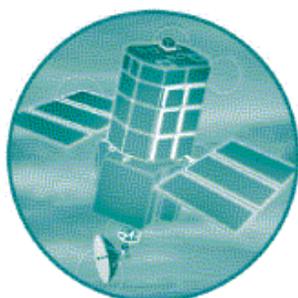


**DEFRA/Environment Agency
Flood and Coastal Defence R&D Programme**



Flood forecasting and warning best practice – Baseline review

R&D Publication 131

Flood forecasting and warning good practice - Baseline review

R&D Publication 131

**Part 1 : Existing Practice
Part 2 : Guidelines for Good Practice**

Final Report: August 2002

Research Contractors:

Mott MacDonald Ltd
in association with
Centre for Ecology and Hydrology
and
Flood Hazard Research Centre Middlesex University

Publishing Organisation:

Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury
BRISTOL, BS32 4UD

Tel: 01454 624400 Fax: 01454 624409
Website: www.environment-agency.gov.uk

ISBN: 185705914X

© Environment Agency 2002

August 2002

The Environment Agency will waive its normal copyright restrictions, and allow this (excluding the logo) to be reproduced free of licence or royalty charges in any form, provided it is reproduced unaltered in its entirety and its source acknowledged as Environment Agency copyright.

This waiver is limited to this document and is not applicable to any other Agency copyright material, unless specifically stated. The Agency accepts no responsibility whatever for the appropriateness of any intended usage of the document, or for any conclusions formed as a result of its amalgamation or association with any other material.

Dissemination Status

Internal: Released to Regions & Areas
External: Released to Public Domain

Statement of Use

This report summarises the findings of research carried out into existing good practice in aspects of the flood forecasting and warning process within the Environment Agency. The information within this document is for use by Environment Agency staff.

Key Words

Flood forecasting, flood warning, good practice, baseline review, National Flood Warning Centre.

Research Contractor

This document was produced under R&D Project W5C-013/2 by:

Mott MacDonald Ltd, Demeter House, Station Road, Cambridge, CB1 2RS.

Tel: 01223 463500 Fax: 01223 461007 Website: www.mottmac.com

Environment Agency's Project Manager

The Environment Agency's Project Manager for R&D Project W5C-013/2 was:
Tim Wood, South West Region

Further copies of this report are available from:
Environment Agency R&D Dissemination Centre, c/o
WRc, Frankland Road, Swindon, Wilts SN5 8YF



tel: 01793-865000 fax: 01793-514562 e-mail: publications@wrcplc.co.uk

EXECUTIVE SUMMARY

Objective

The objective of this study has been to “document current good practice within the Environment Agency and provide recommendations to guide development of Regional and Area flood forecasting and warning systems and procedures to improve timeliness and reliability of flood warnings”.

This record of good practice is required as baseline information for the Environment Agency's major research and development initiative “Flood Forecasting and Warning Research Programme”. It is also intended to provide information to aid the development of the flood forecasting and warning service, and guidance for the policies and programme of the National Flood Warning Centre (NFWC). As such this study builds on the foundations laid by the Easter Flood Actions (EFAs) and the Changing Needs in Flood Defence Review (CNFDR).

Methodology

In order to determine the range of approaches to the many aspects making up the flood forecasting and warning (FF&W) process, visits were undertaken to all Regional, and several Area offices, and discussions held with key flood warning practitioners. Information was also gathered by inspection of event reports prepared by each Region and nationally for recent significant events, in particular those relating to the flood events of Easter 1998 and Autumn 2000. The first round of visits was undertaken during the period February to April 2000 which led to the draft report submitted in September 2000. The change in flood warning codes and the extreme floods of Autumn 2000 followed almost immediately, and it was decided that the report should be revised to take account of these changes and events. A second round of visits was therefore undertaken between April and August 2001.

In carrying out the investigations it was found appropriate to consider the flood forecasting and warning process as a series of six linked elements:

- General Procedures and Organisation
- Incoming Data and Monitoring (Detection)
- Forecasting
- Warning
- Response
- Post Event Data Collection, Reporting and Archiving.

In the course of the study these elements were further sub-divided into a total of over 60 aspects identified by Agency FF&W Practitioners as being distinct parts of the FF&W discipline. Each of these aspects has been reported on.

Whilst the accumulation of relevant information from the visits was straightforward, the abstraction of useful data from event reports prior to Autumn 2000 was more difficult. This reflected the lack of a national standard for event reporting, and the need for a common format which allows assessment of the success or otherwise of the various components of the FF&W process. The Agency issued national guidance to Regions on the reporting of the Autumn 2000

events. The resulting regional reports, whilst still having room for improvement in terms of standardisation, have made it easier to assess the effectiveness of forecasting and warning processes.

Conclusions

The analysis of current practices within the Agency has revealed the need for further development in two areas:

- Aspects where good practice exists within the Agency but there is a requirement for dissemination and, potentially, further development.

In most of the categories of work identified in flood forecasting and warning, good practice exists in at least one Region. In some cases, the need to adopt consistent national standards is self-evident. In other cases careful consideration needs to be given to the benefits of standardisation, given the work involved and limited resources available.

There is a need to identify the areas where more general adoption of good practices is justified and relevant and to prioritise and allocate the work involved. It is strongly recommended that the National Flood Warning Centre manages this process to ensure a consistent policy is adopted. Proposals are made in the report to deal with the implementation of this aspect of the work.

- Aspects where no good practice currently exists within the Agency.

For many of the categories of work identified, R&D or associated work is already underway or scheduled. It is recommended that the NFWC undertake a review of the terms of reference for the relevant projects to ensure that they meet the needs identified in this Report.

There are a small number of items where no work is yet scheduled. These fall into two categories:

a) Policy Development:

- National use of Regional expertise.
- Inter-Regional liaison and cross-functional staffing support to ensure adequate staffing for major events.
- National training programme required for flood duty staff.
- Rationalisation of procedures for opening Incident Rooms at an appropriate stage as an event develops.
- Nationally agreed content for documentation of forecasting and warning procedures.
- Recommended standards for new computer systems to replace ageing mainframes.

- Rationalisation of level datum systems used nationally taking account of future increased sharing of data between Regions and the new Ordnance Survey datum system.
- Strategy for development of level and flow gauge networks to optimise flood warning investment.
- Development of national modelling strategy for forecasting.
- Development of flood maps with inundation areas linked to stage heights.

b) New R&D

- National standards for post-event reporting.
- Forecasting models for unusual events (dam break, reservoir overtopping etc.).
- Improved accuracy of surge residual data from STFS.

It is recommended that the NFWC consider these items for inclusion in future programmes.

CONTENTS

	Page Nr
EXECUTIVE SUMMARY	i
Glossary of Terms	vii
1. INTRODUCTION	1
<i>PART 1 : EXISTING PRACTICE</i>	
2. PROJECT DESCRIPTION	3
3. METHOD	6
3.1 Data Collection	6
3.2 Review of Existing Procedures	8
3.3 Definition of Good Practice	9
3.4 Identification of Areas for Research	9
3.5 Presentation and Consultation	9
3.6 Interface with Other Studies and Initiatives	10
4. INFORMATION AND ANALYSIS	19
4.1 General	19
4.2 Results of Regional Investigations	20
4.2.1 Procedures common to all Regions	20
4.2.2 North East Region	22
4.2.3 Midlands Region	25
4.2.4 Anglian Region	29
4.2.5 Thames Region	31
4.2.6 Southern region	35
4.2.7 South West Region	39
4.2.8 Wales Region	42

PART 2 : GUIDELINES FOR GOOD PRACTICE

5. GOOD PRACTICE BY FLOOD FORECASTING and WARNING TOPIC	50
5.1 Overview	50
5.2 General Procedures and Organisation	51
5.3 Detection – Incoming Data and Monitoring	56
5.4 Forecasting of Fluvial Events	61
5.5 Warnings	62
5.6 Response	66
5.7 Post Event Data Collection, Reporting and Archiving	67
5.8 Summary of Findings	68
6. GOOD PRACTICE AVAILABLE FOR INTERNAL DISSEMINATION WITHIN THE AGENCY	69
6.1 Introduction	69
6.2 General Procedures and Organisation	69
6.3 Detection – Incoming Data and Monitoring	70
6.4 Forecasting of Fluvial Events	71
6.5 Warnings	71
6.6 Response	72
6.7 Post Event Data Collection, Reporting and Archiving	72
6.8 Implementation Recommendations	73
7. AREAS IDENTIFIED FOR FUTURE RESEARCH	74
7.1 Introduction	74
7.2 General Procedures and Organisation	76
7.3 Detection – Incoming Data and Monitoring	77
7.4 Forecasting of Fluvial Events	79
7.5 Warnings	79
7.6 Response	80
7.7 Post Event Data Collection, Reporting and Archiving	80
7.8 Recommendations for Future R&D	80
7.9 Other Recommendations	81
8. CONCLUSIONS AND RECOMMENDATIONS	82

Bibliography	84
---------------------	----

**Follows
Page Nr**

List of Tables

3.1	Initial Round of Visits February to April 2000, List of Principal Agency Practitioners Visited / Consulted	7
3.2	Second Round of Visits April to August 2001, List of Principal Agency Practitioners Visited / Consulted	7
3.3	Documents Giving Current Status of Forecasting and Warning Initiatives as at mid-2001	10
4.1	Regional Comparison of Forecasting and Warning Systems	20
4.2	Key Issues Identified	20
7.1	List of Ongoing and Planned R&D in Flood Forecasting and Warning	74

**Follows
Page Nr**

List of Figures

2.1	Flood Forecasting and Warning: Steps and Issues	4
4.1	Map Showing Principal Elements of Forecasting and Warning Systems by Region	20
4.2	Elements of the Flood Forecasting and Warning Process	20

Appendices

Appendix A Current Organisation, Systems and Procedures in each Region

A1	North East Region	89
A2	Midlands Region	95
A3	Anglian Region	101
A4	Thames Region	105
A5	Southern Region	113
A6	South West Region	120
A7	Wales Region	128
A8	North West Region	138

Glossary of Terms

ABC	Area Base Controller
AFDO	Assistant Forecasting Duty Officer
AFFMS	Anglian Flow Forecasting Modelling System
AFWDO	Assistant Flood Warning Duty Officer
AIR	Area Incident Room
AMAZON	A model used for simulation of wave overtopping of defences
AMDO	Assistant Monitoring Duty Officer
AVM	Automatic Voice Messaging
BMRB	British Market Research Bureau
CASCADE	Catchment Assessment System Concerned with the Accurate Dissemination of Effective flood warnings
CEH	Centre for Ecology and Hydrology (formally IH : Institute of Hydrology)
CNFDR	Changing Needs in Flood Defence Review
CSM	Continental Shelf Model
DDS	Data Distribution Server
DEFRA	Department for the Environment, Food, and Rural Affairs (formally MAFF, see below)
DSM	Duty Strategic Manager
DSR	Daily Situation Report
EDO	Emergencies Duty Officer
EFA	Easter Floods Actions
EFAG	Easter Floods Action Group
EFAP	Easter Floods Action Plan
FDO	Forecasting Duty Officer
FFP	Flood Forecasting Platform (Southern Region)
FFS2	Flow Forecasting System 2 (Midlands Region)
FF&W	Flood Forecasting and Warning
FPI	Flood Plain Information (System)
FWA	Flood Warning Area
FWDO	Flood Warning Duty Officer
FWIS	(National) Flood Warning Information System
FWPGs	Flood Warning Planning Groups
GANDOLF	Generating Advanced Nowcasts for Deployment in Operational Land-based Flood Forecasts
GIS	Geographical Information System
GUI	Graphical User Interface
HYRAD	HYdrological RADar processing and display system
ISIS	Hydraulic modelling software developed by HR Wallingford
JTP	Joint (Midlands, Thames and Wales Regions) Telemetry Project
KPI	Key Performance Indicators
LAN	Local Area Network
MAFF	Ministry of Agriculture, Fisheries and Food (now DEFRA, see above)
MFDO	Monitoring and Forecasting Duty Officer
MIP	Major Incident Plan
MIST	Meteorological Information Self-briefing Terminal

MDO	Monitoring Duty Officer
MMSWFWDS	Multi-Media Severe Weather and Flood Warning Dissemination System
MORECS	Met Office Rainfall and Evaporation Calculation System
MOSES	Met Office Surface Exchange System
MoU	Memorandum of Understanding
NAW	National Assembly for Wales
NFCDD	National Fluvial and Coastal Defence Database
NFDMG	National Flood Defence Managers Group
NFFMSS	National Flood Forecasting Modelling System Strategy
NFFUG	National Flood Forecasting User Group
NFWC	National Flood Warning Centre
NFWDG	National Flood Warning Dissemination Group
NFWMG	National Flood Warning Management Group
NFWPS	National Flood Warning Performance Specification
NIRS	National Incident Reporting System
NTS	Northern Telemetry System
NTSR	National Telemetry Strategy Review
NWRS	National Weather Radar Strategy
NWSA	National Weather Services Agreement
Nimrod	Met Office's system for blending radar and other products for short-term precipitation forecasts
ODO	Operations Duty Officer
PDM	Probability Distributed Model
PRTF	Physically Realisable Transfer Function
POL	Proudman Oceanographic Laboratory
POLTIPS	Tidal Prediction Software from Proudman Oceanographic Laboratory
RBC	Regional Base Controller
RCC	Regional Communications Centre
R&D	Research and Development
REDO	Regional Emergency Duty Officer
REMUS	Remote User System
RIPs	Regional Incident Procedures
ROFFMS	Real-time Operation Flood Forecasting Monitoring System
RFFS	River Flow Forecasting System
SEFFS	Southern Enhanced Flood Forecasting System
SMD	Soil Moisture Deficit
STFS	Storm Tide Forecasting Service
STFSLG	Storm Tide Forecasting Service Liaison Group
STORM	System To Obtain Radar-rainfall Measurements
SWAN	A model used to simulate near-shore sea state conditions
SWANTEL	South West and Anglian Telemetry System
SWW	Severe Weather Warning
TCM	Thames Catchment Model
TRITON	A tidal display and forecasting system
WRIP	Weather Radar Information Processing System

1. INTRODUCTION

The *Flood Forecasting and Warning Good Practice Baseline Review* has been undertaken to provide baseline information for identification of proposals for the Environment Agency's major research and development initiative *Flood Forecasting and Warning Research Programme* which is currently being planned. The Review also provides information to aid the development of the flood forecasting and warning service, and guidance for the policies and programme of the National Flood Warning Centre.

The overall objective of the assignment as set out in the Project Brief is:

“To document current good practice within the Agency and provide recommendations to guide development of Regional and Area flood forecasting and warning systems and procedures to improve timeliness and reliability of flood warnings.”

It is a stated objective of the Agency that the outputs from its R&D projects should be effectively disseminated to add value to its business functions. In order that this may be achieved for this project it is recommended that this report be kept live. The information given in Appendix A could be updated by each Region on a regular (annual) basis to reflect the current procedures within the Region. It is suggested that this process be co-ordinated by the NFWC. The major spreadsheets summarising regional procedures and identifying examples of good practice, Tables 4.1 and 4.2, can be placed on the Agency's Intranet, to be accessed by concerned parties, with updating to be the responsibility of the NFWC. The guidelines would then evolve to reflect the implementation of new nationally agreed good practice.

Part 1 of the R&D Report sets out the existing practice in flood forecasting and warning throughout the Regions, and lists where Regional flood forecasting and warning practitioners consider they exhibit good practice and where they consider procedures could be improved. Information is also presented on the performance of procedures during documented flood events.

Part 2 of the Report identifies existing practice that is good and indicates where it could be adopted by other Regions. It also highlights areas where there is no identified existing good practice and therefore there is an apparent R&D need.

PART 1 : EXISTING PRACTICE

2. PROJECT DESCRIPTION

This study has been undertaken at a time when there are many initiatives being implemented both regionally and nationally to improve flood forecasting and warning services. In particular changes recommended by the Easter Floods Action Group (EFAG) and the Changing Needs in Flood Defence Review (CNFDR) are ongoing in most Regions to a greater or lesser degree. The September 2000 Draft Report for this study presented a snapshot of flood forecasting and warning practice as existing in the first half of the year 2000. This Final Report presents a similar snapshot for the middle of the year 2001, that is, subsequent to the September 2000 changes in warning codes and the Autumn 2000 Floods. Whilst concentrating the analysis on this “existing” situation the study has also taken note of the various changes and proposals which are underway, and comments on the implications.

In reporting and analysing information received from the Agency Regions, it is convenient to adopt a consistent order for listing Regions. For this we have followed the convention adopted in other national reports of following the coastline of England and Wales proceeding clockwise from the North East Region. The order is therefore:

- North East
- Midlands
- Anglian
- Thames
- Southern
- South West
- Wales
- North West.

In identifying good practice in forecasting and warning it must be recognised that within the overall forecasting and warning function there are many contributing factors. Some of these relate to forecasting and warning in general, for example good practice in the documentation of procedures or the set-up of the operations room. Other aspects are specific to particular Regions, Areas, or catchments. There is no one “best” way to forecast and warn on all types of events in all catchments.

It should be noted that in many references the term “Flood Warning” is used as a generic term to cover the full range of activities involved with the collection of data, production of forecasts, compilation and dissemination of warnings and all related activities.

The Agency has had a policy of continuous improvement of its flood forecasting capabilities over many years and, since 1996, its flood warning service. However, these initiatives were given renewed impetus as a result of the floods in Easter 1998, following recommendations made in the Bye report (Bye and Horner 1998). The particularly severe floods that occurred in 1998 exposed some deficiencies in the ability of the Agency to provide accurate forecasts and to disseminate reliable and timely warnings. Improvements in these areas were given priority, and the performance of the Agency during the Autumn 2000 floods was generally assessed to have been much more effective. It is however recognised that there is still much to do to improve the flood warning process to reduce the risk of those living or working in flood prone areas in the future.

The process of delivering timely and reliable flood warnings is complex and requires a sequential approach that is illustrated in Figure 2.1 (and expanded by Figure 4.2). Essentially the process requires:

- the collection and analysis of data
- the formulation of appropriate warnings based on the available information
- the timely delivery of the warnings.

This simple summary belies the complexity of the process. Figure 2.1 amplifies this, giving an indication of the number of steps involved in delivering an effective flood warning service, and issues surrounding these. In order to make an assessment of best practice in the Agency Regions, it has been necessary to examine each of the stages in the process, because the effectiveness of the overall system is only as good as the weakest link in the chain.

In undertaking the study we have attempted to address each element of the process in turn, to establish what is good practice for each stage, taking into account the regional differences that stem from geographic, topographic and climatic factors. For example, Southern and Anglian Regions have to contend with significant coastal flood risk in addition to major lowland river catchments. In the Midlands Region fluvial flooding dominates, most notably from the Severn and Trent rivers and their major tributaries. In some Regions the influence of snowmelt on fluvial floods is much more important than in others. In all Regions there are essential differences between the behaviour of minor and major rivers, as well as in the nature and extent of the areas at risk from flooding. The assessment of good practice has taken these differences into account.

Flooding from ordinary watercourses and sewer systems does not presently fall within the Agency's remit for forecasting and warning, although some Regions do offer some limited services in these areas. Coverage of services offered is being reassessed following the Autumn 2000 floods.

The effectiveness of the flood forecasting and warning system also relies heavily on the Agency staff who have been given the responsibility for the various tasks that make up the process. It has therefore also been necessary to examine the organisation of the flood forecasting and warning service, and this encompasses the following:

- (a) staff training
- (b) staff mobilisation during flood events
- (c) duty rosters and arrangements for weekends and public holidays as well as other periods outside normal working hours
- (d) understanding of the processes by duty staff (e.g. the analysis of data to develop a flood forecast)
- (e) ability of staff to deal effectively with enquiries from members of the public and other interested parties
- (f) overall management of the system.

All of the above have been examined in order to get a complete picture of the service as it stands in each Region, and in order to identify those elements which clearly represent good practice.

The Study Brief required the project to be divided into five stages:

Stage 1 – Data Collection

Stage 2 – Analysis of Data

Stage 3 – Identification of Good Practice and R&D Needs

Stage 4 – Production of a Report

Stage 5 – Presentation of Findings.

In carrying out the study it was inevitable, and indeed desirable, that the stages would inter-link with, for example, an element of data collection continuing throughout Stages 1, 2 and 3, and the analysis of data overlapping with identification of good practice. There has also been a significant element of work in reviewing previous and ongoing studies related to the Baseline Review Study. This has helped to focus the main thrust of the data collection and analysis exercise by gleaning the key issues from other studies and avoiding unnecessary repetition of work. A list of references identified is given in the Bibliography.

3. METHOD

This section describes the procedures undertaken to carry out the study.

3.1 Data Collection

3.1.1 Workshop

The objective of this first stage was to identify and record the current state of systems and procedures in the Regional and Area offices. It was decided that the most efficient way to start the study, and to ensure that any misconceptions about the objectives of the study were eliminated early on, was to hold an Introductory Workshop as soon after the commencement of the study as possible.

It was preferable that the workshop be attended by the eight Regional Flood Warning Managers, and/or other regional staff with direct responsibility for flood forecasting and warning, plus the Agency's Project Team. It was decided that the ideal setting for the workshop would be within one of the regular meetings of the National Flood Warning Management Group (NFWMG, formally NFWIT), since all the required attendees for the Project Workshop would already have made arrangements to attend.

Thus the workshop was held as part of the NFWMG's meeting on 19 January 2000, at Kings Cross, London. The aims of the workshop were to:

- ensure that the Consultant fully understood the issues
- draw together experience on which to base a detailed Interview Framework for use in Regional/Area visits
- find out what information was readily available, and in what form
- allow early identification of key problem areas and regional differences.

This approach was found to be an extremely useful way of getting up to speed and sharing ideas. The output of the workshop was a consensus view, with indications of regional differences, and formed a firm foundation for the initial round of interviews in the Regions and Areas, enabling a commitment from all involved to co-operate fully in this important R&D project.

3.1.2 Interview framework

Following the workshop the Consultant compiled an Interview Framework for use during the initial visits to Agency Offices. This sought to elicit information on how each Region dealt with each stage of the FF&W process.

The framework was distributed in advance to all the Agency Regional staff who would be involved in the interviews. The framework included an indication of the types of data required by the study team, not necessarily with the intention of collecting any or all of it during the interview, but more to ensure that the interview process was not devalued due to lack of preparation.

At the outset of the study it was fully appreciated that there were existing variations between the Regions in the arrangements for carrying out the flood forecasting and warning tasks. For example, prior to September 2000, in Thames Region, both flood forecasting and warnings were centralised at the Reading Regional Office, whereas in the Anglian Region both responsibilities rested with the Area offices. Understanding of these regional differences was enhanced as a result of the introductory workshop and the differences were taken into account in planning the approach to the regional visits. The workshop also led to an understanding of the reasons for the differences, and how they might impact on good practice.

One of the main recommendations of CNFDR was the standardisation of responsibilities for the various aspects of the forecasting and warning process. The extent to which these have been implemented by September 2001 is reported on below.

3.1.3 First round of visits

Visits were initially arranged to each of the Agency's eight Regional Offices during the period February to April 2000. The schedule of visits made and principal Agency Staff met is included as Table 3.1. Discussions during the visits were steered by the Interview Framework as described above. In addition to discussion, the consultant looked at the facilities available to the Agency staff for undertaking their forecasting and warning duties. This included weather displays, telemetry systems, forecasting models, documentation, and the general arrangement of rooms and facilities.

The consultant compiled a record of each visit in the form of minutes. These minutes were sent back to the principal Agency contact in each Region for their comments and additions.

As part of the visit the consultant requested information on recent significant flood events within the Region to allow analysis of forecasting and warning performance on real events. As part of the interview guidelines, three specific forms had been drawn up and circulated in advance of the visits to indicate the range of information sought. It was found however that the most effective way to gather such data was to obtain and study copies of the regional event reports. These were generally regarded as the most accurate and complete record available of the events. The evident variation in detail and extent of reporting is in itself a subject for evaluating good practice.

3.1.4 Second round of visits

The first round of visits and the subsequent analysis led to the draft report submitted in September 2000. The change in flood warning codes and the extreme floods of Autumn 2000 followed almost immediately, and it was decided that the report should be revised to take account of these changes and events. A second round of visits was therefore undertaken between April and August 2001. The schedule of visits made, and principal Agency staff met in this second round of visits, is shown in Table 3.2.

The repeat visits made use of the records from the initial visits to reveal what had changed in the intervening 15 months or so. The Agency staff consulted in the Regions were asked to comment on the Draft Report in general, and the specific sections concerning their individual Regions in particular. The experiences of the Autumn 2000 floods were discussed and particular reference made to the Region's Flood Review Report.

The output from the visits was incorporated into draft updates to the R&D report. The particular sections relating to each Region were submitted to the principal Agency contact in each Region for their comments, which have been taken into account for this final document.

3.2 Review of Existing Procedures

The information collected from the visits, along with additional information collected from other sources both within and outside the Agency, was initially processed to produce a comprehensive record of existing practice across the Regions. In accordance with the objectives of the study, data analysis concentrated on the identification of good practice. It was however apparent that Regions were also concerned to record where they considered they could benefit from improving their practices, either by reference to other Regions or from elsewhere. Three principal sources have been used for the review of the information collected.

3.2.1 Regional perceptions

From the agreed minutes of the initial visits (see above), a list of topics was drawn up to indicate the areas in which each Region considered it was exhibiting (offering for potential use by other Regions) good practice, and those in which it considered it could improve its procedures, and was therefore seeking good practice. This list is given as Table 4.2. As the visits progressed, the list of topics was expanded to incorporate the wide range of factors considered relevant by regional practitioners. Some of the topics are specific to particular geographic or organisational factors and therefore are not relevant to all Regions.

During the second round of visits the regional practitioners were invited to comment on the list and a number of additional topics were added. These second visits also allowed the Regions to consider the topics raised by other Regions and to indicate where they had good practice to offer or were similarly seeking advice. Some of the topics that had been raised in 2000 were no longer issues in 2001, since they had been resolved by the introduction of agreed national standard practices.

3.2.2 Review of forecasting and warning performance for specific events

As noted above, during the initial visits a number of recent event reports were collected from each region. These were analysed to assess where good practices had been evident from successful forecasting and warning, and where existing practices were shown to be in need of improvement. This source proved to be the most difficult of the three from which to abstract conclusions.

During the second round of visits discussions focused on regional experiences of the Autumn 2000 floods, with particular reference being made to each Region's Flood Review Report. The reporting of these events had been standardised to a large degree by the Agency issuing a required contents list for the reports. This simplified the abstraction of information on forecasting and warning practices that had proved to be successful during the event.

3.2.3 Review of recent and ongoing studies and expert opinion

Section 3.6 below lists some of the major recent and ongoing initiatives within the Agency's forecasting and warning operations. The list has been updated from that included with the Draft Report and records the position as at mid-2001.

This information was taken into account in the review of information collected from elsewhere. As part of the consultant's team Professor Dennis Parker of the Middlesex University Flood Hazard Research Centre and Bob Moore of the Centre for Ecology and Hydrology (formally the Institute of Hydrology) have given their observations on the information collected from the Regions in the context of their expert knowledge.

3.3 Definition of Good Practice

The definition of what represents good practice is fundamental to this report. For this report good practice is defined as: “a procedure used in any aspect of the flood forecasting and warning process which is particularly effective in its accuracy, timeliness, reliability and cost effectiveness”.

However it is important to also consider how each individual procedure contributes to the overall effectiveness of the flood forecasting and warning process. In this context a procedure can be considered good if it contributes to the objective of providing an accurate, timely, reliable and cost effective flood warning service.

It is possible that a procedure may satisfy the first definition, but needs to be used in combination with other procedures to contribute meaningfully to the overall effectiveness of the service.

3.4 Identification of Areas for Research

Comparison of the detailed list of the stages in the Flood Forecasting and Warning (FF&W) process with the list of identified good practice allowed the identification of a list of topics for which there was no apparent existing good practice in the Agency at present. These topics are therefore identified as potential areas of future research.

This stage of the Study is set out in Part 2 of the Report.

3.5 Presentation and Consultation

Full and frank consultation was recognised as a key requirement to ensure that this study achieved its objectives. At each stage of the study the consultant has endeavoured to keep the Agency's Project Team, and the forecasting and warning practitioners concerned in each Region, fully aware of how the study was developing. As noted above, the minutes of the initial regional visits were returned to the Regions for comment and agreement. This included an indication of where the Regions were seeking and offering good practice. The regional sections of the Draft Final Report were similarly circulated following the second round of visits.

Reports on progress of the project were given by the consultant to NFWMG meetings held in April and June 2000, and by the Agency's Project Manager on several other dates. Meetings were held at the Agency's Bristol Office in April 2001 at the start of the second phase of the

assignment, and at the NFWC in July 2000 and June 2001. The report was presented to the Flood Warning R&D Theme Advisory Group at their meeting in March 2002.

The Draft Final version of the Part 1 R&D report was submitted for circulation and comment from the Agency Project Team and principal forecasting and warning practitioners within the Regions, with the intention that their views could be reflected in the final document. It was also hoped that some of the conclusions as to existing good practice could find early application in this time of significant changes within Agency procedures.

It was noted that the September 2000 Draft Report had already been referred to by those undertaking further assignments, including the National Flood Forecasting Modelling System Strategy and the Fluvial Flood Forecasting Improvements Project for Wales.

3.6 Interface with Other Studies and Initiatives

As noted in Chapter 2 above, the last few years have been a time of considerable change within the Agency's Flood Forecasting and Warning activities. Many initiatives have been undertaken and several are still ongoing. In producing this report it has been necessary to take account of these various changes to ensure that the conclusions reached here can sit meaningfully within the Agency's overall plans for the future of FF&W.

One of the major objectives following the Easter Floods was that the Agency should move towards the provision of a "seamless and integrated service of flood forecasting warning and response", and that nationally the aim should be for "consistency, but not at the expense of flexibility". The documents described below in many ways reflect this move to consistent procedures. Table 3.3 lists the current relevant documents for each stage of the FF&W process. This list has been updated to mid-2001.

The recommendations of the "Lessons Learned" report on the Autumn 2000 floods have been accepted by central government and are influencing all new actions.

3.6.1 Weather Services Review

One of the recommendations of the Bye Report (Bye and Horner 1998) was that a review be undertaken of the arrangements for procuring Weather Services and to identify best practice for critical forecast information. Such a review was undertaken by an Agency project team that reported in April 1999 (Environment Agency 1999). It involved the review of weather forecasting services and the provision of meteorological data sets across the Regions.

The report identified best practice in the existing procurement arrangements with the Met Office and proposed a model contract for the Regions, including a nationally negotiated set of rates for services to ensure cost effectiveness.

Best practice in weather forecasting was identified as:

- written daily forecasts including synoptic situation, detailed two-day rain and wind forecast and up to ten-day ahead general outlook
- heavy rainfall warnings and a 24-hour consultancy service.

In early 2000 it was decided that a single Agency/Met Office framework Memorandum of Understanding (MoU) would be used to replace the existing regional agreement: this is called the National Weather Services Agreement (NWSA). The agreement came into effect on 1 September 2000 (1 October 2000 in Wales).

Under the NWSA, the Met Office is also providing Agency staff with training in various aspects of meteorology directly related to the FF&W process. This was one of the specific recommendations of the Bye Report.

3.6.2 Rainfall Collaboration Project

There is an ongoing Met Office initiative on the integration of the raingauge networks owned by themselves and the Agency for the collection and sharing of sub-daily data. The project has developed as far as pilot schemes in Southern and North West Regions. Linkages between raingauges and weather radar are under consideration.

3.6.3 National Weather Radar Strategy

The National Weather Radar Network in England and Wales has evolved over the last 16 years with the benefit of joint funding from the Met Office and the Environment Agency. With the signing of a joint Memorandum of Understanding between the two organisations in December 1998, the management of the Network has moved from being regionally focused to a more strategic national footing. Funds have been secured to embark on a programme of Network enhancements designed to meet the needs of both organisations over the next ten years.

In August 2000 the National Weather Radar Project Group produced the Final Version of their report entitled “Environment Agency National Weather Radar Strategy for England and Wales”. The report sets out the current status of weather radar applications within the Agency, and makes recommendations for future developments. The report states the following:

“To date, the Agency has captured, processed and applied radar data in a range of different ways to support regional priorities for flood forecasting and warning and in some cases decision making in other functions. Operationally, the Agency has predominantly used radar data in a qualitative way to monitor the development and movement of storms, although some Regions have introduced more quantitative applications in recent years. The range of benefits that weather radar offers, therefore, has not been fully exploited and there are opportunities for making better use of new radar-based products, communication systems and technology. Some specific areas in which improvements are sought include:

- Greater detection of flood producing storms, including local summer thunderstorms
- The generation of local heavy rainfall alerts using 1 km and 2 km data
- A more integrated approach to the operational use of raingauge and radar data
- Improved short-term quantitative precipitation forecasting
- Improved flow forecasting”

It is noted that the Agency Regions currently use four different stand-alone radar data display/processing systems (HYRAD, STORM, Microradar and MIST). In addition North West Region is currently developing, in conjunction with the Met Office, an alternative

system based on its Enviromet product, which integrates with GIS. The Strategy recommends that there is convergence to one national display system, and that each Region migrates to this system over a period of time.

The current arrangements for disseminating radar products from the Met Office to the Agency, using serial transmission on up to 19 separate links, is recognised as being inefficient, inflexible and costly and hence not sustainable over the medium to long term. It has been agreed that the Met Office will move to the provision of all radar data using file transfer protocol (FTP) to the Agency's data centre in Leeds. The Regions will then obtain their required radar information from the data centre. This initiative is known as the Data Distribution Server (DDS) Project.

3.6.4 Tidal Flood Forecasting Project

In 1997 the Environment Agency carried out a review of tidal flood forecasting arrangements in England and Wales and made recommendations for future improvements. This was presented to MAFF at the Storm Tide Forecasting Service Liaison Group (STFSLG) meeting in February 1998.

At the Liaison Group meeting, the Agency agreed to lead an Action-Plan Group including MAFF, Proudman Oceanographic Laboratory and the Met Office to produce an Action Plan based on the Agency's Review Report which would:

- identify requirements
- prioritise tasks and identify responsibility
- set out an implementation programme
- identify costs and benefits of proposals
- consider the implications of a change to the Storm Tide Forecasting Service for the Met Office.

The Action Plan was agreed by the STFSLG in October 1998. The Action Plan Group has reported on progress in implementing the Plan, the latest report being March 2000.

Under the Agency Tidal Flood Forecasting initiative, a new forecasting system has been developed called Tidebase. This combines all Met Office and POLTIPS data to give forecasts which can be accessed by all Regions, along with all tide gauge data (polled at 15 min intervals). Currently the system can display the tide gauge information; it will be developed to include wind and wave forecasting.

It is considered that for Tidebase to be used efficiently in all Regions it needs to be accessible on the Agency's network. It is expected that Tidebase will be made available throughout the Agency soon under DDS, once the CIS national rollout procedure has been completed. At present there is not much operational tide data on the network.

Regional initiatives on tidal forecasting and display systems are progressing as needs are identified. The developing Triton system looks to address some of the requirements for the West Coast. The system is currently being used to show total predicted height and is being trialled to assess performance, including calculating overtopping volumes at specific sites.

3.6.5 National Telemetry Strategy

The use of telemetry is critical to many of the Environment Agency's operations. In addition to being fundamental to many stages of the Flood Forecasting and Warning process and Flood Defence operations, it is increasingly being used in areas such as Air and Water Quality Monitoring and Catchment Management.

In February 2000 Parsons Brinckerhoff (formally Kennedy and Donkin), as consultants to the Agency, produced its Final Report entitled "National Telemetry Strategy". This makes recommendations for development of telemetry throughout the Agency over the next ten years. The report sets out the objectives of the Agency's strategy to converge its telemetry technology, these being:

- the realisation of common best practices in operation and support of telemetry
- standard interfaces with other Agency and external systems
- optimum use of infrastructure services
- flexibility in the organisation and provision of telemetry services
- competitive procurement of major system and site telemetry components and services
- ready access to telemetry data for all who might have a need for it.

