NRA(96)12
Appendix 1.1(1)

NRA

ANGLIAN REGION TELEMETRY SYSTEM

REVISED STRATEGY FOR PHASES 2, 3 and 4

May 1995

(Version 1)

National Rivers Authority
Anglian Region

ANGLIAN REGION
TELEMETRY SYSTEM

REVISED STRATEGY
FOR PHASES 2, 3 and 4

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(Version 1)

DOCUMENT CONTROL SHEET

Project: **ANGLIAN REGION TELEMETRY SYSTEM**

Title: **REVISED STRATEGY FOR PHASES 2, 3 AND 4**

File Ref:

Document Approval and Amendment Record

Version No. 1

Status: Final

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Checked:

Approved:

Date: 15th May 1995

Purpose and Distribution:

(1) Supporting documentation for NRA SoD Approvals via the National IS PAB.
(2) Submission to MAFF for outline approval of the overall project.

Document History

Previous Version Number	Date	Comments
A to D	10/94 - 1/95	Drafts for consultation internally and with MAFF.
E	20/3/95	Final Draft for Quality Review.

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ANGLIAN REGION TELEMETRY SYSTEM
Revised Strategy for Phase 2, 3 and 4
(May 1995)

SUMMARY

Introduction

This document provides a strategic overview to the further development of the Anglian Region Telemetry System (ARTS). The key section is the business case, which will will be used by MAFF to appraise the overall project and which will underpin the Engineer's Reports / Project Initiation Documents for each phase.

The objective of the ARTS project is to provide an integrated telemetry and flow forecasting system to support all of the NRA's core functions. The business case concludes that this should be achieved by the development of a flow forecast modelling system and the installation of 223 additional outstations, including 26 which require the construction of new or improved gauging stations.

Background

The ARTS project began in 1992. The strategic plan involved 3 phases ;

Phase 1	Replacement of the existing outstation, communication and computing infrastructure.
Phase 2	The development of a flow forecasting system.
Phase 3	Additional outstations.

It aimed to rectify serious inadequacies in the region's telemetry capability, particularly in the areas of flood warning and flood control.

The entire project was approved (Form A value £6.25 million) by the NRA Board. The entire project was approved in outline by MAFF, with full approval for Phase 1 to allow grant in aid.

Phase 1 is now virtually complete and has successfully replaced the outstation, communication and computing infrastructure. Detailed planning for Phases 2 and 3 has been carried out.

Revised Requirements

In the last two years requirements have been re-evaluated in the light of operational experience. Major floods in the Winters of 1992/93 and 1993/94 exposed inadequacies in certain areas. In particular, more outstations are needed, and some of them will require significant civil engineering works. A detailed design study for the flow forecasting system has revealed that the development cost will be more than originally envisaged. The net effect of all of these changes is a substantial increase in the scope and cost of the work encompassed by the ARTS project.

This report details the revised proposals for Phases 2 and 3 and adds a fourth phase to deal with the newly identified requirement for additional flow gauging stations.

The overall approach to seeking approval for this project has been prescribed by MAFF. Plans are initially presented as part of the **Strategy** in order to obtain **outline approval. Detailed plans** for component phases are presented later in **Engineer's Reports** which seek approval for grant aid and **full approval** to commit expenditure. This report presents the overall strategy.

A similar approach is adopted to seeking NRA approvals under the Scheme of Delegation (SoD). Although the objectives and overall approach have not changed, in view of the increased scope and cost it is appropriate to seek internal NRA approvals by re-presenting the later phases as new projects. This document contains the business case for the overall project. This will underpin the **Project Initiation Documents** for each phase which will seek full approval to commit expenditure.

The Business Case

The objective of the ARTS project is to provide an integrated telemetry and flow forecasting system to support all of the NRA's core functions. A specific objective of Phases 2,3 & 4 is to provide a cost effective flood warning service to all property which is known to be at risk of flooding from main river.

Eight options have been evaluated as summarised in the Tables S1 ansd S2.

Considerable work has been undertaken to refine the cost estimates of the project since the original approvals were granted in 1992. As the scope of the project has increased the costs have increased.

In order to be consistent with previous work the assessment of benefits has not changed from those approved in 1992, other than to update them to the same base date as the costs (September 1994).

There remains a very strong economic case for progressing the work. The economic appraisal is summarised in Table S3.

Table S1.
The Relationship Between the Eight Options

Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
		H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7

Table S2
The Options to be Considered

Option	Description
Option 0	**Do Nothing** Abandon the existing telemetry system and stop the provision of a flood warning service in Anglian Region. (This option is included in accordance with MAFF Project Appraisal Guidelines).
Option 1	**Do minimum.** Retain the existing telemetry facilities, but no further development would be undertaken.
Option 2	**Modelling only - High and medium priority sites** Develop a flow forecast modelling system for high and medium priority forecast points only, and only where it is possible to do so using data from outstations which have already been installed.
Option 3	**Modelling only - All sites** Develop a flow forecast modelling system for all priorities of forecast points, but only where it is possible to do so using data from outstations which have already been installed.
Option 4	**Modelling and additional outstations - High and Medium priority sites only** (1) develop a flow forecast modelling system for high and medium priority forecast points only, where it is possible to do so using data from outstations which have already been installed and from 197 additional outstations. and (2) install the 197 high and medium priority additional outstations which do not require the construction of a new gauging station.
Option 5	**Modelling and additional outstations - All sites** (1) develop a flow forecast modelling system for all priorities of forecast points, where it is possible to do so using data from outstations which have already been installed and from 232 additional outstations. and (2) install the 232 high, medium and low priority additional outstations which do not require the construction of a new gauging station.
Option 6	**Modelling, additional outstations and additional gauging stations - High and medium priority sites only.** (1) develop a flow forecast modelling system for high and medium priority forecast points only, where it is possible to do so using data from outstations which have already been installed and from 223 additional outstations. and (2) install the 223 high and medium priority additional outstations, including 26 which require the construction of a new gauging station.
Option 7	**Modelling, additional outstations and additional gauging stations - All sites** (1) develop a flow forecast modelling system for all forecast points. and (2) install all 263 high, medium and low priority additional outstations, including 31 which require the construction of a new gauging station.

