6	0.0	0.0	0.0	0.0	51.9
1969	3.4	1.1	0.0	0.0	1.2	0.4	0.0	0.0	0.1	0.1	0.2	0.1	6.6
1970	0.0	0.0	5.5	7.2	22.3	8.0	7.5	2.4	0.0	0.0	0.0	0.0	52.9
1971	7.6	2.5	0.0	22.1	12.4	87.4	28.8	0.1	0.0	0.0	0.0	0.0	160.9
1972	0.4	0.1	0.0	0.0	4.0	14.7	6.0	0.5	0.0	0.0	0.0	0.0	25.7
1973	0.0	0.0	15.7	81.2	644.2	653.5	151.6	10.5	3.2	0.0	56.3	18.8	1634.8
1974	0.0	1.3	0.4	0.0	21.2	24.7	5.9	0.0	0.0	0.0	0.0	0.0	53.5
1975	0.0	5.0	44.6	71.8	106.0	375.9	129.8	4.7	0.0	0.1	0.0	2.6	740.5
1976	11.1	3.4	0.0	2.1	130.0	25.7	1.1	1.0	0.3	0.0	0.0	0.4	113.9
1977	0.2	0.2	2.1	10.3	4.1	16.9	9.6	1.4	0.0	0.0	0.0	0.5	45.3
1978	0.2	0.0	2.1	1.1	11.2	3.7	0.0	3.4	1.1	0.5	0.2	0.0	23.5
1979	0.5	0.4	0.1	0.0	3.6	8.5	2.5	0.0	0.0	0.0	0.2	0.1	15.8
1980	0.0	5.5	3.2	9.2	116.0	44.2	2.5	0.3	0.1	0.0	41.6	13.9	233.7
1981	0.3	0.1	0.9	0.3	0.0	0.7	8.9	2.9	0.0	0.7	0.3	0.0	15.0
1982	1.7	1.6	0.3	0.0	0.0	0.7	0.3	0.0	0.0	0.1	0.0	0.0	4.7
1983	0.0	3.4	4.3	1.1	0.0	0.1	0.8	0.3	0.0	0.0	0.6	0.2	10.7
1984	12.2	4.2	0.0	7.3	28.5	9.3	0.2	0.0	0.0	0.0	0.0	0.0	61.8
1985	17.9	10.2	24.9	17.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.1
1986	6.6	4.7	0.8	0.0	7.8	2.6	0.0	0.0	0.0	0.0	0.0	24.1	46.6
1987	8.0	27.8	9.3	0.0	482.0	211.0	26.3	5.0	0.0	0.0	0.0	6.0	1080.9
AVG	2.0	5.3	5.3	13.7	38.2	53.5	20.2	4.3	0.8	0.2	1.8	2.0	151.0

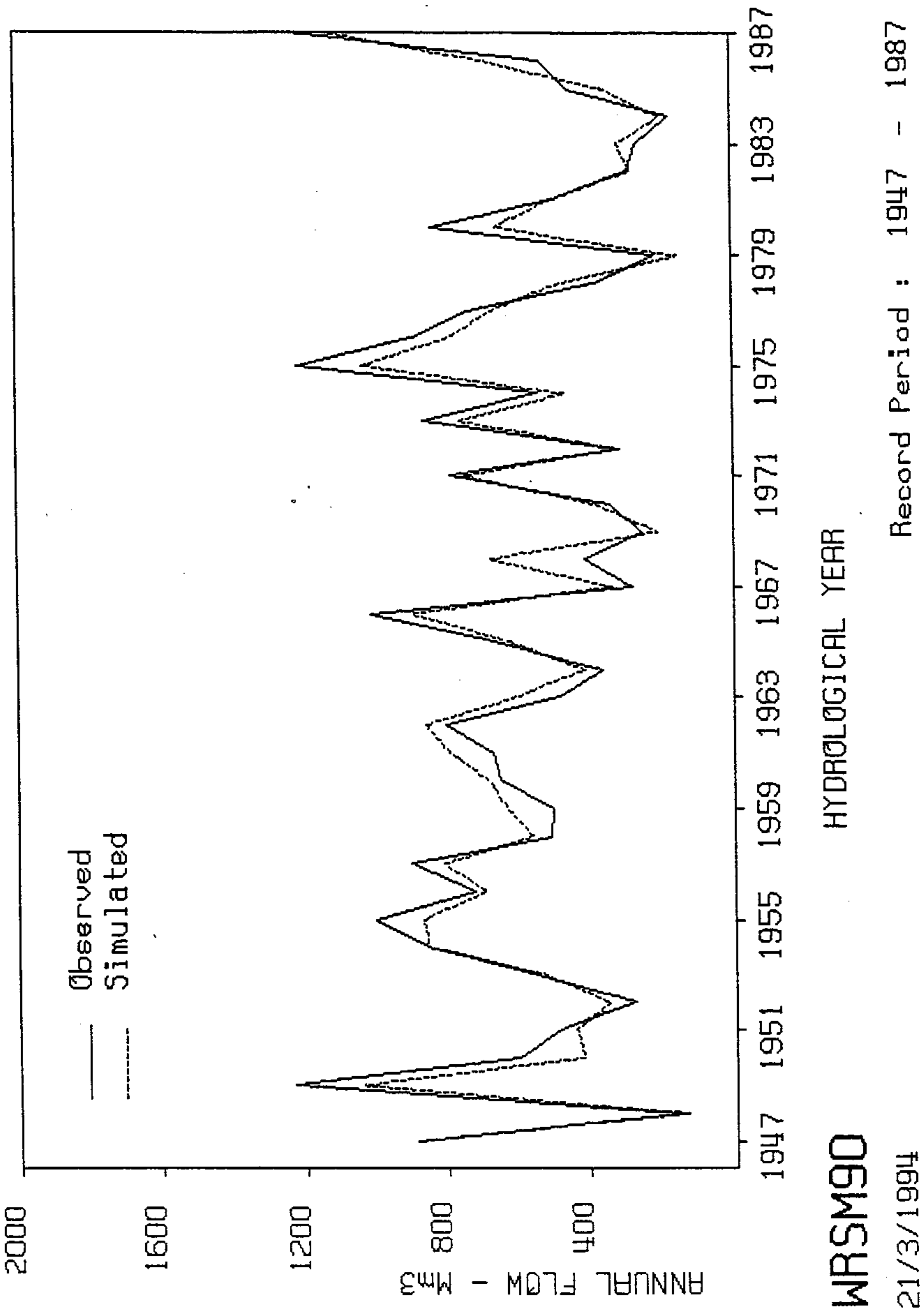

LEGEND
1300
ISOLINES OF MEAN ANNUAL GROSS SYMONS PAN EVAPORATION IN mm
800
MEAN ANNUAL ISOHYETS IN mm
RIVERS
CATCHMENT BOUNDARIES
3
HYDROLOGICAL ZONE NUMBER
RAIN GAUGES USED IN RAINFALL ANALYSIS
EVAPORATION STATION
RIVER GAUGING STATION
TOWNS
Note :
This map only shows those subcatchments of the study area that were hydrologically calibrated.
Mopeli
CLOCOLA
295/539
263/792
263/373
D2H020
Leeu
3
264/022
263/567
HOBHOUSE
D2E006
Caledon River
234/008
D2H001
D2E002
WEPENER
Welbedacht Dam
D2E007
1600
233/439
234/111
233/747
234/150
5
D1H008
204/819
N
0
50km
SCALE



DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		2
MONTHLY HYDROGRAPHS FOR D1H006		



DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		3
MONTHLY HYDROGRAPHS FOR D2H001		