The time scale for the implementation of this strategy has the following implications for the regional systems:

- by the end of year 2001: modern telemetry systems installed or being procured for all Regions, meeting at least the basic requirements of all functions and capable of satisfying the capacity requirements for the expected growth over at least the next five years
- by the end of year 2005: a maximum of four consolidated systems covering all sites
- by the end of year 2010: the service to be provided by either one distributed, highly resilient system, or two similar systems (e.g. North and South systems) capable of completely backing each other up.

This strategy is impacting on the current procurement of the replacement systems for each Region. Southern, North West and North East Regions have completed the upgrading of their systems. The Joint Telemetry Project (JTP) covering Wales, Thames, and Midlands is at the specification stage. South West and Anglian Regions are also replacing their systems with their combined SWANTEL project. Contracts have been awarded under JTP and SWANTEL for the replacement of their telemetry systems in 2003.

3.6.6 National Flood Forecasting Modelling System Strategy (NFFMSS)

The NFWC has identified an urgent need for a clear strategy to direct the investment in flood forecasting modelling systems for the short, medium and long term. The preliminary study that has been carried out and its conclusions were summarised as:

- The Regions currently have different tools and practices for flood forecasting. The NFFMS market is not yet mature, however there are a few leaders, some of whom are already working with the Agency. The R&D is very active, particularly in the field of precipitation modelling and the use of new technology for models. The boundaries

between the weather and sea-state forecasting models run by the Met Office and the Agency's flood forecasting models are being reviewed and should soon be better defined.

- The NFFMS is considered in various roles, particularly as an off-line model development tool as well as a real-time operational flood forecasting system. Another concept established was that the Agency Standard Specification would evolve over the life of the strategy, progressively converging the generic features of the Regions and reducing the amount of "particular requirements" needed for any one implementation.
- The Midlands FFS2 and Southern SEFFS projects are well positioned to lead the development of the initial Agency Standard Specification, with North West, Thames and Wales following in the near future. The North East who already has many years experience with its RFFS, and Anglian who is implementing a new AFFMS can also make a significant contribution to the Agency Standard FFMS Specification.
- With the preliminary study complete Phase 2 has commenced to confirm user requirements, further develop the design concepts on which the strategy will be based, and to define the implementation and procurement strategies for NFFMS. Phase 2 should also assist the Midlands and Southern Regions with their system specifications, by defining the contents list for the generic and particular parts of the specification.
- It is proposed that the Agency develop a single real-time operation flood forecasting monitoring system (ROFFMS) which would be a framework within which different models can be run to produce forecasts in real-time.

3.6.7 National Flood Warning Performance Specification

One of the major Easter Floods Actions resulting from the experiences of Easter 1998 was the production of a National Flood Warning Specification; Version 3.0 of which was issued in March 2000.

It should be noted that since its publication several of the recommendations in this document have been superseded by further developments. The March 2000 document makes recommendations for the following:

Flood forecasting standards

Forecasting is to be applied to all main river and ordinary watercourses where it can be justified, where justification is determined by application of the methodology developed by Posford Duvivier for the Agency's South West Region. Coastal forecasting is to be subject to similar justification.

Assessment of flood risk is to be by application of the "Flood Warning Risk Decision Box", which is used as a prioritisation tool. This is a procedure by which all properties within designated Flood Risk Areas are assigned a Probability, Impact, and Risk of flooding. Regional databases have been produced (completed May 2000) which include addresses and category of risk for all identified properties. Nationally there are some 840 000 properties on the database which receive both a direct and an indirect warning. This compares to a national at-risk total of 1.8 million properties within the indicative floodplain.

The database is being updated as further Section 105 work is carried out. The most recent data was submitted for national collation in Spring 2001. The at-risk properties are checked against the address database nationally, then the information is returned to the Region for checking and completion of categories of risk. This is the primary flood warning data-set and is used for flood defence prioritisation etc.. The database is managed externally and will be widely accessible.

Flood defence standards

The standard of existing flood defences will be checked to ensure their integrity is consistent with the standard required to provide the relevant flood forecast. The standard found is reported to Central Government via the Agency's high level targets.

Use of coded warnings

The former colour coded warning system was replaced from 12 September 2000 by new warning codes for fluvial, tidal and coastal events with consistent interpretations across England and Wales. Full details are given in the "Guidance for Flood Warning Codes for England and Wales" issued by the Agency 1 March 2000. This document has been reviewed and will be updated in the near future.

Warning dissemination systems

A warning system shall be established wherever forecasting can be justified (see above).

The issuing of flood warnings will be the responsibility of the **Area** flood defence managers.

The target standard for the receipt of warnings is two hours before flooding occurs. In slow response catchments and for coastal warnings the two-hour figure may be increased. In flashy catchments a two-hour warning may not be possible and the target may be reduced.

The minimum warning system will consist of at least one broadcast method (local radio/TV or Floodline) and one alert method (primarily AVM). The use of multiple alert systems will be considered, as necessary, to ensure target compliance.

The mix of dissemination methods can vary from location to location according to what is feasible and appropriate. Flexibility is more important than consistency, so long as the arrangements for each locality are clearly documented and understood.

For "All Clear" and "Flood Watch" the minimum system will be selected direct dissemination into communities, including farmers, gatekeepers, Flood Wardens and other recipients who are required to take early action in the relevant flood warning areas. For "Flood Warning" and "Severe Flood Warning" direct dissemination to all nominated recipients in the relevant flood warning areas is required. For operational organisations the minimum requirement is that they should receive all messages direct from the Agency by fax.

Format and contents of warnings

All flood warning messages will have a nationally consistent Agency identity to a specified format and style. This includes formats for fax, voice message, pager message and loudhailer message. The national template for faxes took effect from 12 September 2000 based on the new warnings, and there are national script formats for voice and pager messages. Since this document was produced some time ago in March 2000 the formats have been developed further and are being looked at again.

A new system has been set up called the Flood Warning Information System (FWIS). This makes summary collations of warnings available by Area, Region or nationally in near “real-time”, with 24-hour automatic updating every 15 minutes. The information is available on the Agency Intranet, and from December 2001 on the Agency’s web-site.

Media dissemination standards

Target standards have been set to apply to all radio stations broadcasting flood warnings. This initiative is nationally led but regionally implemented; with agreements being made with individual radio stations.

Managing feedback from the public

Appropriate procedures will be put in place at Area level to manage feedback from the public in line with Customer Charter standards.

Area Incident Rooms are indicated to open at a specific level of flood warning activity; although this is used as a prompt only. The actual opening of Incident Rooms will be determined according to the particular circumstances of each event.

Procedures

Regions and Areas will set up clearly documented procedures to cover all aspects of the flood warning activity linked to the details in the Local Flood Warning Plans.

The procedures are required to define: the roles and responsibilities of Agency staff and their inter-relationships; robust systems to record dissemination activity; actions required to ensure effective reporting of key information; and the rostering and training of flood warning staff.

A list is given of required flood warning documents, their author, and purpose. These documents cover national, Regional, and Area considerations at all stages of the flood warning process.

Quality Assurance

All flood warning documentation is to be subject to audit to ensure consistency between Performance of the Area offices in disseminating documents and within a Region/Area, and compliance with national standards.

Monitoring performance

Performance of Area offices in disseminating warnings will be assessed in accordance with a nationally consistent specification.

Post event surveys will be undertaken to measure the accuracy of the warnings and the effectiveness of the dissemination system.

Control of documentation

All flood warning documents will be controlled in accordance with the Agency Code of Practice for Incident and Emergency documents.

3.6.8 Review of Flood Warning Dissemination Systems

In March 2000 the Agency (through the NFWC) appointed consultants Parsons Brinckerhoff to review the Agency's existing flood warning dissemination equipment and procedures.

The review reported in May 2000. Its conclusions were that Automatic Voice Messaging (AVM) was likely to remain the principal system for warning at-risk members of the public, and that the numbers registered as recipients of such warnings were likely to increase ten-fold over the next few years. Such an increase in numbers would only be achieved by significant improvements in the AVM equipment, however the technology was already available.

This review led on to the Flood Warning Dissemination System Strategy Report, and the Draft User Requirement that will be used to establish the project requirements to implement the next dissemination system. In December 2001 a report was issued on the significant failures of the AVM systems which occurred during Autumn 2001. This was followed in January 2002 by an AVM Action Plan to ensure robustness of this critical system.

As of early 2002 the existing AVM equipment is being modified to allow the automatic collation of information on warnings issued, see Sections 3.6.7 and 3.6.10. A project to deliver a Multi-Media Severe Weather and Flood Warning Dissemination System (MMSWFWD) is underway in collaboration with the Met Office. Part of this system will replace the AVM over the next few years.

3.6.9 Post Event Reviews / Collection of Flood Event Data

The final version of the report "Field Collection of Flood Event Data" was issued in February 2000. This gives guidance on the gathering of field data during a flood event. It covers what data to collect, and offers advice on storage formats to allow transfer to archive systems, FPI or any successor. The report recommends a national standard model with Regions and Areas allowed to add local appendices according to particular circumstances.

The report does not deal with post event reporting. There is no current Agency standard for this part of the FF&W process, however the NFWC is looking carefully at this matter. A standard contents list was issued for use by all Regions in their reporting on the Autumn 2000 floods, however there were still significant variations between the reports.

3.6.10 Data archiving

Archiving of field data is dealt with by the report discussed above. Archiving of other data generated by a flood event such as forecasts and warnings issued is not covered.

As noted in 3.6.7 above, the existing AVM equipment has been modified to allow the automatic collating of information on warnings issued. This new system allows summary collations of warnings by Area, Region or Nationally in near 'real-time'. The information is transmitted to the NFWC, which then carries out dissemination within the Agency and to selected professional partners. Further development has been undertaken, and under the FWIS, information on all warnings is available on the Internet from December 2001.

3.6.11 Floodline

The existing service has been reviewed; at present it comprises two parts. The first is the recorded messaging service (RMS), which allows public access via a number coded system to information about particular reaches or flood warning areas. The information is phoned in by Agency staff from Regional or Area offices as warnings are issued and is recorded in real-time. The aim is to have the floodline message up-to-date before issuing warnings by AVM or other methods. The AVM messages advise the caller to contact floodline for more and updated information. The Agency issues a user guide for the RMS to Agency flood warning staff. This is constantly being reviewed as changes occur. It aims to standardise the content of the messages recorded and takes account of the changes to flood warning codes which took effect from September 2000. The RMS was initially run by Cable and Wireless, was transferred to BT in September 2000, and since September 2001 has been provided by the MM group.

The second part of the floodline service allows members of the public to:

- report flooding, at present by connecting them to their local RCC
- order a Floodpack, by leaving a recorded message
- speak to a call-centre operator who will help them with any aspect, or
- if necessary transfer the caller to the appropriate Area office.

The long-term aim is for Floodline to provide a one-stop shop for all flooding enquiries. It is however recognised that there are many difficulties to overcome before this can be achieved, particularly related to the large number of agencies presently concerned with flooding.

3.6.12 Training

The Agency has identified training courses in a number of topics linked to the National Key Competencies for Flood Warning Staff. These courses include three modules provided by the Met Office: Introduction to Meteorology; Tidal Theory, Surge Forecasting and the Storm Tide Forecasting Service; and Introduction to Radar Hydrometeorology; plus training in Flood Defence Law, provided by the University of Middlesex.

4. INFORMATION AND ANALYSIS

4.1 General

Full details gathered on the current (Autumn 2001) organisation, systems and procedures in use in each Region are given in Appendix A. The main organisational structure and systems used for forecasting and warning in each Region have been set out for comparison in the spreadsheet given as Table 4.1. This information is also summarised on the map given as Figure 4.1.

This Chapter identifies aspects of the flood forecasting and warning procedures and systems in use across the Environment Agency where Regional Practitioners consider they exhibit good practice. Aspects in which the Regions consider they could improve their procedures are also listed.

The flood forecasting and warning process has been considered as a series of linked elements:

- General Procedures and Organisation
- Incoming Data and Monitoring (Detection)
- Forecasting
- Warning
- Response
- Post Event Data Collection, Reporting and Archiving.

Each element is further sub-divided into a range of sub-elements within each main element as shown in Figure 4.2. Although the importance of each element may vary between Regions, all Regions follow this process in one form or another.

The information used to set out the processes used in each Region was derived from the following sources:

- information gathered from visits to Agency offices and interviews with Region and Area Forecasting and Warning Officers, as described in Chapter 3
- analysis of Autumn 2000 Floods Reviews.

Where the same element of good practice was reported from all or most of the Regions it has been included in Section 4.2.1 as “Common to All Regions”. Examples of good practice from analysis of flood event reports proved more difficult to obtain than examples from the interview process. This is because event reports tend to concentrate on the factual events and on the lessons to be learnt rather than on the success or otherwise of the procedures employed.

4.2 Results of Regional Investigations

4.2.1 Procedures common to all Regions

A number of elements of forecasting and warning reported as good practice are already common to most, if not all, Regions. This is to be expected given that Regions have a common objective to issue timely and accurate warnings, and that there have been a number of national initiatives aimed at sharing acknowledged good practice between the Regions (see Section 3.6 above).

Examples include:

- Weather services received - as of 1 September 2000 (1 October 2000 in Wales) all Regions have procured their weather services from the Met Office under the centrally negotiated national Weather Services Agreement.
- Prioritisation of provision of warning services - using risk matrix and flood risk mapping to produce at-risk databases.
- Use of AVM as primary method of warning to at-risk properties - as of 12 September 2000 all Regions have used standard templates for both voice and fax warnings in accordance with the new warning codes.
- AVM databases backed up by duplicates in other offices within the Region.
- Standby power supplies to supply essential services if normal grid supplies disrupted during a severe event.
- Duty staff have laptops at home from which they can access all systems.

In several other elements regional procedures are converging in accordance with identified good practice. For example all Regions are moving towards the organisation model as set out in the “Changing Needs in Flood Defence Review” (CNFDR) whereby the responsibility for forecasting is at Regional level and for warning at Area level.

Table 4.2 gives a list of topics indicating the aspects of the FF&W process in which each Region considers it is exhibiting (offering for potential use by other Regions) “good practice”, and those in which it considers it could improve its procedures, and is therefore seeking “good practice”. This list is amplified by the regional notes given in Sections 4.2.2 to 4.2.9 below.

These regional notes are divided into two sections:

- i) “Good Practice From Visits and Perceptions of Regional Practitioners”, which lists items of good practice as gathered during the visits to the Agency offices for discussion with Flood Forecasting and Warning Practitioners within each Region; and,

ii) “Good Practice From Analysis of Autumn 2000 Flood Events”, which lists items of good practice as evident from the Regional ‘Autumn 2000 Floods Review’ Reports. The notes do not seek to replicate the ‘lessons learned’ or recommendations for the future as contained in the Regional Review Reports, but to draw-out examples of procedures which were proved by events to represent good practice.

4.2.2 North East Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

The North East's system for document management and quality control is reported as a model which other Regions can aspire to. It has been acknowledged that considerable staff time has been needed to set up and maintain the document system but it is considered that this will reap long term benefits.

The existing layout of the Area Incident Rooms is being reviewed to improve their effectiveness.

The Region has organised a number of multi-agency flood exercises over the last two years. These have proved very useful. They are an effective way of testing the plan, training and testing staff and are useful for building relationships with the other agencies.

The North East has been involved in providing liaison officers to a considerable number of Silver and Gold controls with very positive feedback. The use of laptops with access to the telemetry system at control centres has been found to be very useful.

Flood defence asset survey and aerial photographs of past flood events are kept in the Incident Room for reference during events.

Detection - incoming data and monitoring

The North East Region sees its particular strength to be in data acquisition and transmission. The recently introduced Northern Telemetry System (NTS) which is shared with North West Region provides a user friendly interface for monitoring both fluvial and tidal conditions.

Forecasting

Quality of forecasting is monitored with the aim of targeting future investment to improve performance. A programme of re-calibration and improvement of the forecasting models is being started. A dedicated Agency post has been set up to do this.

The Region's flood forecasting is based on its River Flow Forecasting System (RFFS), which is now over 10 years old. Although the basic infrastructure of the system is considered to work well, the forecasting models themselves are in need of recalibration and/or reconfiguration. It has recently been extended to cover the whole Region. Details of RFFS are given in the April 1999 Strategy Report for RFFS development by Parsons Brinkerhoff. Though the platform for the RFFS forecasting system is relatively dated, the models used are still applicable and present a good example of the range of model types that it is possible to run successfully together on the same "open" (generic) system.

Long term planning in forecasting is taken seriously. A strategy for the development of the forecasting system has been prepared and established.

Warning

There has been considerable expansion of the warning service over the year to 2001, and it is recognised that long term planning is critical to success. The North East is expanding its use of non-AVM warning systems, including sirens, loudhailers and community groups.

Sirens are used for warning on the Calder where they work well with the close-knit stable community. The effectiveness of the warning provided is being improved with new sirens. Different types of siren have also been tested. Plans are in-hand to expand the coverage of at-risk areas warned by sirens.

Considerable expansion of the use of loudhailers is planned particularly in areas of low probability, high consequence flooding, such as Hull.

North East used to have a deliberate policy of not having Flood Wardens. Following the June floods on the Upper Calder, the community affected was pro-active in setting up a community group with the aid of the Agency, which includes Flood Wardens. The North East is therefore now encouraging such self-help by communities. It is not intended that Flood Wardens be used as the sole method of warning but to reinforce other systems.

The Region has effective procedures for duty officers to work at, and issue warnings from, home.

Post event data collection, reporting, and archiving

As noted above, the quality (success) of forecasting and warning during an event is monitored and reported on with the aim of determining where best to target investment to improve performance.

Hand written Event Logs are kept as an event progresses. Incident Logging Forms are used to handle incoming information and passed to appropriate staff for action. NIRS is being introduced. However North East considers that there is a need for a comprehensive event management system. From talking with the police, who have a strong culture of logging/recording all aspects of incidents, they are aware that the Agency's performance in logging incidents needs great improvement.

ii) Good practice from analysis of Autumn 2000 flood events

Within the North East Region Autumn 2000 was one of the wettest on record, with the entire Region's river catchments saturated by the time some 250 mm of rain fell in the two-week period from 26 October to 8 November 2000. This deluge caused the most dramatic, widespread and prolonged flood seen for at least half a century. The peak levels on several rivers, including the Ouse through York, were the highest ever recorded.

The Region's Northern Telemetry System (NTS) performed well throughout the event, making an estimated 100 000 calls to its rain and river gauge outstations. Despite the magnitude of the flood, only 12 of 400 stations were lost, primarily through BT communications equipment being flooded. Failure of these few outstations did not affect the

issue of flood warnings since these have up to three separate triggers to ensure reliability. Planned contingency manual gauge board reading procedures were quickly put in place to maintain service.

The North East's involvement with Silver and Gold Controls was considered to have been well handled during the Autumn 2000 floods with very positive feedback, in spite of the large numbers of requests for assistance. Taking laptops that can view the NTS to the Control centres proved extremely valuable.

Although the suite of forecasting models used by the Region's River Flow Forecasting System (RFFS) did not perform particularly well, the framework in which the models are used, which provides links to telemetry and weather radar data, worked well.

This flood provided the first real test of the new flood warning codes introduced in September 2000. The new system is considered to have worked extremely well in the North East, although with a few specific problems, which are now being addressed.

The policy of issuing warnings by a combination of methods was proved to be effective to circumvent difficulties arising with any single method. Direct warnings were issued to the public by AVM, mobile loudhailer units and flood warning sirens. Despite power cuts and breakdown of the telephone service at both the Leeds and York Incident Rooms, the warning service was maintained by using prepared contingency plans which worked smoothly.

With a small number of exceptions all Flood Warnings and Severe Flood Warnings were issued within the Agency's target time scales. Considering the unprecedented number of warnings issued via the AVM, the system coped extremely well, with few faults reported.

Following floods in June 2000 there had been concern that the time taken for AVM to contact the Upper Calder community was too long to react to the short lead times. Changes were made to the AVM database so those on the Upper Calder AVM would be warned first. This resulted in a halving of the time taken to alert that community in the Autumn 2000 floods. This shows the importance of prioritising the AVM database.

All three flood warning sirens used for direct warning to the public were sounded successfully. Loudhailer vans were used extensively throughout the flood event. Many of the routes used were formalised and predefined in the Flood Warning Manuals, however many others were related to the Special Flood Warnings issued, and were devised on site. Many of these special routes were supplemented through door knocking by Agency, police and Local Authority Staff.

In the year to July 2001, 60 new Flood Warning Areas have been set up throughout the Region. Twenty-eight of these along the River Aire proved of immediate use in the Autumn 2000 floods. In addition the service was improved at six existing locations. The Region carries out public awareness campaigns when setting up a new Flood Warning Area, which will often include a road-show. This has proved to be a very effective policy.

Although media coverage was generally considered to have been good, considerable inputs were required from Agency staff who were already fully stretched by operational response needs. One Area nominated a spokesperson whose role was solely to be available for media queries and interviews. This is believed to have worked well.

4.2.3 Midlands Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

The Midlands Region sees its strength to be in its organisation of procedures. It is one of only two Regions which has for the last few years operated with forecasting centralised in the Regional office and warnings issued from Area offices. This was implicitly recognised as good practice by its adoption as the required standard under the CNFDR.

The whole forecasting and warning operation appears to run smoothly with frequent and reliable forecasts generated and warnings efficiently generated and issued.

Midlands also considers that the layout of its offices used for flood forecasting and warning in the Solihull Regional Office demonstrates good practice. The rooms were reorganised following the experiences of the Easter 1998 floods. The Regional Communications Centre (RCC), the Forecasting Room, the Regional Incident Room, and a Public Relations Room are all located adjacent to each other. This is considered an ideal set-up for efficiency of operation during major events, however the Autumn 2000 events revealed the Regional Incident Room itself to be inadequate in size, since it was required to double as a video conferencing room.

During events the Upper Severn Area operates a six-hour shift, which is generally shorter than other Regions/Areas that operate an eight-hour shift. Upper Severn Area has found the shorter shift to be an optimum to avoid fatigue causing a reduction in effectiveness. Between October and March a backup Area Flood Warning Duty Officer is on call. If the main FWDO has been monitoring for some time but without having to initiate opening of the Incident Room then the backup can take over.

Detection - incoming data and monitoring

In the highland areas of the catchments, the Welsh Mountains on the Severn and the Peak District on the Trent, snowmelt can be a major factor. All the Region's raingauges are heated to monitor snowfall, and there is also a network of snow observers who carry out investigations into snow density etc. The observers report their findings back to the Regional Forecasting Centre.

Data collection, and thus model runs, are triggered by the Regional Monitoring and Forecasting Officer. Incoming alarms from outstations act as a backup trigger.

Data from the telemetry are quality controlled after they have been gathered, allowing forecasts to be produced automatically without the attention of the forecaster. Data retrieval from 270 outstations is normally completed within 20 minutes, with success rates of more than 98% on average.

Forecasting

The existing Midland's forecasting system has already been recognised by the Agency as good practice. The real-time forecasting model used, Flow Forecasting System 2 (FFS2), has been in use for over 15 years. Although this means it is somewhat dated in terms of software and

flexibility for upgrading, it also means that the results of many years of observations have been used to improve the model calibration. This continuity is an example of good practice.

Forecasting is completed in less than a minute, using the hydrological models applied to predict flows at over 50 key locations. Forecasts are for up to 72 hours ahead, and include future rainfall predicted by the radar system for the next six hours. If the models predict, or have exceeded, a flood threshold, a synthetic speech alarm will contact the duty flow forecaster to advise of the developing flood. Flow forecasting services are provided around the clock, 365 days of the year.

Forecasts are computed in flows but may be presented as levels or flows. Most warning thresholds are set against levels.

With an ever-increasing number of Flood Warning Areas and gauges FFS2 is becoming difficult to maintain and extend. It is therefore to be replaced by a totally new system which will incorporate the strengths of the existing system whilst taking account of new technology and allowing the use of hydrodynamic models etc.

Warning

Good practice in warning is in evidence from the Midlands Upper Severn Area office at Shrewsbury. This is an area where flooding is relatively frequent, both of agricultural land and urban areas, particularly Shrewsbury. In order to cope with the workload a backup Flood Warning Duty Officer (FWDO) operates during the main flood season from October to March. A nominal six-hour shift is worked which is considered an optimum to avoid fatigue becoming an issue during busy periods.

Since the replacement of the former colour-coded warning scheme in September 2000, the Region has been testing a Flood Watch spreadsheet that uses weather forecasts including soil moisture deficit to trigger the issue of a Flood Watch. Results have shown that the spreadsheet system has potential, but that significant further work is required on its development and calibration.

The spreadsheet is just one of the possible triggers for the issue of a Flood Watch. Heavy rainfall warnings, radar data and severe weather warnings are also used. The Region has designated 15 Flood Watch Areas (compared to 80 Flood Warning Areas). A quarterly report is issued analysing the accuracy of the Flood Watch service.

Warning is facilitated by threshold levels of properties being available for many of the at-risk properties. These threshold levels are used to set-up “Thermometer” type charts that have been found to be particularly useful. The latest versions sub-divide the warning band of levels into up to five sub-bands (Severe Flood Warning being equivalent to the highest sub-band). The maximum of five bands is limited by the existing telemetry system allowing five thresholds. There is a different AVM warning message associated with each sub-band. The Region considers that this procedure allows better targeting of warnings than using a single message for the full band. All AVM messages are pre-recorded.

Maximum level gauges are used at some locations to calibrate off-line hydraulic models.

The Floodline Recorded Message Service (RMS), at least in the Upper Severn Area, is considered as a very important dissemination tool and the primary source of information for the public. This Area benefits from a stable, relatively flood aware at-risk group which means that they are more aware of the meaning and content of Floodline messages. Messages are detailed and specific to well-defined locations.

Considerable effort is made during an event to update messages. A Floodline update form is used which tracks when updates should be made. The interval between updates is typically two to three hours in the upper catchment and six hours around Worcester. There is a target maximum interval of six hours during daytime and eight hours overnight.

Post event data collection, reporting and archiving

The Region monitors the quality (success) of forecasting and warning during events and includes key performance indicators (KPIs) in post event reports.

A strong emphasis is placed in the Region on the assessment of performance, particularly in the area of forecasting, but also in warning. An assessment of the timeliness and accuracy of warnings is made post-event. An assessment is also made of forecasting success in terms of predicted and actual rainfall.

The flood peaks that occurred at each gauge are recorded, during and/or post-event, in a Flood Peak List (kept in Flood Warning Duty Manual for reference) and archived. The data are periodically added to the Emergency Level Forecasting System (ELFS). This is a fallback system that is maintained in case the main forecasting system fails. It is based on level to level correlation.

ii) Good practice from analysis of Autumn 2000 events

During the Autumn 2000 floods, video and telephone conferencing was held twice daily between the Regional and Area teams. The conferences lasted on average for half an hour and involved the Regional Base Controller, Public Relations Staff, Forecasting Staff and the Regional Director in Solihull talking with the Area Base Controllers. The conferences were a major success.

It was found important to follow a set agenda and in future conferencing will be held on the basis of the Region talking to two Areas at a time for a Region-wide event (Severn or Trent).

During the Autumn 2000 events the Region developed standard "Lines to Take" for response to media enquiries. This allowed immediate responses with a consistent message. The information originated from the Areas and was distributed from the Region. The messages are kept as MSWord macros.

All five of the Area Incident Rooms within the Region (two rooms in Lower Trent Area) were operational throughout the event and provided excellent points of contact for all parties involved. The role of Base Controller was better utilised during this event than in 1998, where local resources were stretched, the Base Controller roles were successfully filled by senior staff from adjoining Regions, this being a good illustration of the need for National consistency. There was much evidence of successful cross-functional working, providing

support and assistance to both Incident Rooms and data collection exercises in the field. Approximately 200 staff were involved across the Region manning the various Incident Rooms. Local geographic knowledge was particularly useful and was a worthy substitute for any lack of “flood defence” knowledge. This type of support was essential during an event of this scale. The Flood Defence function alone cannot meet the demands now expected of the Agency during such exceptional conditions.

The preparation of situation reports from the Areas, on a twice-daily basis at specific times, was seen as a significant improvement and one which could be planned and accommodated into the working day. These reports provided the platform not only for public relations, but also for overall regional management of the situation. These twice-daily flood situation reports are now made available on the Agency Intranet giving the latest situation both morning and afternoon.

During the event the FFS forecasting model produced almost 500 separate forecasts for the Severn and Trent catchments, with the reliability and accuracy of forecasts considered to be generally very good. The extreme nature of the event did however expose a number of inadequacies in the FFS. The standby Emergency Level Forecasting System (ELFS) was used extensively in the later stages of the event to predict peak river levels by comparison with historic events. This additional information gave increased confidence in the forecasts that were provided and illustrated the value of an empirical standby to a sophisticated automatic forecasting system.

4.2.4 Anglian Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

The Anglian Region sees its strength to be in its good liaison with town and parish councils at all levels and with the emergency services. This good co-operation works well when introducing new warning services. Liaison is time consuming and the Region is concerned that if there are too many new procedures introduced then they may lose this good co-operation.

Detection - incoming data and monitoring

The Region's existing telemetry system is considered adequate in performance and has recently been extended to incorporate a number of new gauging sites. It is however based on relatively old technology and can be slow. A totally new system (SWANTEL) is to be developed in conjunction with South West Region. This new system will take advantage of recent developments in communication and display technology to produce more timely and more easily assimilated information.

Forecasting

The Region recognises that its existing forecasting models are not good practice. A new Anglian Flow Forecasting Modelling System (AFFMS) is to be introduced in the near future and will incorporate state-of-the-art models and processes. The two principal non-steady hydraulic models under consideration are MIKE-11 and ISIS. PB Kennedy and Donkin is developing the framework whilst W S Atkins is working on models of two trial catchments in the Northern Area. AFFMS should be operational by the end of 2002.

Warning

A menu driven system is used for issuing warnings, which allows relatively untrained staff to carry out the mechanics of issuing warnings, thus releasing the Warning Duty Officer for other duties.

The Region has introduced a siren based warning system to Northampton that is considered good practice for such a low risk - high consequence area.

Post event data collection, reporting and archiving

Considerable resources are assigned to post event data collection. This can include aerial photography and collection of video footage of floods using helicopters. In addition use has been made of thermal imaging to identify wetted area, and extra video footage has been obtained from the police and other partner organisations.

Telephone calls to the Flood Control Room are taped in case of future enquiries about events. It is also envisaged that the tapes could be used for training, though lack of time has prevented this to date.

ii) Good practice from analysis of Autumn 2000 flood events

Although not as seriously affected as other Regions, the flooding of Autumn 2000 was the most serious in the Anglian Region since Easter 1998.

The Region successfully operated its own forecasting and warning systems, and was able to provide significant assistance to neighbouring Regions in terms of both personnel and equipment. Personnel from Anglian Region were deployed on mutual aid in North East Region to inspect flood defences and assist in sandbagging, whilst Public Relations staff assisted in Southern and North East Regions. Over 24 000 sandbags were sent by road to North East, Midlands and Southern Regions over the period.

The forecasting systems in place, particularly in Northern Area, gave accurate predictions of peak flood levels, with good lead times. The Northern Area presently uses a transfer function model which, although limited in its capabilities, performed well due to recent updating and the advance notice of rainfall received from the Met Office. An important factor in the success of the forecasting is considered to be that forecasters were provided with quiet working conditions free from personal and telephone interruptions.

The training of staff in new procedures and the doubling up of forecasters at the beginning of the event proved to be effective strategies.

The provision of event summaries using the new fax format was well received by the RCC and Public Relations.

Public Relations support to the Areas was excellent with good positive media coverage being achieved. A total of 223 newspaper articles were generated, the vast majority of these being favourable to the Agency.

There was a good positive reaction from the public to awareness issues and to the new flood warnings.

Agency staff response to the event was very good. The Direct Services Group performed well, and CIS staff provided roster support and volunteered to assist with telemetry and RCC operations.

The Floodline RMS was seen to be effective in reducing the number of calls to the Area Incident Rooms and thus allowing staff to concentrate on their forecasting and warning duties.

4.2.5 Thames Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

Prior to 1998 Thames had focused very much on the development of its warning and dissemination systems, and it is in these areas where it exhibits particular good practice. On the forecasting side the Region acknowledges that it had fallen behind some of the other Regions, although this aspect is now being addressed.

Within the Region great emphasis is placed on public relations as an effective method of ensuring flood awareness and preparedness. The Agency has its own Education Officer who works with schools. Within the Flood Warning Team there is a Flood Warning Engineer (Warning) who, amongst other things, has produced a "Flood Detective" comic for distribution in schools and a "River of Life" game. It has also commissioned an "Inspector Downpaw" costume which is used on school visits and makes appearances at agricultural shows etc. to publicise the Agency's Flood Warning work. This was particularly useful at the launch of the new warning codes in September 2000.

A newsletter called "River Watch" is produced twice a year for distribution to Flood Wardens and people at high risk. This was used to obtain feedback from the public on the Autumn 2000 floods. Southern Region has taken up this idea and produces its own "Flood Watch" newsletter. North East Region also has something similar.

There is a special "Media Room", adjoining the monitoring and forecasting room, which is soundproofed and can be used for interviews etc. It also has a glass viewing panel to allow TV filming of the room in operation (without interfering with operational activities). This room was much used during the Autumn 2000 floods. The Region has installed an ISDN line to improve the quality of communication with radio stations.

The Region produces a Daily Situation Report (DSR) at 09:00 each working day, giving details of the weather overnight, number of warnings issued, and forecast of weather and river levels. This is very useful as it gets the incoming Duty Officer up-to-date quickly. The DSR is sent out to all Areas, the Barrier, RCC and Public Relations. When an event becomes severe enough (judged by warnings being in force in more than one Area) a Regional Base Controller (RBC) is mobilised. The RBC is responsible for issuing Situation Reports to Head Office giving details of incidents.

Detection - incoming data and monitoring

The CASCADE software, which forms the basis of flood forecasting centre operations, manages the incoming data from the telemetry system. This software was originally developed in the mid-1980s, and the graphical user interface (GUI) is becoming dated (it is not Windows based). However it has the advantage of having been developed by in-house programmers who have kept it up-to-date, and therefore it does exactly what is required of it by the user.

CASCADE also takes in the radar data in various formats. It can show the data on-screen in a variety of formats including comparison of recorded rainfall and radar predicted rainfall for

each gauge site. It shows the trends and alarms. The Region reports the most advanced use of radar data within the Agency both qualitative and quantitative, including single site, Nimrod and GANDOLF.

A member of the forecasting team may stay at home and monitor and forecast away from the distractions of the busy Incident Room. This is reported as good practice in helping in the observation of trends and keeping a detached view of events.

Forecasting

As noted above, the Region has in the recent past concentrated more on warning and less on forecasting, hence its forecasting system is less well advanced. However a new Regional Flood Forecasting System is being developed by Thames in conjunction with CEH.

The new system brings together radar data and telemetry with models such as the Thames Catchment Model (TCM) and a Probability Distributed Model (PDM) to allow forecasting. The system was on-line during the Autumn 2000 floods and presently allows forecasts at 28 sites across the Region. This will be increased to 50 sites over the next year. At present the forecast accuracy is not good, but a PC based calibration version of RFFS has recently been received from CEH, which should make significant improvements.

The Region has a well-developed coastal/tidal forecasting system that was developed by POL. This uses observed levels down the East Coast and is run every 12 hours. Actual readings from tide gauges are compared with predictions.

The accuracy of the tidal model is quite good, generally within 0.1 to 0.2 m; it may be up to 0.5 m out once per year. Actual readings from tide gauges are also received in the Monitoring and Forecasting Room and compared with predictions. Any significant differences may influence the issuing of warnings. Tidal forecasts are also passed on to the Agency Anglian and Southern Regions and to the Netherlands.

Warnings

Thames believes it is unique in offering a flood warning service on all main rivers within the Region. The service is divided into 135 Flood Warning Areas, defined as lengths of river (reaches). The Flood Warning Area system is being updated and details will be sent out to professional partners in GIS format in late 2001. The database will show the 100-year floodplain, plus some indication of the extent of flooding for smaller events.

The annual update of the AVM is currently done by phoning all the recipients rather than relying on post – this obviously takes a long time for 7000 recipients, but ensures a better response.