Table S3
The Costs and Benefits of all Options (£ million)

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
PV Costs	0.00	5.57	7.39	7.60	10.72	11.39	12.34	13.49
PV Flood Damage	164.9	131.6	127.9	127.7	123.9	123.4	122.2	121.7
PV Flood Damage Avoided		33.3	37.0	37.1	41.0	41.4	42.6	43.2
PV Other Quantified losses	19.7	10.0	8.0	7.9	4.9	4.3	4.4	3.7
PV Other losses avoided		9.7	11.7	11.7	14.7	15.3	15.3	16.0
PV Benefits	0.00	42.98	48.68	48.88	55.73	56.75	57.88	59.18
Net Present Value	0.00	37.41	41.29	41.28	45.01	45.36	45.54	45.69
Ave Benefit : Cost ratio		7.7	6.6	6.4	5.2	5.0	4.7	4.4
Incremental Benefit : Cost Ratio (wrt. to the previous option)			3.1	0.9	2.2	1.5	1.2	1.1
Incremental Benefit : Cost Ratio (wrt. to the equivalent sub option of the previous phase)			3.1 wrt. 1	2.9 wrt 1	2.1 wrt 2	2.1 wrt 3	1.3 wrt 4	1.2 wrt 5

The preferred option is option 6 with a total present value cost of £12.3 million. The present value of the quantified benefits are £57.9 million, giving a benefit : cost ratio of 4.7. This is the least cost option which meets the objectives of the project.

Options 0 and 1 are rejected because they would not improve the existing inadequate flood warning system. Options 3, 5 and 7 (which include low priority sites) are rejected because they have lower benefit : cost ratios than the equivalent options 2, 4 and 6 (which include only high and medium priority sites). Option 2 and 4 are rejected because they would not provide cover for all property known to be at risk of flooding from main river.

Table S4 summarises the source of the increased capital expenditure compared to 1992. Capital costs have increased by £3.7 million.

Table S5 summarises the distribution of the capital costs (not discounted) to grant aidable and non grant aidable functions for the preferred option.

Table S4
Capital Costs

	Phase 1 (£m)	Phase 2 (£m)	Phase 3 (£m)	Phase 4 (£m)	Total (£m)
As approved in 1992	3.82	2.43		-	6.25
Revised 1995 (Option 6)	3.4	2.01	2.98	1.52	9.91

Table S5
Eligibility for Grant Aid (Option 6)

	Phase 2		Phase 3		Phase 4		Total	
Function	%	Cost (£m.)	%	Cost (£m.)	%	Cost (£m.)	%	Cost (£m.)
Design & Supervision		0.22		0.75		0.17	18	1.14
Contractors / Specialist Consultants		1.79		2.23		1.35		
Total		2.01		2.98		1.52		
Breakdown of Contractors / Specialist Consultants								
Grant Aidable								
Flood warning	60	1.07	37	0.83	51	0.69		
Flood Control	15	0.27	16	0.36	13	0.18		
Grant Aidable Sub-Total	75	1.34	53	1.18	64	0.86	52	3.38
Non Grant Aidable								
Flood Operations	10	0.18	28	0.63	17	0.23		
Water Resources	10	0.18	14	0.31	10	0.14		
Water Quality	5	0.09	5	0.11	9	0.12		
Non Grant Aidable Sub-Total	25	0.45	47	1.05	36	0.49	31	1.99
Sub-Total for C & SC	100	1.79	100	2.23	100	1.35		
Total							100	6.51

The Project Plan

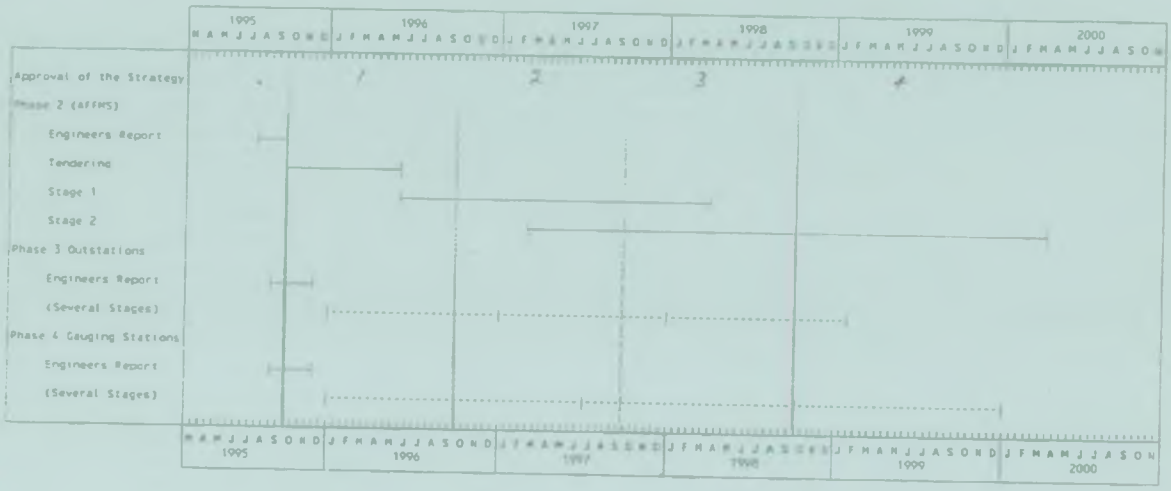
The preferred option would be implemented as three sub-projects (phases) of the overall ARTS project. This reflects the different nature of the work involved and the project management skills which would be required. All three phases would run in parallel (Figure S1).

The expenditure profile is shown in Table S6. The link between project years (Table S6) and the project plan (Figure S1) assumes that approval to work on the Project Initiation Documents is obtained by July 1995.