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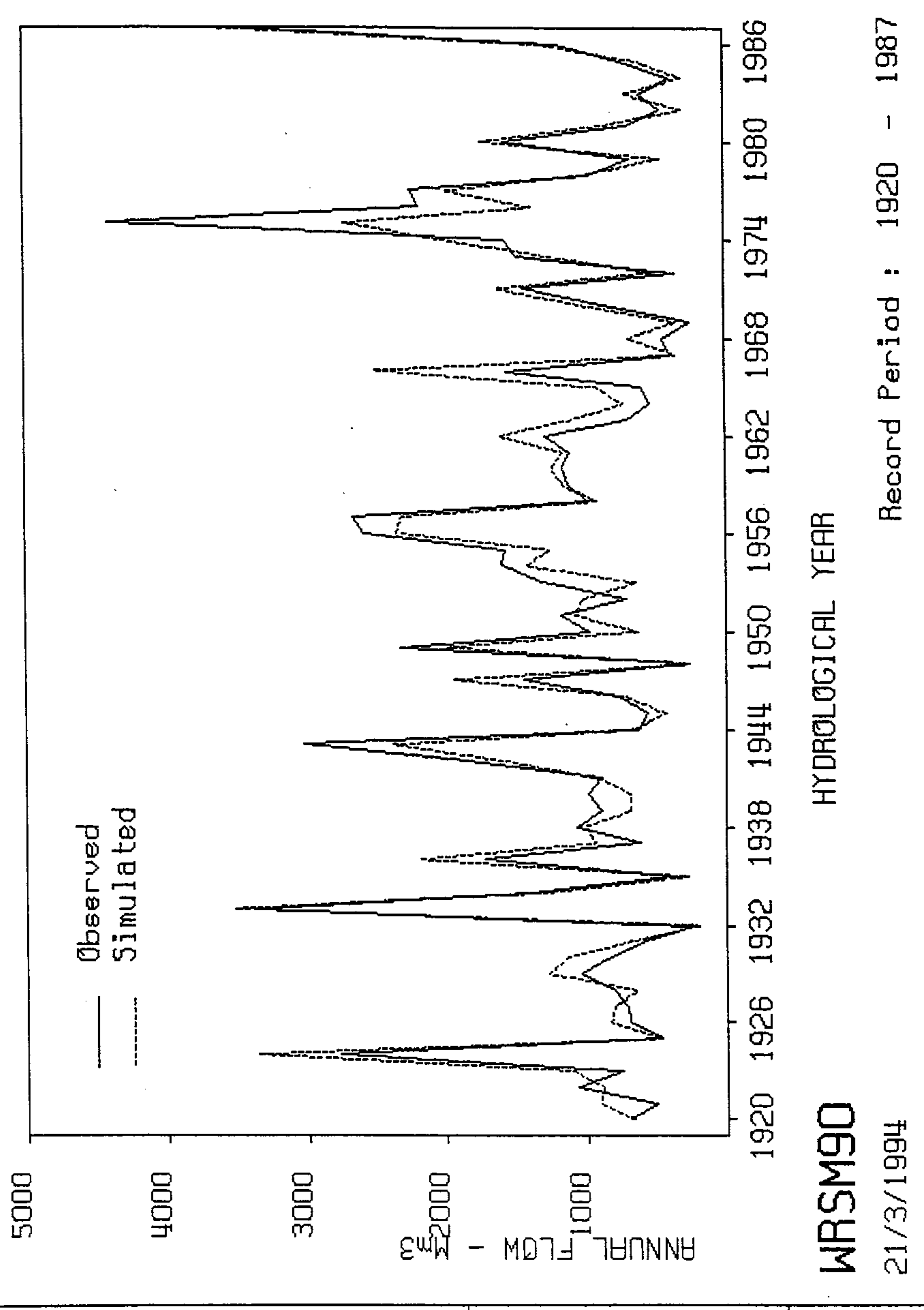
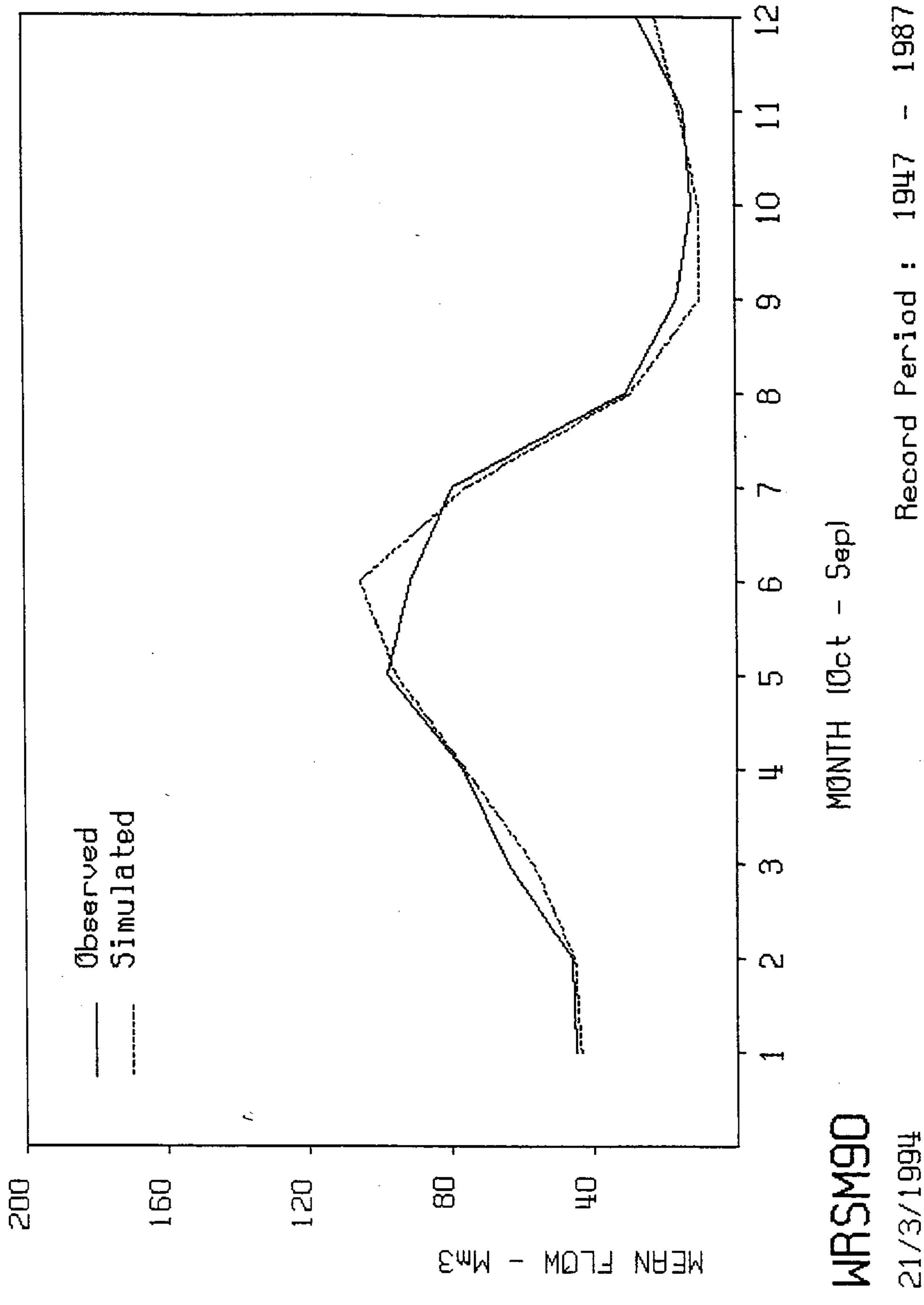
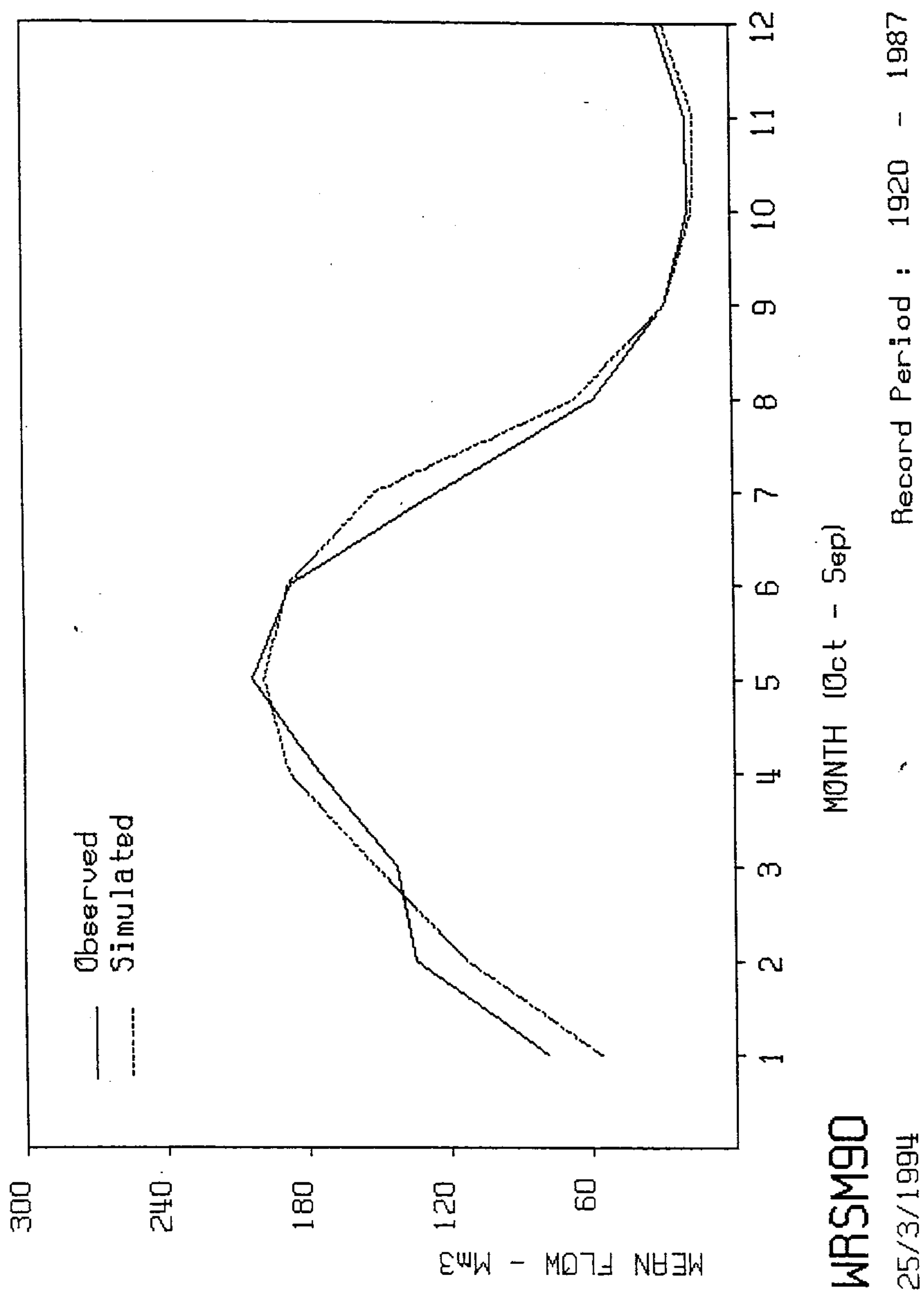
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		4
ANNUAL RUNOFF FOR D1H006		