Although the principal means of warning is AVM, Thames also have an effective and growing network of approximately 100 Flood Wardens which ensures good local contact and public relations. The warden system is seen as complementary, rather than an alternative, to the AVM. People who are part of a warden scheme are also on the AVM. The Region considers that wardens are particularly useful in maintaining good community relations. They also provide

valuable feedback to the Agency with on-the-spot reports, and can advise when the decision to issue a warning is borderline.

At-risk communities are assessed to determine the most appropriate system for warning. The Flood Warning Officers in the Areas look for key people to organise the community and to engender a sense of ownership of the warning scheme. A typical Flood Warden scheme will have three wardens for 40 properties.

Within the Thames Region there are now four officers responsible for warning per Area. The Area based staff responsible for flood warning are also responsible for public liaison and recruitment of wardens and direct warning recipients.

There is a “Status of Current Flood Warnings” board which takes the form of a matrix of catchment names (26 of them) and flood warning area names (up to nine per catchment – average say five). When a warning is current a “Watch”, “Warning”, or “Severe” will be written into the appropriate square on the board. This has the advantage (over other Regional systems) of showing at a glance the overall warning situation for the entire Region. This display is duplicated electronically on the CASCADE system.

Post Event Data Collection, Reporting and Archiving

The Region is moving to a suite of ACCESS/GIS databases to record, store, and disseminate a wide range of information. This will allow Area offices to easily access the information. A regional database of warnings issued was started in September 2000 to replace the old document format, which dates back to 1950.

The collation of flood reports is now the responsibility of the Regional Flood Warning team, previously Flood Defence were responsible. Each Area has a team of standby Flood Data Recording Co-ordinators, who liaise with the Flood Warning Duty Officer (FWDO) and call out staff to observe floods at pre-set “node points” in the catchment. The officers take photographs, levels, record property flooding etc. and arrange for surveys.

The Region is looking to link the data collected in this way into a new ACCESS database. This good practice has been documented and sent to the NFWC.

In the Regional office there are three duty officers, a Monitoring and Forecasting Duty Officer and two assistants, one of whom focuses on River Control Duties.

Thames considers that having a relatively small pool of duty staff (11) from which to draw is advantageous. It allows all staff to be fully trained and to have enough experience to build up expert knowledge.

In the Area Offices there are three duty officers, a Flood Warning Duty Officer (FWDO) and two Assistant FWDOs. These are on a roster from a pool of 12, giving a duty every four weeks. This is shorter than other Regions, but considered good practice as it helps avoid staff forgetting what to do, and is less of an onus on training.

ii) Good practice from analysis of Autumn 2000 flood events

In the Thames catchment the combined rainfall totals for September and October 2000 made the period the wettest for 40 years and the second wettest since records began in 1882. The flooding in Thames Region in October and November 2000 was extensive, a few locations were badly affected, but the impact was felt across the entire Region.

During the Autumn 2000 Floods all media activity was co-ordinated regionally. A specific person was nominated to liaise with the Areas and to talk to the radio stations, TV stations and to set up interviews. This worked very well.

Local radio was a major factor in warning and keeping the public informed in Autumn 2000. The stations were sympathetic to the Agency's problems. The radio stations reported increased audiences, some by as much as 40%, and these have been maintained post flood. With all public phone calls now routed to the Areas, the Region was able to handle the media. Over 70 interviews were given. Potential problems arose where radio stations catchment areas do not coincide with Agency Regions. It would help to exchange press releases with adjacent Regions, Local Authorities and police to present a common message.

Arrangements for inter-regional assistance were established and managed on a sound basis. These arrangements are being formalised as part of regional procedures.

The widespread nature and long duration of the event placed unprecedented demands on staff in the RCC, the regional switchboard, and Area Incident Rooms. The Region successfully made use of personnel from outside of the flood defence function to supplement flood defence staff to ensure that the public needs were met.

With the implementation of the National Weather Services Agreement closer liaison with Met Office staff gave increased confidence in rainfall forecasts.

The revised flood warning codes which had been introduced shortly before the start of the flood period were found to be better understood by the public, and the Flood Action Week and attendant publicity ensured that public reaction to warnings was much improved over previous major events.

4.2.6 Southern Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

Public awareness is the area where Southern Region is particularly strong. A yearly “Flood Link” leaflet is produced and sent out to all AVM recipients, libraries, Local Authorities etc. The Region considers it has learnt how to deal with the media well during events.

In October 1999, some 200 000 flood packs were sent out to all on the at-risk database. This resulted in 5000 additional recruits to the AVM database.

The Region has pioneered the use of GIS based mapping for the identification and management of flood risk areas. All coastal and fluvial areas at risk have been divided into “Flood Warning Zones”, which form the basis for AVM message organisation. There is a continuing process of refinement of these zones via Section 105 studies, and they are presently being rated according to the latest flood risk matrix, High, Medium, Low in terms of Risk, i.e. Potential Damage and Probability.

The output from this work will be the identification of areas where Major Incident Plans (MIPs) are required, and the ability to better target public awareness campaigns and use of AVM/Direct Warning Systems.

The Region has three strong Local Flood Warning Planning Groups (LFWPGs) which meet at least once a year. These are based on the police force boundaries that correspond with the Region’s Area boundaries, Kent, Sussex, and Hampshire/IoW.

There is a six-monthly liaison meeting with all County Emergency Planning Officers for the whole Region that steer the LFWPGs.

Within the Regional Office the RCC, Incident Room, Forecasting Room and Call Handling Area are all located next to each other. Only the Public Relations Function is remote being located two floors away.

Southern sees inter-regional liaison as an important aspect. It exchanges faxes with South West Region on rainfall and coastal matters, particularly for areas such as Christchurch where the Regions’ coasts meet. South West passes on its coastal warnings. There are some of Southern Region’s raingauges actually within the South West Region’s geographical area.

The Region also liaises with Thames Region at the Barrier on conditions in the Thames Estuary. This has been done since the new warning codes were brought in, in September 2000, and has helped in setting up new warning areas.

Detection - incoming data and monitoring

The Region’s telemetry system is considered adequate in performance and has recently been extended to incorporate a number of new gauging sites.

Groundwater levels in critical chalk areas are monitored using boreholes. All are dipped monthly, with 12 of the most important being linked to the telemetry system. This number is expanding. Data from two of the boreholes feed into the Chichester model.

Forecasting

Warning of fluvial events is instigated by a system of trigger levels reported via telemetry. Triggers on rainfall quantities are set to reflect variations in response across the Region, river level triggers are based on historical data. The Region is continuing to extend the telemetry network and to implement more sophisticated fluvial forecasting.

The Region currently has forecasting models in place for 11 of the 85 fluvial Flood Warning Areas. 10 of these models are contained within the Flood Forecasting Platform (FFP) which was developed for the Agency by consultants. FFP takes in telemetered river level and raingauge data, and allows forecast rainfall to be entered. It then runs the models and displays the outputs. In addition there are models of the Medway and of the River Lavant at Chichester which run separately outside of FFP.

The Region has also been developing a number of simple forecasting tools, including the historic event database and the indicative time of travel map.

In parallel with the operational use of FFP, Southern Region is proceeding to design, specify and procure the Southern Enhanced Flood Forecasting System (SEFFS). The project which delivered FFP and under which SEFFS is being developed is known as SURFFS. SEFFS will support the flood warning service for the Region's entire fluvial and coastal Flood Warning Areas. It will include models initially developed for the FFP; conceptual models, complex hydrodynamic models, GIS linked inundation mapping, over-topping and breach models. SEFFS will be designed to interface with any future National Tidal Flood Forecasting System (TFF).

The hydrodynamic model of the Thames Estuary, which is run at the Barrier Office, is available on screen in the Southern Region. This has been found to be very useful for predicting levels from the Regional boundary where the Darent meets the Thames, all along the North Kent coast. The model shows forecast, actual, and updated predictions of tidal levels. Southern would like a similar model for their other lengths of coastline. POL has developed a Solent Model, although this is not yet operational, the Region is very interested in it.

Warning

Southern Region is attempting to offer a flood warning service to all areas at risk from either coastal or fluvial flooding (not just main river reaches). The principal means for direct warnings is the AVM where Southern has a much larger number of recipients than any other Region. It also has an effective and growing network of Flood Wardens, which ensures good local contact and public relations.

Of the 160 000 properties designated as "at risk", the Region is able to offer a four-stage warning service via the AVM to 152 000. The remaining 8 000 are offered a two-stage service using Flood Wardens. The take-up for the AVM service is some 50 000 recipients and rising. Keeping the list up-to-date requires staff inputs equivalent to 0.5 Full-time Equivalent (FTE).

Mailing is organised nationally. No recipients are removed from the database without their expressed wish.

Southern's system uses the full AVM capacity of 30 voice lines and six fax lines per machine. There are five machines, one in each Area, one extra in Sussex, and a backup in the Region. It is planned that over time data will be input locally to Regional standards. The Southern AVMs are connected to the Agency's LAN and this makes data management easier than with the stand-alone machines that some Regions use. The issue of warnings via the AVM tends to be conservative due to the restricted dissemination rate of the equipment. If it were faster then warnings would not need to be issued until there was more certainty of need.

The annual update of the AVM is obviously a major task with 50 000 recipients and the number increasing. A full-time Agency Officer co-ordinates the updates and a local direct mailing company is employed to send out mailings. No recipients are removed from the database without their expressed wish.

Recruitment of wardens has been via the forms sent out with the public awareness mail-shots. Once signed-up, contact with wardens is made via AVM, the wardens pass the warnings on to their "groups". The Agency supports 2800 wardens covering 5000 people. In addition there are some Local Authority warden schemes.

It is planned to display warden and recipient location details on the GIS system.

A newsletter called "Flood Watch" is produced annually for distribution to all AVM recipients and also goes out to libraries and Local Authorities etc.

Post event data collection, reporting and archiving

The Christmas 1999 event was reported by a comprehensive "Performance Review" which considers the event in terms of the Agency's response in six key areas:

- Event Management
- Flood Forecasting
- Flood Warning
- Emergency Response
- Public Relations, and
- Health and Safety.

This appears to be a particularly useful style of report, and was used as the basis for the Regional reports on the Autumn 2000 flooding.

Southern Region makes an effort to use as far as possible Agency standard (harmonised) PCs for running its forecasting and warning software.

ii) Good practice from analysis of Autumn 2000 flood events

Between 15 September and 15 November 2000 a series of storms with associated heavy rain repeatedly swept across Hampshire, the Isle of Wight, Sussex and Kent. Four serious flood events and numerous less serious ones resulted from the severe weather, with flooding to around 2500 properties and businesses.

During the period of flooding it was found that the new organisational improvements worked particularly well with more manpower being available to issue warnings and much clearer event management. The newly established Monitoring Duty Officer and Forecasting Duty Officer roles introduced in September 2000 brought significant improvements over previous arrangements and the introduction of the new Flood Warning codes on 12 September could not have been more timely. The ability to issue a “Flood Watch” allowed in some places for an additional three days’ warning of events developing. Significantly, the previous confusion over the meaning of the warnings appeared to feature far less during this event.

The National Public Awareness Campaign launched on 11 September 2000 had successfully raised the profile of flood risk and provided information to the public on self-help during flooding. A dedicated phone line was provided for the Agency’s professional partners and was used to notify them of the first Flood Watches. Emergency response from professional partners, generally using generic plans for major incidents, also worked well.

The Regions pro-active approach to public relations was vindicated by the overwhelmingly favourable nature of press coverage the Agency received. During the period to mid-November some 65 flood related press releases were issued, over 4500 media calls handled and over 1000 radio and 400 television interviews undertaken.

Business continuity planning carried out for the transition to the new millennium showed its worth as generators which had been purchased were used at various times by the three Areas to keep their AIRs running through power disruptions brought on by severe weather.

New Area Incident Procedures had been issued in September 2000 and these enabled staff to be mobilised quickly and smoothly to open AIRs in response to rainfall much heavier than had been forecast.

Both internal and external liaison worked well. This was due to the efforts that had been made to hold exercises in the previous year.

The Floodline RMS that had been updated prior to the on-set of the event proved resilient under heavy loading and satisfied the needs of 90% of the callers for Flood Warning information.

During the event the availability of accurate “At Risk” maps was essential for the efficient and appropriate evacuation of areas by strategic command centres. Combinations of Local Flood Warning Plan maps and indicative floodplain maps were used to advise across the Region.

The ability to speak to a Met Office duty forecaster under the Weather Services Agreement was very useful, although the accuracy of the forecasts provided was variable.

Although there were a number of intermittent faults with individual machines, the event showed the AVM systems now in place across the Region to be robust and effective. However even with the capacity now at 4800 calls per hour, the increasing number of recipients requires an immediate upgrade of the system, and full replacement within the near future.

4.2.7 South West Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

In the Regional Office the user manuals and troubleshooting guides for all monitoring and forecasting systems are kept next to the appropriate machine or equipment. There are effective document control (quality assurance) systems. Similar systems apply to Area Offices, which have assumed responsibility for warning and dissemination from September 2001.

At the start of a shift there is a formal hand-over from the outgoing to incoming Duty Officer. A standard checklist is used to confirm that the incoming officer understands the current situation and to check systems are operating correctly.

Staff are on duty one week in six with Thursday as the change-over day. The frequency is considered to be about right. If less frequent then things are forgotten, if more then it becomes onerous. Rosters are issued six months ahead.

Monitoring and Forecasting Duty Officers at Regional level, and Flood Warning Duty Officers at Area level, have a checklist of duties to make sure they do not miss anything. This is very useful. All calls to the RCC are taped, and a rolling log of actions taken is kept.

Verbal communications between the Regional Monitoring and Forecasting Duty Officers and the Area Flood Warning Duty Officers are supported by standard spreadsheets sent by email to summarise forecasting and warning status.

The Region has carried out a Flood Warning Level of Service Survey (FWLOSS) to identify where the target level of service was not being achieved. The survey looked at potential solutions to improve the warning service and included basic benefit/cost analysis. It is intended to link this work with the current flood risk area mapping to develop an ongoing programme of improvements to the service.

Detection - incoming data and monitoring

The Met Office at Cardiff provides the Region with standard services under the National Weather Services Agreement. The major items received are the 12 hour rainfall accumulations two days ahead, average rainfall values five days ahead, winds in coastal areas two days ahead, and the general outlook for up to ten days ahead. The information is received by fax and electronically early each day. The Cardiff Met Office also provides local warnings of heavy rainfall, snowmelt, wind and surge to set criteria. These are seen as particularly useful items of information, as is the arrangement for contacting the Met Office on a consultancy basis by telephone at any time.

All threshold levels are alarmed or alerted on the telemetry system.

Forecasting

The forecasting model (suite) used in the South West is the Weather Radar Information Processing System (WRIP) which integrates radar and telemetered rainfall and level/flow gauging.

Within the WRIP package the forecasting is provided by a number of rainfall-runoff models of the Physically Realisable Transfer Function (PRTF) type. WRIP can use both radar and telemetered raingauge data, and any selection of measured and forecast data. Manual intervention is possible to try out different scenarios at the start of an event. The Region is developing methods of adjusting model parameters on the basis of catchment wetness. It is intended that WRIP will remain the primary forecasting platform until a national standard is arrived at.

The Region is in the process of producing peak level to peak level correlation plots for all catchments where the gauge network allows. Together with time of travel plots these relationships will join the suite of available forecasting tools. It is intended that they will be used as backup to WRIP. Other empirical methods are also being investigated to support the forecasting service.

Warning

Within South West Region the expectation is that all warnings will be issued from the Area Incident Room. This enables good communications both internally and externally, and makes it easier to respond to any escalation of the event. This is particularly relevant where rivers are fast responding and events can escalate rapidly.

The Region has taken the lead on the development of Major Incident Plans (MIPs) for Local Authorities where the LA have deemed it important to have such a plan. These have been introduced to cover densely populated areas with defences which are in the low risk and high consequence category. When the process of developing MIPs started in 1999, it was expected that maybe five towns in the Region would qualify. However MIPs have proved very popular with Local Authorities, and now there are some 50 such plans.

Packs have been prepared for staff going to Major Incident Control Rooms (Police Gold and Silver Control) containing instructions, leaflets for distribution to residents etc.

The Region places a strong emphasis on pro-active public relations. This has included undertaking a large number of radio and TV interviews, during as well as after events. The prime benefit of such a pro-active policy is that it allows the Agency to clearly state the current situation and thereby raise public awareness and also to reinforce positive aspects of the Agency's operational response.

Post event data collection, reporting and archiving

An annual report is prepared detailing the numbers of events and number of warnings issued, which is then compared with previous years. A brief description of events during the year and properties flooded is also given. The format could be expanded to give an annual review of performance.

In order to improve their reporting the Region considers that there should be a national standard for post event data to be collected, and also a national standard for reporting.

A post event database is being set up to abstract information from the AVM to create post event statistics. This database will be updated electronically from the AVM. As an off-line database it will enable the maintenance of customer information to be carried out more easily and with more flexibility than is available working within the AVM itself. It will also allow additional fields of information to be stored.

ii) Good practice from analysis of Autumn 2000 flood events

At the end of October and beginning of November 2000 the South West Region faced some of the worst flooding experienced for many years. In the ten days from 29 October there was up to 270 mm of rain, with 90 mm of this rain falling in a 30-hour period in some parts of the Region.

During the Autumn 2000 Flood Events the South West Region was still organised on the basis of both monitoring and forecasting, and warning and dissemination, carried out from the Regional Office in Exeter. Thus a number of the practices in place at the time have been superseded with the Region moving to the CNFDR pattern of responsibilities from September 2001.

In addition, a number of problems within the forecasting and warning systems which became apparent during Autumn 2000 have been addressed, with improvements either already in place, or in the process of being introduced.

Local Met Office forecasts across the Region were assessed as being 75% accurate or better and were issued on time. The consultancy agreement with the local Met Office was found to be particularly useful.

The Regional Telemetry System, SCOPE, performed well but its limitations were apparent. Specification for the replacement SWANTEL system is taking account of the experiences of Autumn 2000.

The WRIP forecasting system performed adequately, however at present model coverage of the Region's Flood Warning Areas is only 5-10%.

A major Public Relations effort was undertaken throughout the event. The Agency took a proactive stance from the outset with early warning of severe weather expected, and media interest was considerable. The media within the Region came to be seen as a real asset to the Agency.

Continued close working relationships with the regional PR team are seen as very important.

4.2.8 Wales Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

All the three Area Incident Rooms are arranged to allow effective operations. There are large wall maps (1: 25 000) showing the Area with all details significant to the forecasting and warning operations. The Region is considering the possibility of projecting geographical information from their GIS databases to complement, or even to replace, the maps.

There is a board listing all flood warning areas with provision for displaying warning status, either flood watch, flood warning, severe flood warning or all-clear. A particular feature is that the area data are printed and may be updated from computer file, as a paper printout with the “write-on” cover being removable perspex. This allows the flood warning area to be updated or extended as necessary without the need to produce a complete new board. Other white boards display the tidal information, and work in progress on rivers.

There are separate rooms immediately adjacent to the Incident Rooms for the dissemination of warnings. These rooms hold the AVM equipment, separate fax machines, a facility for recording floodcall messages and mobile loudhailer units.

There is a strong emphasis on building links with local communities and Local Authorities with benefits for flood awareness and responsiveness. Though this is time consuming it appears effective. Area Partnerships with Local Authorities and community members have been set up in two Flood Warning Areas in North Wales which targets flood awareness within the at-risk community. A series of Public Relations fact sheets have been developed for flooding “hot-spots”. These are kept with the Public Relations teams to allow them to respond quickly to public concerns.

All duty staff have been provided with training in Flood Defence Law. In South Wales full-scale internal exercises are ongoing in accordance with Agency policy. The South West Area undertakes cross-catchment familiarisation processes to ensure that staff are conversant with more than their own particular catchment.

In 1999 the Environment Agency Wales Flood Warning Strategy was published and approved, in amended form, by the National Assembly for Wales in September 2000. This sets out how the Agency in Wales intends to achieve the various targets from the Agency’s “Flood Warning Service Strategy for England and Wales”, and the Agency’s “Response to the Independent Report on the Easter 1998 Floods (The Easter Floods Action Plan)”. It included the implementation of ten projects over the next five years to ensure improvements to the flood warning service within Wales as follows:

- Flood Warning Code Change Project – Complete
- Public Awareness Project
- Hydrometrics Improvements Project
- Joint Telemetry Replacement Project
- Tidal Flood Forecasting Improvements Project
- Fluvial Flood Forecasting Improvements Project

- Weather Radar Project
- Flood Warning and Emergency Response Information System Project
- Coverage Project
- Changing Needs of Flood Defence Project (Migration to Regional Forecasting).

Each time a Duty Officer takes over, a “Current Situation Pack” is handed on with tide tables, states of gauges, and other timely information. Although this takes time, it is considered to be an essential procedure to ensure continuity.

Detection - incoming data and monitoring

In order to address the problem of monitoring water levels during an event at protected sites the use of CCTV cameras is being considered. These could be utilised to observe sites such as the River Taff in Cardiff. This would involve co-operation with the Local Authority who own the cameras, and the police, who monitor them. The use of web-cams as an alternative to CCTV is also being considered.

Most of the major rivers in the Region have water supply reservoirs on their upper reaches. These influence the response of the catchments if they have storage available during a period of heavy rainfall. In the South East Area there are a series of reservoir spill assessment graphs which have been developed to assist with river flow predictions. Reservoir levels are received from Welsh Water gauges on a weekly basis. The Agency also has its own level recorders downstream of reservoirs and is proposing more gauges upstream.

Forecasting

Tidal forecasting procedures have been automated using data from the Met Office with the TRITON forecasting system. Triton is a computer system taking in tide data and comparing calculated levels with warning threshold criteria. Data relating to astronomical predicted levels and surge heights, together with wind and wave action is used. The display shows current alarm status for tides and prompts action when thresholds are exceeded.

In North Wales forecasting is characterised by the use of judgement by a number of experienced forecasters with a long record of forecasting on these rivers. Forecasting on the Dee has been characterised by the building up of experience since the 1950s for operating rules for Bala Lake and other flood control structures. Although this experience is invaluable, it is understood that it must be accompanied by effective succession planning.

Warning

The Vale of Glamorgan comprises a number of predominantly chalk catchments with short dendritic rivers. After extended wet periods groundwater storage is filled and reaction to rainfall becomes very fast. The Agency is looking to provide direct warnings triggered by river levels, as there is no time for forecasting. The triggers would set off sirens and flashing warning signs.

In North Wales a Flood Warning Team Member carries out updating of the AVM. Annual questionnaires and letters are sent out to all recipients within the flood warning area. A reminder is then sent. A response rate of over 50% is achieved and the aim is to improve this. Visits are also made to flood risk sites to discuss any questions relating to the Warning Service. All those on the AVM are contacted directly to discuss the service. In addition all

those given as second contact numbers are contacted to make them fully aware of the service provided.

In the South West Area the AVM lists were made up by Agency staff visiting every property in flood warning areas. Householders were asked to sign to accept or sign to decline the service. There are now 50% of at-risk properties warned by AVM. An earlier mailing campaign achieved only a 4% response. Each year all recipients are telephoned to confirm details. This takes three people working full-time for three weeks. The Region considers that the annual telephoning of recipients is a better method than one based on postal communication.

Post event data collection, reporting and archiving

Documentation is designed to be robust and to provide an auditable trail of actions. This has been found to be particularly useful post-event in clarifying claims about what was and was not done.

The February 2000 report by Matthew Kean on collection of flood event data, although still in draft form, is being incorporated into the regional procedures. South West Area is developing a system of data collection based on the report's recommendations. Term consultants are to be used to supplement Agency staff after severe events to collect data and incorporate it into FPI.

Wales Region is different from the other seven in that reports are required to the National Assembly for Wales (NAW) as well as to the Agency Head Office.

ii) Good practice from analysis of Autumn 2000 flood events

Wales, and in particular North East Wales, was hit by major storms in October and November 2000. The rainfall was exceptional in terms of intensity, cumulative quantity and severity. Some river levels, most notably in North Wales, were the highest on record. Of the total of some 1900 properties flooded throughout the Region, approximately 1500 were in areas not previously considered to be at significant risk, and therefore not covered by an existing flood warning service.

All the gauges, systems and telemetry performed well during the period despite the equipment being 20 years old. There were no critical failures during the period that adversely affected the performance of the forecasting arrangements. Under the Joint Telemetry Project being undertaken in partnership with Midlands and Thames Regions, a totally new system will be in place by 2003 and will bring significant improvements over the existing system.

The consultative arrangement, whereby Agency monitoring and forecasting staff are able to discuss weather forecasts with Met Office staff in Cardiff (South East and South West Areas) and Manchester (North Area), was found to work well.

In South West Wales the weather forecasting of the event was considered to be accurate, timely and provided sufficient information to prepare resources and manage the situation. This contrasts with the experience in the South East and North Areas, where difficulties were encountered with both the accuracy and delivery of the forecasts.

In general it was found that many triggers for the issue of Flood Warnings and Severe Flood Warnings were over-conservative, with people being disrupted but not subsequently flooded. This did mean however that almost all flooded properties benefiting from a flood warning scheme received advance warning of the flooding.

The principal method for dissemination throughout the Region is the AVM system. This was found to work well in all three Areas.

The Floodline service generally operated well, although some problems were experienced with response times and with public understanding of how the system works.

4.2.9 North West Region

i) Good practice from visits and perceptions of Regional Practitioners

General procedures and organisation

Good relationships have been developed with Local Authorities mainly by one-to-one visits on a frequent basis. Though time consuming, improvements have been seen in practice. Local authority staff have also visited Flood Incident Rooms to gain a better appreciation of the Agency's procedures.

Volunteer lists are prepared well in advance and extra staff are put on standby during holidays periods, winter months and if bad weather is forecast.

Detection - Incoming Data and Monitoring

Radar data are obtained from the Met Office, and are received in various forms: Nimrod (actual and forecast) at 30-minute intervals; raw data (actual and forecast, cleaned up) at 15-minute intervals; from Hamelden Hill, Lancashire (nearest radar, actual) at 5-minute intervals. These are displayed within NTS using an integrated display. Met Office Weather forecasts and gale warnings are also used. Enviromet, a GIS radar display system is also being trialled.

The internet is used to display a general satellite picture of the UK, which gives a general weather view for the day. The sites are used qualitatively as a forecasting aid. Good internet sites have been found to be those of the University of Ulm in Germany and the University of Nottingham. These are considered to be better than the BBC or Met Office sites.

Tide table predictions are obtained from POL on disk annually which are fed into the telemetry system. Surge predictions are received from POL twice daily in digital format giving surge predictions 36 hours in advance. Tide gauges at four locations are monitored: Heysham, Fleetwood, Workington and Gladstone Dock, Liverpool. The latter is used as a trigger level. The gauges also measure wind speed and direction. The surge predictions cover each of the four gauges. All the data is contained and displayed in NTS.

Under NTS gauging sites are polled at 07:00 hours and 15:00 hours. If any rainfall gauge alarm is triggered all stations will be automatically polled. If any river gauge alarm is triggered all gauges within that catchment are automatically polled. A range of different poll options can be carried out but the aim is to poll only those gauges within affected catchments to avoid unnecessary polling (which runs down batteries). NTS is set up to flash up alarms at a standby level to mobilise staff.

The user interface of NTS was developed in-house to ensure displays show what staff want. There is an ongoing NTS user group to further improve and develop the system.

A Service Level Agreement is being drawn up with the Regional Hydrometric Unit to agree maintenance for key sites and procedures for gauging during events.

Alarms are passed from the RCC (out of office hours) to the MFDO who passes the alarm to the FWDO. The FWDO is responsible for acknowledging the alarm on NTS ensuring that the alert “loop” is closed.

Forecasting

The Region currently uses a number of forecasting methods. A regional forecasting strategy is being developed.

The MFDO has a daily telephone conference with a senior forecaster in the Met Office.

Warning

The North West has concentrated on providing warnings for a number of well defined Flood Warning Areas where the proportion of AVM recipients is high and flood awareness is good. Public meetings have been used as a means of increasing flood awareness and for adding people at risk to the AVM.

The Region uses a defined scoring system to prioritise the expansion of the warning service to new Flood Warning Areas.

Loudhailers are used exclusively in one Flood Warning Area (Salford) and are used as a secondary warning method in most other Areas.

Post event data collection, reporting and archiving

Agency staff have attended Emergency Planning courses run by the Home Office at their Emergency Planning College.

Inter-Regional co-operation has included the development of the Northern Telemetry System with North East Region, passing of tidal forecasts to Welsh Region and sending staff during events to Midlands and North East Regions.

After major events joint debriefs are held with partner organisations.

Positions on rosters are formally recruited based on the skills and competencies of individuals and their role is recognised in the description of their job responsibilities.

ii) Good practice from analysis of Autumn 2000 flood events

Across the North West Region there was exceptionally high total rainfall during October and November 2000. This included a sequence of closely separated bands of very heavy rain. These bands caused a number of flooding incidents that followed on closely from one another and led to a high level of flood warning activity throughout the period.

Over the period of the events the weather forecasts received from the Manchester Weather Centre were generally to an “acceptable” level of accuracy. On occasion the actual rainfall varies significantly from that originally forecast, but a revised forecast is usually issued prior to the event, either by telephone or as a Rainfall Warning.

There were very few problems with the availability of telemetry communications during the event. Outstations were generally robust. Much of the flooding that did occur was on ungauged smaller watercourses. A number of areas for improvement of the forecasting service have been identified and a detailed and fundamental review of forecasting needs and user requirements has been commissioned.

As expected the introduction from 12 September 2000 of the new four stage Warning System resulted in increased activity for the Area Incident Room and Regional Forecasting Room Staff, with duty teams being active more frequently and for longer. However it is believed that the new system has improved the service provided. Flood Watches were found to be particularly informative as an early warning to both public and professional partners. There were also however some comments from professional partners that the volume of Flood Watches was too great.

The general conclusion from both South and Central Areas was that the AVM operated effectively throughout the event.

There is only one Flood Warden in the Region however it was reported that he proved useful as an intermediary between the Agency and the public. He helped to locate sandbags and to feed back information to the AIR. He also provided information for the post event report.

Central Area reported a noticeable improvement from the local media in respect of the quantity and quality of warnings issued by radio. The new four-stage warning system was found to provide a clear message, which was understood by the public, media, and professional partners.

PART 2 : GUIDELINES FOR GOOD PRACTICE

5. GOOD PRACTICE BY FLOOD FORECASTING AND WARNING TOPIC

5.1 Overview

In this Chapter, the information documented in Part 1 of the Report has been analysed to produce a list of good practice in each of the topics comprising the flood forecasting and warning process.

Each element is further sub-divided into a range of sub-elements as shown in Figure 4.2. Though the importance of each element may vary between Regions, all Regions follow this process in one form or another.

There are strong indicators that over the last few years Regions have moved towards greater national consistency and that this process is accelerating. Evidence of this includes the recent establishment of the National Flood Warning Centre at Frimley; the Changing Needs in Flood Defence Review; the National Flood Warning Performance Specification; and national groups such as the National Flood Warning Management Group (NFWMG), the AVM User Group, the National Flood Forecasting User Group (NFFUG) and the National Flood Warning Dissemination Group (NFWDG).

Moves towards greater consistency in the delivery of the warning service ought to be welcomed by the Agency and the public alike. However, in changing procedures and organisational structures to gain greater consistency, care must be taken not to dispense with procedures that are particularly successful in certain Areas or Regions. The abandonment of such systems could result in a poorer service than at present.

The tables in Sections 5.2 to 5.7 present examples of good practice under a number of pertinent headings. The list of “Requirements” has been derived from what is understood to be needed to provide a timely, accurate and reliable flood warning system. In each case the good practice is categorised (see column headed “Cat”) as follows:

- **St** : Indicating that there is a nationally agreed Standard for the item which is either already in use by all Regions or is scheduled for imminent adoption.
- **Av** : Indicating that “good practice” in the item is not standardised nationally but is Available in one or more Regions and could be transferred to the benefit of other Regions. Although in many cases convergence to similar procedures will be appropriate, there will also be cases where local good practice may not be transferable to other Areas or Regions.
- **Re** : Indicating that there is no satisfactory “good practice” for the item existing at present within the Regions and there is therefore a case for Research. This category is considered further in Chapter 6.

Where applicable, cross-references are given to the topics identified in Table 4.2 using numbers in *italic* under “Item”.

5.2 General Procedures and Organisation

5.2.1 Roles and responsibilities

Item	Requirement	Good Practice – September 2001	Cat
5.2.1.1 (1)	Responsibility for forecasting to be at Regional Office level in accordance with CNFDR.	North East, Midlands, Southern, South West, and North West Regions fully compliant. Thames has tidal forecasting at Barrier which should be allowed to continue. Anglian moving to this model by January 2002, Wales has a “migration plan” setting out how it will implement the changes.	St
5.2.1.2 (2)	Responsibility for warning to be at Area Office level in accordance with CNFDR.	All Regions fully compliant with CNFDR model.	St

5.2.2 Liaison arrangements

Item	Requirement	Good Practice – September 2001	Cat
5.2.2.1 (5)	Clear instructions for liaison between Regions to pass on information relating to detection (sharing of raingauge data, movement of storms, surge tides).	Thames pass on the results from its Thames Estuary model to Anglian and Southern . Southern and South West Regions liaise on coastal issues. North East and North West have a joint telemetry system which allows the sharing of gauged data – although this is not done at present. North West passes on tidal warnings to Wales (North Area) . The ongoing initiative between the Agency and the Met Office on the national sharing of gauge information will impact on this, as will the move to more inter-regional telemetry systems. London Weather Centre already has access to the Thames Region raingauge data in real-time.	Av
5.2.2.2 (5)	Clear instructions or arrangements for liaison between Regions to share expertise.	There needs to be more interaction between staff in different Regions and Areas to share knowledge in particular subjects. This report should help in identifying where particular expertise is available.	Re
5.2.2.3 (6)	Clear guidelines for liaison with Local Authorities in planning for events.	North West and Anglian Regions report particularly effective liaison arrangements with Local Authorities.	Av

5.2.2.4 (6 & 8)	Clear guidelines for liaison with emergency services - Gold Control etc.	North East Region has successfully tested its liaison arrangements with LAs, police, fire and ambulance services, carrying out a number of major flood exercises in the last two years.	Av
5.2.2.5 (12)	Arrangements to be in place to ensure public are aware of the extent of the flood risk, and how to respond in a flood event.	Thames Region places great emphasis on this as an effective method of ensuring flood preparedness. A twice yearly “River Watch” magazine is distributed to all “at-risk” properties. The Region employs its own Education Officer who works with schools on flood awareness and it has developed several other initiatives. Southern Region also concentrates on public awareness with their “Flood Watch” magazine. Wales (Northern Area) has successfully used schools as a focus for dissemination.	Av
5.2.2.6 (7)	Community liaison in urban areas where residents frequently move house.	No Region has identified an effective strategy to promote flood awareness in such areas.	Re

5.2.3 Layout of offices for effective management of events

Item	Requirement	Good Practice - September 2001	Cat
5.2.3.1 (14)	Rooms used for monitoring and forecasting, and for warning, to be arranged for optimum effect, including communications between all concerned.	Midlands Region has the RCC, Forecasting Room, Regional Incident Room, and a Public Relations Room all adjacent to each other which leads to efficiency of operations during major events. Southern Region has noted significant benefits since it reorganised its Regional Office accommodation. South West Region has the RCC combined with the Forecasting Room which also has advantages.	Av

- St : Indicates there is a nationally agreed Standard for the element which is either already in use by all Regions or is scheduled for imminent adoption.
- Av : Indicates “good practice” in the item is not standardised nationally but is Available in one or more Regions and could be transferred to the benefit of other Regions.
- Re : Indicates that there is no satisfactory “good practice” existing at present within the Regions and there is therefore a case for Research.

