PAPUA NEW GUINEA
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
BUREAU OF WATER RESOURCES

PAPUA NEW GUINEA
FLOOD ESTIMATION MANUAL

Prepared by

SNOWY MOUNTAINS ENGINEERING CORPORATION LIMITED
COOMA NSW AUSTRALIA

SMEC

DECEMBER 1990

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

LIST OF SYMBOLS AND ABBREVIATIONS

TITLE

α_1, etc	Energy coefficient at section 1, etc
A	Catchment area for Rational Method = AREA (km^2 or ha)
A	Area of channel cross-section (m^2)
ABM	Australian Bureau of Meteorology
AEP	Annual exceedance probability (decimal)
AREA	Catchment area (km^2)
AR	Ratio of catchment areas
ARI	Average recurrence interval (years)
B	Top width of channel flow area (m)
BCL	Bougainville Copper Limited
BWR	Bureau of Water Resources
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
C_T	Rational Method runoff coefficient for flood with a return period of T years
$DA_{T,t}$	Catchment average total storm depth of duration t hours and return period T years (mm)
$D_{T,t}$	Point rainfall depth of duration t hours and return period T years (mm)
DPI	Department of Primary Industry (now Department of Agriculture and Livestock)
ELVN	Mean catchment elevation (m above sea level)
f	Proportion of urban catchment which is impervious
F_T	Runoff coefficient frequency factor (= C_T/C_{10}) for urban application of Rational Method
h_e	Eddy head loss (m)
h_f	Friction head loss (m)
$I_{T,t}$	Point rainfall intensity of duration t hours and return period T years (mm/h)
IFD Curves	Point rainfall intensity-frequency-duration curves
J	Probability of T-year return period event being experienced in a given period. (decimal)
KA	Areal rainfall reduction factor
KARST	Proportion of karstic landform in catchment (%)
k_c	Dimensionless coefficient in RORB model
KP_5, etc	Daily rainfall frequency factor for return period of 5 years, etc
KQ_5, etc	Peak discharge frequency factor for return period of 5 years, etc
KS	Swamp adjustment factor
L	= LENGTH (km)
LENGTH	Length of main channel of catchment (km)
L_o	Overland flow path length (m)
m	Order number (highest = 1) for frequency analyses
m	Dimensionless exponent in RORB model
n	Manning's channel roughness coefficient
n	Number of years of record (after amalgamation of incomplete records)
n*	Overland flow surface roughness or retardance coefficient
NWS	National Weather Service
NCD	National Capital District
OTML	Ok Tedi Mining Limited
P	Annual exceedance probability = 100/T (%)
P_2, etc	Point daily rainfall with an annual series return period of 2 years, etc (mm)
PJV	Porgera Joint Venture
PMF	Probable maximum flood
PMP	Probable maximum precipitation

LIST OF SYMBOLS AND ABBREVIATIONS (cont'd)

TITLE

PNG	Papua New Guinea
PNGRIS	Papua New Guinea Resource Information System
P_w	Wetted perimeter of channel (m)
Q_2, etc	Peak discharge with an annual series return period of 2 years, etc (m^3/s)
Q_b	Discharge at commencement of flood (m^3/s)
Q_E	Peak discharge from flood envelope curve (m^3/s)
Q_f	Pipe full discharge (m^3/s)
Q_p	Peak discharge of flood (m^3/s)
Q_{PMF}	Peak discharge of probable maximum flood (PMF) (m^3/s)
R	Hydraulic radius of channel $= A/P_w$ (m)
RMU	Resource mapping unit (of PNGRIS)
RAFTS	A runoff routing model for flood estimation
RORB	A runoff routing model for flood estimation
RSWM	A runoff routing model for flood estimation
S	Channel slope for Manning's formula (m/m)
S_o	Overland flow ground slope (m/m)
SHAPE	Shape index of catchment
SLOPE	Slope index of main channel of catchment (m/km or %)
SMEC	Snowy Mountains Engineering Corporation or Snowy Mountains Engineering Corporation Limited (since July 1989)
SWAMP	Swamp or flood-prone land index of catchment
t	Duration of storm rainfall (hours)
t_c	Time of concentration of catchment (hours)
t_d	Travel time in piped sections of urbanised catchment (min)
t_o	Overland travel time (min)
T	Return period (annual series) (years)
T_p	Time of rise of flood hydrograph to peak (hours)
V	Average flow velocity (m/s)
V_f	Pipe full velocity (m/s)
W_{25},etc	Hydrograph width at discharge of $Q_b + 0.25 (Q_p - Q_b)$, etc (hours)
WBNM	A runoff routing model for flood estimation
WEI	Wau Ecology Institute
WIDTH	= AREA/L (km)
Δx	Length of river reach between adjacent cross-sections (m)
y	Depth of flow in open channel (m)
$\bar{y}$	Mean depth of flow in channel = A/B (m)
Z_1, etc	Height of water surface above datum at section 1, etc (m)