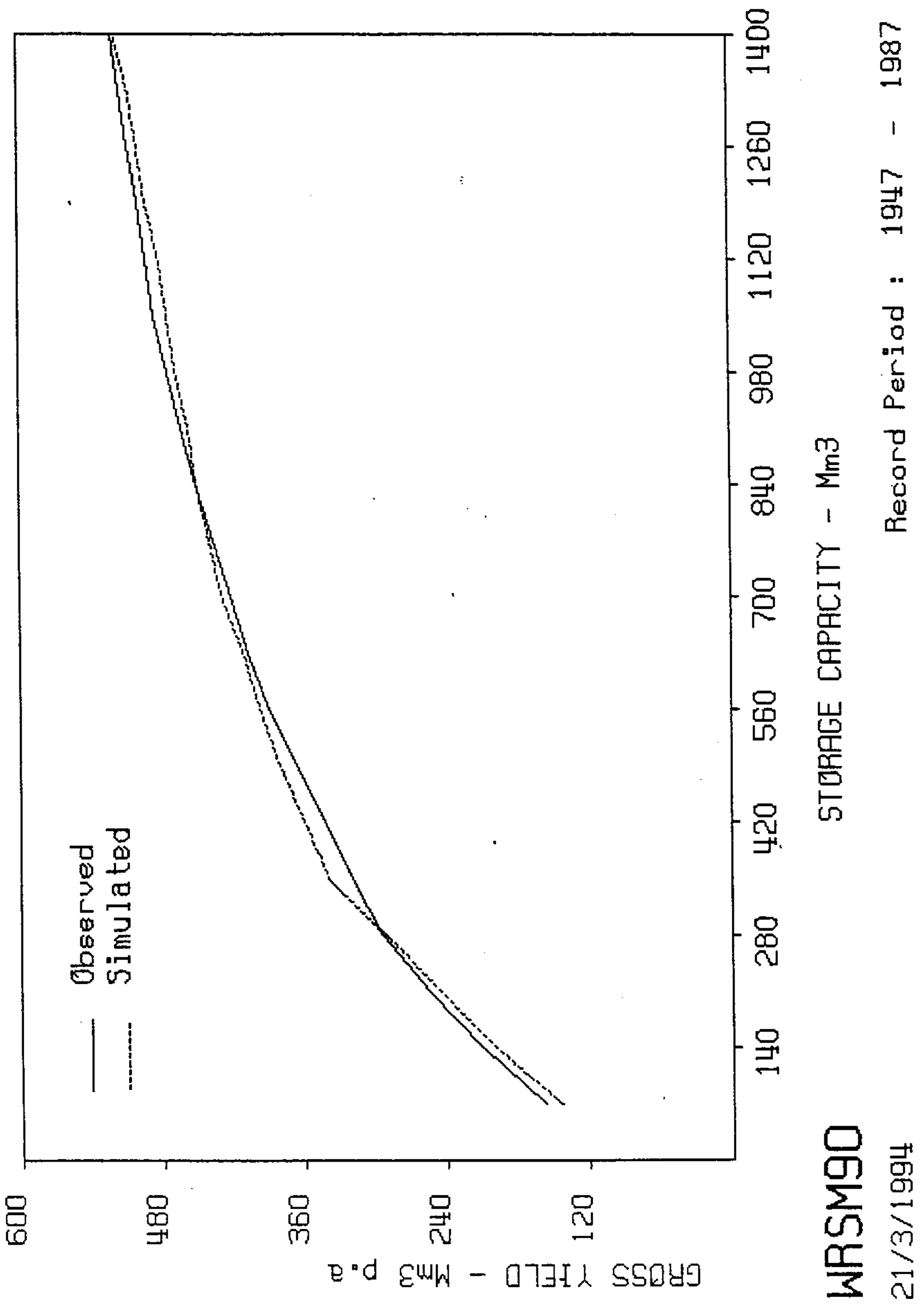
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		5
ANNUAL RUNOFF FOR D2H001		