5.2.3.2 (15)	Current status of warnings issued throughout the Region to be available clearly in forecasting and warning rooms and to management on the information system.	Most Regions have “battleboards” on which status of warnings is displayed. Those used in Wales (SE Area) and Thames permanently list all flood warning areas/zones with provision for displaying warning status. This gives a good overall picture of Regional flood status. The format used in Wales (SE Area) is particularly versatile in that it allows easy updating if warning areas are added or changed.	Av
5.2.3.3 (16)	Information on current status of warnings to be available to other Regions and national HQ for incident situation reports.	All Regions pass situation reports to Agency HQ. No Region previously had a satisfactory system for making information available to other Regions. However FWIS, being installed in late 2001, should achieve this objective when fully developed.	St
5.2.3.4 (22)	Quick and easy access to flooded area maps and forecasting lists.	South West Region keeps its flood risk maps in its Incident Rooms. North East keeps flood defence asset survey information and aerial photos of previous events in its Incident Rooms.	Av
5.2.3.5 (28)	Systems should be consistent across, and portable between, Regions.	Southern Region has recognised this as an issue and uses Agency Standard (harmonised) PCs. This is following the national standard. This needs to be taken up in other Regions.	Av
5.2.3.6 (27)	Replacement for outdated VAX computer systems.	VAX mainframe computers are still used in North East, Midlands, Thames and South West Regions , but are limited in performance and becoming difficult to maintain. New systems are being sought. Anglian Region is implementing a new system, but no standard exists.	Re

- St : Indicates there is a nationally agreed Standard for the item which is either already in use by all Regions or is scheduled for imminent adoption.
- Av : Indicates “good practice” in the item is not standardised nationally but is Aailable in one or more Regions and could be transferred to the benefit of other Regions.
- Re : Indicates that there is no satisfactory “good practice” existing at present within the Regions and there is therefore a case for Research.

5.2.4 Staffing

Item	Requirement	Good Practice - September 2001	
5.2.4.1 (17)	Staff on duty rosters to be adequately trained to be able to operate effectively.	Several national courses are organised for the Agency as part of Key Competencies for FF&W Staff. These include: Meteorological training from the Met Office and training in Flood Defence Law from Middlesex University; but there is no national training programme for flood forecasting and warning staff. In Midlands Region all staff on duty rosters are given 12 x one hour training sessions and undertake site visits so that they can relate office duties to reality on site. They are required to take a competency test. Annual reviews are undertaken and the need for further training assessed. Training in Flood Defence Law is given to all staff in Wales and is considered good practice.	Re
5.2.4.2 (19)	Duty rosters to be organised and managed to provide optimum service.	Thames Region organises its rosters to give a duty every four weeks or less. This is shorter than other Regions but keeps staff familiar with procedures and avoids the need for training a larger pool of staff. South West considers one week in six to be less onerous, it issues rosters six months ahead.	Av
5.2.4.3 (21)	Procedures for major events to be tested and staff to be familiar with the requirements of major events.	In order to test procedures and give staff practice, Wales Region has carried out major internal training exercises. North East Region has carried out a number of major exercises involving Local Authorities and Emergency Services in the last two years.	Av
5.2.4.4 (18)	Adequate staffing available for major events.	Even with short period duty rosters (5.2.4.2 above) there will never be enough flood defence staff for the really major events. If the event is local to the Region there may be the opportunity to borrow flood defence staff from other Regions. There was some successful lending of staff during recent major events. Following its experiences of Autumn 2000 Thames Region is formalising arrangements for inter-regional liaison as part of its regional procedures. Otherwise, staff have to be pulled in from other functions. No Region at present considers it has adequate arrangements (training etc.) for such cross-functional support.	Re

5.2.4.5	Hand-over arrangements for long events when several teams may be involved.	South West Region uses a formal hand-over with a standard checklist. Staggered hand-overs may be considered to ensure continuity. Wales Region pass on a current-situation pack.	Av
---------	--	--	----

5.2.5 Event recording

Item	Requirement	Good Practice - September 2001	
5.2.5.1 (24)	To prevent forecasting and warning staff being overwhelmed by telephone calls from the public and elsewhere during a major event, a system is needed to effectively prioritise and manage calls.	The Floodline RMS service has gone a long way towards reducing the number of calls requiring answer by forecasting and warning duty staff. However there is room for improvement and the Floodline operators need better training in which calls to send where.	St
5.2.5.2 (25)	Ability to refer back to timing and content of calls received and made and warnings issued, for use in post-event audits and in preparing reports.	Anglian Region records on tape all calls to and from the control room. These are kept nominally for one year.	Av
5.2.5.3 (63 & 64)	Data from all events to be stored to a nationally agreed format so that it may easily be retrieved, manipulated and presented.	There is presently No National Standard for event data storage.	Re

5.2.6 Documentation

Item	Requirement	Good Practice - September 2001	
5.2.6.1 (9)	Documentation of procedures needs to be comprehensive, consistent and concise with a formal system for updating to ensure procedures are maintained.	North East Region has a regional code of practice for incident and emergency documents. This is approved by the Agency Head Office Emergency Planning Section. However there is no nationally agreed content for procedures.	Re

5.2.6.2 (20)	A nationally consistent database of “at-risk” property with associated level of risk.	The National Flood Warning Specification of March 2000 includes the Flood Warning Risk Decision Box. By June 2000 all Regions had completed flood risk mapping and designation of properties according to category of risk which allows prioritisation of provision of warning service.	St
5.2.6.3	Check lists for duty staff to ensure that procedures are fully complied with.	South West Region has a Duty Officer checklist for commencement of duty week. North East and North West Regions have similar lists.	Av

5.3 Detection - Incoming Data and Monitoring

5.3.1 Weather forecasts

The Weather Services Review (Environment Agency 1999) reported in April 1999 on best practice in weather services to be supplied by the Met Office to the Agency. The single Met Office / Agency agreement was implemented in all Regions with effect from 1 September 2000 (1 October 2000 in Wales). The following region-specific items of good practice have been identified during this review.

Item	Requirement	Good Practice - September 2001	
5.3.1.1	Regions require the provision of weather services to allow them to produce an accurate and timely flood forecasting and warning service.	This matter has been addressed by the Weather Services Review and the NWSA. All Regions have implemented the new arrangements, from 1 September 2000 in England and from 1 October 2000 in Wales. But there is some concern about accuracy and timing of forecasts to support Flood Watch.	St
5.3.1.2	Warning of extreme weather and short-term updates. Information to be consistent.	All Regions receive Severe Weather Warnings from the Met Office in Bracknell, plus Heavy Rainfall Warnings from their Local Weather Service Providers. Several Regions report that these two sources can give contradictory advice. The preference is for all weather information within a Region to be received from a single source. The Met Office is currently looking at improving the detail of SWWs.	St

5.3.2 Tidal/Coastal forecasts

The joint Agency/MAFF (now DEFRA) Tidal Flood Forecasting Review was published in October 1998. Progress on the implementation of the recommendations made was most recently reported on in March 2000. The following region-specific items of good practice have been identified during this review.

Item	Requirement	Good Practice - September 2001	
5.3.2.1	Display of tidal predictions with tide curve and current levels from telemetered tide gauges.	North West Region uses tide tables received on disk annually from POL. Surge predictions are received from STFS twice daily in digital format giving surge predictions 36 hours in advance. Tide gauges at four locations are monitored, the gauges also measure wind speed and direction. Tidebase provides all Regions with current and predicted tide levels at key reference ports.	Av
5.3.2.2 (43)	Tide data input into estuarial models.	North East Region has incorporated tidal forecasting into their River Flow Forecasting System. This takes in wind, wave and residuals data from STFS along with tide data. Thames Region has a model of the Thames Estuary that was developed by POL. This uses observed levels down the East Coast, and is run every 12 hours. Actual readings from tide gauges are compared with predictions. Tidal forecasts developed in Thames are passed to Anglian and Southern Regions. The R&D Project "Extreme Water Levels in Estuaries" has now reported and national guidelines are soon to be published.	St
5.3.2.3	Incorporation of wave height data to predict onset of overtopping and maximum flood volume at vulnerable locations.	No Region yet has this facility. Development of onshore wave forecasts was EFAP Action 4.2; this is not yet completed. Development and implementation of wave overtopping/damage models for all forecasting centres was EFAP Action 4.3; this is also not yet completed. North West Region is piloting a wave overtopping model in their version of TRITON.	Re

- St : Indicates there is a nationally agreed Standard for the item which is either already in use by all Regions or is scheduled for imminent adoption.
- Av : Indicates "good practice" in the item is not standardised nationally but is Available in one or more Regions and could be transferred to the benefit of other Regions.
- Re : Indicates that there is no satisfactory "good practice" existing at present within the Regions and there is therefore a case for Research.

5.3.2.4	Accurate surge residual data.	Several Regions, particularly Wales and South West , are dissatisfied with the accuracy of surge predictions, particularly for large residuals which are generally the cause of flooding. Tidebase provides all Regions with current and predicted tide levels at key reference ports.	Re
---------	-------------------------------	--	----

5.3.3 Rainfall radar

Most of the Regions are constrained in their use of Radar by the availability and accuracy of data from the Met office. The joint Agency /Met Office National Weather Radar Group has most recently reported in August 2000, see Part 1 Report Section 3.6.3. The following region-specific items of good practice have been identified during this review.

Item	Requirement	Good Practice – September 2001	
5.3.3.1	Quantitative use of radar data in forecasting models.	Midlands and Thames Regions have this facility. In Midlands, Nimrod forecasts up to six hours ahead are fed into their “Flood Forecasting System”. In Thames, single site and Nimrod sub-catchment data are used in rainfall-runoff models within the RFFS. North West, North East and South West use data for small scale quantitative forecasts. Quality and coverage of existing data has been recognised by NWRS and the existing R&D programme as needing improvement.	Re
5.3.3.2	Receipt and display of weather radar information at Region and Area offices.	Thames, Midlands and North West Regions have weather radar information displayed at Regional and all Area offices. The other Regions all have displays in their Regional and some Area offices. The NWRS recommends that there is convergence to one national display system, and that each Region migrates to this system over a period of time.	Re
5.3.3.3	Detecting and tracking of thunderstorms.	GANDOLF is used by Thames Region but it is accepted that the system needs further development. A joint Met Office / Environment Agency project is underway to address this, funded under the operational budget.	Re
5.3.3.4 (30)	Single rainfall radar prediction product.	The Met Office and Agency are working on combining the facilities of Nimrod and GANDOLF.	Re

5.3.4 Antecedent conditions

Item	Requirement	Good Practice – September 2001	Cat
5.3.4.1 (44)	Need to incorporate data on antecedent conditions into monitoring/forecasting.	South West Region uses catchment wetness index and antecedent precipitation index using MORECS data received from Met Office, for fluvial monitoring. Midlands Region use Soil Moisture Deficit (SMD) derived from MORECS to identify Flood Watch status. MORECS is being phased out by Met Office. An R&D project is investigating the use of the replacement, MOSES, for representation of antecedent conditions.	Re
5.3.4.2	Real-time measurement of catchment wetness at sufficient resolution for incorporation in floodwatch and other models.	Midlands Region uses catchment wetness data in floodwatch prediction. However data needs to be available at closer resolution in space and time than at present.	Re

5.3.5 Rain and level/flow gauges

Item	Requirement	Good Practice – September 2001	Cat
5.3.5.1	Accurate and reliable network of short-period raingauges providing coverage of Region.	In accordance with Easter Floods Action A1.16 all Regions are reviewing gauge coverage and extending as necessary.	St
5.3.5.2	Accurate and reliable river level monitoring to give coverage of all catchments in vulnerable locations.	In accordance with Easter Floods Action A1.16 all Regions are reviewing gauge coverage and extending as necessary.	St
5.3.5.3	Provision for recording snowfall and monitoring its contribution to runoff.	Midlands Region have heated raingauges to monitor amount of snowfall and a network of snow observers who investigate and report on snow density etc. Snowmelt models are used by Anglian, North-East and Midlands Regions .	Av
5.3.5.4 (32)	River gauging sites should be appropriate for measuring high flood flows and rating curves at existing gauging sites should be verified for high flows.	Anglian Region is extending rating curves at existing sites. Agency R&D Project W6-060 “Extension of Rating Curves at Gauging Stations Using Hydraulic Models” started in late 2000.	Av

5.3.5.5 (31)	Regions to have a strategy for development of their level and flow gauge networks to optimise their flood warning investment.	There is no National Guidance for this at present.	Re
5.3.5.6 (33)	Rationalised level datum system to be used nationally, taking account of future increased sharing of data between Regions and the new Ordnance Survey datum system.	No Region has an existing strategy to deal with this.	Re

5.3.6 Telemetry and monitoring

The Agency National Telemetry Strategy was published in February 2000. This makes recommendations for developments over the next 10 years - see Part 1 Report Section 3.6.5. The following region-specific items of existing good practice have been identified during this review.

Item	Requirement	Good Practice - September 2001	
5.3.6.1 (34)	Regional telemetry systems to provide accurate and timely data for use in facilitating effective flood warnings.	North West and North East have recently commissioned the Agency's most up-to-date and effective telemetry system, NTS. Anglian and South West have initiated the replacement of their old system (with SWANTEL). Midlands, Wales and Thames are planning the joint procurement of a linked system (JTP).	St
5.3.6.2	Nationally consistent, clear and easily assimilated display of current situation and trends at Regional and Area offices.	The new North West and North East system and the planned systems for Anglian, South West, Midlands, Wales and Thames will all have these facilities and will be required to provide consistent facilities under national telemetry guidance.	St
5.3.6.3	Maintenance of telemetry and communications systems, both routine and emergency.	Within the Regions arrangements for maintenance vary. Although the experiences of Autumn 2000 showed that arrangements were generally satisfactory, further investigation is needed to ensure that resilient systems are in place. National Telemetry Systems Review currently underway is looking at this area.	Re

5.4 Forecasting of Fluvial Events

The NFWC has identified the need for a strategy to direct investment in flood forecasting modelling systems. The preliminary study for the National Flood Forecasting Modelling System Strategy (NFFMSS) has been carried out with the Final Report dated March 2001. Subsequent to this the National Flood Forecasting User Group (NFFUG) has been set up.

The Agency has also commissioned a review of Rainfall-Runoff Models. As of the date of this report no information was available on its findings. The following region-specific items of existing good practice have been identified during this review.

Item	Requirement	Good Practice – September 2001	Cat
5.4.1 (41)	Forecasting models for steep (fast response) catchments.	Although no Region reports a satisfactory system for this at present, rainfall-runoff type models should be applicable to such catchments. Further investigations obviously required.	Re
5.4.2 (42)	Forecasting models for large (slow response) catchments.	Midlands Region has developed an accurate and reliable system for forecasting on the Severn and Trent catchments; this is a combination of rainfall-runoff/routing models. In North East Region the RFFS uses a combination of model types within its open system.	Av
5.4.3 (43)	Forecasting models for fluvial/tidal reaches.	R&D Project W5-010 “Predicting extreme water levels in estuaries for flood warning” has produced draft best practice recommendations in this area. A formal Guidelines document for staff is to be produced early in 2002.	St
5.4.4 (45)	Forecasting/warning method for unusual events (dam break, reservoir overtopping).	No Region has systems to forecast such events.	Re
5.4.5 (37)	Forecasting method for flooding from groundwater	Southern Region successfully monitors groundwater levels and uses the information in its forecasting procedures.	Av
5.4.6 (36)	Taking account of influence of water supply reservoirs on flood forecasts.	Wales Region receives data on reservoir levels from Welsh Water and use this in river flow forecasts. It also has its own gauges upstream and downstream of major water supply reservoirs.	Av

5.4.7 (65)	Quality of forecasts should be monitored to allow for improvements to systems.	North East and Midlands Regions have systems in place to monitor quality of forecasts and use the output to improve model calibration.	Av
5.4.8 (40)	Strategy for future development of forecasting service.	In addition to the NFFMSS discussed above, Anglian Region is in the process of procuring a new system based on an agreed strategy. Midland Region has a User Requirement Specification and a Technical Feasibility Report for its replacement system, implementation is scheduled over the next four years. North East Region has completed a strategy study of their future requirements which makes recommendations for future policy. There is no nationally agreed strategy for modelling.	Re

5.5 Warnings

The Agency National Flood Warning Performance Specification was issued in Draft in March 2000 giving recommendations for future good practice in warning. Several parts of this document have already been superseded by further developments, and the National Flood Warning Dissemination Group (NFWDG) has been set up. The following Region-specific items of existing good practice have been identified during this review.

5.5.1 General

Item	Requirement	Good Practice - September 2001	
5.5.1.1 (48)	Flood warning to be provided for all main river and ordinary watercourses which can be justified.	Southern Region is attempting to offer a flood warning service to all areas at risk from coastal, tidal or fluvial flooding. Thames Region currently offers a warning service on all their Main River reaches. In all Regions , provision of a warning service is being prioritised according to the "Flood Warning Risk Decision Box".	St
5.5.1.2 (6)	Procedures to be in place to co-ordinate response with Local Authorities and emergency services in case of a major event affecting a significant urban area.	South West Region has developed Major Incident Plans for a large number of vulnerable towns. The Autumn 2000 events in North East Region showed that arrangements for Silver and Gold Controls worked well.	Av

5.5.1.3 (52)	Effective method for disseminating warnings in major urban areas	No Region has identified an effective method.	Re
5.5.1.4 (51)	Procedures to be in place for opening of Incident Room at appropriate stage of event development.	South West and North West Regions will open the forecasting/warning room before issuance of any warning. Midlands Region allows flood watches to frequently flooded areas to be issued from home. Thames often issues flood watches and some warnings from home. There is a need for some rationalisation of these different practices.	Re
5.5.1.5	Clear and understandable warning messages.	From September 2000, all Regions have been using the new national standard AVM voice and fax messages that reflect the new warning codes.	St
5.5.1.6 (20)	Well defined areas/properties for issue of warnings.	Thames and Midlands Regions have lists of properties at risk for increments in levels on many of their river systems. All Regions have prepared maps showing flood warning areas/zones for Local Flood Warning Plans.	Av
5.5.1.7 (20)	Clear flood maps with inundation areas linked to stage levels upstream.	No Region has this facility at present.	Re

- St : Indicates there is a nationally agreed Standard for the item which is either already in use by all Regions or is scheduled for imminent adoption.
- Av : Indicates “good practice” in the item is not standardised nationally but is Available in one or more Regions and could be transferred to the benefit of other Regions.
- Re : Indicates that there is no satisfactory “good practice” existing at present within the Regions and there is therefore a case for Research.

5.5.2 Automatic Voice Messaging (AVM)

A review of the Agency's flood warning dissemination systems was completed in May 2000. This concluded that AVM was likely to remain the principal system for warning at-risk members of the public and that the numbers registered as recipients of such warnings were likely to increase ten-fold over the next few years. Standard AVM voice message templates have been in use since the warning code changes of 12 September 2000.

Recent developments following the significant failures of the AVM systems which occurred during Autumn 2001 and the proposed Multi-Media Severe Weather and Flood Warning Dissemination System (MMSWFWDS) are discussed in Part 1 of this Report, Section 3.6.8.

The following region-specific items of existing good practice have been identified during this review:

Item	Requirement	Good Practice - September 2001	Cat
5.5.2.1 (50)	Management of large list of AVM recipients.	Southern Region has by far the largest list of AVM recipients. Management of the list is a full-time job for one Agency employee and a local direct mailing company is employed to send out mailings to recipients. National contracts for maintaining such databases are being set up by the NFWC.	Av
5.5.2.2 (63)	AVM system to incorporate reporting package.	The existing AVM system in all Regions is being modified to allow the electronic collation of warnings and their transmission to the NFWC. Further development to put all warnings onto the internet is planned by the end of 2001.	St
5.5.2.3	AVM equipment to be adequately backed up: hardware and database.	Southern Region keeps its database on the LAN, all other Regions have databases duplicated on backup machines.	Av

5.5.3 Use of media

Item	Requirement	Good Practice - September 2001	Cat
5.5.3.1 (53)	Local radio stations to co-operate with timely and effective dissemination of warnings.	Radio stations, particularly in urban areas are often reluctant to emphasise forecast problems. North West Region contacts the traffic-news section which gives a good response. Thames Region developed particularly good relationships with local stations during the Autumn 2000 events and has recently installed an ISDN line to improve the quality of communication.	Av

5.5.3.2 (54)	Effective use of TV, teletext and internet for warnings.	No Region has found an effective way to do this. National dissemination of warnings via the internet is planned by the end of 2001.	Re
-----------------	--	--	----

5.5.4 Other warning methods

Item	Requirement	Good Practice - September 2001	
5.5.4.1 (55)	Effective use of sirens for warnings.	North East Region (River Calder) considers that it has a system which is effective, the public are familiar with it since it has been in place for many years. Anglian Region has an effective siren system in their Northern Area (Wisbech), and has installed a new system in Northampton. Midlands Region have sirens at Llanidloes which trigger automatically by water levels.	Av
5.5.4.2 (59)	Effective use of loudhailers.	North West Region successfully use vehicle mounted loudspeakers/loudhailers in Salford. They are also used by Wales Region in Cardiff and North East Region in Wakefield and Durham.	Av
5.5.4.3 (58)	Effective use of Flood Wardens.	Thames Region has maintained and expanded its network of Flood Wardens over the last few years. Southern Region is also committed to its system of wardens.	Av
5.5.4.4 (56)	Effective use of illuminated/flashing signs for warnings.	Thames Region from the Barrier Office has successfully implemented such a scheme to warn motorists against parking in car parks and roads where flooding is forecast.	Av
5.5.4.5 (57)	Effective use of direct warnings triggered by levels.	This has been identified as having potential value in catchments with very fast response. Midlands Region has recently installed a siren system triggered directly by river levels in Llanidloes.	Av

- St : Indicates there is a nationally agreed Standard for the item which is either already in use by all Regions or is scheduled for imminent adoption.
- Av : Indicates “good practice” in the item is not standardised nationally but is Available in one or more Regions and could be transferred to the benefit of other Regions.
- Re : Indicates that there is no satisfactory “good practice” existing at present within the Regions and there is therefore a case for Research.

5.6 Response

Item	Requirement	Good Practice - September 2001	Cat
5.6.1	Dealing with media during busy event.	Southern Region takes a very pro-active approach to the media during major events and believes this is an important part of the warning process. Thames Region has a dedicated Media Room that allows interviews and filming of the operations room without disturbing operational activities.	Av
5.6.2 (6)	Liaison with Local Authorities during events.	North West and Anglian Regions report particularly good liaison arrangements with Local Authorities during events. North East Region has successfully tested its liaison arrangements with Local Authorities during its full scale exercise in Kirklees, West Yorkshire, and during the major flood events of Autumn 2000.	Av
5.6.3 (8)	Liaison with emergency services - Gold Control etc. during events.	North East Region has successfully tested its liaison arrangements with police, fire and ambulance services during their full scale exercise and the Autumn 2000 events as above.	Av
5.6.4 (10)	Public Relations to increase flood awareness and response by the public during events.	Thames Region places great emphasis on this as an effective method of ensuring flood preparedness. A twice yearly "River Watch" magazine is distributed to all "at-risk" properties. The Region employs its own Education Officer who works with schools on flood awareness and it has developed several other initiatives. Southern Region also concentrates on public awareness with its "Flood Watch" magazine and mailings to all at-risk properties.	Av
5.6.5 (7)	Community liaison in urban areas - mobile populations - during events.	No Region has identified an effective strategy to optimise public response to flood events in such areas.	Re

5.7 Post Event Data Collection, Reporting and Archiving

There is a National Standard for post-event data collection, “Field Collection of Flood Event Data”, issued February 2000. This gives guidance on what data to collect and storage formats to allow transfer to archive systems. However, it does not deal with post-event reporting. There is no current Agency standard for this part of the Forecasting and Warning process.

The following region-specific items of existing good practice have been identified during this review

Item	Requirement	Good Practice - September 2001	Cat
5.7.1	National standard for post-event reporting.	There is no effective National Standard for post-event reporting at present. Anглиan Region is implementing the “National Incident Reporting System” and North East and North West are also starting to use it. Thames Region has developed a new system of flood data recording which it is linking into an ACCESS database.	Re
5.7.2 (65 & 66)	Monitoring success of forecasting and warning.	Midlands and North East Regions have systems in place to monitor success of forecasting and warning.	Av

- St : Indicates there is a nationally agreed Standard for the item which is either already in use by all Regions or is scheduled for imminent adoption.
- Av : Indicates “good practice” in the item is not standardised nationally but is Available in one or more Regions and could be transferred to the benefit of other Regions.
- Re : Indicates that there is no satisfactory “good practice” existing at present within the Regions and there is therefore a case for Research.

5.8 Summary of Findings

The analysis of existing good practice, as summarised in Sections 5.2 to 5.7 above, has allowed the current status of the various aspects of the Agency's FF&W process to be categorised as follows:

- (i) aspects where all Regions exhibit common procedures which may be considered good practice or where agreement has been reached on convergence to a common procedure or set of procedures
- (ii) aspects where one or more Region exhibits good practice (which may or may not be similar) whilst other Regions are seeking guidance
- (iii) aspects where it is apparent that none of the procedures currently available within the Agency for the particular aspect constitutes good practice.

Aspects in category (i) are generally covered by a nationally agreed standard, and either are, or will be, incorporated into a National Specification. Before 1998 there were relatively few aspects standardised in this way, but the number has grown rapidly, and is continuing to grow, following initiatives such as the EFAP and the establishment of the NFWC.

For aspects in category (ii) there is a need for the evident good practice to be further evaluated, and if found to be merited, adopted, with additional development and adaptation if necessary, by other Regions. It can be seen from Sections 5.2 to 5.7 that approximately half of the identified aspects of the FF&W process fall into this category. This shows that the Agency, considered as a whole, is able to demonstrate good practice in a significant proportion of the aspects of the FF&W process. The aspects falling into this category have been abstracted from Chapter 5 and are considered further in Chapter 6 below.

For aspects in category (iii) there is a need for further investigation. It may be that good practice exists outside of the Agency, that R&D work is already underway or scheduled, or that there is a case for commissioning new research. The aspects falling into this category have been abstracted from Chapter 5 and are considered further in Chapter 7 below.

6. GOOD PRACTICE AVAILABLE FOR INTERNAL DISSEMINATION WITHIN THE AGENCY

6.1 General

Aspects have been identified where one or more Regions exhibit good practice. All Regions need to look critically at their own arrangements for these items and adopt similar good practice where there is a need. The process has to be properly managed on a National basis to avoid inconsistency and potential duplication of effort.

The National Flood Warning Centre should facilitate the process using the National Flood Warning Management Group for liaison, publicity, programming and implementation. A suggested Implementation Plan is set out in Section 6.8.

The tables in Sections 6.2 to 6.7 below summarise where good practice has been found to be available.

Where applicable, cross-references are given to the topics identified in Sections 5.2 to 5.7 using numbers in italic under 'Item'.

6.2 General Procedures and Organisation

Item	Requirement	Source Region(s)
6.2.1 <i>(5.2.2.1)</i>	Clear instructions for liaison between Regions to pass on information relating to detection (sharing of raingauge data, movement of storms, surge tides).	Thames, Anglian, Southern, South West, North East, North West, Wales
6.2.2 <i>(5.2.2.3)</i>	Clear guidelines for liaison with Local Authorities in planning for events.	North West, Anglian
6.2.3 <i>(5.2.2.4)</i>	Clear guidelines for liaison with emergency services - Gold Control etc.	North East
6.2.4 <i>(5.2.2.5)</i>	Arrangements to be in place to ensure public are aware of the extent of the flood risk, and how to respond in a flood event.	Thames, Southern, Wales
6.2.5 <i>(5.2.3.1)</i>	Rooms used for monitoring and forecasting, and for warning, to be arranged for optimum effect, including communications between all concerned.	Midlands, Southern, South West
6.2.6 <i>(5.2.3.2)</i>	Current status of warnings issued throughout the Region to be available clearly in forecasting and warning rooms and to management on the information system.	Wales, Thames

6.2.7 (5.2.3.4)	Quick and easy access to flooded area maps and forecasting lists.	South West, North East
6.2.8 (5.2.3.5)	Systems should be consistent across, and portable between, Regions.	Southern
6.2.9 (5.2.4.2)	Duty rosters to be organised and managed to provide optimum service.	Thames, South West
6.2.10 (5.2.4.3)	Procedures for major events to be tested and staff to be familiar with the requirements of major event.	Wales, North East
6.2.11 (5.2.4.5)	Hand-over arrangements for long events when several teams may be involved.	South West, Wales
6.2.12 (5.2.5.2)	Ability to refer back to timing and content of calls received and made and warnings issued, for use in post-event audits and in preparing reports.	Anglian
6.2.13 (5.2.6.3)	Check lists for duty staff to ensure that procedures are fully complied with.	South West, North East, North West

6.3 Detection - Incoming Data and Monitoring

Item	Requirement	Source Region
6.3.1 (5.3.2.1)	Display of tidal predictions with tide curve and current levels from telemetered tide gauges.	North West
6.3.2 (5.3.5.3)	Provision for recording snowfall and monitoring its contribution to runoff.	Midlands, Anglian, North East, Midlands
6.3.3 (5.3.5.4)	River gauging sites should be appropriate for measuring high flood flows and rating curves for existing gauging sites should be verified for high flows.	Anglian

6.4 Forecasting of Fluvial Events

Item	Requirement	Source Region
6.4.1 (5.4.2)	Forecasting models for large (slow response) catchments.	Midlands, North East
6.4.2 (5.4.5)	Forecasting method for flooding from groundwater	Southern
6.4.3 (5.4.6)	Taking account of influence of water supply reservoirs on flood forecasts.	Wales
6.4.4 (5.4.7)	Quality of forecasts should be monitored to allow for improvements to systems.	North East, Midlands

6.5 Warnings

Item	Requirement	Source Region
6.5.1 (5.5.1.2)	Procedures to be in place to co-ordinate response with Local Authorities and emergency services in case of a major event affecting a significant urban area.	South West, North East
6.5.2 (5.5.1.6)	Well defined areas/properties for issue of warnings.	Thames, Midlands
6.5.3 (5.5.2.1)	Management of large list of AVM recipients.	Southern
6.5.4 (5.5.2.3)	AVM equipment to be adequately backed-up: hardware and database.	Southern
6.5.5 (5.5.3.1)	Local radio stations to co-operate with timely and effective dissemination of warnings.	North West, Thames
6.5.6 (5.5.4.1)	Effective use of sirens for warnings.	North East, Anglian, Midlands
6.5.7 (5.5.4.2)	Effective use of loudhailers.	North West, Wales North East
6.5.8 (5.5.4.3)	Effective use of Flood Wardens.	Thames, Southern
6.5.9 (5.5.4.4)	Effective use of illuminated/ flashing signs for warnings.	Thames
6.5.10 (5.5.4.5)	Effective use of direct warnings triggered by levels.	Midlands

6.6 Response

Item	Requirement	Source Region
6.6.1 (5.6.1)	Dealing with media during busy events.	Southern, Thames
6.6.2 (5.6.2)	Liaison with Local Authorities during events.	North West, Anglian North East
6.6.3 (5.6.3)	Liaison with emergency services – Gold Control etc during events.	North East
6.6.4 (5.6.4)	Public Relations to increase flood awareness and response by the public during events.	Thames, Southern

6.7 Post Event Data Collection, Reporting and Archiving

Item	Requirement	Source Region
6.7.1 (5.7.2)	Monitoring success of forecasting and warning	Midlands, North East

6.8 Implementation Recommendations

Section 6.2 to 6.7 show items where good practice is evident. A process is required to ensure that the good practice is considered, documented and taken up by each Region.

- The overall management of the process should be carried out by the NFWC following consultation with the NFWMG.
- All Regions will be consulted on the priority of the implementation process for each item. This Report lists good practice as found during visits in years 2000 and 2001. There will almost certainly be subsequent Regional initiatives, which can and should feed into the process.
- The source Region for each good practice should document their procedure. This should be forwarded to the NFWC for expansion, e.g. adding value from operational practices elsewhere or completed R&D.
- The NFWC should be responsible for turning this document into a National Guideline/Strategy where appropriate, and for circulating to practitioners.
- Regions will be responsible for implementing the guidelines in accordance with any approved Regional or National Action Plan.
- There should be periodic review of any guideline to ensure that it is kept current and incorporates any future R&D output and developments in operational practice. The guidelines should be controlled documents.

7 AREAS IDENTIFIED FOR FUTURE RESEARCH

7.1 Introduction

For aspects where it has been established that none of the Regions currently exhibit good practice there is a need for further investigation. It may be that good practice exists outside of the Agency, that R&D work is already underway or scheduled, or that there is a case for commissioning new research. The number of aspects falling into this category is relatively small. They have been abstracted from Chapter 5 and are considered further in Sections 7.2 to 7.7 below.

Where applicable, cross-references are given to the topics identified in Sections 5.2 to 5.7 using numbers in *italics* under 'Item'.

The current status of Agency and DEFRA funded R&D work is summarised in Table 7.1.

The 'Notes' column in the Sections 7.2 to 7.7 refer to the projects in this table.

For example 'T9' against Item 7.3.8 'Realtime Measurement of Catchment Wetness' indicates that this subject will be addressed, at least in part, by scheduled R&D Project reference T9.

'NEI' indicates that there is No Existing Initiative for this Item.

'EFA' indicates that the Item is being addressed under the Easter Floods Actions.

'NWRS' indicates that the Item is being addressed under the National Weather Radar Strategy.

'NWSA' indicates that the Item is being addressed under the National Weather Services Agreement.

'NTSR' indicates that the Item is being addressed under the National Telemetry Strategy Review.

Table 7.1**List of Ongoing and Planned R&D in Flood Forecasting and Warning**

Project Nr	Agency or DEFRA Ref.	Title	Funded by	Start Date	End Date	Status
C1	W5C(99)01/2	Good Practice Review	EA	Dec 99	Nov 01	Ongoing
C3	W5C(99)01/3	Reducing Impact of Flooding – Stage 1	EA	Mar 00	Jun 01	Ongoing
C5	W5B(95)03	Extreme Water Levels in Estuaries	EA	May 98	Sep 01	Ongoing
C6	W5C(00)03	Autumn 2000 Floods QRP	EA	Feb 01	Mar 01	Complete
T1	W5C(99)01/4	Rainfall Forecasting	EA	Mar 01	Feb 02	Ongoing
T3	FD 2201	Extreme Event Recognition	DEFRA	Sep 01	Mar 02	Ongoing
T6	W5C(01)01	FW Management System	EA	Oct 01	Sep 05	Approved
T8	W5C(99)01/5	Real-time Modelling	EA	Mar 01	Feb 02	Ongoing
T9	W5C(01)02	Antecedent Conditions Phase 1	EA/Met	Oct 01	Sep 02	Approved
T15	FD 2202	Dissemination Methods	DEFRA	Oct 01	Sep 04	High
T18	FD 2206	Coastal Flood Forecasting	DEFRA	Jan 02	Mar 03	Planned
T19	NYA	Storm Scale Numerical Modelling	DEFRA	Jan 02	Dec 04	Planned
T20	NYA	Uncertainty Associated with Nimrod	EA	Apr 02	Mar 03	Planned
S1	W5C(00)01	Vulnerable Groups	EA	Jul 01	Dec 02	Ongoing
S2	W5C(00)02	Social Performance of FW Technology	EA	Jun 02	Dec 02	Approved
S3&S5	W5C(00)03	Organisations and Flood Warning	EA	Oct 01	Mar 03	Approved
S4	NYA	Low Risk Zone Awareness	EA	Jun 02	Dec 02	Approved

Note: NYA = Project not yet allocated.

7.2 General Procedures and Organisation

Item	Requirement	Current Status	Notes
7.2.1 (5.2.2.2)	Clear instructions or arrangements for liaison between Regions to share expertise.	There are no procedures for identifying particular Region/Area expertise for use nationally. This is common in other functions.	NEI
7.2.2 (5.2.2.6)	Community liaison in urban areas where residents frequently move house.	R&D Project S1 is looking at vulnerable populations. Project S3/5 is looking at organisations. There is a need to check the coverage of the projects.	S1 & S3/S5
7.2.3 (5.2.3.6)	Replacement for outdated VAX computer systems.	NFFMSS will identify framework for forecast models to fit into, but no plans to standardise computer hardware.	NEI
7.2.4 (5.2.4.1)	Staff on duty rosters to be adequately trained to be able to operate effectively.	Identified as problem by Regions. Use of staff from other functions has training implications. No national training programme for flood duty staff. See also 7.2.5.	NEI
7.2.5 (5.2.4.4)	Adequate staffing available for major events.	Identified as problem by Regions. There are two aspects: (a) Use of staff from other Regions, liaison arrangement required. (b) Use of staff from other functions, training required.	NEI
7.2.6 (5.2.5.3)	Data from all events to be stored to a nationally agreed format so that it may easily be retrieved manipulated and presented.	Flood event data recording identified as R&D need (Project T16) but project not yet approved for inclusion in the R&D programme. Data format will also be included in specification for Flood Warning Management System under Project T6.	T6 & T16
7.2.7 (5.2.6.1)	Documentation of procedures needs to be comprehensive, consistent and concise with a formal system for updating to ensure procedures are maintained.	There is no nationally agreed content for procedures.	NEI

- For explanation of Notes see Section 7.1 on page 74.