1. INTRODUCTION

The purpose of this Manual is to provide a standard guideline for the estimation of floods in Papua New Guinea. It is intended for general use in the planning and design of small and medium sized engineering works throughout Papua New Guinea, in particular for the planning and design of bridges, culverts, drainage works, small dams and flood mitigation works.

This Manual should not be used for the design of major works such as large dams, major bridges or for major flood mitigation works in urban areas. In these cases special investigations should be carried out for the specific project and, if necessary, the advice of a specialist hydrologist should be obtained. It is emphasised that the user of this Manual should become acquainted with the basis of the derivation of each procedure presented and exercise professional judgement as to whether any particular procedure is applicable to the specific location and problem. In this regard it is expected that local knowledge of the specific catchment will sometimes result in the adoption of a design flood discharge which differs from the flood estimates derived by using the generalised "cook book" procedures presented in this Manual.

This Manual replaces the previous "Flood Estimation Manual" (SMEC, 1973). Some of the flood estimation procedures used in the previous manual have been retained; but this Manual is based on additional data and some different analysis techniques.

Flood estimation procedures are presented for rural catchments of any size (up to 50 000 km^2 or more) at any location in Papua New Guinea and for return periods (average recurrence intervals) ranging from 2 years to 100 years. Guidelines are given for the estimation of floods in urban areas, for return periods exceeding 100 years and for the conversion of design discharges to design water levels. The procedures in this Manual are principally directed to the estimation of design peak flood discharges, but procedures are also presented for the estimation of the complete hydrographs of design floods.

The flood estimation procedures presented in this Manual provide "best estimates" of floods. That is, no "factor of safety" is built into the procedures to allow for inaccuracies in the flood estimates. The estimation of "best estimates" is the normal case for other flood estimation manuals also, and the user should be aware of this when adopting a design flood estimate. An indication of the accuracy of each flood estimation procedure is provided in this Manual.

Throughout this Manual the adopted terminology for the probability of occurrence is "return period". Unless specifically stated otherwise, the "return periods" stated refer to the annual series analyses. "Return period" is equivalent to the commonly used term "recurrence interval" and is defined as the long-term average interval in years between the occurrence of annual maximum values (floods or rainfalls) equalling or exceeding the stated value. For example, a flood with a return period of 50 years means that one could expect 20 annual maximum floods of this magnitude or larger to occur in any period of 1000 years. However, it also means that there is a 2% chance that such a flood could be equalled or exceeded in any single year, or a 18% chance that such a flood could be equalled or exceeded in any 10 year period. The adopted terminology "return period" is equivalent to the inverse of the "Annual Exceedance Probability" (AEP) terminology used in Australia (IE Aust, 1987) and, for return periods exceeding about 10 years, is practically equivalent to the "Average Recurrence Interval" (ARI) used in the same publication.

In some sections of this Manual, reference is made to sections of the "Report". This refers to the "Papua New Guinea Flood Estimation Manual - Report on Investigations" (SMEC, 1990) prepared for the Bureau of Water Resources which describes the investigations undertaken during the preparation of this Manual. Access to the Report is not essential for the use of this Manual; but an appreciation of the basis of the adopted flood estimation procedures would be useful.