Table S6
Expenditure Profile

Year	Phase 1 Ongoing rev cost	Phase 2 (Modelling)		Phase 3 (addit. o/stations)		Phase 4 (add. gauging stns)		Total	
		Cap	Rev	Cap	Rev	Cap	Rev	Cap	Rev
1	0.756	0.180		1.339				1.519	0.756
2	0.756	0.900		1.339		0.684		2.923	0.756
3	0.756	0.525		0.298		0.684		1.507	0.756
4	0.756	0.405	0.041		0.119	0.152	0.061	0.557	0.977
5	0.756		0.041		0.119		0.061		0.977
6	0.756		0.041		0.119		0.061		0.977
7	0.756		0.041		0.119		0.061		0.977
8	0.756		0.041		0.119		0.061		0.977
9	0.756		0.041		0.119		0.061		0.977
10	0.756		0.041		0.119		0.061		0.977
Sub-Total	7.560	2.010	0.287	2.976	0.833	1.520	0.426	6.506	9.109
Total	7.560	2.297		3.809		1.946		15.615	
PV Total								12.343	

Figure S1
The Project Programme



1. INTRODUCTION

As early as 1990, Anglian Region identified severe inadequacies within their telemetry capability, particularly in the area of Flood Warning and Flood Control. The system inherited from the Water Authority on vesting did not provide the necessary facilities or functionality needed to operate within the NRA environment. The system was unreliable, resulting in high operating costs. Additional sites and facilities were required to fulfil operational obligations.

The Region therefore set out to determine requirements needed to achieve suitable operational standards. This was done via a user specification study conducted throughout 1991 and encompassing all functions of the Region. This specification was used as the basis for a strategic plan to develop a new telemetry system.

The strategic plan involved three phases. In 1992 the entire project was approved (Form A value £6.25 million) by the NRA Board. The entire project was approved in outline by MAFF, with full approval for Phase 1 to allow grant in aid.

Phase 1 is now virtually complete and has successfully replaced the outstation, communication and computing infrastructure. Detailed planning for Phases 2 and 3 has been carried out.

In the last two years requirements have been reevaluated in the light of operational experience. Major floods in the Winters of 1992/93 and 1993/94 exposed inadequacies in certain areas. In particular, more outstations are needed, and some of them will require significant civil engineering works. A detailed design study for the flow forecasting system has revealed that the development cost will be more than originally envisaged. The net effect of all of these changes is a substantial increase in the cost of the proposed work encompassed by the ARTS project.

MAFF have been informed of the additional requirements. They have asked for a Revised **Strategy** covering all (telemetry and engineering) expenditure related to flood forecasting and flood control. This document fulfils that role. If the strategy is approved, Engineers Reports will provide full detail on each component phase when applications are made for grant in aid.

Although the objectives and overall approach have not changed, in view of the increased scope and cost it is appropriate to seek internal NRA approvals for further development of the ARTS project as a new project. This report provides supporting documentation for consideration by the Regional and National IS Project Appraisal Boards, and by senior management as directed by the scheme of delegation. It contains the Business Case which will form the basis of the Project Initiation Documents for each component phase which will be submitted at a later date.

This report documents ;

- the original requirements
- the current position
- the revised requirements
- the business case for further work
- the project plan

2. THE ORIGINAL REQUIREMENTS

2.1 Objectives

The objectives of the ARTS project were ;

(a) To assist in achieving the Aims of the NRA ;

- To achieve a continuing improvement in the quality of rivers, estuaries and coastal waters through the control of water pollution.
- To assess, manage, plan and conserve water resources and to maintain and improve the quality of waterfor all those who use it.
- To provide effective defence for people and property against flooding from rivers and the sea.
- To provide adequate arrangements for flood forecasting and warning.
- To improve efficiency in the exercise of the NRA's functions.

(b) To allow improved response times when dealing with emergencies.

(c) To enable better utilisation of existing limited staff and other resources, particularly during flooding and pollution events.

(d) To reduce routine visits to site for routine data collection, checking on plant status and water levels.

(e) To improve day to day river management for navigation, fisheries, recreation and conservation due to enhanced knowledge of river levels, flows, structure status and water quality parameters.

(f) To enable early action in the event of operational malfunction and to provide data for the assessment of the need for assett replacement and improvement.

(g) To provide a framework to allow future advantage to be taken of advances in monitoring technology.

(h) To improve and update the existing telemetry hardware and software which is becoming outdated.

2.2 Project Structure

The project was originally viewed as a single entity spanning eight years, taking the Region to the year 2000. However, MAFF were unwilling to commit grant in aid on any project greater than 2 years in duration. As various components of the project would be implemented serially, the project was broken down into distinct phases.

Three phases were envisaged, neatly packaging the project at natural boundaries, these being;

Phase 1 Replacement of the existing outstation, communication and computing infrastructure.

Phase 2 Flow forecasting models.

Phase 3 Additional outstations.

The order of implementation was logical, as Phase 2 was seen as being dependant on a sound telemetry infrastructure and was in turn likely to clarify requirements for the additional outstations comprising Phase 3.

2.3 Phase 1 - Replacement of the existing infrastructure

Phase 1 is now virtually complete. A new telemetry system known as SCOPE-X has been provided by Servelec Ltd. The present position is summarised in section 3.1.

Approximately 70% of the 343 existing outstations were to be retained, thus maximising the investment already placed in telemetry within the Region.

2.4 Phase 2 - Flow Forecast Modelling System

Better flow forecasting facilities were seen as vital in order to provide adequate facilities for flood warning. However, the subject is technically complex, and there was little information on the likely cost. As part of the Phase 1 contract, a detailed design study was to be carried out to provide a firm indication of the requirements, effort involved and cost.

2.5 Phase 3 - Additional Outstations

In order to provide enough information for satisfactory operation of the Flow Forecasting System, it was recognised that further monitoring would be needed. Further sites would also be needed in order to improve both the efficiency and effectiveness of NRA operations in all functions.

The site requirement on which approval was based originated in a project which gained approval in 1990 (ref.1) and was incorporated into the overall ARTS project. Some 170 outstations were identified in this report. With MAFF approval the contents and recommendations of this report were taken on by the ARTS project to become Phase 3. The total number of outstations planned for the whole project was 670.

2.6 The original economic appraisal

An economic appraisal of Phases 1 to 3 was carried out by Sir William Halcrow and Partners in 1991 (ref.2). The analysis emphasised the interdependency of the three phases and assessed the combined costs and benefits in a single project. This approach underpinned the approvals which were gained in 1992.