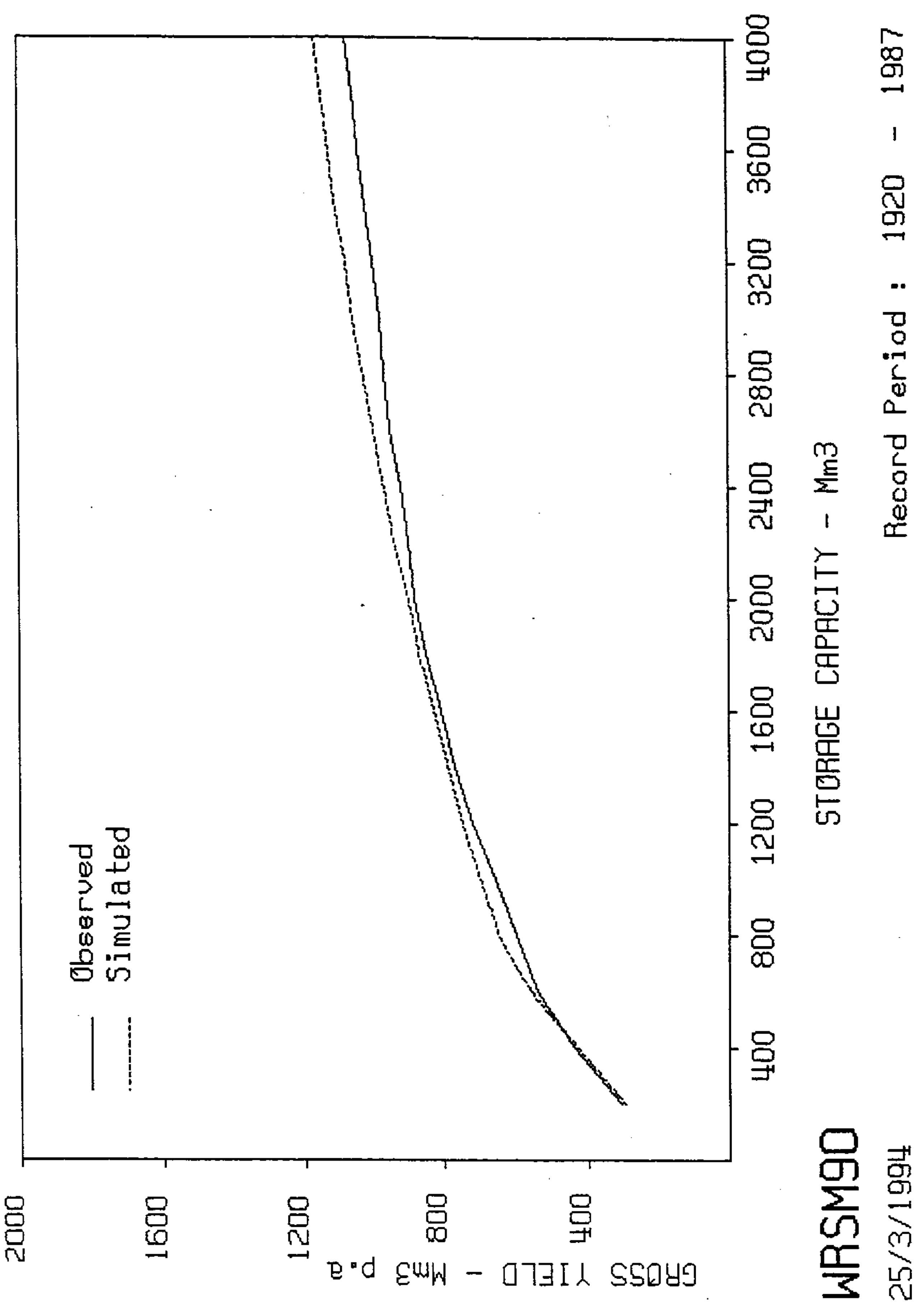
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		6
MEAN MONTHLY RUNOFF FOR D1H006		



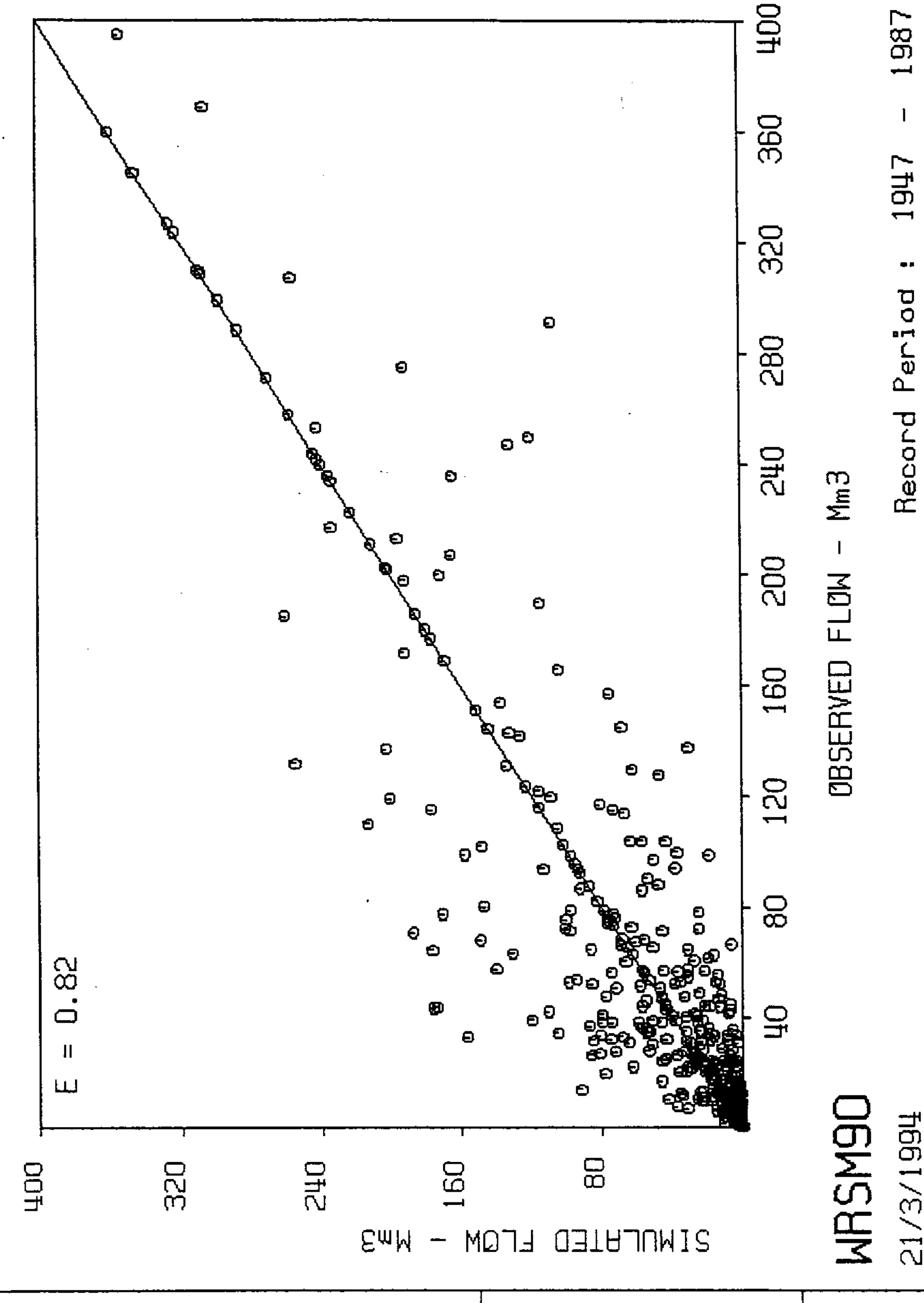
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		7
MEAN MONTHLY RUNOFF FOR D2H001		