2. SELECTION OF PROCEDURES

2.1. INTRODUCTION

The various flood estimation procedures presented in this Manual are:

- regional flood frequency method
- local flood-level data analysis
- local or nearby flood discharge data analysis
- regional flood hydrograph shape estimation method
- rational method
- runoff routing method
- flood envelope curve method
- computation of design water levels
- flood estimation in urban catchments
- estimation of large and extreme floods.

The choice of the flood estimation procedure to use for a specific situation will depend on a number of factors, including:

- whether a design peak discharge is sufficient, or a complete design flood hydrograph is required
- whether flood data are available on the same river or in a nearby similar catchment
- whether the catchment is rural or urban
- whether the catchment has any "abnormal" characteristics (eg swamp, karst)
- the catchment area
- the importance of the works (eg culvert or major dam)

A flow chart for the selection of the flood estimation procedures is presented in on Page 6. The applicability of each procedure is summarised in Sections 2.2 and 2.3.

The user should use professional judgement in the selection of procedures. The most appropriate flood estimation procedure should be selected from the choices given below. However, other less appropriate procedures may also be used for comparison with the derived flood estimate.

Specialist hydrologic advice should be sought for the design of major works or for flood estimates with return periods exceeding 100 years. Similar advice should be obtained if the user (in future years) wishes to use basic flood or rainfall data which were not used in the derivation of this Manual.

2.2. SELECTION OF PROCEDURES FOR RURAL CATCHMENTS

The applicability of each rural flood estimation procedure is detailed below, together with general guidelines on when it should be used.

Regional Flood Frequency Method

- For rural catchments

- For catchment areas of 4 km^2 and greater
- For return periods of up to 100 years
- When design peak discharges are required
- When design flood hydrographs are required (in conjunction with the Regional Flood Hydrograph Shape Estimation Method or the Runoff Routing Method).

Use of Local Flood Level Data

- For rural catchments
- For return periods of no more than the length of data available
- When design water level estimates are required (eg for bridges but not for culverts)
- When the levels of past floods are known at the location of interest.

Use of Local or Nearby Flood Discharge Data

- For rural catchments
- For return periods of up to 100 years
- When design peak discharges are required
- When the local or nearby flood data are of acceptable quality
- When the flood data are located at the location of interest, in the same catchment or on a nearby similar catchment - the ratio of the two areas should not exceed 4.0.

Rational Method

- For rural catchment areas less than 4 km^2
- For return periods of up to 100 years
- When design peak discharges are required.

Flood Envelope Curve Method

- For rural catchment areas exceeding 10 km^2
- When an approximate, independent check on the design peak discharge is required.

Regional Flood Hydrograph Shape Estimation Method

- For rural catchment areas exceeding 20 km^2
- For return periods of up to 100 years
- When preliminary estimates of design hydrograph shape are required.

This method must be used in conjunction with the Regional Flood Frequency Method.

Runoff Routing Method

- For rural catchment areas between 5 km^2 and 1000 km^2 (or larger if model calibration is possible)
- For return periods of up to 100 years
- When design estimates of flood hydrograph shape are required.

This method is to be used in conjunction with the Regional Flood Frequency Method or using local or nearby flood data except for catchments where the runoff routing model can be calibrated.