Options which were considered included the replacement of the old system with 'like for like' or replacement with upgrading and expansion to take advantage of new technology. It was accepted that an enhanced system would realise a larger proportion of the potential benefits of telemetry. For example, it is estimated that the new system would realise 16% more (than the old system) of the potential benefits of operating a flood warning system. The marginal 16% is taken as the benefit to flood warning of enhancing the functionality (eg. flow forecasting) and adding more outstations. Similar calculations were made for flood control, water resources management and water quality monitoring. The marginal benefits were used to identify the preferred option.

When the economic appraisal was assessed by MAFF a number of adjustments were made (ref.3). In particular the benefits of flood control measures were significantly reduced. Table 1 summarises the present value (PV) of the benefits and costs (discounted for a life of 10 years) as approved by MAFF.

Table 1
Summary of the Business case as Approved by MAFF in 1992
(From Reference 3)

	Breakdown	Preferred Option (3b) £ million
Total Scheme	PV Absolute Benefits	45.84
	PV Costs	9.52
	Net Present Value	36.32
	Benefit : Cost Ratio	4.80
	PV Marginal Benefit (cf. Option 1b - see footnote)	13.53
	PV Marginal Costs	4.25
	Net Present Value	9.28
	Marginal Benefit : Cost Ratio	3.20
Flood Defence Element	PV Absolute Benefits	33.49
	PV Costs	4.31
	Net Present Value	29.18
	Benefit : Cost Ratio	7.80
	PV Marginal Benefit (cf. Option 1b - see footnote)	9.50
	PV Marginal Costs	1.92
	Net Present Value	7.58
	Marginal Benefit : Cost Ratio	4.90

Footnote

Option 1b was the 'Do Nothing' Option. This was to "Continue with the current System of 343 outstations for its remaining life, and then completely replace the hardware, retaining the outstations".

This is a different 'Do Nothing' option to the one now required by MAFF project appraisal guidelines and used in the business case for further work (section 5). Direct comparison is therefore not possible.

3. THE CURRENT POSITION

3.1 Phase 1 - Replacement of the Existing Infrastructure

The first phase of the project is now nearing completion. The central infrastructure was taken over after full system testing on 30th September 1994.

3.1.1 Handover from MC16

As part of the Phase 1 contract 100 new outstations have been supplied and installed. This has given an ability to test the system without interfering with the existing operational system (MC16). Sufficient existing outstation types (MicroMedina II and DTS TG1150's) have been added to prove their communication functionality and complete operation. The system is now ready to accept the outstations currently connected to the old system.

97 sites have been added to the telemetry system since 1991. The total at the end of Phase 1 is 540.

A migration strategy has been developed to assist in the transfer of outstations from the old MC16 system to the new SCOPE-X system. Transfer is scheduled for completion in June 1995. The maintenance of operational capabilities is paramount.

3.1.2 Staff Training

Any large computer based system requires considerable knowledge both in order to operate it and also to use it to best advantage. Considerable emphasis has been placed on training staff throughout the Region to conduct these activities.

Training has been successfully given to approximately 120 staff to date. Further training is scheduled for identified specialist users and access to training for new staff will be available on a continuous basis. The trainers are themselves Regional Information Systems staff who will maintain and develop the system in the future, thus ensuring close links between those who develop the system and those who use it.

3.2 Phase 2 - Flow Forecast Modelling System

A design study was supplied as part of Phase I by Servelec (ref.4) and the Institute of Hydrology (ref.5). It had originally been anticipated that permission would be sought to develop their proposals as Phase 2 of the ARTS project. However, several factors have led to a decision that a different approach is now required. Those factors are ;

Costs
The indicative price received from Servelec and IH was significantly higher than had been budgeted for.

Procurement rules
For contracts of this value it is now mandatory to seek competitive tenders following EC procurement rules.

Detailed requirements
In recent years there have been several major flooding incidents which have highlighted the need for additional flow forecasting capability. More detail is given in Table 2.

In anticipation of the need to seek approval for ARTS Phase 2, work has recently been carried out to review the requirements, options and costs. Consultants have been appointed to assist in this work. Their report (ref.6) forms the basis of the revised proposals which are outlined in section 4.2 and 5.2.

Limited flow forecasting facilities are available on the existing system. These 'transfer function' rainfall-runoff models run on very old computer hardware, cover a very small proportion of the region and have been used with only limited success.

3.3 Phase 3 - Additional Outstations

As part of the re-evaluation process and in conjunction with the Phase 2 review, the list of sites requiring telemetry has been re-examined. The original requirement based on the 1990 Appraisal has changed with time, and therefore has been re-evaluated and revised to suit the current need. This shows an overall increase in the number of outstations required both for forecasting and for operational purposes. Details are provided in section 4.3.

3.4 Newly identified civil engineering requirements

As part of the re-evaluation a requirement for additional river flow gauging stations has been identified. This requirement for major civil engineering works was not identified, costed or included in the original scheme.

3.5 Phase Interdependencies

Although divided into individual phases, the ARTS Project must be viewed as a whole in order to realise the full benefit. The later phases are all dependent on a sound infrastructure which has been provided as Phase 1. The flow forecasting models require data that will be provided as part of Phases 3 and 4.