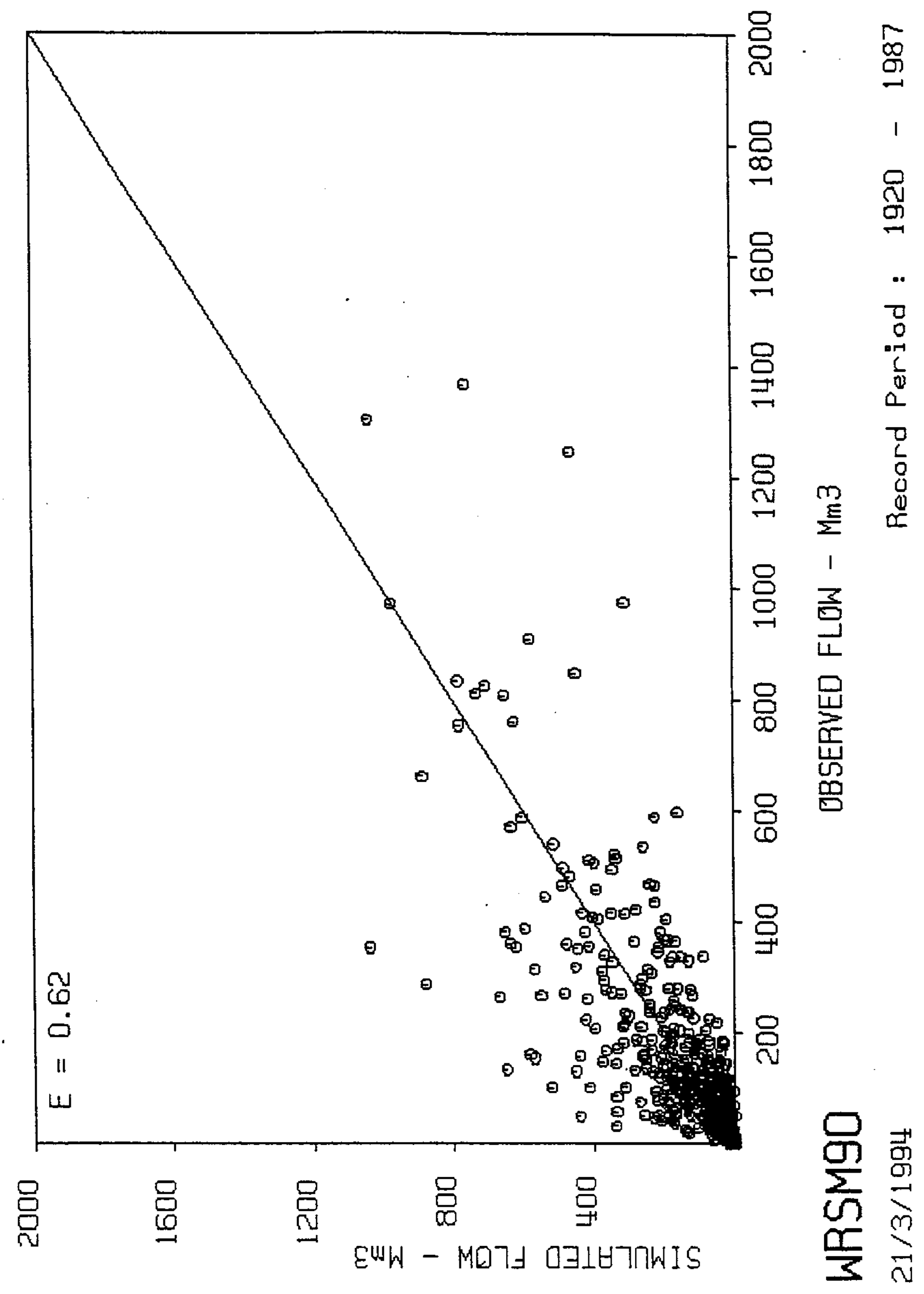
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		8
STORAGE/GROSS YIELD CURVES FOR D1H006		



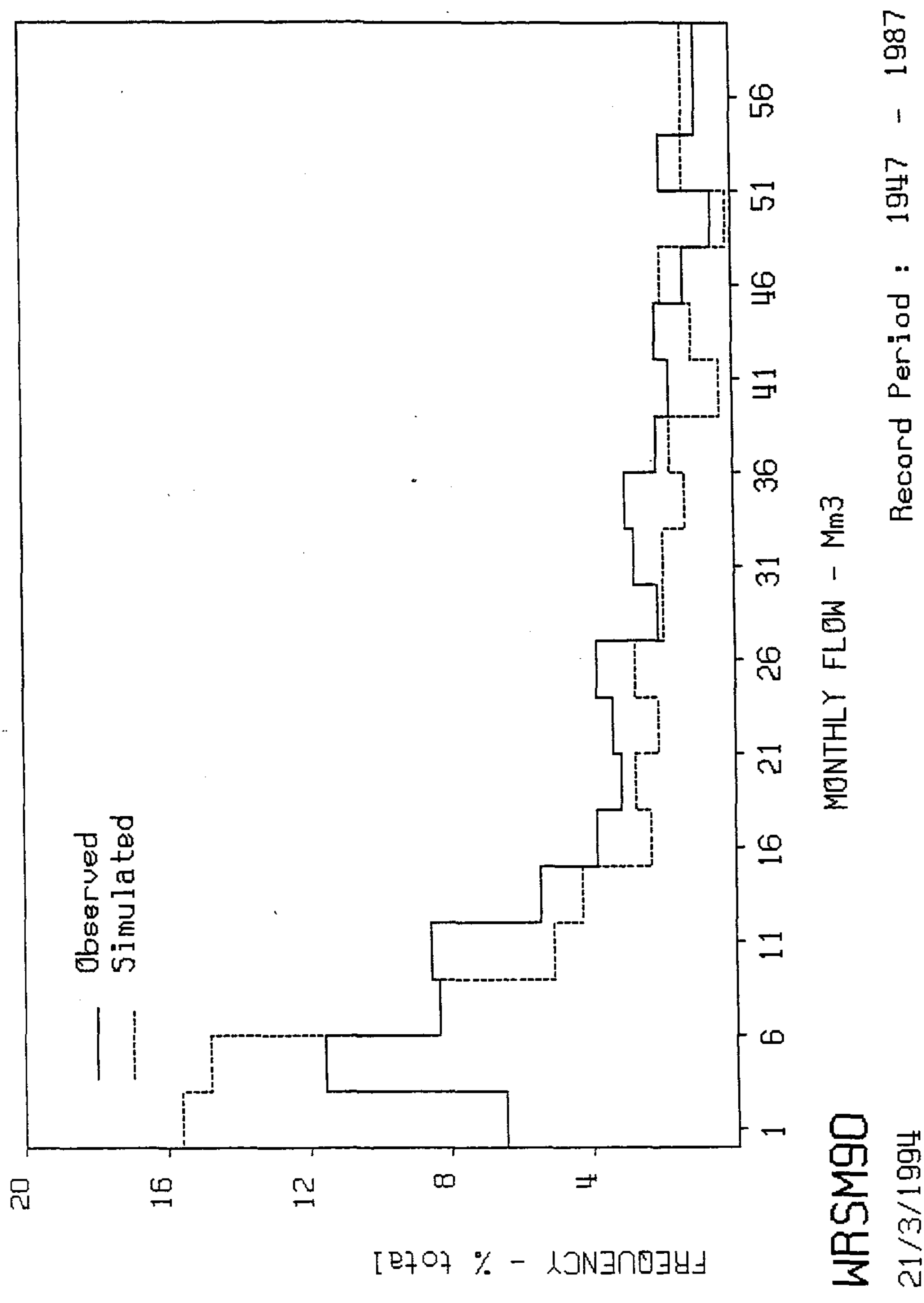
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		9
STORAGE/GROSS YIELD CURVES FOR D2H001		