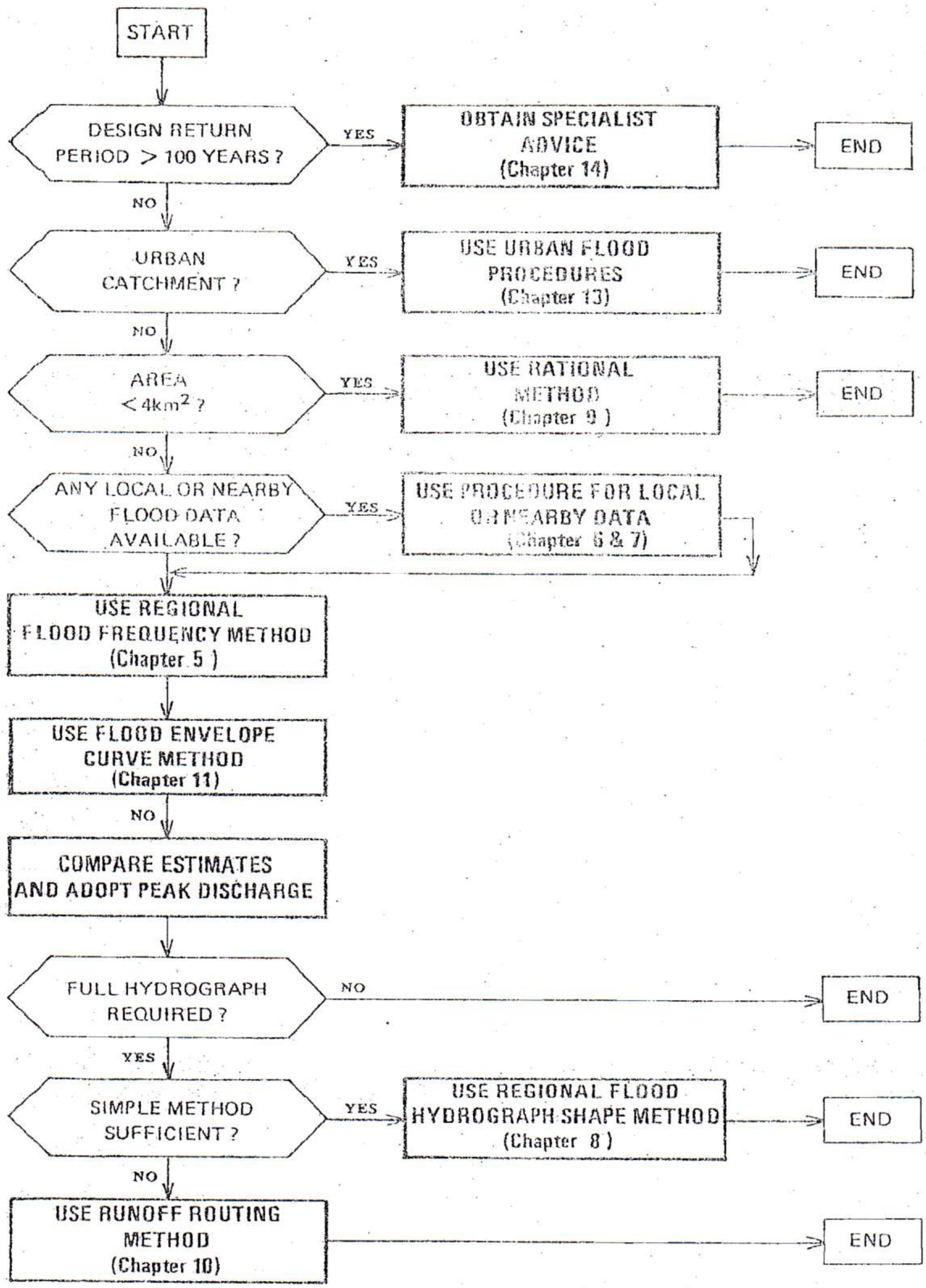
Site Specific Estimates by Hydrologic Specialist

- For return periods exceeding 100 years, including the probable maximum flood (PMF)
- For the feasibility study or design of major structures (eg dams) or works of major social or economic value (eg urban or mine flood mitigation works).

2.3. SELECTION OF PROCEDURES FOR URBAN CATCHMENTS

Of the numerous urban catchment flood prediction models that are available, only the methodology using the Rational Method for small urban catchments is presented in this Manual.

The Rational Method, as presented in this Manual, may be used for determining peak discharge estimates in urban catchments of up to 4 km^2 area.



PROCEDURE SELECTION FLOW CHART