7.3 Detection - Incoming Data and Monitoring

Item	Requirement	Status - September 2001	Notes
7.3.1 (5.3.2.3)	Incorporation of wave height data to predict onset of overtopping and maximum flood volumes at vulnerable locations.	R&D Project T18 Coastal Flood Forecasting will identify current best practice guidelines for modelling overtopping and flood extent and any further R&D needs.	T18
7.3.2 (5.3.2.4)	Accurate surge residual data.	Several Regions dissatisfied with current accuracy of surge data from STFS.	NEI
7.3.3 (5.3.3.1)	Quantitative use of radar data in forecasting models.	Inaccurate data currently restricts use of radar data in models. R&D Project T1 Rainfall Forecasting aims to identify measures to improve accuracy of radar rainfall data. NWRS is looking at operational improvements.	T1 & NWRS
7.3.4 (5.3.3.2)	Receipt and display of weather radar information at Region and Area offices.	NWRS is developing a specification for a national display system.	NWRS
7.3.5 (5.3.3.3)	Detecting and tracking of thunderstorms.	Development of GANDOLF is in progress under a joint Met Office / Environment Agency project funded under the operational budget.	NWRS
7.3.6 (5.3.3.4)	Single rainfall radar prediction product.	Work is proceeding under NWRS to combine the facilities of Nimrod and GANDOLF.	NWRS
7.3.7 (5.3.4.1)	Need to incorporate data on antecedent conditions into monitoring/forecasting.	South West Region use catchment wetness index and antecedent precipitation index using MORECS data received from Met Office, for fluvial monitoring. Midlands Region use Soil Moisture Deficit (SMD) derived from MORECS to identify Flood Watch status. MORECS is being phased out by Met Office. An R&D project is investigating the use of the replacement, MOSES, for representation of antecedent conditions.	T9 & NWSA

7.3.8 (5.3.4.2)	Real-time measurement of catchment wetness at sufficient resolution for incorporation in floodwatch and other models.	The second phase of Project T9 Antecedent Conditions will address this problem. However it is not yet included in the R&D programme.	T9
7.3.9 (5.3.5.5)	Regions to have a strategy for development of their level and flow gauge networks to optimise their flood warning investment.	There is no National Guidance for this at present.	NEI
7.3.10 (5.3.5.6)	Rationalise level datum system to be used nationally taking account of future increased sharing of data between Regions and the new ordnance survey datum system.	No Region has an existing strategy to deal with this.	NEI
7.3.11 (5.3.6.3)	Maintenance of telemetry and communications systems, both routine and emergency.	Within the Regions arrangements for maintenance vary. Although the experiences of Autumn 2000 showed that arrangements were generally satisfactory, further investigation is needed to ensure that resilient systems are in place. National Telemetry Systems Review currently underway is looking at this area.	NTSR

For explanation of Notes see Section 7.1 on page 74.

7.4 Forecasting of Fluvial Events

Item	Requirement	Status - September 2001	Notes
7.4.1 (5.4.1)	Forecasting models for steep (fast response) catchments.	R&D Project T8 Real-Time Modelling will identify best practice guidelines for all catchments, plus further R&D needs if appropriate.	T8
7.4.2 (5.4.4)	Forecasting/warning method for unusual events (dam break, reservoir overtopping).	No Region has systems to forecast such events. There is a related ongoing R&D Project being carried out by HR Wallingford (not funded by the Agency or DEFRA), but no proposals for application to the Agency.	NEI
7.4.3 (5.4.8)	Strategy for future development of forecasting service.	Although NFFMSS gives a framework for Regional modelling, and is closely involved with individual Regional programmes, there is no nationally agreed strategy for modelling.	NEI (links to T1 & T8)

7.5 Warning

Item	Requirement	Status - September 2001	Notes
7.5.1 (5.5.1.3)	Effective method for disseminating warnings in major urban areas	The R&D Project T15 Dissemination Methods is covering this area. There is a need to check that the scope of the project includes this aspect.	T15
7.5.2 (5.5.1.4)	Procedures to be in place for opening of Incident Room at appropriate stage of event development.	Regional practices vary quite significantly. There is no existing initiative for standardisation.	NEI
7.5.3 (5.5.1.7)	Clear flood maps with inundation areas linked to stage levels upstream.	No Region has this facility at present.	NEI
7.5.4 (5.5.3.2)	Effective use of TV, teletext and internet for warnings.	The R&D Project T15 Dissemination Methods is covering this area. There is a need to check that the scope of the project includes this aspect.	T15

For explanation of Notes see Section 7.1 on page 74.

7.6 Response

Item	Requirement	Status - September 2001	Notes
7.6.1 (5.6.5)	Community liaison in major urban areas - mobile populations - during events.	The R&D Project S3/5 Organisations and FF&W is covering this area. There is a need to check that the scope of the project includes this aspect.	S3&S5

7.7 Post Event Data Collection, Reporting and Archiving

Item	Requirement	Status - September 2001	Notes
7.7.1 (5.7.1)	National standard for post-event reporting.	Regional practices vary significantly. There is no existing initiative for standardisation.	NEI

7.8 Recommendations for Future R&D

It can be seen from the Tables above that there are a relatively small number of items identified for further investigation where there is no existing or planned R&D initiative.

There are several other items where planned initiatives could be tailored to satisfy the listed requirements. It is recommended that the existing specifications for the planned research be checked against the detailed findings of this study, including those documented in Part 1 - Existing Practice.

The areas that have been identified where research is not either already underway or included in the Agency / DEFRA programme are as follows:

- (i) Improved accuracy of surge residual data from STFS.
- (ii) Forecasting models for unusual events (dam break, reservoir overtopping etc.).
- (iii) National standards for post-event reporting.

7.9 Other Recommendations

In addition to the aspects identified for R&D there are a number of subjects for internal Agency policy development rather than general research.

- (i) National use of Regional expertise.
- (ii) Inter-Regional liaison and cross-functional staffing support to ensure adequate staffing for major events.
- (iii) National training programme required for flood duty staff.
- (iv) Rationalisation of procedures for opening Incident Rooms at appropriate stage as event develops.
- (v) Nationally agreed content for documentation of forecasting and warning procedures.
- (vi) Recommended standards for computer systems to replace ageing mainframes.
- (vii) Rationalisation of level datum systems used nationally taking account of future increased sharing of data between Regions and the new Ordnance Survey datum system.
- (viii) Strategy for development of level and flow gauge networks to optimise flood warning investment.
- (ix) Development of national modelling strategy for forecasting.
- (x) Flood maps with inundation areas linked to stage heights.

8. CONCLUSIONS AND RECOMMENDATIONS

The analysis of current practices within the Agency has revealed the need for further development in two areas:

- Aspects where good practice exists within the Agency but there is a requirement for dissemination and, potentially, further development.

In most of the categories of work identified in flood forecasting and warning, good practice exists in at least one Region. In some cases, the need to adopt consistent national standards is self-evident. In other cases careful consideration needs to be given to the benefits of standardisation, given the work involved and limited resources available.

There is a need to identify the areas where more general adoption of good practices is justified and relevant and to prioritise and allocate the work involved. It is strongly recommended that the National Flood Warning Centre manage this process to ensure a consistent policy is adopted. Proposals are made in the report to deal with the implementation of this aspect of the work.

- Aspects where no good practice currently exists within the Agency.

For many of the categories of work identified, R&D or associated work is already underway or scheduled. It is recommended that the NFWC undertake a review of the terms of reference for the relevant projects to ensure that they meet the needs identified in this Report.

There are a small number of items where no work is yet scheduled. These fall into two categories:

a) Policy Development

- National use of Regional expertise.
- Inter-Regional liaison and cross-functional staffing support to ensure adequate staffing for major events.
- National training programme required for flood duty staff.
- Rationalisation of procedures for opening Incident Rooms at appropriate stage as an event develops.
- Nationally agreed content for documentation of forecasting and warning procedures.
- Recommended standards for new computer systems to replace ageing mainframes.
- Rationalisation of level datum systems used nationally taking account of future increased sharing of data between Regions and the new Ordnance Survey datum system.

- Strategy for development of level and flow gauge networks to optimise flood warning investment.
- Development of national modelling strategy for forecasting.
- Development of flood maps with inundation areas linked to stage heights.

b) New R&D

- National standards for post-event reporting.
- Forecasting models for unusual events (dam break, reservoir overtopping etc.).
- Improved accuracy of surge residual data from STFS.

It is recommended that the NFWC consider these items for inclusion in future programmes.

BIBLIOGRAPHY

- | | | |
|---|---------|---|
| Aucott, C., Grigg, W., Han, D., and Cluckie, I. | 1992 | Developing Applications of Weather Radar in the Wessex Flood Forecasting System. |
| Austin, R. and Moore, R. J. | 1996 | Evaluation of Radar Rainfall Forecasts in Real-Time Flood Forecasting Models. |
| Bailey, R | 1999 | Easter Floods Response Internal Action Plan, Policy and Implementation Plan for Management. |
| British Market Research | 1999 | Flood Warning Qualitative Research, Research Series No 3 fact sheet. |
| Butts, M. | 1997 | A review of the Optimum Accuracy of Flow and Rainfall Forecasting. |
| Bye, P. and Horner, M. | 1998(a) | Easter 1998 Floods, Preliminary Assessment by the Independent Review Team (The Bye Report). |
| Bye, P. and Horner, M. | 1998(b) | Easter 1998 Floods, Final Assessment by the Independent Review Team (The Bye Report). |
| Cadman, D. and Moore, R. J. | 1998 | A Best Practice Guide to the use of Trigger Mechanisms in Fluvial Flood Warning. |
| Carron, C. | 2000 | TIDEBASE - Assorted notes on capabilities of system and state of implementation. |
| CIWEM | 1999 | CIWEM Conference Papers - Flood Forecasting, Warning and Response. |
| Environment Agency & Met Office | 2000(a) | A Framework for Co-operation between the Environment Agency and the Met Office. |
| Environment Agency & Met Office | 2000(b) | Agency / Met Office Framework for Co-operation: Briefing Note. |
| Environment Agency & Met Office | 2000(c) | Weather Services Agreement 2000-2005 between the Environment Agency and the Met Office. |
| Environment Agency National Floodline Project | 2000(a) | Guide to the Environment Agency's Flood Warning Codes - Leaflet for Environment Agency's 'Professional Partners'. |
| Environment Agency National Floodline Project | 2000(b) | Floodline Recorded Message Service (RMS) User Guide. |

Environment Agency Easter Floods Action Group	2000(a)	Easter Floods Response Internal Action Plan.
Environment Agency Easter Floods Action Group	2000(b)	National Flood Warning Project Specification.
Environment Agency	1998(a)	Tidal Flood Forecasting Project Report.
Environment Agency	1998(b)	Tidal Flood Forecasting Joint Action Plan.
Environment Agency	1998(c)	Lessons Learned From The October Floods.
Environment Agency	1998(d)	Environment Agency Response to the Independent Report on the Easter 1998 Floods.
Environment Agency	1999(a)	Action Plan for Flood Forecasting, Warning and Response. Progress Report March 1999.
Environment Agency	1999(b)	Guidance for the Production of R&D Outputs.
Environment Agency	1999(c)	Flood Warning Service Strategy for England and Wales.
Environment Agency	1999(d)	Weather Services Review.
Environment Agency	2000(a)	Environment Agency National Weather Radar Strategy for England and Wales.
Environment Agency	2000(b)	Tidal Flood Forecasting Joint Action Plan, Implementation Progress to March 2000.
Environment Agency	2001(a)	Lessons Learned Autumn 2000 Floods.
Environment Agency	2001(b)	Autumn 2000 Floods Review Regional Report, South West.
Environment Agency	2001(c)	Autumn 2000 Floods Review Regional Report, Anglian.
Environment Agency	2001(d)	Autumn 2000 Floods Review Regional Report, Thames.
Environment Agency	2001 (e)	Autumn 2000 Floods Review Regional Report, Southern
Environment Agency	2001(f)	Autumn 2000 Floods Review Regional Report, North East.
Environment Agency	2001(g)	Autumn 2000 Floods Review Regional Report, Midlands.

Environment Agency	2001(h)	Autumn 2000 Floods Review Regional Report, Wales.
Environment Agency	2001(i)	Autumn 2000 Floods Review Regional Report , North West.
Environment Agency	2001(j)	Floods in the South West - The Story of Winter 2000.
Environment Agency Wales (National Assembly for Wales)	2000	Environment Agency Wales Flood Warning Strategy
Flood Hazard Research Centre Middlesex University	1997	Public Perceptions of Flood Risk, Rivers and Flood Defence
Flood Hazard Research Centre Middlesex University	1998(a)	The Role of Unofficial Flood Warning Systems.
Flood Hazard Research Centre Middlesex University	1998(b)	Making Flood Warnings work in Europe.
Flood Hazard Research Centre Middlesex University	1999(a)	Criteria for Evaluating the Condition of a Tropical Cyclone Warning System.
Flood Hazard Research Centre Middlesex University	1999(b)	The Health Effects of the Easter 1998 Flooding in Banbury and Kidlington - Full Report.
Flood Hazard Research Centre Middlesex University	1999(c)	Audit of Flood Warning Research – Research Series No 2 fact sheet.
Flood Hazard Research Centre Middlesex University	1999(d)	Flood Warning in Britain: Social and Institutional Issues.
Golding, B.	2001	ICE Commission on Flood Risk Mapping in England and Wales, Presentation.
Haggett, C., May, B., and Crees, M.	1995	Advances in Operational Flood Forecasting in London
Haggett, C.	2000	A New Flood Warning System for England and Wales - MAFF Conference Paper.
Haywood, J. - NFWC	2000	National Flood Warning Centre Briefing Document Issue 1 Pages 4-8.
Heinji, Robinson & Chatterton	1999	An Assessment of the Costs and Benefits of Fluvial Flood Forecasting.

Jordan, M.	1999	Easter Floods Action Progress: NAT/738
Kennedy & Donkin	2000	National Telemetry Strategy.
Khatabi, R.	2001	The concept of open architecture for flood forecasting and its associated professional environments.
Khatabi, R. et al.	2001	Open Architecture in Flood Forecasting Systems.
Kitchen, M. and Haggett, C	2001	National Agreement on Weather Radar for England and Wales between Environment Agency and Met Office.
Lane, G. et al.	2000	Flood Defence Incident Management, Units of Competence.
Mance, G. et al.	2001	Report of Presidential Commission reviewing flood risk management in England and Wales.
Met.Office	2000	Proposals for the Provision of Training to Environment Agency Flood Warning Staff.
Moore, R. J. et al.	1990	A Basin-Wide Flow Forecasting System for Real-Time Flood Warning, River Control and Water Management.
Moore, R. J. and Jones, D.	1991	A River Flow Forecasting System for Region-Wide Application.
Moore, R. J. et al.	1994	RFFS and HYRAD: Integrated Systems for Rainfall and River Flow Forecasting in Real-Time and their Application in Yorkshire.
Moore, R. J. and Bell, V.	1996	A Grid-Based Flood Forecasting Model using Weather Radar, Digital Terrain and Landsat Data
Moore, R. J. and Jones, D.	1997	Linking Hydrological and Hydrodynamic Forecast Models and their Data
Moore, R. J. and Bell, V.	1997	A Water Balance Storm Model for Short-Term Rainfall and Flood Forecasting at the Catchment Scale Using Radar and Satellite Data.
Moore, R. J.	1999	Real-Time Flood Forecasting Systems: Perspectives and Prospects.
Moore, R. J., Bell, V., Austin, R., and Harding, R.	1999	Methods for Snowmelt Forecasting in Upland Britain

National Audit Office	2001	Inland Flood Defence – Background Briefing Notes
National Flood Warning Centre	2000(a)	Flood Detection and Forecasting – Process Overview (Version 1 Draft 3).
National Flood Warning Centre	2000(b)	Flood Detection and Forecasting - Planning and System Development.
National Flood Warning Centre	2000(c)	National Weather Services Agreement (NWSA) Briefing Note - July 2000.
National Weather Radar Project	2000	Environment Agency - National Weather Radar Strategy for England and Wales.
Parker, D.	1999	Flood Warning Dissemination and Response Lessons from International Research.
Parsons Brinkerhoff	2001(a)	National Weather Radar Scoping Report - Issue 2.
Parsons Brinkerhoff	2001(b)	National Flood Forecasting Modelling System Strategy - Preliminary Report.
Tinnion, M.	2000	Major Flooding Incident Exercise – MAFF Conference Paper.
Various	1995	30th MAFF Conference of River and Coastal Engineers. Papers presented.
Various	1999	34th MAFF Conference of River and Coastal Engineers. Papers presented.
Various	2001	National Audit Office - Inland Flood Defence March 2001, Background Briefing Topics.

APPENDIX A

CURRENT ORGANISATION, SYSTEMS and PROCEDURES IN EACH REGION

The key elements of the organisation, systems and procedures in each Region as of mid-2001 are summarised in Chapter 4 as Figure 4.1. This summary is expanded by the details below.

A1 North East Region

Office Locations, Responsibilities and Liaison

The Region is divided into three Areas, the Dales, Ridings and Northumbria. The Area offices are at York, Leeds and Newcastle respectively. The Regional office is also in Leeds and is separate from the Ridings Area office.

In line with the Changing Needs in Flood Defence Review, a regional monitoring and forecasting service is provided from the Regional office in Leeds and warning is provided from the three Area offices.

At-Risk Properties, Catchment and Event Types

The Region has a wide range of catchment types. Northumbria Area is characterised by a number of relatively short linear catchments with sources on the moors running west to east, such as the Tyne and Wear.

The Dales and Ridings Areas are dominated by the River Ouse basin, which may take 24 hours to rise, but then will remain high for many days. The lower Ouse is fed by the Swale, Ure and Wharfe which contribute to the major lowland floodplain, the Vale of York. There is also the Tees catchment within the Dales Area, and a range of smaller catchments.

Ridings Area also has a number of heavily urbanised steep flashy catchments, for example the upper Calder valley and the River Sheaf in Sheffield.

There is limited flood risk along the coast mainly confined to small settlements. The exception is the Humber Estuary where there are a large number of properties, particularly in Hull, at risk from tidal flooding, though with a low probability.

There are 211 000 properties at risk within the Indicative Floodplain in the Ridings Area alone. In Northumbria and Dales Areas there are about 7600 and 38 000 respectively.

Monitoring Systems and Procedures

Weather forecast data is received from the Met Office under the National Weather Services Agreement. The information comes in to the Regional Office from the Manchester Weather Centre. The Leeds Weather Centre, which formally supplied data to the Dales and Ridings Areas, and the Newcastle Weather Centre, which formally supplied data to the Northumbria Area, have now been closed. The Regional Office uses the weather forecast data to prepare

river and tidal level forecasts which are disseminated to the three Area offices. The “raw” weather forecast data is not routinely distributed to Areas.

There is a MIST (Meteorological Information Self-briefing Terminal in the Regional office. This is used to access other Met Office products such as “spherics” thunderstorm predictions, and as a backup access to weather radar data.

There are two weather radar sites, at Hameldon Hill and Ingham, that provide good coverage of Nimrod data for Yorkshire (Dales and Ridings Areas). There is inadequate coverage at present in Northumbria and northern parts of the Dales Area. The National Memorandum of Understanding with the Met Office aims to improve coverage. The Nimrod data received is displayed in the Dales and Ridings Area offices and is used for input of rainfall predictions into the flow forecasting system, see below.

HYRAD is used to display and process all radar data streams into the RFFS.

The Agency and Met Office are looking to the future combination of Nimrod and GANDOLF to give a single rainfall radar forecast package applicable to all conditions.

Telemetry in the Region is managed by the recently introduced Northern Telemetry System (NTS) which has been jointly developed with North West Region. This is a state-of-the-art system. There was a very high polling success rate in the Autumn 2000 floods and North East is happy with its reliability.

Forecasting Systems and Procedures

Forecasting in Yorkshire is carried out primarily using the River Flow Forecasting System (RFFS) which was developed in conjunction with the Institute of Hydrology (now CEH) Wallingford. The system is now over ten years old and runs on a VAX platform (two VAXs are used, one as an operational system, the other on standby) that is slow and inflexible when compared to the latest systems available. It is anticipated that major improvements will be made within the next few years.

Plans to replace the hardware are awaiting the outcome of the Flow Forecasting Strategy project. At present it covers mainly the Yorkshire Ouse catchment but since the RFFS is an “open system” more catchments can easily be plugged in. It has been recently expanded to cover the Region. The Tees has been added to the RFFS and development will then move on to add the smaller catchments in Northumbria.

Inside the model Met Office rainfall predictions and radar data are used as input to rainfall-runoff models. These input into linked kinematic wave and real-time hydrodynamic models. RFFS was developed alongside the old telemetry system and uses the bulk real-time data transfer from the telemetry system as the basis for updated (error correction and/or state updating) forecasts.

Forecasts are automatically run every two hours, but can be run as required by the forecaster, including “what-if” type scenarios. Level to level correlation and simple routing models on spreadsheets are mainly only used as backups.

North East monitors the quality of forecasting, with the aim of determining where investment is required to improve performance. There is now a specific project underway to improve performance following the June and Autumn 2000 floods. This includes a programme of model re-calibration and re-configuration over the next two years. Additional funds have been made available to keep the system up-to-date and to develop it in the future. An Agency post has been created to carry out this re-calibration and development backed up with three consultants. CEH provides system maintenance and training for the RFFS.

The Tidal Forecasting System is on the same platform as RFFS. It pulls in wind, wave and residuals data from the storm tide forecasting service along with tide data. The data are combined through a series of critical condition tables to indicate the need for a possible warning.

A Strategy Report was prepared to recommend the way forward for flow forecasting in the Region in the medium to long term. This report recommended that the Region proceed towards replacing RFFS with a new open-model system but retain most of the existing model algorithms at least in its early phases. There is now a national forecasting strategy study in progress.

Warning Systems and Procedures

AVM is a major method of direct warning. The number of voice recipients is approximately:

Northumbria:	1200
Ridings:	5600
Dales:	2500.

This represents an increase of over 100% in the last 12 months.

Each Area has a backup of the others' AVM databases. There are daily checks on the system as set out in a checklist prepared by the national AVM Operations Group. There have been some concerns about being able to change AVM fax messages in real-time as there is a danger of, for example, deleting the message by accident. Flood Watch messages are edited in real-time. Tidal warnings are also edited in real-time as lead times are greater than for fluvial events.

Following floods in June 2000 there was concern that the time taken for AVM to contact the Upper Calder community was too long to react to the short lead times. Changes were made to the AVM database so those on the Upper Calder AVM would be warned first. This resulted in a halving of the time taken to alert that community in the Autumn 2000 floods.

Public awareness and database updating is carried out by annual mailing. A full-time member of staff carries out database maintenance. North East would like to see a national approach to databases and AVM recipient management. It should be a major issue for the national AVM Operators Group. There is a lot of information held in different forms required for varying purposes (e.g. AVM information, at-risk data, FPI). North East would like to see this coming together under a database system. It has considered the outline that such a database could take. This proposal could be taken up and owned by the NFWC.

The number of Floodline lines is being increased from 16 to 72.

Over the last year 60 new Flood Warning Areas have been set up throughout the Region. Twenty-eight of these along the River Aire proved of immediate use in the Autumn 2000 floods. In addition the service was improved at six existing locations. Public awareness campaigns are also carried out when setting up a new Flood Warning Area, which will often include a road-show. This has proved to be a very effective policy.

North East formerly had a deliberate policy of not having Flood Wardens, because it did not want to put members of the community into a position where they might be liable to their fellow citizens if they failed in their duty in some way. Following the June floods on the Upper Calder, this policy was reviewed, and the use of Flood Wardens is now considered acceptable where an alternative method of dissemination is also used. The community affected was therefore proactive in setting up a community group that includes Flood Wardens with the aid of the Agency. The North East is now encouraging such self-help by communities.

Sirens are used on the River Calder and are considered to work well. North East plans to expand the use of sirens and there is interest nationally on this issue. Eight new klaxon type sirens have recently been purchased to gain better coverage in the Flood Warning Area. Different types of siren were investigated and tested prior to purchase. They have been used for many years and the public is familiar with them. This is helped by there being a close-knit stable community. Regular public awareness/testing is carried out. The sirens are located at public buildings such as fire stations. Sirens can be set off from the Incident Room and their status checked on screen.

There are plans to expand the coverage. Dewsbury is the next location planned and planning consent was recently received. Public awareness of the sirens will be by leaflet, tests, advertisements, radio interviews, and possibly using loudspeaker vans.

The two main concerns with sirens are being unable to hear them (asleep, double-glazing, etc.) and the inability to target precise properties, as those outside the flood risk area will also hear warning, and may react unnecessarily.

The media (particularly BBC local radio) have proved very useful in certain circumstances e.g. BBC Radio York at Malton in 1998 and the York/Selby area in Autumn 2000. However they still sometimes look for "an angle" rather than being a "public service". Media driven public perceptions can be difficult to manage and minor incidents can be blown out of proportion. Teletext is used but has shortfalls, such as only being an in-hours service.

Floodline messages are put on the RMS before the AVM messages are issued.

Loudhailers are used quite a lot and their use is expanding mainly for low probability high impact urban areas e.g. in Wakefield and Durham. Recent developments have included expansion of the service using loudhailers in Hull where there are potentially 157 000 at risk from a low probability event. A range of breach scenarios in the Humber tidal defences have been considered and their consequences have been used to develop a loudhailer-warning plan.

All warnings are issued to Local Authorities. They take a different approach depending on the council. For example Calderdale DC will put vans on standby as they take it very seriously, with the Calder having a very fast response.

Indicative Floodplain Maps were used at the Malton flood event in 1998 to provide additional dissemination information and would be used to help deal with a flood event outside defined Flood Warning Areas.

Post Event Reporting Systems and Procedures

Post-event reporting procedures were considered to be reasonably well defined by CNFD.

Lists of flooded properties are generally obtained by the in-house workforce, or by the Survey Term contractor. Halcrow are currently collecting information of the 2000 floods.

Documentation, Training, Rosters and Technology

Forecasting and Warning procedures are laid out in detail in a suite of Procedures Documents. A lot of work has gone into the development and maintenance of a comprehensive suite of manuals. The manuals comprise Regional and Area manuals, field data services manuals, flood dissemination plans, manuals from Local Authorities and user guides for all the systems.

Roles and duties are in accordance with CNFD:

Two Duty Officers are on duty at the Regional level at any time:

Monitoring Duty Officer (MDO) responsible for telemetry system – polling, monitoring gauging sites etc.,

Forecasting Duty Officer (FDO) responsible for forecasting – running models, interpretation, noting trigger levels exceeded etc.

At Area there are:

Flood Warning Duty Officer (FWDO) responsible for warning dissemination – AVM etc.,

Assistant Flood Warning Duty Officer (AFWDO), (two in Ridings, one each in Dales and Northumbria),

Operations Duty Officer (ODO) responsible for operational response, and

Emergency Duty Officer (EDO).

Following the 2000 floods the Region is reviewing the roles and tasks of the ABC and RBC and the liaison officers who would attend Gold and Silver multi-Agency control and command groups.

Rosters change over on Wednesdays with Wednesday morning briefings and training.

Flood Defence and Water Resources are one business unit at Area level.

All laptop computers can access all the systems, allowing working from home.

There are set procedures for when to open an Incident Room.

Alarms are distributed on a cascade system until they are acknowledged. They are automatically sent to Duty Officers' pagers. The RCC monitors, picks up, and contacts the Duty Officer directly if there is no response.

Aerial photographs of past flood events are kept in the form of an album in the Area Incident Room. Flood Defence asset survey information is also kept to hand in the Area Incident Room. The layout of the Area Incident Rooms is currently being reviewed and the rooms will be re-organised to improve for example seating arrangements, facilities and access to information.

In accordance with an Easter Flood Action, North East is using the RCC's database of contact numbers so that the Area Incident Room has an up-to-date contact list.

Local Authorities are becoming more aware of the need for Major Incident Plans. For example Leeds City Council has been pro-active and has nearly completed its Plan. Doncaster and York are also progressing plans. A member of staff is working full-time on the development of and liaison for Major Incident Plans.

The North East's involvement with Silver and Gold Controls was considered to have been well handled during the Autumn 2000 floods with very positive feedback, in spite of the large numbers of requests for assistance. Taking laptops that can view the NTS to the Control centres proved extremely valuable.

North West and Anglian Regions provided inter-Regional aid to North East in Autumn 2000.

There have been six multi-agency flood exercises within the last 18 months. They have proved very useful. They are an effective way of testing the plan, training and testing staff and are useful for building relationships with the other agencies.

Hand written Event Logs are kept as an event progresses. Incident Logging Forms are used to handle incoming information and passed to appropriate staff for action. NIRS is being introduced. However North East considers that there is a need for a comprehensive event management system. From talking with the police who have a strong culture of logging/recording all aspects of incidents it is aware that the Agency's performance in logging incidents needs great improvement.

Widening the availability of information on river levels is thought to be an issue that should be considered nationally. Making such information available on websites for example is quite common practice in some countries.

A2 Midlands Region

Office Locations, Responsibilities and Liaison

The Region is divided into four Areas: Upper Severn, Lower Severn, Upper Trent and Lower Trent. The Area offices are in Shrewsbury, Tewkesbury, Fradley (near Lichfield) and Nottingham respectively. The regional office is at Solihull.

Forecasting is centralised at the regional office. The Area offices are responsible for issuing flood warnings and for operations. Responsibilities are therefore in accordance with the requirements of CNFDR. Midlands Region was already organised on this basis before the Easter 1998 floods.

The only exception to the forecasting arrangements is that tidal forecasting is presently done in the Tewkesbury and Nottingham Area Offices for the Lower Severn and Lower Trent respectively. This is scheduled to move to the Regional office and it is perceived this will enhance forecasting in the fluvial/tidal range.

Where Midlands Region differs from the other Regions is that the Flood Forecasting Service is integrated with the Water Resources Function as a “Flow Forecasting Service”.

There are Local Flood Warning Plans covering all areas designated as “at-risk”. These plans are in accordance with CNFDR recommendations. Meetings are held yearly or twice yearly of planning liaison groups comprising representatives from the Police, Ambulance Service, Fire Service, Councils, and the Agency. Since the meetings are held by county there will often be more than one Region involved and several Areas. This system has been found to work better than one based on one catchment with many counties. The plans were most recently audited in mid-2000.

At-Risk Properties, Catchment and Event Types

Overall the Region has some 186 000 properties “at-risk” from flooding, 100 000 of these being in the Lower Trent Area. Most are at risk from fluvial flooding, except 3000 on the Severn estuary and 20 000 on the tidal Trent. Of the 186 000, some 117 000 are on river reaches with a flood warning service, 20 000 on the Severn and 80 000 on the Trent.

The Region covers a wide range of catchment types. There are mountainous areas on the upper reaches of both the Severn (the mid-Wales mountains) and the Trent (the Peak District). The middle reaches of the two rivers are typically rural but also include major conurbations such as Shrewsbury and Gloucester on the Severn, and Stoke and Nottingham on the Trent. The two catchments are different in that the Trent floodplain has a much higher population, particularly in areas such as Nottingham, and there are significant urban flood defences with towns protected to the 100 or 200 year level. The Severn has much less in the way of formal defences, with towns such as Shrewsbury flooding to some extent in the 1 in 20 and even 1 in 10 year event.

The Severn Estuary and the Tidal Trent have long lengths of tidal defences. The only sea defences are at Severn Beach.

Monitoring Systems and Procedures

As of September 2000 Midlands has adopted the standard Weather Services Agreement negotiated nationally with the Met Office. Under the agreement ten-day-ahead weather forecasts are received daily at 15:00 hours. These include rainfall amounts for the next two days. Severe Weather Warnings are obtained from Bracknell. Heavy Rainfall Warnings are obtained from the Birmingham Weather Centre. This latter service is seen as more useful than the Severe Weather Warnings since it is more targeted, with the Region being split into seven Forecast Areas. There is also a consultancy arrangement whereby Agency Duty Officers can discuss the forecast with Met Office Staff. Other forecasting products, including Nimrod radar rainfall forecasts and MORECS soil moisture data are also obtained from the Met Office.

Hourly catchment rainfall totals are received continuously in single site format from the radar stations at Clee Hill and Ingham. Six hour forecast rainfall totals are derived from Nimrod. Coverage is generally at 2 km grid resolution. The exception is a small gap in coverage over the Soar valley. The forecast rainfall quantities (using the Nimrod system) are used as input to the flow-forecasting model. These data, and the images, are also retransmitted to remote users.

In the highland areas of the catchments, the Welsh Mountains on the Severn and the Peak District on the Trent, snowmelt can be a major factor. All the Region's raingauges are heated to monitor snowfall, and there is also a network of snow observers who carry out investigations into snow density, etc. The observers report their findings back to the Solihull Forecasting Centre at 09:00 hours each day to adjust the modelled snowpack if required.

The Midlands Region telemetry system is integrated with the flow forecasting system, see below.

Forecasting Systems and Procedures

The Midlands Flow Forecasting and Telemetry System is an integrated telemetry, alarm handling and flow forecasting system. This real-time forecasting model is called Flow Forecasting System 2 (FFS2). It has been in use for over 15 years. Although this means it is somewhat dated in terms of software and flexibility for upgrading, it also means that the results of many years of observations have been used to improve the model calibration. This continuity is an example of good practice.

Over 400 sites are monitored to provide real-time data on precipitation, river levels and flows and status indicators such as fire or intruder alarms. The telemetry is linked to a suite of flow models that can provide predictions of flooding for up to 72 hours in advance. Over the last year a number of new Flood Warning Areas have been added, but further expansion is limited by the capabilities of the software.

The flow forecasting and alarm handling system relies on intelligent data loggers for hydrometric monitoring and alarm raising. Data transmission is by a PSTN phone line. The battery powered outstations continuously monitor sensors to detect exceptions, so alarms can be issued if required.

A DEC MicroVAX computer based in the Region's forecasting centre in Solihull houses the master station for data collection and alarm handling. This master station provides a platform

for software developments and the forecasting system, as well as interpreting data requests by remote users.

Data from the telemetry are quality controlled after they have been gathered, with outliers being eliminated. This allows forecasts to be produced automatically without the attention of the forecaster. Data retrieval from 350 outstations is normally completed within 20 minutes, with success rates of more than 98% on average.

As noted above, the forecast radar data are input to FFS2 from Nimrod.

Forecasting is completed in less than a minute, using the hydrological models applied to forecast flows at over 50 key locations. Forecasts are for up to 72 hours ahead.

Headwaters of catchments and minor tributaries are modelled using rainfall-runoff models. Output from these models, updated by observed flows from gauged tributaries, is input to a simple conceptual flow routing model.

If the models expect, or have exceeded, a flood threshold, a synthetic speech alarm will contact the duty flow forecaster to advise of the developing flood.

Flow forecasting services are provided around the clock, 365 days of the year. For the majority of this time duty officers are working from home. Remote users can request the bulk transfer of modelled and recorded data from the master station and display the results on their portable computer terminals using a system called REMUS (Remote User System).

The forecasting room contains two identical systems of hardware, on one side of the room for the Severn catchment, and on the other for the Trent catchment.

As noted above there are difficulties with FFS2, particularly in maintaining the ageing hardware and software and in expanding the coverage. A new telemetry and forecasting system is planned, and is being specified in conjunction with Wales and Thames Regions. The new Regional Flow Forecasting System is scheduled to be implemented over the next four years.

Warning Systems and Procedures

The Regional flood warning service covers over 40% of main river length. The Region is looking to expand the service to more main river, particularly the Severn estuary, and to non-main river reaches with particular flood problems. The areas that are presently warned are divided up into some 100 Flood Warning Areas.