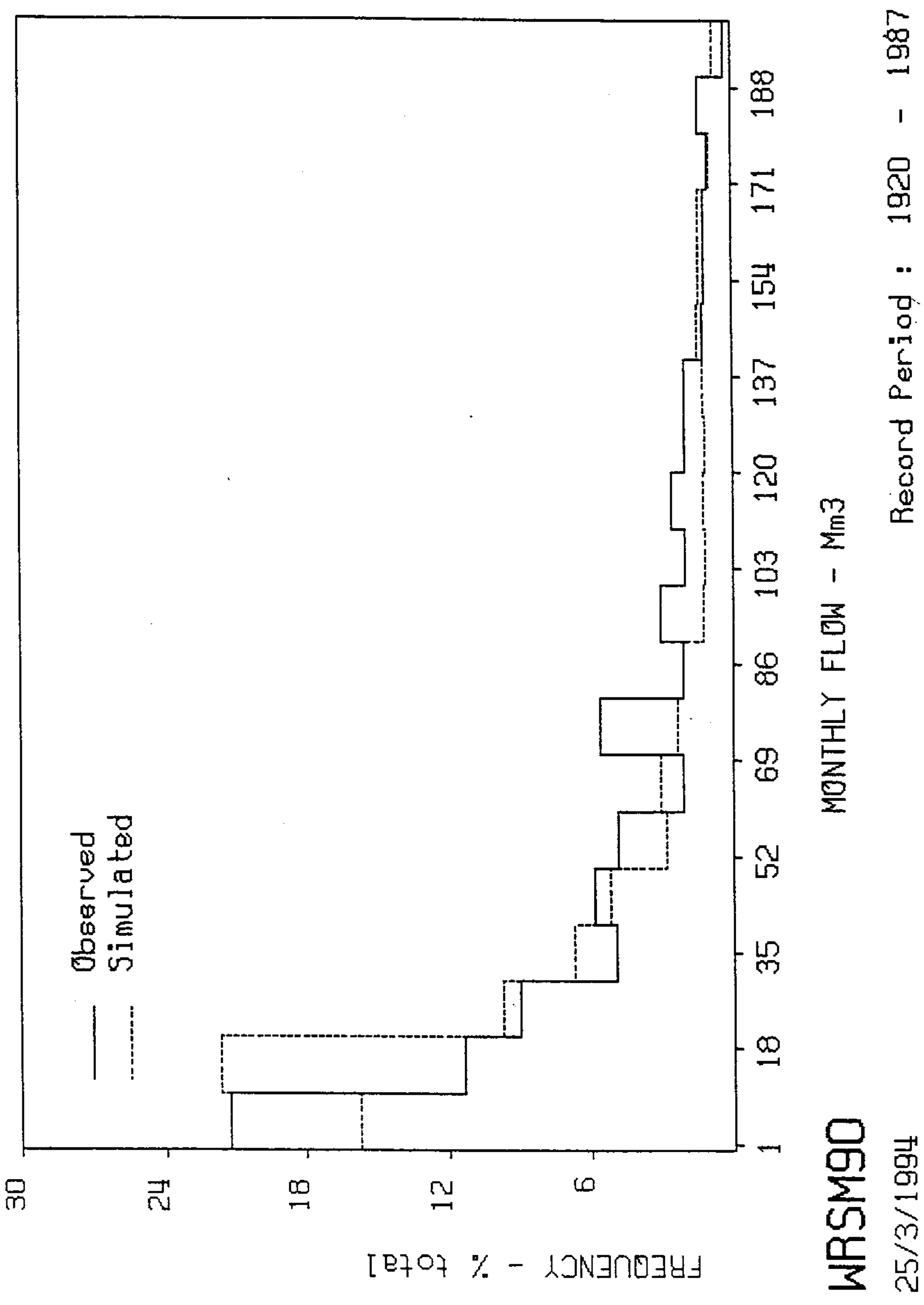
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		10
SCATTER DIAGRAM FOR D1H006		



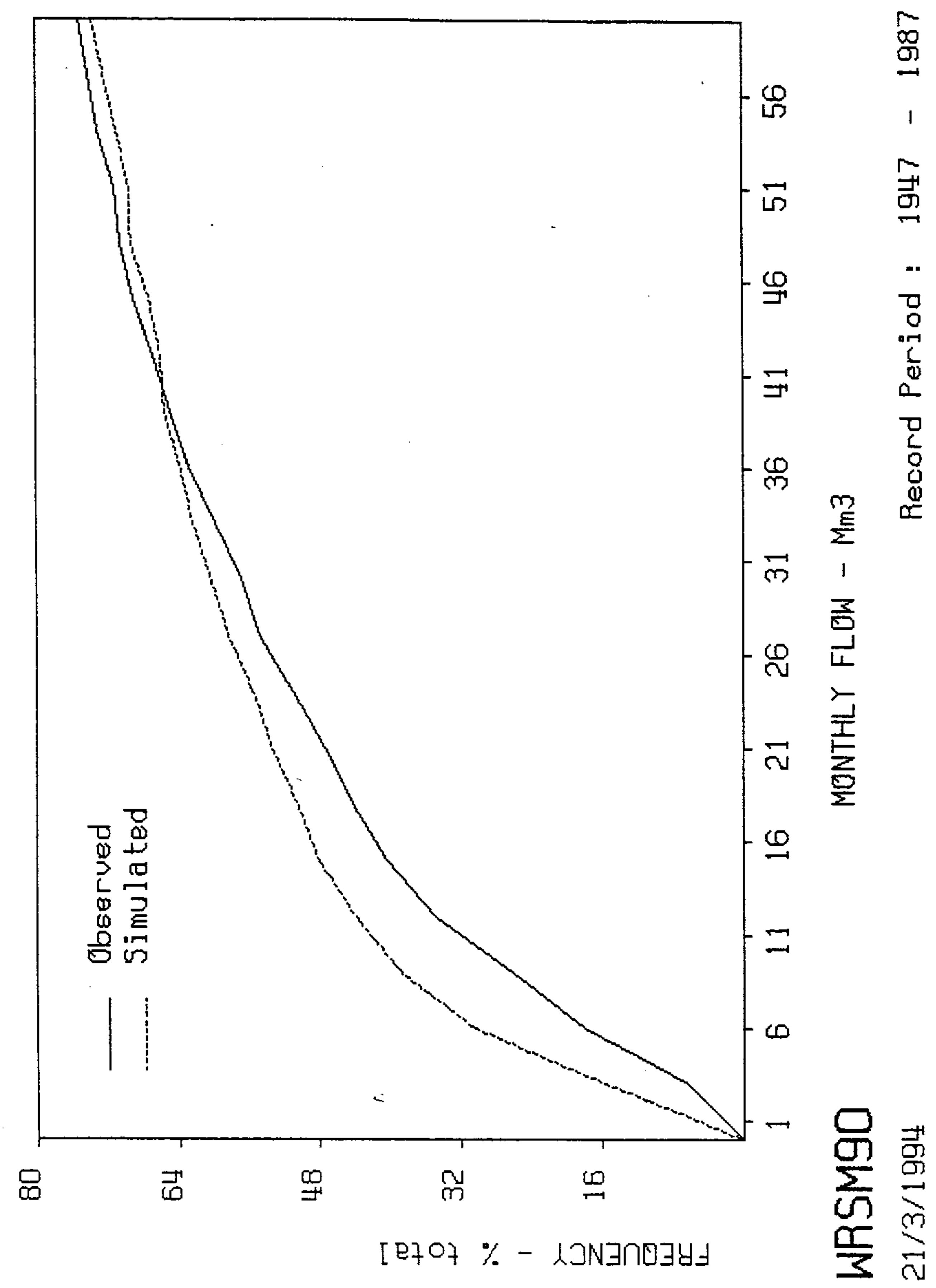
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATIÓN PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		11
SACTTER DIAGRAM FOR D2H001		