Table 2
Recent Major Floods

Area	Description
River Great Ouse. September 1992.	Several locations suffered the worst flood in living memory. There was disruption to over 500 properties and industrial units. Levels in Newport Pagnell were only 60mm less than the 1947 level. Better telemetry and flood forecasting capability would have helped considerably, as illustrated by the following quotes from the Area Flood Report (ref. 7). • "Critisisms will be addressed against the Authority (and some already have) for failure to warn individual properties and some communities. At the same time the Authority is also open to critisism for 'crying wolf' in requesting a major incident situation at Bedford for a predicted river level, which ultimately created little property flooding". • "The flood warning systems for the Upper Great Ouse catchment, especially it's Bedford Ouse tributaries (ie. R.Ouzel, R.Flit, Alconbury Brook, R.Kym, Riseley Brook) need re-appraisal and improvement".
Welland & Nene September 1992	Rainfall with return periods between 1 in 45 and 1 in 120 years was widespread. Severe flooding of property was experienced in several villages (eg. Weedon, Kislingbury, Clipston, Geddington, Nether Heyford and Southwick). Better telemetry and flow forecasting facilities were recommended in the note of the flood washup meeting (ref 8) ; • "Improvements to the telemetry network are required.....additional flow outstations are required.....submit requirements ..... justification should be clear." • "...there are additional telemetered level recorder sites programmed for the Nene catchment and these should significantly improve the accuracy of forecasting ..... However, it is desirable to have a computerised operational hydraulic model of the river system and indeed for all the main catchments within Northern Area".
Linconshire. October 1993.	Flows with a return period greater than 1 in 40 years were widespread (ref.9). There was property flooding in the R.Bain valley at Horncastle, Kirkby on Bain and Conningsby, the E and W Fen Catchwater, the Barlings Eau, Middle and Market Rasen, Brigg, Louth and Covenham.
Norfolk and Suffolk October 1993.	Flows with a return period greater than 1 in 25 years were widespread. Better telemetry and flood forecasting capability would have helped considerably, as illustrated by the following quotes from the Area Flood Report (ref. 10). • "With only yellow level defined on the telemetry screens for Norfolk and Suffolk it is difficult to interpret data in the area incident room". • "Control room staff were in the dark in the early stages of the incident and learned more from watching local and national news reports". • "The telemetry system was out of action for several periods of time during the event, especially at catchment offices. It also required considerable effort at Area level to keep it updated. We are all reliant on the new system being far quicker and more reliable". • "With new telemetry due to come on line next year, an urgent review of sites needs to be carried out with additional sites to be identified and funded as soon as possible". • "The event has highlighted the need for additional fluvial telemetry information. Detailed appraisal needs to be carried out".

4. THE REVISED REQUIREMENTS

4.1 Introduction

The objectives and the overall approach of the ARTS project have not changed from those which were approved in 1992.

Detailed requirements have changed in the light of operational experience. They are described below in sections relating to ;

- Flow Forecast Modelling
- Additional outstations

4.2 Requirements for flow forecast modelling

4.2.1 Overview

The consultants Kennedy and Donkin Systems Control (KDSC) were employed to review the requirements, options and costs for the proposed regional flow forecast modelling system. This involved ;

- A fundamental re-evaluation of the locations, purposes and types of forecasts which are required.
- A business case to consider options for the geographical and technical scope of systems which could provide the necessary functionality, together with cost benefit analysis to identify the preferred option.
- Development of a project implementation plan.

The results are documented in the 'Draft Project Initiation Document' for the 'Anglian Flow Forecast Modelling System (AFFMS)' (ref.6) and form the basis of these proposals. (Note - The requirement for a PID for Phase 2 has been superseded by the decision to present all of the remaining phases of ARTS together as new project).

Flow forecasting is an essential element in many of the NRA's specific obligations under the Water Resources Act (1991), to provide services in the field of flood defence, flood warning and flood control, as well as the monitoring of water resources and water quality.

The NRA's Mission and Aims include an aim to "Provide adequate arrangemnts for flood warning and flood forecasting". Sections 3.2 and 4.2.2 demonstrate that arrangements in Anglian Region are not adeqaute.

The NRA's national Flood Defence Strategy places it's flood warning and operational role at the heart of its flood defence work and states that the NRA seeks to "encourage development of information technology and extension of facilities which will further improve the procedures for the warning of, and responding to, emergencies". It goes on to say that the NRA will "use the knowledge gained from existing sophisticated flood forecasting systems to raise the standards of all such systems, and continually review other technical developments to enhance flood forecasting and warning".

Flow forecasts are required for the full range of flows. At low to medium flows accurate forecasting is important to allow water resources management decisions to be made and assists in water quality management. At high flows the accuracy of forecasts determines the effectiveness of the flood warning system, and whether correct operational decisions are made. The benefits of the AFFMS project derive primarily from this improved real-time flood forecasting.

A flood warning system comprises of 3 components; information gathering, information appraisal and action. ARTS Phase 1 will soon provide Anglian Region with a telemetry system designed to deal with all aspects of data capture. The region also has good emergency procedures which specify what actions to take in order to provide flood warnings. However, the arrangements for flood forecasting, which provide the essential link between data capture and the issue of warnings are inadequate.

The arrangements are inadequate because (with some exceptions) they rely on simple empirical relationships between telemetered observations and flooding incidents. This approach is not able to provide the lead times, speed, precision or reliability offered by computer based forecasting systems. Limited facilities for rainfall-run-off modelling are available on the old regional telemetry system, but are not widely used due to a lack of confidence in their reliability. There are no facilities for real-time flow routing except those in the Lincoln Flood Alleviation model. The AFFMS project seeks to develop comprehensive region-wide flow forecasting models which will strengthen the current weak link in the flood warning system.

4.2.2 Flood Risk Zones

Fluvial Flood Risk Zones (FRZ) are defined as land or property for which a warning is (or should be) issued. They are listed in Appendix 1, giving details of the nature of flood risk and a high / medium / low prioritisation. Their locations are shown on Figure A1.1 (Appendix 1).

The definition of high, medium and low priority is given in Table 6. Table 3 summarises the numbers of flood risk zones classified by priority. (Note -There is considerable scope for inconsistencies between Areas in defining a FRZ. eg. To what extent should properties be grouped. Forecasting requirements are better indicated by Forecast Points, described below).

Table 4 shows that the new system is required in order to allow warnings to be issued for 249 new flood risk zones (an increase of 84%).

Table 3
Fluvial Flood Risk Zones Classified by Priority

Priority	N.Area	C.Area	E.Area	Total
High	104	81	151	336
Medium	26	17	68	111
Low	26	3	68	97
Total	156	101	287	544

Table 4
The Number of Current and Proposed Flood Risk Zones.