The Region's Automatic Voice Messaging (AVM) warning service covers 5310 recipients, most of these being isolated properties with high frequency of flooding. Using AVM has not previously been considered appropriate in low risk/high consequence areas, such as Nottingham. There are 27 000 defended properties in Nottingham, where because of the large numbers with a low risk of flooding, flood awareness is low. In these conditions it would be difficult to maintain the AVM database. In such a situation where there is a long lead-time available to provide warnings, the use of the media (radio and television) was previously considered appropriate as the primary warning method. However the primary warning method set out in the new Local Flood Warning Plans for Nottingham and similar areas is using loudhailers. The implementation of these plans is now under review.

Loudhailers have in the past been used infrequently. There are two mobile units available in each Area Office. It is possible to send them out with operators ringing back every two hours or so, to obtain an update from the Incident Room. They can be useful in urban residential areas and were used in Easter 1998 and were successfully mobilised in Burton-upon-Trent in Autumn 2000. The loudhailers broadcast a pre-recorded message.

Where the areas identified as being at-risk are more discreet, the properties are added to the AVM database. For example on the Severn there were 50 properties flooded in December 1999 in the Severn Estuary (Severn Beach) and these have since been added to the AVM list, as have 400 properties in Leamington Spa.

Regional warning staff carry out audits of the Area AVM systems. Annual letters are sent out to all AVM recipients to check details and give them a chance to opt out. Recipients remain on the list unless they actively opt out.

There has been a long established use of Flood Wardens in certain areas, though this is now on the wane. In some rural areas a particular farmer will take on the responsibility. In Shrewsbury a scheme is operated by the Local Authority (LA) using its employees. Similarly in Ironbridge the Local Authority carries out the function. In other areas LAs are still able to administer Flood Warden schemes, but it is becoming difficult to get volunteers. Prior to the Autumn 2000 floods there was a warden scheme in Worcester, but the at-risk properties have now been transferred to the AVM service.

A siren has recently been installed at Llanidloes to replace the former Flood Warden system. The siren is triggered automatically by telemetry based on river level exceedances.

Since the replacement of the former colour-coded warning scheme in September 2000, the Region has been testing a Flood Watch spreadsheet that uses weather forecasts including soil moisture deficit to trigger the issue of a Flood Watch. Results have shown that the spreadsheet system has potential, but that significant further work is required on its development and calibration.

The spreadsheet is just one of the possible triggers for the issue of a Flood Watch. Heavy rainfall warnings, radar data and severe weather warnings are also used. The Region has designated 15 Flood Watch Areas (compared to 80 Flood Warning Areas). A quarterly report is issued analysing the accuracy of the Flood Watch service.

Although the “accuracy” of Flood Watch is improving this is at the expense of timeliness. At present the Midlands Region considers that the Flood Watch message is not really getting through to the public, and there is only a mixed response from Professional Partners. It is considered that the current national initiative on Flood Watch definition is important.

Post Event Reporting, Systems and Procedures

Post event reports are produced following all significant events. These are submitted to Agency Head Office after each significant event and have been commended for their high standard.

After each significant event a “Wash-up Meeting” is held for forecasting and warning staff, and a report produced. After the Autumn 2000 floods there was a wash-up in each Area and a Regional wash-up which led to the production of a Regional Action Plan.

For large enough events, videos and aerial photographs of the flood taken from helicopters are used to assess and plot flood extents. There is some liaison with Local Authorities to determine properties flooded and extents. Photographs of the edge of the flood are taken in urban areas for future reference and survey. For major events at critical locations, levels are pegged out and surveyed, but this is time consuming. Flood levels are obtained from reading gauges as the event progresses. Gauge coverage is steadily increasing.

Maps are being developed in order to produce lists of flooded properties for post-event reviews and are used in the Flood Risk Mapping (Section 105) Studies. Maximum level gauges are set up at some locations (water sensitive tape within a tube). These are temporary installations and are mainly used for model calibration. These data are collected by the hydrometric teams or workforce staff.

Threshold levels of properties have been surveyed for much of the river lengths. These data, which have been collected since 1985, can be used together with the depth to which property was flooded, to derive flood level data.

A database is kept of warnings, AVM, Floodcall statistics, manpower, resources, etc. during events. The format used is based on the national database which was developed in 1996 but which has not been maintained.

The flood peaks that occurred at each gauge are recorded, during and/or post-event, in a Flood Peak List (kept in Flood Warning Duty Manual for reference) and archived. The data are periodically added to the Emergency Level Forecasting System. This is a fallback system that is maintained in case the main forecasting system fails. It is based on level to level correlation.

Documentation, Training, Rosters and Technology

Flood warning documentation comprises Regional Emergency Procedures; the Flood Emergency Procedures, which give an overview of regional flood forecasting and warning procedures; and a Flood Warning Duty Manual for each of the four Areas.

The manuals are not standardised in their content but are considered adequate. Some contain ‘Thermometer’ type charts that have been found to be particularly useful. These charts list the areas, and in some cases properties, which are at risk for increasing levels of flood. The latest versions sub-divide the warning band of levels into up to five sub-bands (Severe Flood Warning being equivalent to the highest sub-band). The maximum of five bands is limited by the existing telemetry system allowing five thresholds. There is a different AVM warning message

associated with each sub-band. The Region considers that this procedure allows better targeting of warnings than using a single message for the full band. All AVM messages are pre-recorded.

Not all the Region's Flood Warning Areas are covered by this system, others present the information in different formats. The Lower Severn manual comes complete with tide table and Severn bore tables.

At the Regional level, for minor events out of normal working hours, 08:30 to 17:00 Monday to Friday, both forecasting and warning are run from home. The Regional Base Controller will liaise with the Regional Monitoring and Forecasting Duty Officer (RMFDO) on when an event becomes severe enough to require the RMFDO to relocate to the office.

The Regional forecasting team goes on familiarisation visits to at-risk areas, gauging sites etc. Administration of the Regional Flow Forecasting Roster is set out in a "Code of Practice". This document sets out the requirements of the flow forecasting duties and allowances made. All staff on the roster are given 12 one-hour training sessions and undertake site visits to relate the models to reality. In addition there is an annual training session to review recent flood events and lessons learnt. Staff are required to take a competency test. Annual reviews are undertaken and the need for refresher training assessed. This training has been in place since the Easter 1998 events.

At Area level staff spend half to one day going through the details of procedures, AVM, software etc. This is followed by practical experience under the guidance of an experienced Duty Officer. A Flood Warning Duty Officer (FWDO) package is now being developed for new Area Officers. This is to a similar format to that used for RMFDO.

At present there are no official rosters for AFWDOs; they are called in as required to record Floodline messages. There are also lists of volunteers to act as "call-handlers" during busy events when a large number of calls are passed to the Area Offices from Floodline. Upper Severn Area has developed a call-handling training package in the form of a half day course. This is being implemented in all Areas.

The Region is recruiting a lot of new staff and is looking to more formalised training for FWDOs across the Areas.

Rosters generally change over on a Wednesday. There is usually between five and seven staff on each roster, which is considered to give an appropriate time period between duties.

A3 Anglian Region

Office Locations, Responsibilities and Liaison

The Region is divided into three Areas: Northern, Central and Eastern. The Area offices are in Lincoln, Brampton and Ipswich respectively. The Regional office is in Peterborough.

The Area offices are responsible for monitoring, forecasting and warning. There is a regionally based Flood Warning Officer with overall responsibility for forecasting and warning operations throughout the region. It is recognised that the “Changing Needs in Flood Defence” (CNFD) initiative requires forecasting to be centralised at the Regional Office and warnings to be issued by the Areas. The Region has therefore now set up its Regional Flood Monitoring and Forecasting Centre (RFMFC) in the Peterborough Regional Office. As of mid-2001 the RFMFC is shadowing the tidal forecasting and from September 2001 will shadow the fluvial forecasting. It is planned to move all forecasting to the Region by January 2002. The Areas will be left with a flood monitoring role in addition to their warning responsibilities.

The Region also has Catchment Offices (Manby, Kettering, Spalding, Bedford, Ely/Kings Lynn, Kelvedon, Norwich). In general these do not have a forecasting or warning role but act to direct operations. The Direct Service Group (DSG) have other offices and report to Area Managers.

Anglian (in common only with Southern) has separate Flood Defence and Water Resource Managers. In other Regions these were combined as one Function. The reason for this is that the extent of coastal and fluvial responsibility within Anglian Region is too big for the job to be combined. The disadvantage is that the division makes the organisation of staff resources for warning duties more difficult.

The Region has some problems with Local Authority liaison meetings in counties where there is more than one Region involved. It is considered important for the Agency to present a combined front for a Gold Control situation. This ideally requires a person with executive authority who also has the detail of what is happening everywhere. This is a bit of a conundrum. (The police expect a top person, the Agency wants to send someone with good local knowledge).

The Region has a Local Flood Warning Plan for each county. Where county and Agency regional boundaries do not coincide, the major Region or Area will hold the plan, but the others will contribute to the plan and attend meetings. An example of a difficult area is Uttlesford District which spans two Agency Regions and three Areas. Anglian keeps unitary authorities within their former counties.

At Risk Properties, Catchment and Event Types

The Region has a variety of catchment types that can be summarised by Area as:

Northern: Long estuaries with defences; upland rivers; fenland (flat, much below sea level and with 200-year defences); fast responding clay; significant defended urban areas (such as Lincoln, Northampton and Corby).

Central: Some 50% of Area is fenland and is below sea level; the Wash (difficult to predict levels); the Great Ouse catchment (outfalling at Kings Lynn, small tidal risk - very long tidal effect but defended); short length of high risk coast; some flashy flooding from storms on clay.

Eastern: Huge tidal risk area (not so well defended); the Broads (tidal/fluvial, many small flashy rivers in areas of high population); Canvey Island (high defence levels - disaster if breached); North Bank of Thames and barriers on northern tributaries.

Overall the Region has some 300 000 properties in floodplains, 200 000 of these being in high flood risk categories with major defences.

Widespread urban flooding is rare in the Region. Many areas fall into the low risk high danger category. There were nine severe flood warnings during the Autumn 2000 floods. In the exceptional floods of 1998 there were about 20 red warnings.

Monitoring Systems and Procedures

Radar data are received but only used qualitatively. HYRAD radar display from CEH is going to be introduced by September 2001 as part of a complete new forecasting system (see below) and will help process Nimrod data. HYRAD is seen as the national interim solution for radar display. The Agency is in the process of specifying its long-term needs.

ARTS is the existing Anglian Regional Telemetry System. There are nearly 900 sites regionally (rainfall and levels/flows). There is automatic polling of all stations early each morning at 06:00 hours. Alarms are automatic if thresholds are exceeded, for example 20 mm in 24 hours. In addition there are other triggers.

The control system is SCOPE X and runs on a UNIX system. This is now old and slow.

A new telemetry system is now being specified and has reached the user specification level. This new system will be developed in conjunction with South West Region and is known as SWANTEL. It is expected to replace the existing system by late 2002.

All warnings go to the RCC in Peterborough as well as the appropriate Area. All data are logged. In addition to rain, levels, and flows, the system has several dissolved oxygen and other sensors included for water quality monitoring.

Forecasting Systems and Procedures

Anglian does not use forecasting models at present. However this is changing as they are introducing the Anglian Flow Forecasting Modelling System (AFFMS) for fluvial analysis. This is a framework for using models rather than actual models themselves. The two principal non-steady hydraulic models under consideration are Mike-11 and ISIS. PB Kennedy and Donkin is developing the framework whilst W S Atkins is working on models of two trial catchments from the Northern Area. AFFMS should be operational by the end of 2002.

With the move to regional forecasting and the introduction of AFFMS, systems are changing. However, at present, tidal flooding is easier to predict than fluvial, with surge and onshore wave heights being added to tide data. The warning rosters can concentrate on tidal information that is

known well in advance. In the Wash particular conditions make forecasting difficult, and POL is working on an improved model.

Software for tidal forecasting is available on a stand-alone computer. It comprises simple models.

Warning Systems and Procedures

The principal system used for directly warning the public is the AVM. There are now approximately 7000 recipients, and maintenance of the database has proved to be time consuming. Each year every recipient is contacted by mail to ask for changes and if they want to stay on. If there is no reply then two further letters are sent. If there is still no reply then the property is removed from AVM. The Region understands that the NFWC is working towards a national contract for maintaining the various databases related to the flood warning process including AVM and public awareness. Anglian would like to be able to utilise a call-off contract for updating databases.

Faxed warnings are sent to Professional Partners via Surefax rather than AVM. The Surefax system has "List Master" which is very good. It allows Surefax lists of fax contacts to be amended in real-time on the NTL Surefax system.

The Region understands that the national specification for a new AVM system is due by September 2001 with the system to be operational by September 2002. This system will offer more facilities than the existing AVM, including improved fax facilities.

Eastern Area is set against the use of Flood Wardens. Central Area supports warden systems set up by others, but does not organise wardens itself. In the Northern Area wardens are organised by Local Authorities rather than the Agency.

Sirens have been installed in Northampton. Coastal sirens were generally the responsibility of others (councils, coastguard), except in Salthouse where the Agency is responsible. There are also sirens used in Wisbech.

With respect to direct public liaison the Region is reactive and will reply to enquiries. The NFWC has instigated a standard national pro-active approach to public liaison.

The flood risk mapping exercise, which was completed in 2000, has allowed letters to be sent out to properties at specific risk.

Post Event Reporting Systems and Procedures

For post event reviews a combination of methods is used according to the nature and severity of the event. In 1998 and 2000 Agency staff carried out interviews in flooded areas. Aerial surveys are used to record flood extents. Helicopters have been found to give better detail as they are able to fly lower. Thermal imaging from the air has been used in addition to optical photography. Extra video footage has been obtained from police and other bodies. Ground surveys are used to pick up wrack marks etc.

The National Incident Reporting System (NIRS II) is to be implemented in the Region by November 2001.

Documentation, Training, Rosters and Technology

The documentation consists of six Regional procedures, three Area procedures and specific catchment area operational flood procedures.

The new staffing system that has been introduced to the Central and Eastern Areas has five or six flood warning staff in each Area, each with a specialisation, but all knowing the overall picture to allow cover of duties. In the Northern Area there was previously more integration of the warning staff with the flood defence improvement staff. The staffing in all Areas now complies with the National Staffing structure prescribed by CNFD.

For a typical event the Duty Staff would be:

- Flood Warning Duty Officer
- Assistant Flood Warning Duty Officer(s)
- Dissemination Officer
- Catchment North Representative (or South according to event): ODO
- Contractors (Direct Services): EDO

There are separate teams of duty staff to cover fluvial events and tidal events.

The scheduled frequency of duty period for flood warning duty officers and flood warning disseminators and their respective training is considered to be good, however it is difficult to keep to this because of the shortage of staff. Planning and running of exercises is to be carried out in line with Agency policy and MAFF high level targets. Consultants may be employed to assist with this. Meetings of all roster staff are held every three months.

In addition to the rosters for particular duties there are typically call-down lists for less critical roles. Organisation is in line with CNFDR recommendations. The only outstanding non-compliance is forecasting still being at Area level.

The Region is contributing to the National Fluvial and Coastal Defence Database (NFCDD) which is being implemented nationally and will link with the F-DIMS (flood defence information management system), FPI (floodplain information system) and output from the National Flood Risk Mapping (formally Section 105) Programme.

All telephone calls to and from the Incident Room are recorded and stored on tape for one year nominally. These tapes could be used for training, but are not at present because of lack of time. All RCC lines are also taped.

The Region is concerned that it is difficult to keep up with the many initiatives emanating from the NFWC.

A4 Thames Region

Office Locations, Responsibilities and Liaison

The Region is divided into three Areas: North East, West and South East. The Area offices are in Hatfield, Wallingford and Frimley respectively. Office responsibilities are in line with the Changing Needs in Flood Defence Review. All forecasting is centralised in Regional HQ in Reading, except for that relating to tidal flooding which is dealt with from the office at the Thames Barrier. As of 12 September 2000 all warning is carried out by the Area Offices with warnings of tidal flooding being the responsibility of the Thames Barrier Office.

The Thames Barrier at Charlton comes under the Thames Region South East Area (Frimley) and is the only 24-hour seven-day operational office within the Agency. The Barrier Office acts as an out-of-hours deputy to the Agency's Bristol Head Office for the receipt and relaying of emergency information and liaising with other agencies.

The Thames Region covers approximately 100 Local Authorities. It also covers six police forces, 40 radio stations, many utility companies, and a population of 13 million.

At Risk Properties, Catchment and Event Types

Thames is the only one of the eight Regions without any coastline, its responsibilities extending to the limits of the Thames Estuary. There are some 200 000 properties at risk from fluvial flooding in the Thames Region. If those at risk from tidal flooding in London are added in then this number rises to approximately 625 000. Of these, 7000 properties currently have a direct warning service, with this targeted at the areas of highest risk.

In the Region fluvial events are typically associated with fast response clay (and heavily urbanised) catchments, and with slow response chalk catchments which are particularly vulnerable to winter events.

On average the Region may have six events per year where warnings are issued. Severe Flood Warnings (or their predecessors Red Warnings) are rare, although there were nine issued in October/November 2000, the last previous to this were in September 1998. On average the Region may have one or two Severe Flood Warnings per year.

The Thames Barrier and the down-river defences have been designed to protect against a 1000-year return period event based on predicted sea levels in the year 2030.

The up-river defences were raised in the years immediately prior to the construction of the Barrier and are designed to protect against high fluvial flows coinciding with tides that are not sufficiently large to warrant a barrier closure.

Thus with the Barrier in place and operational there is a relatively small number of "at-risk" properties which have to be warned of potential flooding. Areas that are at-risk are principally upstream of the Barrier on the river side of the defences. This includes many roads, amenity areas and car parks and a number of residential properties. There are also a large number of commercial properties.

Potentially the biggest risk is of upstream defence failure. There are several areas in central London where the defences are in poor condition and/or subsiding. When a particular area is being worked on with a temporary lower level of defence, this is entered into the forecasting model that reports areas of reduced freeboard or potential overtopping (see below). This can sometimes be influential in deciding a marginal closure of the Barrier.

Monitoring Systems and Procedures

The Met Office five-day forecasts are received from the London Weather Centre before 09:00 hours daily, with evening updates at 16:00 hours. Heavy rainfall warnings are also received. Assessments of forecast accuracy are now made by the Region on a weekly basis, and are fed back to the London Weather Centre for comment. Severe weather warnings are received separately from the Bracknell Centre. Thames has found that these warnings sometimes conflict with the heavy rainfall warnings from the London Weather Centre. The Region would prefer to receive all weather warnings from one source.

With the recent closure of the Norwich and Southampton Weather Centres the London Centre has to deal with the forecasting needs of Anglian and Southern Regions in addition to Thames. During the Autumn 2000 Floods the Weather Centre had difficulty in coping with the amount of data required.

Weather Radar is considered very important, and the Region is working with the Met Office to improve accuracy. Nimrod data are received with forecasts from one to six hours ahead. The HYRAD system displays predicted rainfall two hours ahead, and the predicted movement of rain over the period through advection. It does not allow for decay etc. GANDOLF has been developed by the Met Office and Thames for convective rain (such as in thunderstorms). It forecasts three hours ahead, and alerts are received every five minutes by text. The performance of GANDOLF has not met Thames' expectations for forecasting accuracy.

The Nimrod and GANDOLF systems are currently being integrated by CEH and the Met Office at their joint centre at Wallingford.

At present all Regions receive radar data separately from the Met Office. The Agency is now moving to a national communications system by which the Met Office will feed all radar data to the Agency's data centre in Leeds. Regions will obtain their radar information from the data centre. The HYRAD display system is also being installed on the server in Leeds for Regions to access. The Agency is looking to see if HYRAD meets its needs in the long term, or if a new product is required.

Thames Region already has an extensive telemetry network. There are over 100 raingauges and these are being added to at a rate of three to five per year for the next five years. An additional 24 river level sites were installed last year, and a further 18 will be installed this year. This increase is needed to deliver the Region's target of providing a direct warning to all high-risk areas. The Autumn 2000 floods identified additional sites to be gauged.

There have been problems with telemetry in the past. Much of it was originally installed primarily to monitor low flows for water resource studies. In the 1998 floods on the Cherwell most of the river level telemetry malfunctioned in some way. This has all been audited since, but some sites are still limited in what they can record. Equipment that had previously been installed in manholes has now been moved above flood level.

The new gauge sites are concentrated in areas upstream of flood risk areas. However to have the whole network able to measure flows for 100-year-plus events (as Bye recommended) would be prohibitively expensive; particularly in areas with very flat floodplains.

The hydrometry and telemetry network is maintained by an Area-level hydrometry team within the Water Resources Function who provide 24 hour standby cover. The financing for the system is split between water resources and flood warning functions.

A project is going ahead in conjunction with Wales and Midlands Regions to upgrade the Thames telemetry system. A new telemetry system is being developed as part of the Joint Telemetry Project (JTP) and is programmed to be installed in 2003/4 in the Thames Region.

At present the incoming data from the existing telemetry system is managed by the CASCADE software, which forms the basis of flood forecasting centre operations. This software was originally developed in the mid-1980s and the graphical user interface (GUI) is becoming dated (it is not Windows based). However it has the advantage of having been developed by in-house programmers who have kept it up-to-date and therefore it does exactly what is required of it.

In addition to receiving telemetry via PSTN, CASCADE also takes in some radio telemetry via a link to a Ferranti Argus computer system, particularly from River Thames sites. Radio telemetry can be expensive and inflexible but offers a continuous datastream. Under the RTS the Ferranti will be replaced, but the radio telemetry will be retained.

CASCADE takes in the radar data in various forms. It can show the data on-screen in a variety of formats including comparison of recorded rainfall (radar and raingauge) and radar predicted rainfall for each gauge site. It shows the trends and alarms.

There is the facility to mock-up a radar image from raingauge data. This feature has been incorporated in HYRAD and is useful in the event that radar data is lost since it allows the radar image to be replicated.

Forecasting Systems and Procedures

Thames does not at present make extensive use of hydrological/routing models in real-time. CEH has evaluated catchment and rainfall-runoff models that will input into the River Flow Forecasting System (RFFS) which is currently under development for Thames Region.

This system will be based on that which is already running in the North East. It is installed but undergoing further development in Thames. The system brings together radar data and telemetry with models such as the Thames Catchment Model (TCM) and Probability Distributed Model (PDM) to allow forecasting. The system was on-line during the Autumn 2000 floods and presently allows forecasts at 28 sites across the Region. This will be increased to 50 sites over the next year. At present the forecast accuracy is not good, but a PC based calibration version of RFFS has recently been received from CEH which should make significant improvements.

The forecasting model presently runs on the VAX mainframe and takes in data from the PTSN telemetry system. This will continue for at least the next two years. When the RTS is introduced

a separate forecasting system will be purchased. Thames is looking to Midlands Region for a lead on this.

The Region is looking to the introduction of hydrodynamic river models for use in real-time forecasting. A pilot study is being set up on the reach of the Thames through Reading.

The principal forecasting tool used to determine when Thames Barrier closure is necessary is the 'Thames River Model'. This was initially developed a number of years ago (in the 1970s), and through ongoing calibration has proved to provide accurate predictions of levels both upstream and downstream of the Barrier under most conditions. It is a 1-D hydrodynamic model and extends from the tidal limit at Teddington to Southend. The fluvial input to the model is the gauged flow at Teddington. Warning conditions or trigger levels can be set up in the model such that they have to be acknowledged.

Although the model includes a representation of the Barrier it is not much used, as its accuracy is not high. The model is run every 12 hours and the forecast is for 36 hours ahead. The length of the forecast means that it is possible to close the Barrier within two hours of low tide. This gives maximum storage upstream and allows time for any problems with the gates to be overcome.

A new hydrodynamic river model using the ISIS software (Halcrow/HR Wallingford) is under development and will improve on the existing model.

For tidal forecasting POLTIPS (Proudman Oceanographic Laboratory Tidal Prediction Service) data are received at the Barrier for 32 ports around Britain. Also the astronomical tide is received from POL, and surge residual data from the Met Office. MIST gives surge residuals from the Met Office; this is a 36-hour ahead forecast.

Surge residuals come from the continental shelf model (CSM) which is run every six hours by the Met Office.

Thames uses its own model which was developed by POL to give a forecast based on observed levels down the East Coast from North Shields to Newhaven. This is run every 12 hours and the results are used for input to the Thames River model. The tide takes nine hours to travel down the East Coast from North Shields to the Thames Estuary.

The accuracy of the tidal model is quite good, generally within 0.1 to 0.2 m; it may be up to 0.5 m out once per year. Actual readings from tide gauges are also received in the Control room and compared with predictions. Any significant differences may influence the issuing of warnings. Tidal forecasts are also passed on to the Agency Anglian and Southern Regions and to the Netherlands.

Warning Systems and Procedures

The primary public warning system is the AVM. Thames has some 7000 recipients on its system and this is increasing. This number includes duplications, since if a property registers alternative numbers then all are rung. In adding new areas, prioritisation is according to flood risk. This is done via a Flood Warning Area System that lists all at-risk properties.

There is an AVM machine in each of the three Area offices plus one at the Barrier. All are backed up between Areas. This was found to be essential during the Autumn 2000 floods.

The annual update of the AVM is currently done by phoning all the recipients, rather than relying on post. This obviously takes a long time for 7000 recipients, but ensures a better response.

The AVM is also the principal method used to warn the residential properties in the undefended upstream areas on the Tidal Thames. Of some 280 potential recipients there are 150 (including duplicates) who have signed up to have the AVM service. These receive flood watches and flood warnings according to the predicted levels. The limited number of recipients, who all live along the banks of the Thames, means that they are knowledgeable recipients and the Agency has a good relationship with them. In spite of this, in the annual mail-shots to the 280 at risk, only about 70 will respond.

For faxes to professional partners (Local Authorities and emergency services etc.), Thames now uses the standard system built into the AVM. Since September 2000 this has replaced fax routines built into the CASCADE software. There are two groups of faxes, one to Local Authorities and emergency services which are standard according to the Flood Warning Area to be warned, and one for the media which may be customised on screen.

Although the principal means of warning is AVM, Thames also has an effective and growing network of approximately 100 Flood Wardens which ensures good local contact and public relations. The warden system is seen as complementary, rather than as an alternative to the AVM. People who are part of a warden scheme are also on the AVM. The Region considers that wardens are particularly useful in maintaining good community relations. They also provide valuable feedback to the Agency with on-the-spot reports, and can advise when the issuing of a warning is borderline.

At-risk communities are assessed to determine the most appropriate system for warning. The Flood Warning Officers in the Areas look for key people to organise the community and to engender a sense of ownership of the warning scheme. A typical Flood Warden scheme will have three wardens for 40 properties.

Within the Thames Region there are now four officers responsible for warning per Area. The Area based staff responsible for flood warning are also responsible for public liaison and recruitment of wardens and direct warning recipients.

Thames believes it is unique in offering a flood warning service on all main rivers within the Region; this is divided into 135 Flood Warning Areas. This Flood Warning Area system is being updated and details will be sent out to professional partners in GIS format in late 2001. The database will show the 100-year floodplain, plus some indication of the extent of flooding for smaller events.

The Region has a dedicated Regional Public Relations department within the forecasting and warning team, including a duty PR officer. All staff in the flood warning team are media trained.

There is a special "Media Room" adjoining the monitoring and forecasting room which is soundproofed and can be used for interviews etc. It also has a glass viewing panel to allow TV

filming of the room in operation (without interfering with operational activities). This room was much used during the Autumn 2000 floods. The Region has now installed an ISDN line to improve the quality of communication with radio stations.

Within the Region great emphasis is placed on public relations as an effective method of ensuring flood preparedness. The Agency has its own Education Officer who works with schools. Within the Flood Warning Team there is a Flood Warning Engineer (Warning) who, amongst other things, has produced a Flood Detective comic for distribution in schools and a "River of Life" game. They have also commissioned an "Inspector Downpaw" costume which is used on school visits and makes appearances at agricultural shows etc. to publicise the Agency's Flood Warning work. It was particularly useful at the launch of the new warning codes.

At the Thames Barrier there is a classroom for giving talks to visiting school children.

Following all major events a video is made which is shown at planning groups and seminars.

A newsletter called 'River Watch' is produced twice a year for distribution to Flood Wardens and people at high risk. This was used to obtain feedback from the public on the Autumn 2000 floods. Southern Region have taken up this idea and produce their own "Flood Watch" newsletter. North East Region also have something similar.

Post Event Reporting Systems and Procedures

The Region is moving to a suite of ACCESS/GIS databases to record, store, and disseminate a wide range of information. This will allow Area offices to easily access the information. A regional database of warnings issued was started in September 2000 to replace the old document format, which dated back to 1950.

With warnings now all being issued via the AVM there is no automatic reporting. However the new national system should help. The collation of flood reports is now the responsibility of the Regional Flood Warning team, previously Flood Defence were responsible. Each Area has a team of standby Flood Data Recording Co-ordinators, who liaise with the Flood Warning Duty Officer (FWDO) and call out staff to observe floods at pre-set 'node points' in the catchment. The officers take photographs, levels, record property flooding etc. and arrange for surveys.

The Region is looking to link the data collected in this way into a new ACCESS database. This good practice has been documented and sent to the NFWC.

Phone calls to the RCC are taped, but those to the flood control room are not.

Post event reporting from the Region is produced to what was understood to be a former national standard format. This covers hydrology, forecasting, etc. There is no current national standard for reporting. "After Event Reports" from Area staff include photos and maps of areas flooded. There is also a report from the relevant operations team. For future events it has been decided that these three reports will be combined.

The report for the Autumn 2000 Floods was produced to the specific format specified nationally. The format for future reports will however revert to that used previously until a permanent national standard is agreed.

After a major event a wash-up meeting is held which is chaired by an Officer from outside of the affected Area. This Officer is responsible for co-ordinating reporting.

During the Autumn 2000 Floods all media activity was co-ordinated regionally. A specific person was nominated to liaise with the Areas and to talk to the radio stations, TV stations and to set up interviews. This worked very well.

Local radio was a major factor in warning and keeping the public informed in Autumn 2000. The stations were sympathetic to the Agency's problems. The radio stations reported increased audiences; these have been maintained post flood. With all public phone calls now routed to the Areas the Region was able to handle the media. Over 70 interviews were given. Potential problems arise where radio stations' catchment areas do not coincide with Agency Regions. It would help to exchange press releases with adjacent Regions, Local Authorities and police to present a common message.

Documentation, Training, Rosters and Technology

Flood warning documentation at Regional level comprises four quality controlled documents as follows:

- Regional fluvial flood warning procedures
- Regional flood warning dissemination plans
- Regional flood warning area system documents
- Regional flood warden and direct warning recipients manual.

Staffing is now fully in accordance with CNFDR. In the regional office there are 11 staff on the rosters for Monitoring and Forecasting Duty Officer (MFDO), Assistant MFDO, and River Control Duty Officer.

Thames considers that having a relatively small pool of staff (11) from which to draw is advantageous. It allows all staff to be fully trained and to have enough experience to build up expert knowledge. The use of "outsiders" is resisted, and even in Autumn 2000 the team of 11 just about coped.

In the Area offices there are three duty officers, a Flood Warning Duty Officer (FWDO) and two Assistant FWDOs. These are on a roster from a pool of 12, giving a duty every four weeks. This is shorter than other Regions but considered good practice as it helps avoid staff forgetting what to do and is less of an onus on training.

Change-over on the rosters is 09:00 hours on Monday morning.

The telemetry alarms come direct to the CASCADE system (see above) rather than through the RCC. The RCC cannot cope with the volume of alarms during a major event. From 09:00 to 17:00 hours Monday to Friday, alarms are taken in the Regional Flood Forecasting Centre. Outside of office hours the alarm goes to the Duty Officer at home, or mobile. Officers on the duty roster now have three home phone lines, one for alarms, one for the computer system, and one voice communications. In addition they have a mobile phone and a pager. Computers at home can refer to all telemetry data, modelling and radar software on CASCADE, and issue warnings, including accessing the AVM system.

There are four levels of telemetry alarms: “standby”, “bank-full”, “floodplain” and “property”. As the number of telemetry sites increases, the number of alarms during a major event is becoming too large to handle. The Region is considering introducing a system whereby standby alarms may be suppressed when a flood watch is in force. This would involve amendment of the CASCADE software. It is understood other Regions, in particular Southern, have also raised this issue.

The MFDO and AMFDO are the key members of the standby teams. The MFDO decides when to come into the office and when to activate the warning service. The RCC may prompt this if it is receiving a high number of calls. The other two Duty Officers can then be called in.

Thames recognises that it does not staff-up its Area Incident Rooms as fast as some other Regions. There is an expectation that a significant amount of work will be done from home. Staff location and travel times (due to traffic density) are factors in this policy.

The Regional Flood Forecasting Centre is very busy during events. However the moving of public calls to the Area offices has allowed the team to concentrate better on their forecasting duties. Area Incident Rooms now get very busy during major events.

There are several white boards on the control room walls that are used to display information relating to flood events. These are mimicked in the Areas.

There is a “Status of Current Flood Warnings” board which takes the form of a matrix of catchment names (26 of them) and flood warning area names (up to nine per catchment – average say five). When a warning is current a “Watch”, “Warning”, or “Severe” will be written into the appropriate square on the board. This has the advantage (over other Regional systems) of showing at a glance the overall warning situation for the entire Region. This display is duplicated electronically on the CASCADE system.

A weather report board gives for each day Monday to Friday the “outlook” the “forecast”, “rainfall”, and “confidence”.

Each working day the Region provides a Daily Situation Report (DSR) at 09:00 giving details of the weather overnight, number of warnings issued and forecast of weather and river levels. This is very useful as it gets the incoming DO up-to-date quickly. The DSR is sent out to all Areas, the Barrier, RCC and Public Relations. When an event becomes severe enough (judged by warnings being in force in more than one Area) a Regional Base Controller (RBC) is mobilised. The RBC is responsible for issuing Situation Reports to Head Office giving details of incidents.

Historically Thames has focused on development of its warning systems, and forecasting has fallen somewhat behind. There is now an emphasis on catching up with forecasting. The Areas have high expectations of Regional forecasting, and it is important that the Region is seen as adding value to information already available to the Area. The Region insists that it is contacted before flood warning codes are issued, and has produced forecast templates for each catchment. Flood intelligence files are also being set up for each catchment and it is planned that forecast reports will be sent to the Area every few hours during an event.

A5 Southern

Office Locations, Responsibilities and Liaison

The Region is divided into three Areas: Kent with the Area Office in Addington, Sussex with the Area Office in Worthing, and Hampshire/Isle of Wight with the Area Office in Winchester. The Regional Office is in Worthing.

As of September 2000 the Region has implemented the organisation model set out in the “Changing Needs in Flood Defence Review” (CNFDR). Thus forecasting is centralised at Regional level and the Area offices have responsibility for warnings. Southern Region successfully used a migration plan to manage the move from its previous organisational structure to that required by the CNFDR.

During the Autumn 2000 floods it was found that the new organisation worked particularly well with more manpower being available to issue warnings and much clearer event management.

Within the Regional Office the RCC, Incident Room, Forecasting Room and Call Handling Area are all located next to each other. Only the Public Relations Function is remote being located two floors away.

The Region has three strong Local Flood Warning Planning Groups (LFWPGs) which meet at least once a year. These are based on the police force boundaries that correspond with the Region’s Area boundaries, Kent, Sussex, and Hampshire/IoW. There is also a local meeting on the IoW. There is some overlap with Thames Region which covers a minority of both Hampshire and Sussex

There is a six-monthly liaison meeting with all County Emergency Planning Officers for the whole Region that steer the LFWPGs.

Southern exchanges faxes with South West Region on rainfall and coastal matters, particularly for areas such as Christchurch where the Regions’ coasts meet. South West passes on its coastal warnings. There are some of Southern Region’s raingauges actually within the South West Region’s geographical area.

The Region liaises with Thames Region at the Barrier on conditions in the Thames Estuary. This has been done since the new warning codes were brought in, in September 2000, and has helped in setting up new warning areas.

Within the Region the move to Area based warnings has helped with local liaison. National mailing contracts have been set up with local companies.