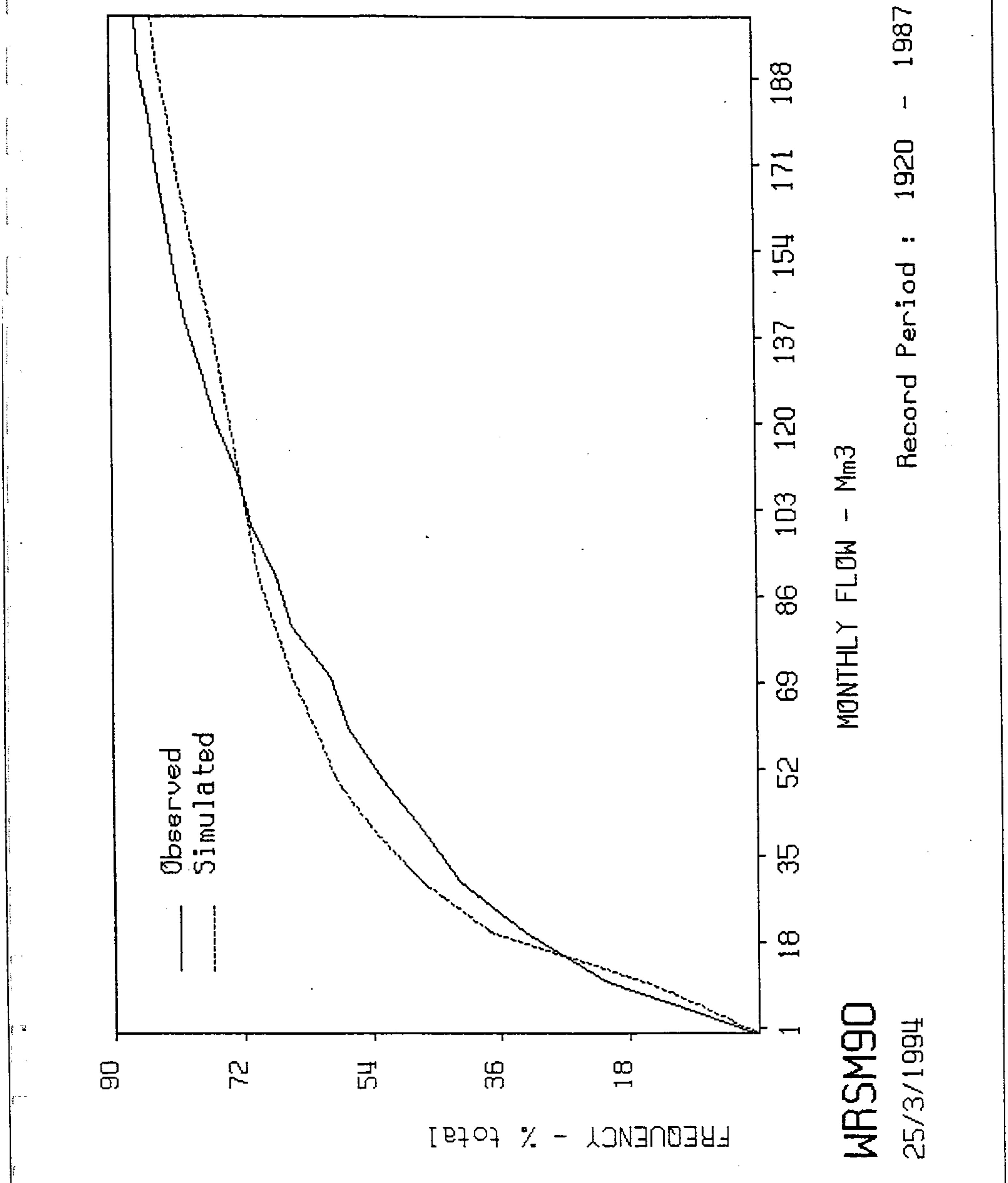
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		12
MONTHLY HISTOGRAMS FOR D1H006		



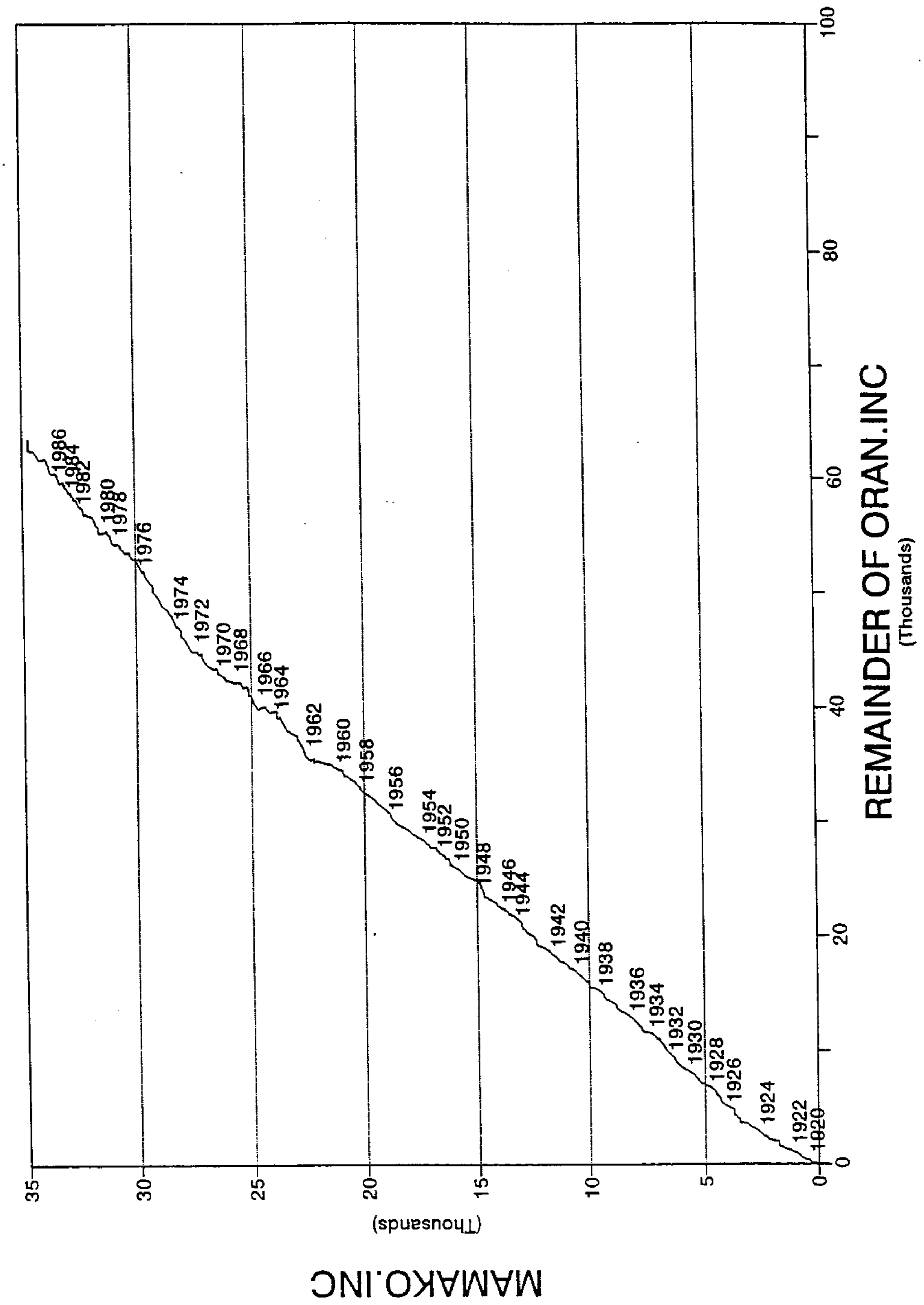
DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		13
MONTHLY HISTOGRAMS FOR D2H001		



DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		14
CUMULATIVE FREQUENCY PLOT FOR D1H006		



DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		**15**
CUMULATIVE FREQUENCY PLOT FOR D2H001		



DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		16
MASS PLOT OF MAMMAKO RUNOFF vs REMAINDER OF ORAN.INC RUNOFF		

LEGEND :