		N.Area	C.Area	E.Area	Total
1.	No. of FRZ for which warnings are currently issued	105	33	151	289
2.	No. of FRZ for which warnings will could be issued in the future without improved forecasting	0	5	1	6
3.	No. of FRZ for which the issue of warnings is dependant on improved forecasting	51	63	135	249
	Total	156	101	287	544

The Area forecasters were asked whether the forecasting technique used for each of the existing flood risk zones is adequate. In 88% of cases it is felt that they are not. In each case a reason was given, with a high level of commonality emerging. The most common reasons are ;

1. In many situations warnings are issued when a flow / level threshold is exceeded at a telemetry outstation. This is often inadequate because ;
   - When the telemetry site is close to the flood risk zone the site-site correlation may be good but the travel time is short. In order to issue a warning with adequate lead time the threshold is necessarily set low, resulting in many false alarms.

- When the telemetry site is some way upstream of the flood risk zone the travel time may be long enough to allow an adequate lead time, but the reliability of the site-site correlation is often poor. Inaccurate and unreliable forecasts result.
- A unique site-site correlation may not exist due to factors such as sluice / gate operation or variable backwater / tidal effects.

Flood forecasting models can overcome all of these problems, by forecasting flows at the telemetry site and/or routing flows downstream to the flood risk zone.

2. Telemetry data in the catchment upstream of the flood risk zone is inadequate. A model may not improve the situation unless additional telemetry is provided. In some cases construction or improvement of a monitoring site is also required.

3. The existing (Transfer Function) rainfall-runoff model is not sufficiently reliable.

4. The existing models require manual initiation and can only be run one at a time. (The proposed new system will automatically initiate model runs and alarm based on forecasts of threshold exceedances).

5. Flood storage reservoir /washland routing is not currently taken into account.

6. Facilities to run 'what if' scenarios are usually not available.

7. Warnings are currently issued manually. The proposed new system will incorporate fax transmission by computer.

In each case proposals have been made to rectify the inadequacy and these have been incorporated into Phases 2, 3 and 4.

4.2.3 Forecast Points

Warnings for one or more flood risk zone are issued when it is forecast that certain threshold conditions will be exceeded. These are commonly threshold flows or levels at one or more 'forecast point'. A fluvial forecast point is defined as a location within the flow forecasting model for which output is required. Forecasts of future levels and/or flows will be used to assess a situation as it develops, anticipate and then trigger the issue of a warning.

Fluvial forecast points are listed in Appendix 2 and summarised in Table 5. Their locations are shown on Figure A2.1 (Appendix 2).

Flow forecasts are required for purposes other than flood forecasting. Forecast points have been classified according to the priority of the flood risk zone(s) for which they provide information, or according to the importance of the purpose for which it is required. The classification scheme is summarised in Table 6.

Table 5
Fluvial Forecast Points Classified by Priority

Priority	N.Area	C.Area	E.Area	Total
High	192	99	154	445
Medium	47	19	48	114
Low	19	3	7	29
Total	258	121	209	584

Table 6
The Forecast Point Classification Scheme

Priority	Purpose
High	Flood warnings are issued for urban areas, groups of properties, Railtrack structures, major roads or fords
	Flow forecasts will improve the efficiency of operating major raw water transfer schemes.
Medium	Flood warnings are issued for isolated properties or agricultural land where damage mitigating action can be taken.
	Flow forecast will assist in the monitoring of minor raw water transfer schemes / river regulation.
Low	Flood warnings are issued for minor roads or agricultural land where no action can be taken.
	Flow forecasts will assist with licence enforcement, consent enforcement and catchment monitoring.

Area hydrologists have assessed what type of model is likely to be needed to provide adequate flood forecasting capabilities. The extent of hydrodynamic modelling requirements has a significant influence on the cost of model development.

The list of forecast points underpins the requirements which Phase 2 must endeavour to meet. Area requirements have been evaluated for regional consistency and rationalised following further consultation.

This comprehensive review from first principles has produced site specific requirements for model output which can be linked back to flood risk zones. The scope of the Phase 2 proposals and the impact on phases 3 and 4 are thus clearly defined.

4.2.4 The Modelling System

The prime requirement is to provide comprehensive, reliable and timely forecasts of the magnitude and timing of river levels, flows and/or risk levels.

The geographical scope considered in this PID is the NRA Anglian Region. However, flexibility for change, including change to the geographical scope, has been a major factor in planning the proposed Anglian Flow Forecast Modelling System (AFFMS).

The functional scope of AFFMS is the 'real-time' forecasting of fluvial and tidal flows in rivers at high and low levels, primarily for use in predicting imminent behaviour. Forecasting can be achieved through the use of snow melt models, rainfall runoff models utilising rainfall and flow data provided by the telemetry system plus real-time weather radar data. Flow routing, including hydrological or full hydrodynamic modelling is needed in many of the flat, regulated rivers of East Anglia.

'Off-line' models which are normally used as design tools may not be directly suitable for use within a real-time modelling system. Simulation and design modelling are therefore only within the scope of AFFMS where they can be performed by real-time models. The re-use of existing developments in off-line models is however seen as essential to the cost-effective development of AFFMS, and the project will be closely coordinated with other modelling work in the Anglian and other regions.

In the early planning stages for the AFFMS a User Requirements Specification was produced. Key points are summarised below. Much more detail, which would be incorporated into the system specification, is available in reference 11.

- The AFFMS should generate forecasts of river levels and flows at a number of specified points. These points, as currently planned are listed as forecast points in Appendix 2.

- Data required by the AFFMS will be obtained primarily from the telemetry system, weather radar, Met. Office forecasts, Storm Tide Warning Service forecasts and manually entered data.

- Where appropriate, the AFFMS should be designed to meet the NRA's targets for Emergency Response Levels of Service (ERLOS). Automatic performance monitoring should be built in.

- The AFFMS should be modular in that it must be able to use a range of real time hydrological forecasting models.

- Hydrodynamic models which are currently used for design purposes should be utilised within the AFFMS wherever possible. The rivers for which it is envisaged that hydrodynamic models will be required are listed in Table 7.

- The AFFMS must have sufficient flexibility to cope with operational and organisational changes. It must be able to accommodate input from more than one telemetry system in case the Anglian region should be merged or share facilities with another region.