At Risk Properties, Catchment and Event Types

The Region has substantial areas at risk, both from coastal/tidal, and from fluvial flooding. Southern has the most populated stretch of coastline in Europe with 91 200 properties at risk from coastal/tidal flooding. It also has 38 300 properties at risk from fluvial flooding, and a further 30 700 properties which are at risk from both coastal/tidal and fluvial flooding.

The North and East Coast of Kent are susceptible to North Sea surges. The South Coast of the Region is susceptible to Atlantic storms.

The Region's fluvial catchments are quite varied. In the Weald of Kent and Sussex there are several clay catchments which are susceptible to fast runoff from convectional rain and thunderstorms. There are also highly urbanised catchments, such as the Cray and Shuttle close to London, which exhibit similar response.

The chalk catchments in Hampshire and parts of Kent and Sussex have a very slow response. Until recently some of them had been dry for years. The very wet autumn and winter of 2000 to 2001 however have resulted in significant flood problems in such areas. The IoW has a number of short rivers with very responsive catchments. The Medway is the largest river in the Region and is highly controlled, in particular by the Leigh Barrier scheme. There are several other large tidal estuaries around the Region where the Agency would like to develop a better understanding of the fluvial/tidal interface.

It is very difficult to define an "average" year for flood warnings. The number of warnings issued has approximately doubled every year since 1996. This is in part due to the increase in number of flood warning areas, but mainly due to the increase in frequency of severe weather.

Monitoring Systems and Procedures

The Met Office in London provides the Region with standard services under the National Weather Services Agreement. The monthly prospects service is received via Midlands Region.

The Met Office's Storm Tide Forecasting Service at Bracknell provides 36-hour coastal forecasts, plus Severe Weather Warnings. At present this storm tide information is provided only as paper copy; the Region would like it also in electronic form.

The weather forecasts are distributed by fax to Areas and put onto the Agency intranet via email.

The Region produces its own annual book of tide tables based on information received electronically from the Proudman Oceanographic Laboratory (POL). These tables are made available on the Regional Telemetry System. The tables generally give accurate predictions, but in Southampton there is need for improvement.

Despite recent improvements, weather radar coverage continues to be a major problem for the Region. Data at 5 km grid square detail is available for the whole of the Region, but this is too coarse for accurate flood forecasting. The 2 km coverage has recently been improved with the installation of new equipment at the Chenies and Wardon Hill radar sites which has increased their ranges from 75 to 100 km. However this still leaves significant areas of east Kent, south-east Sussex and the City of Portsmouth without 2 km coverage.

Nimrod forecast data is received from the Met Office. The predictions during the recent events have been found to be inaccurate to the extent that they cannot be used quantitatively. This is to a large degree because the Nimrod system is poor with convective storm development. As yet the Region has not used the GANDOLF system which has been developed specifically for predicting convective storm development, but looks to the

proposed single radar system which will integrate the features of Nimrod and GANDOLF as the way forward.

The Region uses the Nimrod forecast data qualitatively to predict the direction and speed of weather systems. Ensuring complete weather radar coverage is a priority for the Region to permit accurate flood forecasting. Further work to locate new radar sites and improve Nimrod forecast data is seen to be urgently required.

The Region has an ongoing project for the installation of additional gauges: rain, level, flow, tide and wave. This project started in 1998 and will extend into 2003/4. Existing gauges are also being upgraded, many were initially installed to measure low flows – particularly in Hampshire's chalk rivers.

The telemetry system is known as the RTS, for Regional Telemetry System. This was developed by Servelec and was completed in 1999. Maintenance of the system is provided by the Regional CIS staff. RTS displays rainfall, flows, levels, and tides. Some water quality data are also involved. Alarms come up on screen in the RCC and are acknowledged by the Monitoring Duty Officer (MDO) during events.

All RTS features and HYRAD can be accessed and operated by Officers working from home. The Forecasting Duty Officer (FDO) will decide when an event requires the opening of the Forecasting Room, and will advise the FWDOs in the Areas. The Regional Base Controller (RBC) decides, based on his judgement and experience, when to open the Incident Room.

Groundwater levels in critical chalk areas are monitored using boreholes. All are dipped monthly, with 12 of the most important being linked to the telemetry system. This number is expanding. Data from two of the boreholes feed into the Chichester model.

Forecasting Systems and Procedures

The Storm Tide Forecasting Service is considered to be good but is known to under-predict at Sheerness. On the South Coast problems arise from Atlantic depressions leading to high waves rather than surges. These types of event take 5 or 6 hours to move up to the Southern Region coastline from Cornwall.

Southern is contributing to the National Tidal Flood Forecasting Project on the development of breach models, overtopping models, off-shore to near-shore wave transformations, and other initiatives to improve forecasting and warning. The Region have been disappointed with the recent lack of progress on the project which appears to have been side-tracked by the national emphasis on fluvial forecasting.

The Region currently has rainfall-runoff models in place for 11 of the 85 fluvial Flood Warning Areas. These models are contained within the Flood Forecasting Platform (FFP) which was developed for the Agency by consultants. FFP takes in telemetered river level, raingauge and radar data. In addition there are models of the Medway and the River Lavant at Chichester which run separately outside of FFP.

In areas not covered by these models, warning of fluvial events is instigated by a system of trigger levels reported via telemetry. Triggers on rainfall quantities are set to reflect variations in response across the Region, river level triggers are based on historical data. The Region is

continuing to extend the telemetry network and to implement more sophisticated fluvial forecasting.

In parallel with the operational use of FFP, Southern Region is proceeding to design, specify and procure the Southern Enhanced Flood Forecasting System (SEFFS). The project which delivered FFP and under which SEFFS is being developed is known as SURFFS. SEFFS will support the flood warning service for all the Region's fluvial and coastal flood warning areas. It will include models initially developed for FFP, conceptual models, complex hydrodynamic modelling, GIS linked inundation mapping, over-topping and breach models. SEFFS will be designed to interface with any future National Tidal Flood Forecasting System (TFF).

The hydrodynamic model of the Thames Estuary, which is run at the Barrier Office, is available on screen in the Southern Region. This has been found to be very useful for predicting levels from the Regional boundary where the Darent meets the Thames, all along the North Kent coast. The model shows forecast, actual, and updated predictions of tidal levels. Southern would like a similar model for its other lengths of coastline. POL has developed a Solent Model, and although this is not yet operational, the Region is very interested in it.

Warning Systems and Procedures

Southern Region attempts to offer a flood warning service to all areas at risk from either coastal or fluvial flooding (not just main river reaches). The principal means for direct warnings is the AVM where Southern has a much larger number of recipients than any other Region. They also have an effective and growing network of Flood Wardens, which ensures good local contact and public relations.

Of the 160 000 properties designated as "at risk" the Region is able to offer a four-stage warning service via the AVM to 152 000. The remaining 8 000 are offered a two-stage service using Flood Wardens. The take-up for the AVM service is some 50 000 recipients and rising. Keeping the list up-to-date requires inputs equivalent to 0.5 FTE. Mailing is organised nationally. No recipients are removed from the database without their expressed wish.

There is a database listing all "at-risk" properties. This is obtained by combining the flood mapping polygons with a commercial postcode/address database and contains some 160 000 properties. This long list is used for mailing on such matters as the October 1999 public awareness initiative, i.e. directories and AVM forms.

Note that when the Agency took over warning responsibility from the police there were only 600 at-risk properties on the police warning list. It is expected that the number on the AVM list will stabilise at around 50 000 to 60 000.

Southern's system uses 30 voice lines and six fax lines per machine. There are five machines, one in each Area, one extra in Sussex, and a backup in the Region. It is planned that over time data will be input locally to Regional standards. The Southern AVMs are connected to the Agency's LAN and this makes data management easier than with the stand-alone machines that some Regions use. The issue of warnings via the AVM tends to be conservative due to the restricted dissemination rate of the equipment. If it were faster then warnings would not need to be issued until there was more certainty of need.

Faxes are sent out via the AVM. Templates are held on the system for all the warning areas and for the four stages of warning codes. They are in WORD format and are edited in real-time before dissemination.

At Christmas 1999 some 72 000 AVM messages were sent out and in Autumn 2000 some 200 000.

There are many difficulties in keeping the AVM lists up-to-date. Phone numbers change often as people switch telephone companies or move to mobiles only. Many people tie up their lines for long periods using the internet.

The Region is uses email to warn by using the AVM to send faxes that are converted to email and distributed internally.

The AVM database is difficult to manipulate within the existing AVM software. A separate ACCESS database is maintained outside of the AVM to manipulate the data as necessary. It is expected that this difficulty will be overcome when the next generation of AVM equipment is introduced.

Recruitment of Flood Wardens has been via the forms sent out with the public awareness mail-shots. Once signed up, contact with wardens is made via AVM, the wardens passing the warnings on to their "groups". The Agency has registered 2800 wardens covering 5000 people. This is being reviewed and new groups set up following the Autumn floods. In addition there are some Local Authority warden schemes.

It is planned to display warden and recipient location details on the GIS system.

The Region currently has 20 loudhailer units available in areas such as Dartford, Hythe, Selsey, Pevensey Bay, and Lyminster. These are areas of very high risk and are used to back up severe flood warnings. The areas are primarily those at risk from coastal flooding. For units to be mobilised there needs to be a long lead-time.

Public relations is lead by the Regional Public Relations department through the Regional Flood Warning Team. All frontline staff in the flood warning team are media trained. A member of the Regional Flood Warning Team has a public relations role to interface with the Agency's Regional Public Relations Function.

A newsletter called "Flood Link" is produced annually for distribution to all AVM recipients and also goes out to libraries and Local Authorities etc.

It is considered important that when communicating with the public the Agency standardises as far as possible its stationary etc. to get across a branded image which will help the public identify with the Floodline information.

The Region would like to be able to offer more advice to the public on protecting their homes from flooding. Aspects such as use of sandbags and flood-boards could be covered, but more resources would be required.

Post Event Reporting Systems and Procedures

The Region believes there is a need for a National Standard for post event reporting. Prior to 1998 summary reports were prepared to a national standard format, but these have been discontinued.

The Christmas 1999 event was reported by a comprehensive 'Performance Review' which considers the event in terms of the Agency's response in six key areas:

- Event Management
- Flood Forecasting
- Flood Warning
- Emergency Response
- Public Relations, and
- Health and Safety

This was accepted by the Agency nationally as a particularly useful style of report and was used as the basis for the Regional reports on the Autumn 2000 flooding. The main difficulty identified in compiling such a report is the identification of the extent of flooding which occurred, and in particular the number and extent of property flooding. In Autumn 2000 the Region used aerial photography which was useful but it was difficult to capture the peak of the floods. The Region is exploring the use of satellite and side aperture radar data in this respect.

After an event it is difficult to find out what was flooded unless owners actually report to the Agency. It is also difficult to get a consistent definition of what "flooding to property" means – some members of the public interpret this as a shed, garage, or even the garden getting flooded. Southern defines property flooding as wet carpets/floors. There is also a difficulty with obtaining timely information as required for post event reporting. The Southern Region was still receiving data on flooding experienced in Autumn 2000 six months after the event.

As noted above it has proved very difficult to obtain accurate post flood information. The document "Field Collection of Flood Event Data" which was produced by Matthew Kean in Thames Region (part of Easter Floods Action) should help with this task in future. However it is noted that this has not yet been issued as a final document.

The traditional method of data collection involving sending Agency staff out to knock on doors has been used following Autumn 2000 with staff numbers supplemented by consultants. Such work is not without difficulties; those who have had to move out of their homes may be difficult to trace. In addition people who have been flooded may resent being asked repeated questions. It is recognised that in this respect co-ordination with emergency services and Local Authorities could be improved and communication routes properly defined.

After a major event a wash-up meeting is held.

For post event audits it has been found that it is very difficult to obtain reliable data. Agency Duty Officers rarely get time to leave the operations room during an event to see what is actually happening.

Under a national initiative co-ordinated by the NFWC, the British Market Research Bureau is employed to carry out surveys at sites identified by the Regions at three levels:

- 1) The omnibus awareness survey – this has been ongoing since 1996.
- 2) At-risk survey – in which staff visit addresses on the at-risk database and ask how much they know about flood risk etc., what they have received, etc.
- 3) Post event surveys – in which staff visit sample areas following a major event.

Documentation, Training, Rosters and Technology

The Region's flood warning documentation comprises five Regional procedures, three Area procedures and four county plans for warning dissemination.

The arrangements for duty officers are in accordance with the CNFDR recommendations. Thus in the Regional Office there will be a Regional Duty Officer (RDO), Regional Base Controller (RBC), Monitoring Duty Officer (MDO) and a Forecasting Duty Officer (FDO). In the Area Offices there will be an Area Base Controller (ABC), Flood Warning Duty Officer (FWDO), Assistant Flood Warning Duty Officer (AFWDO), Operations Duty Officer (ODO) and Emergency Duty Officer (EDO). For Kent and Sussex the latter two posts are duplicated. This gives a total of 23 staff on standby at any time. Personnel are on duty one week in six under normal circumstances. During the Autumn 2000 floods this came down to one in three or even one in two.

RCC officers are on continuous roster, they do not deal with routine incoming calls to switchboard during office hours; only with emergencies.

All officers are on duty for a week at a time, change-over day being Monday morning 09:00 hours. The Autumn 2000 event exposed difficulties with having sufficient trained staff for prolonged events.

Southern is training the Area staff to deal with calls during a busy event.

A6 South West

Office Locations, Responsibilities and Liaison

The Region is divided into four Areas: Cornwall with Area Office in Bodmin, Devon with Area Office in Exminster, North Wessex with Area Office in Bridgwater, and South Wessex with Area Office in Blandford. The Regional Office is in Exeter. From 11 September 2001 responsibilities will be in accordance with the CNFDR guidelines. Monitoring and forecasting will be carried out from the Regional Office, and warning and dissemination will be carried out from the Area Offices. The Areas have newly set-up Incident Rooms for undertaking their warning and dissemination duties. North Wessex has two teams of staff to cover the Bristol Avon and Somerset sub-divisions of its Area. This is in accordance with the organisation of other flood defence duties in North Wessex where there are two Local Flood Defence Committees.

For many monitoring and forecasting duties the Region divides into two parts, Wessex North and South, and Devon and Cornwall. The monitoring and forecasting room is set up to cover the two parts with “mirror image” facilities.

In Devon, Cornwall and South Wessex the Area Flood Warning Team Leaders are also the Strategic Planning and Improvements Team Leaders. Only North Wessex Area has a dedicated Flood Warning Team Leader.

Communications between Regional Monitoring and Forecasting teams and Area Flood Warning teams will be primarily by telephone. A dedicated line is to be installed between each Area Incident Room and the Regional Forecasting Room. The verbal communication will be logged at both Region and Area. It will be supported by Region-to-Area and Area-to-Region spreadsheets, completed by the appropriate Duty Officer and emailed or faxed to their opposite number in Area or Region. The “Region to Area” spreadsheet summarises the monitoring and forecasting status; the “Area to Region” spreadsheet summarises the status of warnings.

The Region has carried out a Flood Warning Level of Service Survey (FWLOSS) to identify where the target level of service was not being achieved. The survey looked at potential solutions to improve the warning service and included basic benefit/cost analysis. It is intended to link this work with the current flood risk area mapping to develop an ongoing programme of improvements to the service.

At Risk Properties, Catchment and Event Types

There are some 81 000 properties determined to be at risk from flooding in the region. Of these 48 000 are at risk from fluvial events and 33 000 at risk from tidal/coastal events.

The Region has a wide range of catchment types:

- Rapidly responding steep catchments with a two-to-three-hour response time.
- The moorlands of Exmoor, Dartmoor and Bodmin Moor, and associated rivers, where the peat soils overlying granite give rapid response combined with high rainfall. There is very little groundwater element.

- Larger Devon and Cornwall rivers such as Tamar, Exe, Taw and Torridge, which have longer response times, up to 24 to 36 hours, due to their length. The headwater reaches still rise rapidly.
- The Bristol Avon, which is a special case, being very tributary biased, resulting in an unusual response.
- The Hampshire Avon, and to a lesser extent the River Stour, with significant groundwater contribution from the chalk making it a very slow response catchment. It is difficult to track peaks which may take weeks to develop in the case of the Avon.
- The Somerset Moors and Levels, where tidelock effects can be significant.
- Significant urban areas such as Bristol. This includes major tributaries of the Avon.
- Coasts:
 - i) Bristol Channel, which has a wide tidal range and significant surges. There are a large number of hard and shingle ridge defences with low land behind them. South-west and north-west waves are a problem.
 - ii) Devon and Cornwall coastal cliffs. There are generally good defences with isolated problems at ports such as Bideford. The tidal range reduces around the coast in an anti-clockwise direction from a maximum of around 15 m at Avonmouth to less than 3 m at Bournemouth.
 - iii) Dorset Chesil Bank which has a major wave action problem. The bank protects the road to Portland and approximately 100 properties.
 - iv) Poole, Christchurch etc. which are at risk from surge, with much potential damage from a small increase in levels.

Monitoring Systems and Procedures

The Met Office at Cardiff provides the Region with standard services under the National Weather Services Agreement. The major items received are the 12-hour rainfall accumulations two days ahead, average rainfall values five days ahead, winds in coastal areas two days ahead and the general outlook for up to 10 days ahead. The information is received by fax and electronically early each day. The Cardiff Met Office also provides local warnings of heavy rainfall, snowmelt and wind to set criteria. They also provide notification of when certain meteorological conditions are met which give rise to large surges. These are seen as particularly useful items of information, as is the arrangement for contacting the Met Office on a consultancy basis by telephone at any time.

The Met Office at Bracknell also provides Severe Weather Warnings. The Region has difficulties when the data received from Bracknell contradicts that received from Cardiff. The information from the local Weather Centre is generally much more useful as it is more focused.

Synoptic charts are provided for T hours (midnight) and T+24 hours. Storm tide and surge forecasts are received from the Met Office's Storm Tide Forecasting Service (STFS) and provide 36-hour coastal forecasts. These give heights above or below those given in the Proudman tide tables. South West principally uses Proudman data; it is noted that the Proudman and Admiralty data can give different answers.

Offshore wave heights are predicted by the Met Office's Continental Shelf 3 Model. There are also Bristol Channel and River Severn models used by STFS to improve surge residuals within the Bristol Channel. Within the Region, waves are very important in some locations, less so in

others, according to shelter. For example Chiswell at the easterly extent of Chesil Bank is very vulnerable to waves.

The Region uses the STORM system, which is now Windows based, to display radar data. STORM will be retained until a new nationally convergent system is adopted. The Region is also obtaining HYRAD which will be used as a backup. STORM takes in Nimrod actual and forecast data and displays current and predicted rainfall. It was developed by the University of Salford and is now supported by the University of Bristol. The software display is via PCs, with data managed on a VAX system. The data are presently received on a 5 km grid at 15 min intervals. It is used qualitatively, to give a general guide to the development and movement of rainfall, and can be used quantitatively as input to the WRIP forecasting system (see below). The Region would like to receive the 2 km grid data when it becomes available as a standard Met Office service. The radar network gives good coverage over the Region with stations located on the Lizard in Cornwall, Mid-Devon, Dorset and Wales.

The regional telemetry system is known as SCOPE-3, which was originally developed in 1988/89. There are currently approximately 400 outstation sites, the majority of which are for flood warning and flood defence. Although the system continues to perform, it is based on dated technology (both software and hardware), has limited graphics and is difficult to manage and update. Servelec continues to maintain the software, but this is becoming more expensive because of its age.

In order to determine future strategy the Region has produced its own Flood Warning Level of Service Study. This is driving the programme of installing new telemetry and river and raingauges.

There is an ongoing three-year programme to renew the telemetry system in conjunction with Anglian Region. The new system, currently being specified and procured as a joint project with Anglian Region (SWANTEL), will take advantage of recent developments in communication and display technology to provide improved functionality, display mimics and system management support tools.

Most of the gauges in Devon and Cornwall are currently set to local datums. In North and South Wessex some are to Ordnance Datum.

With the existing SCOPE system daily polling of outstations is at 06:00 GMT. During an event polling will be hourly or more frequent. Pre-defined polling rosters can be set-up. Information may be displayed by a variety of mimics.

When a pre-determined trigger level is reached on site, an alarm is initiated and displayed on screen in the Regional Monitoring and Forecasting Room with a beeping and flashing until accepted. This is to ensure nothing is missed. Monitoring and Forecasting Duty Officers manage the alarms. All alarms come first to the RCC which in South West Region is combined with the Monitoring and Forecasting Room. The RCC is manned 24 hours and identifies appropriate duty staff according to the nature of the alarm. Some alarms may be for pollution etc. All Flood Warning alarms are passed to the MFDO.

Procedures are in place to ensure that alarms are acknowledged following appropriate action being undertaken by the MFDO. SCOPE is effective in providing an audit trail of alarms so that it is possible to look back at times when alarms were acknowledged etc. This feature will be

retained and extended in SWANTEL. Since the SCOPE user interface operates in the DOS operating system, it tends to be used on stand-alone rather than Agency harmonised PCs.

It is noted that most alarms are on levels rather than on flows. Both level and flow values are archived. Not all gauge sites have associated warning levels. The archive facility in SCOPE has in the past been poor for retrieval of data after 100 days. A transfer procedure is now in place for the transfer of data from SCOPE to HYDROLOG, however the system will not be fully satisfactory until SWANTEL is in place.

The telemetry outstations are maintained by the South West Regional Telemetry Service which is part of CIS. The expansion of the system and the routine maintenance of the sites is managed by the Regional Flood Warning Team. This arrangement works well.

Fluvial monitoring includes an assessment of catchment wetness index (CWI). Several catchments are very sensitive to antecedent conditions. For example, with a CWI greater than 140, even 20 mm of rain may cause flooding problems.

Monitoring of a developing high tide situation for parts of the Dorset coast can be critical and there can be difficulties in providing adequate warning lead time.

Forecasting Systems and Procedures

The forecasting model (suite) used in the South West is the Weather Radar Information Processing System (WRIP). This integrates radar and telemetered rainfall and level/flow gauging. WRIP has been developed by the University of Bristol who supplies maintenance, support, and development in conjunction with a third party contractor.

The system covers the whole of the Region. Calibrated models are now available for 11 catchments. Wessex is well developed, but in Devon and Cornwall there are only three model sites so far. Within the WRIP package rainfall-runoff models are of the Physically Realisable Transfer Function (PRTF) type. These models can utilise both raingauge and radar data to provide the forecasting. Calibration is currently based on raingauge data. The radar inputs are from Nimrod and thus allow forecasts up to six hours ahead. Manual intervention is possible to try out different scenarios at the start of an event, and models are typically run weekly outside of events. Work is ongoing to integrate catchment wetness into the models. The system allows the addition of new PRTF models for new locations, but cannot easily incorporate different types of models. At present a routing model for the Bristol Avon is being evaluated within WRIP.

The Region is in the process of producing peak level to peak level correlation plots for all catchments where the gauge network allows. Together with time of travel plots these relationships will join the suite of available forecasting tools. It is intended that they will be used to support WRIP modelling. Other empirical methods are also being investigated to support the forecasting service.

It is intended that WRIP will remain the Region's primary forecasting platform until the National Flow Forecasting and Modelling System Strategy clarifies the future direction of a national specification.

Warning Systems and Procedures

A set of four fluvial warning procedures are utilised, one for each Area. A corresponding set of tidal warning procedures are available. These detail the threshold levels at which warnings should be issued. The procedures give all information about each catchment with warning facilities. Data on what happens during the recession of a flood is being introduced to the procedures and is proving useful.

The target for high tide warnings is to give a six-hour lead-time. This should be flexible to reach recipients at suitable times, e.g. within office hours / in time for evening news etc. A two hour lead time is the target for most fluvial warnings.

The flood warning manuals give procedures for different predicted tide levels at different places with different weather (winds etc.) and gives outline details of defence type and operational response etc.

Ideally the Region aims to issue tidal flood watches and warnings to Local Authorities etc. at times when they will be able to act on them, i.e. 09:00 to 17:00 Monday to Friday. The aim is to get any warnings to Local Authorities by Friday afternoon if high tides were predicted over the weekend.

The Region has taken the lead on the development of Major Incident Plans (MIPs) for Local Authorities where the LA have deemed it important to have such a plan. These have been introduced to cover densely populated areas with defences which are in the low risk and high consequence category. When the process of developing MIPs started in 1999, it was expected that maybe five towns in the Region would qualify. However MIPs have proved very popular with Local Authorities, and now there are some 50 such plans.

The Region has tried with mixed success to restrict MIPs to places with many at-risk properties and a reasonable lead time. Ideally there needs to be four to six hours lead time for an MIP to be set up to warn successfully, however this is not always possible.

The MIP documents include flood risk maps. MIP packs are available containing instructions for the Agency Staff going to the Major Incident Local Control Room including leaflets ready to be given out to residents in the MIP areas.

MIPs became operational in spring 1999. Four were triggered in Autumn 2000, although the long-term average was expected to be around one per year. There is also a pre-MIP warning level to provide advance warning to selected professional partners. In Autumn 2000 this was reached in the case of 10 plans.

There is ongoing work to improve existing MIPs by better identifying flood risk areas, clarifying the response to be provided, improving lead times, and refining the criteria for initiating the plans. Within MIP areas the primary warning method generally uses loudhailers.

South West, like all Regions, uses the AVM as its primary method for issuing direct warnings. From 11 September 2001 there will be five AVM machines, one in each of Cornwall, Devon, South Wessex and North Wessex Area Offices, and one in the Regional Office. Each machine will hold the full Regional database of recipients and messages, and

thus will be able to act as backup to the others. Messages for the Floodline RMS will also be recorded from the Area Offices.

The AVM fax facility is used for issuing warnings to Professional Partners. The machines all have 24 of their lines dedicated to voice messages and the other six to faxes. The Region uses an off-line database to maintain the AVM database. This makes access easier and allows the creation of additional fields for other information.

Of the 81 000 properties at risk in the Region the AVM provides the primary warning to the 2500 most frequently flooded. A further 35 000 are covered by MIPs, and the others are warned via the media. The Region intends to introduce a systematic method for increasing the number of recipients on the AVM database. This is based on the national guidelines using the risk assessment matrix box.

AVM messages are sent out in parallel with floodline being updated. AVM warnings are reissued if levels drop then go back up again even if the warning has not been officially downgraded.

The annual update of the AVM database is carried out by telephoning all those on the database to check that details are correct. This task usually requires two temporary staff working for approximately one month. This direct contact is also used to check on flooding problems which recipients may have encountered and has been found to be effective. Additions to the AVM lists are invited during direct visits to at-risk properties.

Within the Region 70% of at-risk locations are covered by approximately 200 designated Flood Warning Areas. Not all of these Areas have a direct warning service at present. The Region is moving to increase the number who do receive direct warnings. The Area Offices are investigating the wider use of warden schemes as the community involvement aspect is seen as essential. Warden schemes are not however being considered as primary warning methods.

Within the Region there are a few warning schemes using sirens.

The Region places a strong emphasis on pro-active public relations. This has included undertaking a large number of radio and TV interviews, during as well as after events. The prime benefit of such a pro-active policy is that it allows the Agency to clearly state the current situation and thereby raise public awareness and also to reinforce positive aspects of the Agency's operational response.

Post Event Reporting Systems and Procedures

With the use of the AVM for issue of warnings, event referencing is less of an issue than with the system previously used. Defining events in terms of their duration in time is expected to be adequate.

The four Area Flood Warning Procedures document all threshold levels for all warnings. This is a key document since it holds this source data.

A regional annual flood report is produced. In addition to this specific reports for individual or groups of major events are also produced.

Operational Performance Measures (OPM) giving details of flood statistics are reported to the Agency HQ at Bristol.

South West has developed an Event Reporting Database. This was originally developed by South West and North East Regions in Access and was circulated to all Regions. It is not known how much it is used elsewhere. This allows statistics on historic events to be abstracted in a number of different formats.

This post event database is being set-up to abstract information from the AVM to create post event statistics. The database will be updated electronically from the AVM. As an off-line database it will enable the maintenance of information to be carried out more easily and with more flexibility than is available working within the AVM itself. It will also allow additional fields of information to be stored, including lead times.

Documentation, Training, Rosters and Technology

Duty Officers for the Regional team responsible for monitoring and forecasting are drawn mainly from the Water Resources, Flood Defence and Capital Works functions. There are 36 people on the duty rosters. They work in teams of three; a Duty Officer and two assistants (one technical and one administration).

There is a Devon and Cornwall roster and a Wessex (North and South) roster. Staff are on duty one week in six, with Thursday as the change-over day. The frequency is considered to be about right. If less frequent then things are forgotten, if more then it becomes onerous. Rosters are issued six months ahead.

The user manuals and troubleshooting guides for all systems are kept next to the appropriate machine or equipment. There are effective document control (QA) systems.

Approximately every six weeks there is a Monitoring and Forecasting Duty Officers' meeting chaired by the Regional Flood Warning Officer. The Areas are to instigate similar meetings for the Area Flood Warning Duty Officers. Each MFDO produces a weekly report, which is distributed to all concerned in the regional flood warning process. Again the process will be repeated in the Areas for the FWDOs. There is a debrief after major events.

In Area Offices tide-watch duties are carried out by Area Teams. In the Areas there is an Operations Duty Officer (ODO), primarily responsible for operation of FD schemes.

At present the guidelines for opening Area Incident Rooms or the Regional Flood Forecasting Room are not definitive. Although warnings can be issued from home, there is an expectation that the Area Incident Room will be opened in time to issue any warning. The RCC has a full database of staff on duty and contact details, it does however rely on telephone and pager connections. Most phone calls come into the RCC who passes them on to the FWDO. There is a dedicated number for LAs, police etc. for direct contact with the FWDO.

Monitoring and Forecasting and Flood Warning Duty Officers have a checklist of both routine and operational duties to make sure they don't miss anything. This is very useful. All calls to the RCC direct lines are taped. A rolling log of actions taken is kept.

In order to allow staff on rosters to attend promptly when necessary they are generally required to live within 30 minutes of their office. However this is proving difficult to achieve in some areas.

There will be a dedicated line for the Regional MFDO to contact the Area FWDO. This will ensure contact at critical times.

Despite the movement of warning duties to the Areas, the Region has retained a reporting role and responsibility for public relations. During events the Regional Office will co-ordinate dealings with the media and will collate information from the Areas.

Duty Officer meetings are held every six weeks and are important for discussing operational issues. A programme of training for both Monitoring and Forecasting and Warning and Dissemination Staff has been undertaken as part of the transfer to CNFDR organisation. This has involved flood warning familiarisation, systems and scenario training, plus an internal exercise. The Region is keen to continue a programme of formalised training and will be developing this.

A suite of Met Office training programmes is being fully supported in the Region in line with National guidelines. It is expected that future training will be linked with the new 'Incident Management Competencies'. It is planned that both Regional and Area teams will continue to undertake group site visits for familiarisation with warning areas.

A7 Wales Region

Office Locations, Responsibilities and Liaison

At present both forecasting and warning are carried out from the three Area Offices. For South East the Area Office is in Cardiff, with Monmouth available as backup. In South West the Area Office is at Haverfordwest with offices also at Lampeter, Coychurch and Crosshands. In the North the Area Office is in Bangor with offices also at Buckley and Bala.

It is recognised that CNFDR has recommended that all Regions move to a standard pattern of Regional Forecasting and Area warning, but it is considered that this will be difficult to implement successfully in Wales in the short term. A draft migration plan for moving to the recommended structure has been prepared with a six-to-seven-year implementation time-scale. The Regional Flood Warning Officer has responsibility for this.

The two Southern Areas report a shortage of Agency staff in almost all aspects of the forecasting and warning process. This could cause significant problems in a prolonged event. In particular the Flood Warning function does not have its own dedicated hydrologist in any of the three Areas. A hydrologist from the Water Resource function has to be paid for. At any time there are seven forecasters on duty in Wales, two in each of South East Area and South West Area, and three in North Area.

There is an overall shortage of staff to collect data during and after a flood event. This has resulted in much potentially useful data being unrecorded, such as actual freeboard on flood alleviation schemes during events, which would be invaluable for future forecasting. The Region is moving towards the staffing set-up recommended in CNFDR, however full compliance will not be achieved until the responsibility for forecasting has been moved to the regional office.

It is apparent that in Wales, the Local Authorities, like the Agency, are short of staff to respond to flood events. There are no Agency Major Flood Incident Plans in South Wales. A plan for North Wales is currently being prepared as a pilot (Flood Defence Emergency Response Plan). There is an annual forum meeting of emergency planning officers in North Wales. The LAs have their own Flood Plans to which the Agency contributes. In the urban areas flooding often results from blockage of culverts on non-main rivers.

Tidal forecasting for the North Area is provided by North West Region for the north coast and by Wales South West Area for the west coast.

The Wales Region has more complicated reporting responsibilities than the other seven Regions, since it is accountable politically to the National Assembly of Wales (NAW). The political boundaries of Wales do not coincide with the Agency's catchment boundaries. The major disparity is that a large area of the Upper River Severn catchment is within the Welsh national boundary. Thus although the forecasting and warning responsibility for this area lie with the Agency's Midlands Region via its Upper Severn Area office at Shrewsbury, Wales Region is required to report on the area to the National Assembly. This requires close co-operation with Midlands Region.

There are also implications for such matters as the setting of High Level Targets where the NAW seeks a one-hour minimum lead time for warnings as against two hours for the Agency generally.

At Risk Properties, Catchment and Event Types

The indicative floodplain maps have been integrated with the “Address Point” database to produce a list of at-risk properties. The results indicate 14 200 properties in the South West and 53 000 in the South East. Of these some 10 000 are within the 79 (18 tidal, 61 fluvial) designated flood warning areas in the South West; and 32 000 are within the 80 (8 tidal, 72 fluvial) designated flood warning areas in the South East. These flood warning areas were defined in the early 1970s.

In the North Area the indicative floodplain contains approximately 29 400 properties in tidal areas and 8000 in fluvial areas. There are 2300 properties within identified fluvial flood warning zones.

The catchment types can be categorised by Area. In the North Area the land is mainly agricultural. Catchment types vary from the high mountainous areas of Snowdonia and the Upper Dee Valley, to the low-lying floodplains of Cheshire. The North Wales coast is vulnerable to tidal flooding. The catchments in the North Area have typically high rainfall with a very rapid response. A rise in water level of a metre in four hours is not uncommon. Rivers may rise and fall within 24 hours. Duty Officers are therefore set up to work from home.

The exception to the above is the Lower Dee where the wide flat Cheshire floodplain means that there is a slower response but water levels can remain high for a number of days. The Dee is unusual in that the flood warning system is part of a river regulation scheme covering flood defences, high and low flow management, fisheries etc. and is managed on a 365 days a year basis.

The South East Area comprises a mixture of semi-rural and urban catchments. The valleys and river catchments of Rumney, Ebbw and Llwyd are typical of South Wales, being steep, narrow and heavily urbanised. In contrast the Usk catchments encompass the mainly agricultural Black Mountains and the towns of Abergavenny and Brecon. The tidal flood warning service in this Area extends from the Wye Estuary through the Caldecot levels in the Bristol Channel to the Usk Estuary and Wentlooge Levels.

In the South West Area principal catchments include the Eastern and Western Cleddau catchments as well as the catchment areas of the Rivers Loughor and Tawe. Catchment types can vary from the industrialised Loughor and Tawe catchments to the mainly rural steep forestry catchments of the River Teifi. The catchments of the Rivers Neath, Afan, Kenfig and Ogmore are generally steep sided valleys with fast flowing rivers. The North Ceredigion and Pembrokeshire coastlines are covered by flood warning schemes and wave overtopping is a problem.

Monitoring Systems and Procedures

All Areas receive the standard Met Office forecasts on a regular basis in accordance with the National Weather Services Agreement. A five-day forecast is received by all Duty Officers by

email. Direct communication with the Senior Forecaster is also available to discuss conditions in detail. This has been particularly useful because of the difficult forecasting conditions.

Over a six-month period to the end of 2001 North Area will be receiving forecasts from the Cardiff Weather Centre as well as the Manchester Weather Centre. At the end of this run-in period the aim is to abandon the contract with the Manchester Weather Centre, so that there is one point of contact with the Met Office for the Wales Region, using the Cardiff Weather Centre. Formerly a contract was set up by North Area with Manchester Weather Centre for Heavy Rainfall Warnings for both Snowdonia and the Dee catchment. These are sent to all Flood Warning Centres within the North Area.