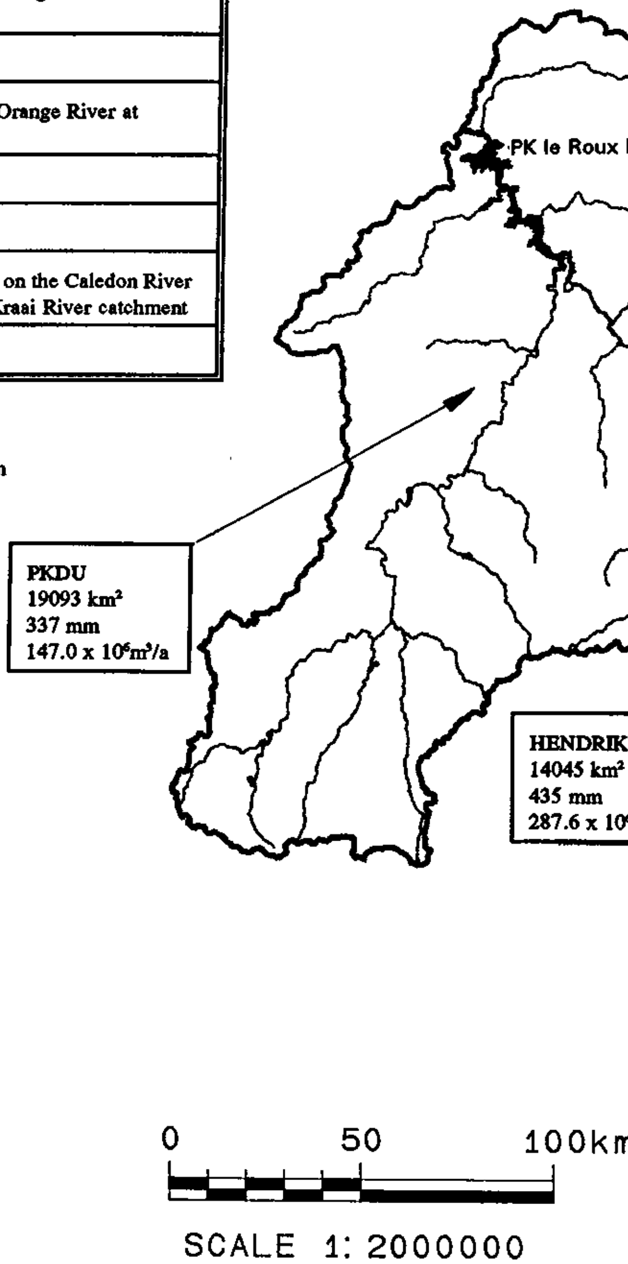
KATJE	-	Subcatchment Reference (also used for electronic file name)
2400 km²	-	Catchment Area (km²)
845 mm	-	Catchment Mean Annual Precipitation (mm/a)
296.9 x $10^6m^3/a$	-	Mean Annual Runoff ($10^6m^3/a$)

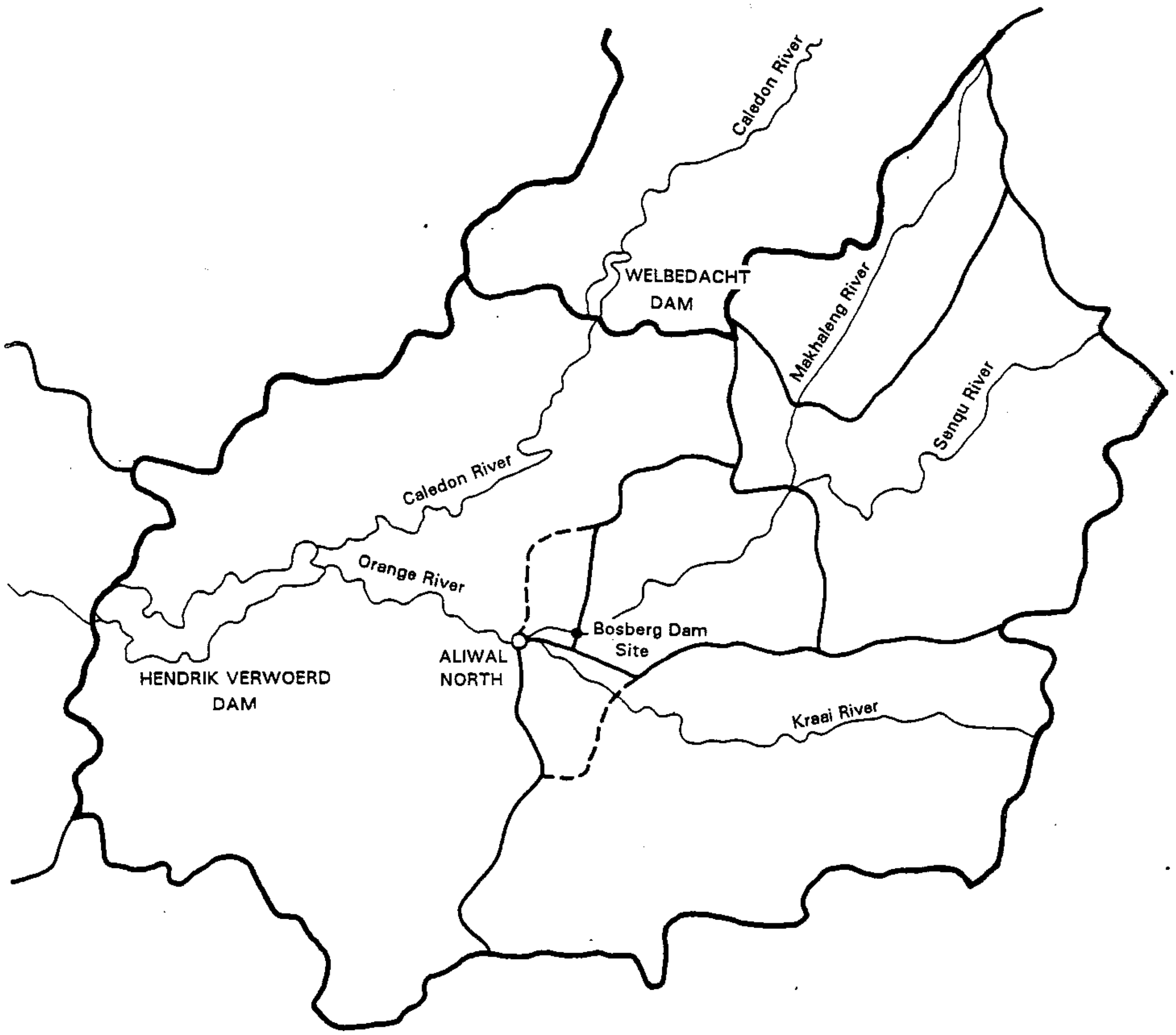
SUBCATCHMENT DESCRIPTION

REFERENCE	DESCRIPTION
KATJE	Katjiesberg Dam
HLOTS	Hlotse Dam
WATER	Waterpoort Dam
KNEL	Knellpoort Dam
WELBB	Area from the Katjiesberg, Hlotse, Waterpoort and Knellpoort Dams to Welbedacht Dam
UPPER LESOTHO	Refers to the seven incremental subcatchments inside Lesotho upstream of the Oranjedraai incremental catchment
MAMKO	Makhaleng River catchment to the Mammako Dam site (upstream of river gauging station D1H006)
ORANB	Oranjedraai incremental catchment, but excluding Makhaleng River catchment upstream of Mammako Dam site
BOS	Oranjedraai to Bosberg Dam site
KRAAI	Total Kraai River catchment to the confluence with the Orange River at Aliwal North
FINLAYSDYK	Welbedacht Dam to Finlaysdyk Dam site
BAKENKOP	Area between Finlaysdyk Dam and Bakenkop Dam sites
HENDRIK VERWOERD	Area between HF Verwoerd Dam and Welbedacht Dam on the Caledon River and Bosberg Dam site on the Orange River, excluding Kraai River catchment
PKDU	Area between HF Verwoerd Dam and PK le Roux Dam

Note :

HFDAM (file) = Finlaysdyk Dam + Bakenkop Dam + Hendrik Verwoerd Dam





LEGEND

INCREMENTAL CATCHMENTS USED IN THIS STUDY

INCREMENTAL CATCHMENTS PREVIOUSLY USED

DEPARTMENT OF WATER AFFAIRS AND FORESTRY	ORVAAL CONSULT	FIGURE
VAAL AUGMENTATION PLANNING STUDY PRE-FEASIBILITY STUDY OF THE ORANGE VAAL TRANSFER SCHEME		18
SUBCATCHMENT BOUNDARY CHANGES		

ANNEX 1

COEFFICIENT OF EFFICIENCY (E)

$$E=\frac{\sum (x-\bar{x})^2 - \sum (x-y)^2}{\sum (x-\bar{x})^2}$$

where	x	=	observed values
	$\bar{x}$	=	mean of observed values
	y	=	simulated values.

CORRELATION COEFFICIENT (r)

$$r=\frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2}\sqrt{\sum (y-\bar{y})^2}}$$

where	x	=	observed values
	$\bar{x}$	=	mean of observed values
	y	=	simulated values
	$\bar{y}$	=	mean of simulated values.