Table 7
Rivers Requiring some Hydrodynamic Modelling

Name	Length (km) for diff priorities		
	High only	H+M	All
Current Models			
LFAM (U. Witham and Lincoln)	40	40	40
Lower Witham	75	100	100
Welland and Glen	90	90	90
Nene	135	135	135
Lower Great Ouse	210	210	210
Norfolk Broads	125	125	125
Outdated Models			
Woldgrift Drain	13	13	13
Ancholme	28	28	28
East and West Fen	12	30	30
East Halton Beck	0	13	13
Colne	8	8	8
No model			
South Forty Foot	28	28	28
Steeping	5	5	5
Louth Canal / Waithe Beck	5	5	5
Barrow Beck	5	5	5
Freshney	5	5	5
Middle Bedford Ouse	50	50	50
Upper Bedford Ouse	22	30	30
Heacham	8	8	8
Ingol	8	8	8
Nar	13	13	13
Gipping (Ipswich)	5	5	5
Canvey Island	5	5	5

- The system must be supplied by a sound, stable and experienced supplier who can demonstrate proven and robust software already in use at at least one other site.

- The AFFMS must be easy to use. As far as possible the user interface should have the same look and feel as the telemetry system.

- The system should operate as automatically as possible, but provide for manual interaction when appropriate.

- Facilities for the automatic generation of flood warnings should be provided, but they would not be transmitted without verification from an authorised officer.

4.3 Requirements for additional outstations

The original requirements for extra outstations were defined in May 1990 (ref.1). This list has been revised in the light of recent operational experience, particularly the severe flooding during the Winters of 1992/93 and 1993/94. The total number of outstations considered for this project has increased from 670 to 803. 540 already exist. The 263 proposed outstations are listed in Appendix 3 and summarised in Table 8.

The revised list has been compiled following detailed re-evaluation of Area requirements. The process of identifying sites where outstations will be needed for flow forecasting was described in section 4.2. Area and Catchment Flood Defence Engineers have also reevaluated their requirements for real time monitoring in the light of recent experience which exposed inadequacies in certain areas..

The proposed additional outstations have been classified as high, medium or low priority. They have been evaluated for regional consistency and rationalised following further consultation.

232 sites would require no more than minor engineering works to accommodate the outstation and instrumentation.

31 sites have been identified where new or replacement flow gauging stations are required. This is one of the principal causes of variation between the original cost estimates for ARTS and the new proposals. In 1992 no consideration was given to the need for additional river flow gauging.

Appendix 4 contains details of the requirements for additional river flow gauging stations.

Table 8
Requirements for additional outstations

Priority		Northern Area	Central Area	Eastern Area	Total
High	Not involving the construction of a new gauging station	101	12	39	152
	Involving the construction of a new gauging station	8	3	7	18
	Total	109	15	46	170
Medium	Not involving the construction of a new gauging station	20	9	16	45
	Involving the construction of a new gauging station	7	0	1	8
	Total	27	9	17	53
Low	Not involving the construction of a new gauging station	8	23	4	35
	Involving the construction of a new gauging station	5	0	0	5
	Total	13	23	4	40
All	Not involving the construction of a new gauging station	129	44	59	232
	Involving the construction of a new gauging station	20	3	8	31
	Total	149	47	67	263

5. THE BUSINESS CASE

5.1 Introduction

The Business Case is presented in accordance with guidelines contained in the NRA Project Management Procedures (PM1/PM/0001). The following steps are taken ;

- Definition of the objectives
- Definition of the Options
- Identification of the costs for each option
- Identification of the benefits for each option
- Consideration of the unquantified benefits
- Consideration of environmental factors
- Consideration of risks
- Evaluation of the options
- Consideration of eligibility for grant aid
- Reference to future developments

The basis of the business case is ;

1. Requirements and costs have been reviewed in considerable detail. The scope and hence the cost of the project have both increased since the original approvals were given in 1992.

2. The benefits as originally approved in 1992 have not been changed, other than to inflate to the same base date as the costs. In order for options to be compared it has been necesary to apportion the total benefits to the various components of the project.

It must be emphasised that the costs are (good) current best estimates. As the project progresses and more detailed planning is carried out they will be refined.

5.2 Objectives

The objectives of the ARTS Project (section 2.1) have not changed. Phase 1 has allowed considerable progres to be made towards achieving many of them, and this is reflected in the benefit calculations. The area where least progress has been made is in the improvement of flow forecasting facilities.

A specific objective of Phase 2 to 4 is to provide a cost effective flood warning service covering all property which is known to be at risk of flooding from main river.

5.3 Options

Three aspects of the project are particularly relevant when defining options. These are;

1. The nature of the work. ie. Is it necessary to both develop flow forecasting models and install new outstations?
2. The prioritisation of the work. ie. Is it necessary to develop the system for all of the high, medium and low priority sites?
3. A few of the proposed additional outstations involve the construction of new gauging stations. The cost will be much higher than for a site which requires only the instrumentation, electronics and minor accommodation works.

To reflect these factors three 'phases', each with two sub options, will be considered. The main distinction is between the nature of the work ;

Phase 2 The development of a flow forecast modelling system
Phase 3 The installation of those additional outstations which do not involve the construction of a gauging station.
Phase 4 The installation of those outstations which involve the construction of a gauging station.

Use of the term 'phases' does not imply sequential implementation. All three phases would be developed in parallel.

Sub-options within each phase allow for the inclusion of only high and medium priority sites or the inclusion of all sites. This distinction is based on the fact that high and medium priority sites are required in order to protect property (Table 6).

A total of eight options are therefore considered. Their relationship is summarised in Table 9 and they are described in more detail in Table 10.