Rainfall gauges will often measure heavy rainfall without the Met Office issuing a heavy rain warning. The situation arises where the Agency is alerting the Met Office to heavy rain. The North Area has set up its own criteria for Heavy Rainfall Warnings with the Met Office.

The North Area receives tidal forecasts/warning from North West Region (who uses some tide gauges within Wales e.g. Llandudno). Tidal forecasts for Cardigan Bay are passed to North Area from Haverfordwest.

In all three Areas Microradar provides weather information (specifically rainfall intensity). Data is obtained from the Met Office and displays are installed in all Flood Warning Centres. In addition Bangor has satellite images available using a system called Meteosat. This runs on a stand-alone PC. It is not supported by the Met Office but gives a general outlook of weather patterns with a greater range than the radar. It is used purely for backup if Microradar fails.

The Region recognises the potential value of radar in providing forecasts of rainfall, however its use at present in Wales is limited for a number of reasons. Nimrod data are received in South Wales, but not displayed. It is considered that its accuracy in Wales is poor and that it is not well calibrated. There is a problem with the orientation of the existing radar stations for picking up the movement of rainfall in the Welsh valleys that are generally aligned north to south.

Weather systems pick up moisture from the Irish Sea, which is not always shown by radar. Orographic enhancement is particularly severe over the Welsh mountains, which again means that radar under-predicts rainfall. North Area is considering obtaining radar data from the Republic of Ireland (Dublin radar) to give better advance warnings of weather systems.

In both Southern Areas there are ongoing programmes to install additional short period raingauges and river level gauges, all with associated telemetry. The impetus for the extension of the networks is the recommendations of the Easter Floods Action.

The river gauges currently being installed are all level-only installations and are being installed in accordance with the Anglian Region model. Many existing river gauges were originally installed for water resource purposes and were set up to gauge low flows only. Converting them to gauge flood flows is now largely complete.

There are currently approximately 300 gauges with telemetry in the Wales Region. Of these approximately 200 are for river level/flow monitoring, eight are for tidal monitoring and 78 for rainfall monitoring. The older installations are of the DTS type, the newer ones are Dynamic Logic.

The existing regional telemetry management system is slow. The existing 100 sites in each Area are interrogated one at a time and each takes some 45 seconds. This results in over one hour being required to download all data. The problem is being addressed via the joint telemetry project underway in conjunction with Midlands and Thames Regions. This new state-of-the-art system is expected to be operational by January 2003.

The existing system provides the Flood Warning Duty Officer with river and rainfall alarms. ODIN (telemetry display software platform) is used in all Flood Warning Centres and laptops. The software provides access to real-time water levels and enables the Monitor/Forecaster to plot and disseminate warnings appropriately.

In order to address the problem of monitoring water levels during an event at protected sites the use of CCTV cameras is being considered. These could be utilised to observe sites such as the River Taff in Cardiff. This would involve co-operation with the Local Authority who own the cameras, and the police, who monitor them. The use of web-cams as an alternative to CCTV is also being considered.

Forecasting Systems and Procedures

The implementation of the JTP is discussed above. However, even when this system is in place, Wales will not be able to make efficient use of the data received for forecasting purposes until new forecasting systems are decided on. This matter is addressed by the scoping study for National Flood Forecasting Modelling Systems which has been carried out by Parsons Brinckerhoff. This study is now moving to the feasibility stage but will take up to seven years to implement. In addition WS Atkins is undertaking a national tidal forecasting project.

Under the system recommended for future forecasting in Wales there will be a single “open shell” model, which will incorporate both fluvial and tidal forecasting elements.

In the North Area forecasting is characterised by the use of judgement by a number of experienced forecasters with a long record of forecasting on these rivers. Forecasting on the Dee has been characterised by the building up of experience since the 1950s for operating rules for Bala Lake and other flood control structures. Bala office now has facilities to control some of the structures that it operates using laptops via modems.

A band rather than a single value is used for triggering warnings. When a water level reaches the lower bound of the band it alerts the forecaster to the possible need to issue a warning. As the level rises through the band the forecaster judges when and whether a warning should be issued. The warning should be issued before the indicator reaches the top of the band.

The Dee had a real-time flow forecasting model developed in 1976 but this is not now used as it was found to be less useful than the current operating procedures.

Telemetered raingauges are generally used for forecasting, backed up with water level to flow correlations and trend plotting. Alarms are triggered by water levels.

The principal technique used for forecasting in the South East Area is based on trigger levels. For example potential flooding in Cardiff is forecast when the level of the River Taff in Pontypridd, some 15 km upstream of Cardiff, reaches a certain trigger level. This can give just half an hour warning to Cardiff.

The main difficulty in applying the trigger level forecasts is the uncertainty in threshold levels for flooding. This is particularly a problem in the many areas where flood alleviation schemes have been constructed following the major floods of 1979.

In the South West Area there are rainfall-runoff models available for forecasting on some 50% of the catchments. These are used, but in many cases are known to require re-calibration to improve accuracy. However there is no time or resources available at present to carry out re-calibrations.

A forecasting and warning service is provided on all major rivers throughout the Region. Not all Main Rivers are covered due to lack of available lead-time.

In 1999 the Environment Agency Wales Flood Warning Strategy was published, and approved, in amended form, by the National Assembly for Wales in September 2000. This sets out how the Agency in Wales intends to achieve the various targets from the Agency's "Flood Warning Service Strategy for England and Wales", and the Agency's "Response to the Independent Report on the Easter 1998 Floods (The Easter Floods Action Plan)". It included the implementation of ten projects over the next five years to ensure improvements to the flood warning service within Wales as follows:

- Flood Warning Code Change Project – Complete
- Public Awareness Project
- Hydrometrics Improvements Project
- Joint Telemetry Replacement Project
- Tidal Flood Forecasting Improvements Project
- Fluvial Flood Forecasting Improvements Project
- Weather Radar Project
- Flood Warning and Emergency Response Information System (FERIS) Project
- Coverage Project
- Changing Needs of Flood Defence Project (Migration to Regional Forecasting).

Warning Systems and Procedures

In the North warnings are mainly aimed at alerting farmers to flooding of agricultural land. There are also a number of towns and villages targeted for warnings, for example St Asaph on the Clwyd, Llanrwst on the Conwy and Bala, Bangor on Dee and Corwen on the Dee. A good relationship has been developed with the "frequent flooders" who are mainly farmers.

Of 2300 properties identified within the North's fluvial flood warning zones, 1400 are actual recipients requiring the flood warning service. In total there are 2200 telephone contacts on the AVM database (many recipients have two telephone contact numbers). Tidal warnings are only disseminated to Local Authorities, Emergency Services, Utilities, and Media via AVM and fax. There may be a move to issue tidal warnings directly to at-risk properties; this is being looked at nationally.

Two new Flood Warning Areas have been added to the service since last year on the River Alyn (about 800 to 900 properties) and River Clwyd at Ruthin (under 300 properties). These were set up following flooding in the year 2000. A coverage project is being undertaken from the Regional Office to review the extent of the service. North Area has previously considered it to

be uneconomic to greatly expand the service, however the events of Autumn 2000 have demonstrated the need for this position to be reassessed.

Area Partnership Schemes have been set up in two Flood Warning Areas bringing together the Agency, the local authority and community members. This includes the setting up of Flood Wardens and activities to involve the local community. For example a calendar is being produced with a local school within the floodplain which contains all the Floodline information, Flood Warning Codes etc.. The aim is to have a very targeted approach to the partnership involving those in the community at flood risk rather than a more general flood awareness campaign.

Updating of the AVM is provided by a Flood Warning Team member. Annual questionnaires and letters are sent out to all recipients within the flood warning area. A reminder is then sent. A response rate of over 50% is achieved and the aim is to improve on this. Visits are also made to flood risk sites to discuss any questions relating to the warning service. Some people had been put off because they thought they had to pay for the service.

All those on the AVM are contacted directly to discuss the service. In addition all those given as second contact numbers are contacted to make them fully aware of the service provided. There is a feeling that there has been a background of being poorly resourced that has hampered expansion of the warning service.

AVM messages are given out in English and Welsh with alternate sentences in each language.

Trigger levels for the Dee are set up to start flood control measures rather than simply warnings. Because Gwynedd and Elwy catchments are so rainfall dominated the rivers can still be low when warnings are issued.

There is a generator so the AVM can still be run if mains power fails. A backup of the North AVM list is held in the Cardiff and Haverfordwest offices. As of September 2000 all faxes are sent using the AVM.

Radio and TV stations are faxed with flood warnings. Local radio stations are generally reasonable in issuing warnings depending on timing and other news etc. There have been meetings with local radio to try to ensure that warnings are broadcast. The general agreement is that Severe Flood Warnings will be broadcast immediately, with Flood Watches and Flood Warnings given out with the next scheduled news bulletin.

Teletext (HTV and Granada) is used. Warnings are sent via the Regional Duty Officer. Cardiff office is faxed with each warning issued and on opening and closure of the Flood Incident Room.

Loudspeaker vans are available and are included in Flood Warning Plans. Floodline messages are prepared in both Welsh and English.

In the South Areas the AVM system is considered to be an excellent system for warning and despite recent increase in the number of contacts still has capacity for further expansion. It is particularly effective in warning regular flooders, mainly farmers, who are experienced in its use. One farmer is even reported to have included the floodcall number on his "family and friends" scheme.

In the South West Area the AVM lists were made up by Agency staff visiting every property in flood warning areas. Householders were asked to sign to accept or sign to decline the service. There are now 50% of at-risk properties warned by AVM. An earlier mailing campaign achieved only a 4% response. Each year all recipients are telephoned to confirm details. This takes three people working full-time for three weeks.

The number of recipients is 3500 in the South West Area and 1250 in the South East Area; this includes multiple numbers for the same address. In the South East Area the Agency inherited lists of properties when it took over responsibility for warning from the police. New Agency staff appointed in 1999 have developed a strategy for offering the flood warning service to a number of additional flood warning areas.

In the South East Area the message is given out in English only. In the South West Area the message is given out in both English and Welsh. This restricts the amount of information that can be given out within the limited message length. There are several disadvantages of having too long an AVM message, not least that the call cannot be cut off by replacing the receiver, thus delaying the use of the phone for other messages. The AVM machines all use 30 phone and six fax lines. Their maximum capacity is 800 messages per hour.

The AVM is used for faxes. It would be preferable to add real-time information, e.g. times of peaks, to the faxes but this is not done because of short lead times and the unsuitability of AVM for real-time editing. Surefax is now only used for the distribution of messages within the Agency itself.

There are three address databases. The indicative floodplain envelope addresses, the flood warning area envelope addresses, and the AVM recipient addresses.

In Flood Warning Areas not covered by AVM the principal method of warning is via vehicle mounted loudhailers. The areas involved are generally those with high population density and low risk of flooding. For example there are 8000 such properties in Cardiff City. There are 24 demountable loudhailers available for use in the South East and South West Areas.

There are no existing siren systems in use in the South West or South East Areas. The potential for using sirens as a backup method of warning is recognised. There are two specific locations in the South West Area where the use of sirens is being actively considered because of the particular nature of their flooding problems.

The Vale of Glamorgan comprises a number of predominantly chalk catchments with short dendritic rivers. After extended wet periods groundwater storage is filled and reaction to rainfall becomes very fast. The Agency is looking to provide direct warnings triggered by river levels as there is no time for forecasting. The triggers would set off sirens and flashing warning signs. Piezometers have been considered to monitor groundwater levels, but are not being progressed due to lack of correlation with actual flooding.

Carmarthen is the second area where direct warning with sirens and/or flashing signs is proposed. This is an area with houses at particular risk of rapid onset deep flooding. It is known that the South West Region has direct warning schemes in place at Polperro, Allerford and Bossington. It is thought that experience from these places could be usefully studied.

When the Agency (then NRA) inherited the flood warning responsibility from the police in 1996 there were a number of Flood Warden schemes, particularly in the South East Area. Unfortunately almost all of these schemes have since been discontinued due to their poor performance. Following the major flood event of October 1998 there were a large number of complaints of messages not being effectively passed on. In many areas the increasingly mobile nature of the population has made continuance of the schemes unfeasible. In areas where warden systems have been discontinued the residents have been offered an AVM service.

The most effective medium for dissemination of warnings is local radio. BBC Wales gives good co-operation. There is a lot of public interest in flooding because of the high proportion of rural and farming communities. Warnings are put on teletext but its effectiveness is difficult to monitor and would appear to be marginal.

All residents in flood warning areas were sent the "Floodline Pack" during the National campaign in October 1999. In the South West Area all living in flood warning areas are contacted each year with information on the warning service supplied to them. In the South East Area only those on the AVM lists are contacted.

Post Event Reporting Systems and Procedures

The February 2000 report by Matthew Kean on collection of flood event data, although still in draft form, is being incorporated into the regional procedures. South West Area is developing a system of data collection based on the report's recommendations. Term consultants are to be used to supplement Agency staff after severe events to collect data and incorporate it into FPI.

Aerial survey has proved very valuable in assessing flood extents but it is essential that experienced staff are on hand to guide the pilots to the areas of concern.

In the North Area procedures are contained in the Monitor/Forecaster Flood Warning Procedures. A duty report is kept by forecasters detailing rainfall/level gauge information, summary of incidents and alerts issued, plots of levels against trigger bands etc. The summary of alerts details date, time, and level of warnings and stand-downs plus AVM details etc. A monthly summary is kept of all warnings issued. Flood incident reports are compiled by the Areas for all but minor events.

The National Incident Reporting System (NIRS) is being set up and has begun to be implemented.

North Area considers that there is a need for a Regional call-handling centre and a standard database for logging events, warnings issued etc.

Documentation, Training, Rosters and Technology

In the South East and South West Areas documentation is seen as a most important aspect, but it is very time consuming to keep all documents up-to-date. Particular effort is put into recording performance of schemes, relating levels to risk, and assessing trigger levels. Procedure documents are written in a form such that the forecasting and warning procedures can be carried out by staff with a minimum of training, without reference outside of the procedures themselves. Documentation is designed to be robust and to provide an auditable trail

of actions. This has been found to be particularly useful post-event in clarifying claims about what was and was not done.

Local flood warning plans are available for all warning areas in accordance with the ministerial directive. These are not used in real-time.

All the Area Incident Rooms are arranged to allow effective operations. There are large wall maps (1: 25000) showing the Area with all details significant to the forecasting and warning operations. The Region is considering the possibility of projecting geographical information from its GIS databases to complement or even replace the maps.

There is a board listing all flood warning areas with provision for displaying warning status, either flood watch, flood warning, severe flood warning or all-clear. A particular feature is that the area data are printed and may be updated from computer file, as a paper printout with the "write-on" cover being removable perspex. This allows the flood warning area to be updated or extended as necessary without the need to produce a complete new board. Other white boards display the tidal information, and current maintenance work in progress on rivers.

The South West Area Incident Room is open full-time and used for general monitoring and forecasting duties. In the South East Area the Incident Room is only opened during an event. There is a separate room immediately adjacent to the Incident Room for the dissemination of warnings. This holds the AVM equipment, separate fax machines, a facility for recording floodcall messages and mobile loudhailer units.

Staffing and organisation is as set out in the Regional Incident Procedures (RIPs). For the three Areas there are 15 rosters of duty officers for flood defence and water resources. All officers are on duty for a week with the change-over day being Wednesday in most places. The number of officers on each roster is shown in brackets. Monitoring, forecasting and warning are undertaken by rosters in each Area.

South East Area: Wye/Usk District	-	(8)
East Valleys District	-	(8)

South West Area: East Roster (5)	(10)
West Roster (5)	

North Area (including Neptune coastal/tidal)	
Dee District	(4)
Gwynedd District	(5)
Elwy District	(4)

At present the Regional Office does not make use of non flood defence staff on rosters. In all Area Offices staff from Water Resources are used, and in the South East Area staff from Fisheries also.

In North Area a Gauging Duty Officer is on the roster who co-ordinates gauging teams working in the field.

In the South Areas full scale internal exercises have been undertaken to test procedures. All duty staff have been provided with training in Flood Defence Law.

The flood warning duty officer is able to access all data available on the telemetry system via a link to a PC or laptop at home. The AVM can be operated from home, although in practice this is only done for flood watches to a particular area on the River Wye, which is frequently flooded. For all other circumstances the Area Incident Rooms are always opened.

Each time a Duty Officer takes over, a “Current Situation Pack” is handed on with tide tables, states of gauges, and other timely information. Although this takes time, it is considered to be an essential procedure to ensure continuity.

Rosters are for 4, 5 or 6 weeks depending on the number of staff available for each role, with a Wednesday changeover. Staff are drawn from Flood Defence and Water Resources. Forecasters will pre-warn the disseminator if it appears that an event is developing.

There is a strong emphasis on teamwork. There are close links between Forecasters, Disseminators and Operations staff. The North Area has also concentrated efforts on getting staff on the ground to disseminate, report back conditions etc. The Area has also concentrated on liaison and establishing good relationships with Local Authorities.

Operations staff collect data on the ground for incident reports. On the Dee there is a person responsible for all aspects of the Dee scheme (flow and water level management, flood control etc). This multifunctional continuous role has benefits in managing and being able to respond to a range of incidents on the Dee. Staff are local to catchments so any move to centralise would be difficult.

If the Duty Officer judges during office hours that a flood event could develop out of office hours, a pre-meeting is held in office hours to see who is available to be called up if an event develops. Lists of volunteers who can be called up are kept.

A8 North West Region

Office Locations, Responsibilities and Liaison

The Region is divided into three Areas: North, with Area Office in Penrith; Central with Area Office in Preston; and South, with Area Office in Birchwood. All forecasting is carried out at the Regional Office at Richard Fairclough House, Warrington. All warnings are issued from the Areas (AVM, Floodline, teletext etc.), including warnings to LAs, police utilities etc. which are issued by fax and phone. The responsibility for the latter was moved from the Regional Office in compliance with CNFDR during 2000.

County Emergency Planning Units (multi-agency organisations) have prepared Flood Response Plans in conjunction with Local Authorities and the Agency. These stem from the Flood Defence Emergency Response project arising out of the Easter Flood Actions. The Plans cover the whole of each County with general Major Incident Procedures, but concentrate on the 26 Flood Warning Areas. In a major event the police will set up an Incident Room and request a liaison officer from the Agency. The Agency has been encouraging Local Authorities to prepare Flood Plans for Flood Warning Areas. There has been a mixed response from Local Authorities depending on such issues as resources and perceived risk. For example, some Councils have been pro-active in developing their Flood Plans, whilst others remain sceptical.

The Agency is required by DEFRA to aid in the preparation of Flood Plans by High Level Target 3. This involves an audit and reporting procedure. However clarification of the audit role is being sought.

North West Region has developed good relationships with Local Authorities. This has largely been achieved by visits on a one-to-one basis with main drainage staff/emergency planning officers. Though time consuming it has proved useful and resulted in improvements that have been seen in practice. Local authority staff have also been invited to meetings in Area Incident Rooms to gain an appreciation of the Agency's work.

There are joint debriefs after major events with Local Authorities, police etc. There are annual meetings at County level of the Flood Warning Emergency Response Planning Groups.

At Risk Properties, Catchment and Event Types

Catchments in the North West Region are typically flashy with rapid response and recession. There are thus short warning lead times, with rapid mobilisation in a matter of hours being essential. In addition some areas are heavily urbanised, such as Greater Manchester, which exacerbates the problem. Catchments are numerous but relatively small, so unlike say the Trent or the Severn, it is not possible to build up large forecasting networks. The Region has a long coastline (765 km) affected by storms and surges with about 172 km of tidal and coastal flood defences. The main defences are along the Lancashire coast which is protected to approximately a 100 year standard. In this area breaches are the main concern.

Each Area Incident Room is typically open 15 to 20 times a year. This is a similar figure to that prior to the Warning Code change. However the AIRs are probably open for longer durations during events for early monitoring and issuing of Flood Watches. It therefore gets very busy with a high level of activity at Area offices. Regional staff went to Areas during the October 1998 floods to help.

Monitoring Systems and Procedures

The current network of rain and river gauges is being expanded in accordance with Action 16 of the Easter Flood Actions. It is in the final year of a three-year programme. Most of the Action 16 gauges have been level gauges. Though flow gauges are an important element of the telemetry network they have often been less suitable than level gauges for forecasting and using as trigger levels for issuing warnings. This has been either owing to the lack of a high flow rating curve or because the gauge has been designed for low flow monitoring. There is an ongoing project to review forecasting needs. It is intended that once these needs have been identified a targeted programme for developing the monitoring network can be prepared.

Gauges have used radio in the past for telemetry but have recently been converted to fixed telecom lines.

The Northern Telemetry System (NTS) was successfully implemented in August 2000 to replace the 20-year old River Communications System (RCS). The forecasting and warning teams have been very impressed with the functionality of the system. The user interface of NTS was developed in-house to ensure displays show what staff want. There is an NTS Users Group, which is a forum for ideas to modify and develop the system. It is hoped that this will ensure ownership of the system as well as improving and keeping it up-to-date with forecasting and warning needs.

The FWDO has access to NTS both at Area and from home via modem.

Under NTS the gauging sites are polled at 07:00 hours and 15:00 hours. If any rainfall gauge alarm is triggered all stations will be automatically polled. If any river gauge alarm is triggered all gauges within that catchment are automatically polled. A range of different poll options can be carried out automatically but the system aims to poll only those gauges within the affected catchment. This avoids unnecessary polling which runs down batteries. The Forecasting Officer decides what further polling is required, for example, polling of adjacent catchments. The North East Region makes use of rainfall data from the North West Region via the shared NTS to aid forecasting.

NTS is set up to flash up alarms at standby levels to alert staff at different stages of the warning process. The standby level may for example be used to alert staff to prepare to issue a Flood Watch on a particular reach.

Trigger levels have not changed significantly following the Warning Code change. Some have been changed as a result of lessons learnt from the Autumn 2000 floods. A review of trigger levels is planned.

The procedure for handling an alarm out of office hours is for the RCC to alert the MFDO who alerts the FWDO. It is the responsibility of the FWDO to acknowledge receipt of the alarm on the NTS. In this way the alarm "loop" is closed.

Radar data are obtained from the Met Office and are received in various forms: Nimrod (actual and forecast) at 30-minute intervals; raw data (actual and forecast, cleaned up) at 15-minute intervals; from Hameldon Hill, Lancashire (nearest radar, actual) at five-minute intervals. These are displayed in the Regional Forecasting Room and in the Area Incident Room. The radar display is now accessed using an integrated display within NTS (using a web browser).

Formerly a stand-alone display was needed. Met Office Weather forecasts and gale warnings are also used.

The North West Region is undertaking a pilot study to display radar data (actuals) in GIS format using a system called Enviromet. The project is being undertaken in collaboration with the Met Office and will report back to the NFWC. It will feed into the National Weather Radar Strategy. Enviromet will display background GIS maps and actual rainfall accumulation. There may also be the potential for forecasting. Ultimately the system may be able to trigger alarms, though it is not yet clear whether this will be practical.

Coverage from Hameldon Hill is generally good, though Scottish radar is used for parts of the Cumbrian Area. Even when both radars are used, coverage in Cumbria is poor. Accuracy problems can arise in radar predictions for Cumbria as some locations are in a rain shadow whilst others suffer orographic enhancement (clouds rising over the fells result in more rain than shown on radar).

The internet is used to display a general satellite picture of the UK, which gives a general weather view for the day. The sites are used qualitatively as a forecasting aid. Good internet sites have been found to be those of the University of Ulm in Germany and the University of Nottingham. These are considered to be better than the BBC or Met Office sites.

Weather forecasts are received daily from the Met office each morning, and are placed on an intranet bulletin board. Forecasts are five-day forecasts and three-day rainfall totals. The MFDO has a daily conference with a senior forecaster at the Manchester Weather Centre at about 16:00 hours. This has proved very useful and has further developed good relations with the Met Office. The North West Region pays for an on-call consultancy service from the Met Office allowing calls to the Manchester Weather Centre as needed. Heavy rainfall warnings are received from the Met Office for 15 catchments using pre-set triggers defined by the Agency. Thunderstorm and gale warnings are also received. MORECS soil moisture data is received weekly.

Severe Weather Warnings are received from Bracknell. However the North West Region has experienced problems with the consistency and accuracy of the SWWs. It is understood that this issue is being addressed nationally.

Tide table predictions are obtained from POL on disk annually which are fed into the telemetry system. Surge predictions are received from POL twice daily, by fax and in digital format directly into the NTS, giving surge predictions 36 hours in advance. Tide gauges at four locations are monitored: Heysham, Fleetwood, Workington and Gladstone Dock, Liverpool. Gladstone Dock is used as a trigger level. The gauges also measure wind speed and direction. The surge predictions cover each of the four gauges.

Forecasting Systems and Procedures

The forecasting systems currently used are:

- WRIP originally developed by Salford University (as also used in the South West Region). This is a software platform for rainfall-runoff transfer function models using data from both radar and raingauges.
- Correlation forecasts (level to level) within NTS.

- Trend plotting of levels.
- Real-time hydrodynamic modelling – a real-time ISIS model of the River Eden has been developed and is currently being rolled out to MFDOs.
- TRITON, a tidal forecasting system using matrices based on off-line wave transforms and over-topping models (SWAN and AMAZON).

A forecasting strategy is being developed leading on from the National Forecasting Strategy. A new integrated forecasting system is programmed for implementation within the next two years. The forecasting strategy will address tidal as well as fluvial forecasting. WS Atkins has just carried out a user-requirement survey in order to prepare a brief for the strategy.

North West Region is reviewing how it communicates forecasts. A forecast log has been introduced to improve the audit trail. It is also looking at the content of forecasts to address issues such as whether to include the degree of confidence in the forecast, and whether to forecast a single time and level, or to forecast a range of likely times and levels.

Thunderstorms can be a problem particularly in the urban areas around Manchester, for example. Forecasting would be difficult due to its localised nature but effort is being put into at least being aware that it is going on (by radar accumulation and GIS using Enviromet).

Tidal forecasting is carried out using NTS. All information arrives electronically apart from wind data. Thus surge predictions 36 hours in advance can be viewed against trigger levels. Waves are accounted for by different trigger levels e.g. a Flood Watch might be triggered either by a 5.5 m tide or by a 5.0 m tide with a force 8 wind.

The North West Region is just commencing a tidal forecasting project drawing on the work from the National Tidal Forecasting Project. The aim is to divide the coast into a number of Coastal Areas with more specific forecasting for each Area.

Warning Systems and Procedures

Warnings are concentrated on 25 fluvial Flood Warning Areas and one tidal Flood Warning Area. These are discrete locations such as towns or villages where there is known to be a fairly high density of properties at flood risk, and in some cases where it has not been possible to justify a flood improvement scheme on economic grounds. Examples of Flood Areas are Northwich, Carlisle, Diddesbury and Northernden and Appleby. In Carlisle, for example, there are 900 properties at risk and a Flood Warning may be issued on average about once a year.

Some Areas are high impact, low probability locations. Some Areas were introduced prior to the subsequent implementation of a flood improvement scheme and therefore the frequency of flooding may be less than in other areas that do not receive a warning.

The justification of which locations receive warning is being looked at in conjunction with Section 105 floodplain mapping using GIS to identify different risk levels (using the latest flood risk matrix). This aims to expand and target warning at high risk areas. All the at-risk areas have been identified and are currently being prioritised. North West has used a prioritisation system based on the Flood Defence Management Manual (FDMM) which uses a scoring system to prioritise flood warning expenditure based on a range of factors such as social, economic and urgency.

Since flood warning is concentrated in these Areas there is a good knowledge of the areas at risk. This has meant that a high proportion of the properties in an Area are covered by AVM, typically about 75%, though this varies considerably between Areas.

Over 9 000 properties are on AVM out of 13 000 within Flood Warning Areas. There are about 40 000 properties at risk from fluvial flooding and about 120 000 properties at risk from tidal/coastal flooding.

Direct tidal flood warnings are not given out. Instead an indirect warning is given for the whole coast. These warnings are issued to Local Authorities, police, utilities etc. The warning is based on a trigger level at Liverpool. Local Authorities then use their judgement to decide how it will affect their stretch of coastline and some have developed their own warning plans/procedures, for example Blackpool Borough Council has a plan involving warning by loudhailer and door-to-door contact. The Region is looking at the issue of coastal warnings and will move to a more targeted approach, resulting in a larger number of tidal Warning Areas.

AVM is issued at Area level and is the responsibility of the Flood Warning Duty Officer. There is an annual mail-shot to update the database. After the Autumn 2000 floods, a door-to-door campaign was carried out to add properties to the AVM. This resulted in a good response. Properties are left on the database unless they request removal. Public meetings are another way that people are added to the database. Each Area has a backup of the other Areas' AVM. The backup system has been successfully used in a flood event.

A new AVM system is in the process of being procured at a national level with a September 2002 roll-out planned. Greater automation of phone number/address collection and updating is proposed using web-based systems. There is an ongoing debate about whether the system should be opt-in or opt-out.

There is an aim to move away from blanket AVM in some areas of high density, low probability, and mobile populations such as Salford, which has high numbers of students and transient businesses.

Fax warnings are sent using the Surefax bureau. The fax message is compiled using a WORD macro where additional text can be added to standard text for each Warning Type/area/sub-area. The software for this is kept on the hard disk of the computer in case of network failure. Hard copies of all fax warning templates are kept and can be used if the computer system fails. Surefax fax back a status report of who has received the fax. One of the fax machines is also on Surefax's sending list so that the Agency can confirm that the correct message has been sent.

Warnings are sent to local media (radio stations, teletext, BBC, Granada, AA Roadwatch). There is variable interest (time of day, other news etc.) but it has been possible to build up a good relationship with some radio stations within an Area. North West has an ongoing programme of visiting television companies to set up and build up relationships. There are regular meetings with the PR Manager and an ongoing PR programme focused on flood warning.

Sirens are used in one location. Loudhailers are used as a secondary method of warning in many areas, particularly in areas of low AVM take-up. They are used as the primary warning method in one area (Salford).

Flood Warning Areas are sub-divided into parts that have differing trigger levels for warnings as the flood envelope expands.

The Region recognises the need to use the community more, possibly using Flood Wardens. It recognises the difficulty in developing community interest in urban areas with mobile populations.

It is essential that warnings are direct and targeted. It is suggested that public awareness could be increased by such measures as the Agency being listed in phone book under "Flooding".

Post Event Reporting Systems and Procedures

North West Region has found information gathering during and after an event a huge task. It is considering setting up an Information Officer role. The Information Officer would be responsible for collecting and collating information, during and immediately after an event, and in the long term.

An event management database is in the first stages of being developed to log phone calls, reports of flooding etc.

The Region considers that there are issues to be addressed concerning how to manage information, who is accountable for collection and how it is stored. Areas collect information on the ground for inclusion in reports. Generally there is good information collection due to presence on ground and good contacts with other authorities, police etc., in spite of the issues described above.

Documentation, Training, Rosters and Technology

The Regional Team consists of:

- the Regional Flood Warning Officer,
- two forecasting staff,
- three flood warning operations staff (procedures, warning, dissemination etc).

There are five staff on the Regional roster:

- Duty Strategic Manager (DSM)
- Two Monitoring and Forecasting Duty Officers (MFDO1 and MFDO2)
- Assistant Forecasting Duty Officer (AFDO)
- Assistant Monitoring Duty Officer (AMDO).

The DSM is a high-level multifunctional staff member drawn from the Regional Management Team. They are not involved in the management of an event but have a strategic and media role. The MFDOs carry out pro-active monitoring, monitoring alarms and decide when to open the Forecasting Room. They are drawn from Water Resources and the National Capital Programme Management Service. Positions on the teams are now advertised and there is a recruitment process. The aim is to appoint based on skills and competencies rather than it simply being assumed that certain staff will adopt those roles. Their position on the flood warning or

forecasting teams becomes part of their defined duties and there is recognition that this takes priority over their other duties.

In spite of the above there are still issues of how staff drafted into an event then catch up with their commitments on their day jobs during and after a large event.

The MFDO1 assumes the role of Regional Base Controller (RBC) but also has the responsibility for providing forecasts. A separate RBC is invoked for a large event. The MFDO2 also prepares forecasts. The AFDO assists in preparing forecasts and alarm handling.

At Area there are (on standby rosters):

- Flood Warning Duty Officer (FWDO)
- Two Assistant Flood Warning Duty Officers (AFWDO1 and AFWDO2)
- Operations Duty Officer (ODO)
- Regional Emergency Duty Officer (REDO).

The FWDO co-ordinates and is responsible for flood warning dissemination and initiation of operational response. The FWDO becomes the Area Based Controller (ABC) when the Area Incident Room is opened. As with the regional set-up, a separate ABC will be invoked when an event is large enough to require this. AFWD1 sends AVMS, fax warnings etc. AFWD2 provides administration support. The ODO is the focus for the operational response in the Area Incident Room. The REDO is drawn from the Emergency Work Force and co-ordinates the work of the ODO.

There is also a Site Controller who is mobile, supervising operational activities, visiting flooding incidents and reporting back to the Area Incident Room. There may be more than one Site Controller in a large event.

A second FWDO may be called in if a large event develops. It is likely that in some small Area Offices there may be problems finding staff available to fill both roles.

There is a long list of volunteers from other functions that can be called on for different tasks. In a typical event there is at least ten staff in the Area Flood Warning Office. During holiday periods, winter months and if bad weather is forecast, additional staff are put on standby.

Rosters are run on a seven week basis at Region and on a five-to-eight week basis at Area, depending on the number of staff at the Area office.

There is a quarterly meeting of MFDOs. There is a Tuesday morning hand-over session between Duty officers to go over current conditions and problems, and training in new systems, FWAs, etc.

The Hydrometric Section is within Water Resources. This has allowed the build-up of a good relationship with hydrometry staff, for example when commissioning new gauges. Hydrometry staff turn out on a “best endeavours” basis for gauging during flood events. A Service Level agreement between Flood Warning and the Hydrometric Unit is being developed for maintenance of agreed gauging sites. This identifies which sites are important for flood monitoring and what information FW are seeking from the site. A good relationship has

developed with the Hydrometric Section through working together as a team on Action 16 gauging stations.

Out of hours RCC staff handle alarms and pass to relevant Duty Officer, normally the MFDO, unless the alarm is an operational issue. The MFDO and FWDO increasingly work from home, particularly since the Warning Code change. NW Region will shortly be installing additional phone lines (data-quality lines using Home Highway) to Duty Officers' homes to give two fixed phone lines.

The FWDO aim to be in office in time to issue the first Flood Watch. In the case of tidal events the Incident Room will generally open six hours ahead of a high tide.

Agency staff from flood warning have been sent on courses in Emergency Planning run by the Home Office at their Emergency Planning College. Flood warning procedures are set out in a set of Flood Warning Manuals:

- MFDO Manual (Region)
- RBC Manual (Region)
- FWDO Manual (Area)
- ABC Manual (Area).

In addition an Operational Manual is being developed which will set out the procedures for the ODO, Site Controller and operational staff.

Any available County or Local Authority Flood Plans are held in the Area Incident Room. A review of MIPs is being undertaken to check that they cover and could in fact cope with major incidents, for example covering such aspects as access to and failure of operational sites, inter-Regional aid.

There are now inter-Regional aid procedures in place. Staff were sent to the North East Region during the Autumn 2000 floods. Staff were sent from a range of functions including Operations, Emergency Work Force, Flood Defence Engineers (for inspection of defences), Public Relations and Forecasting Duty Officers. It was noted that it may be difficult for the recipient Region to gain an overview of manpower requirements as an event develops. This can make it difficult to specify the numbers and types of staff required and when they are needed. It appears easier to send the recipient Region a list of available staff from which to choose who it would be useful to mobilise. It is suggested that it would be useful to prepare a list of staff and their skills so that a Region can respond quicker to a request for aid.

The new Agency standard National Incident Reporting System (NIRS) is being used post-event to record flooding incidents. However it is considered that the system is slanted towards discreet incidents e.g. a pollution incident at a defined location, and may be less suitable for recording flooding incidents.