Table 9
The relationship between the eight options

Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
		H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7

Table 10
The Options to be Considered

Option	Description
Option 0	**Do Nothing** Abandon the existing telemetry system and stop the provision of a flood warning service in Anglian Region. (This option is included in accordance with MAFF Project Appraisal Guidelines).
Option 1	**Do minimum.** Retain the existing telemetry facilities, but no further development would be undertaken.
Option 2	**Modelling only - High and medium priority sites** Develop a flow forecast modelling system for high and medium priority forecast points only, and only where it is possible to do so using data from outstations which have already been installed.
Option 3	**Modelling only - All sites** Develop a flow forecast modelling system for all priorities of forecast points, but only where it is possible to do so using data from outstations which have already been installed.
Option 4	**Modelling and additional outstations - High and Medium priority sites only** (1) develop a flow forecast modelling system for high and medium priority forecast points only, where it is possible to do so using data from outstations which have already been installed and from 197 additional outstations. and (2) install the 197 high and medium priority additional outstations which do not require the construction of a new gauging station.
Option 5	**Modelling and additional outstations - All sites** (1) develop a flow forecast modelling system for all priorities of forecast points, where it is possible to do so using data from outstations which have already been installed and from 232 additional outstations. and (2) install the 232 high, medium and low priority additional outstations which do not require the construction of a new gauging station.
Option 6	**Modelling, additional outstations and additional gauging stations - High and medium priority sites only.** (1) develop a flow forecast modelling system for high and medium priority forecast points only, where it is possible to do so using data from outstations which have already been installed and from 223 additional outstations. and (2) install the 223 high and medium priority additional outstations, including 26 which require the construction of a new gauging station.
Option 7	**Modelling, additional outstations and additional gauging stations - All sites** (1) develop a flow forecast modelling system for all forecast points. and (2) install all 263 high, medium and low priority additional outstations, including 31 which require the construction of a new gauging station.

5.4 Costs

5.4.1 Option 0. Do Nothing.

This is the baseline option. It is assumed that the costs are nil. (This is a conservative assumption as there could be costs associated with decommissioning the present system).

5.4.2 Option 1. Do Minimum.

The costs of continuing to operate the existing system have been estimated and are summarised in Table 11.

Table 11
The cost of continuing to operate the existing Telemetry and Flood Warning System.

	Cost (£ million) per year.
Telemetry incl. computer hardware & software maintenance, outstation maintenance, computer networking, PSTN and NRA Systems staff costs.	0.408
Communications incl. the costs of faxes, pagers and phones which are attributable to flood warning.	0.010
Met. Office costs incl weather forecasts and rain radar data.	0.107
Hydrology incl. the development / maintenance of flood forecasting facilities (data analysis and modelling) and flood warning procedures.	0.143
Duty Officers incl. Regional and Area staff.	0.009
Control Rooms incl. manning Regional and Area control rooms during flood events.	0.079
Total	0.756

These are the costs of operating and using the current ARTS system. It is assumed that they would apply to all of the development options. This assumes that the increased workload generated by the provision of an improved service will be balanced by savings due to improved efficiency and effectiveness. The extra costs of maintaining the enhancements developed by Phases 2-4 are considered later.

5.4.3 The Development Options

The costs for each option have been derived from separate analysis for each phase. This work is documented in reference 12 and reproduced here to an appropriate level of detail. The costs for each phase as they would apply as a component cost to each

option are detailed below, then summarised in Table 23.

5.4.3.1 *Development of the Flow Forecast Modelling System*

A detailed appraisal of options for developing a Flow Forecast Modelling System is documented in reference 13. That analysis is used as the basis for the costs presented here.

In all options the costs allow for ;

- The development of rainfall runoff and hydrological routing models.
- The adaption of design hydrodynamic models for real time use.
- The implementation and testing of models on a networked computer system.
- The training of staff in their use.
- Ongoing maintenance and support.

It would only be possible to model those catchments where telemetry data was adequate. The increasing cost of the modelling component in each option reflects the increasing extent of modelling as more outstations become available.

The implementation plan (more details in section 6) involves two stages. Stage 1 is the system specification, purchase, implementation and testing on a pilot area and take-on of existing rainfall runoff models. Stage 2 would extend the modelling to the rest of the region. The spend profile which has been used to calculate present value costs is shown in Table 12.

Table 13 shows the capital costs of the modelling component within each option. These costs are based on a quotation which was provided as part of ARTS Phase 1 by the telemetry supplier, Servelec Ltd, with the Institute of Hydrology as their subcontractor. Adjustments have been made to include items omitted, but also to reduce some costs due to the effects of competitive tendering. The differences between the options relate primarily to the calibration effort required for systems of differing geographical extent.

A more detailed breakdown of the capital costs for one of the options is shown in Table 14. Supporting information is contained in reference 6.

Ongoing revenue costs allow for computer hardware and software maintenance, modelling software maintenance and a system manager. It is estimated that these will total £41,000 pa. and it is assumed that these would apply to all of the development options, commencing in year 4.

The life of the system has been estimated to be seven years (from the completion of stage 1), 10 years in all. Although the system would continue to be operational after that time the conservative assumption has been made that it would have no residual value.

Table 12
Capital expenditure profile for the Flow Forecast Modelling System.

Year	Stage 1	Stage 2
1	15%	0%
2	75%	0%
3	10%	50%
4	0%	50%
Total	100%	100%

Table 13
Capital expenditure for the modelling component of each option

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Stage 1	0.000	0.000	1.200	1.200	1.200	1.200	1.200	1.200
Stage 2	0.000	0.000	0.686	0.949	0.767	0.894	0.809	0.945
Total	0.000	0.000	1.886	2.149	1.967	2.094	2.009	2.145
Present value	0.00	0.00	1.631	1.846	1.697	1.801	1.732	1.843

Table 14
A Breakdown of Capital Expenditure for the Flow Forecast Modelling System (Option 6)

Element	Cost (£ million)
Stage 1	
Computer Platforms	0.125
Model Development	0.215
Pilot Implementation	0.257
Testing	0.150
Ancillaries [Contract management (NRA / consultant / contractor), training and documentation, warranties].	0.237
Telemetry Interfacing	0.080
Engineer to the contract	0.083
NRA project management	0.051
Stage 1 total	1.198
Stage 2	
Data analysis	0.031
Data take-on	0.091
Model Calibration	0.465
Model Configuration	0.039
Training	0.048
Testing	0.009
Supervision	0.056
Contractor's contingency	0.018
NRA project management	0.054
Stage 2 total	0.812
Total	2.010
Present value	1.732

5.4.3.2 *The installation of Phase 3 outstations (those which do not require new gauging stations)*

The costs of all elements required to install Phase 3 sites are detailed in Table 15.

Table 15
Installation Costs for Phase 3 Sites

Element	Cost
Power	Where mains power is required a figure of **£6,000** has been used, based on the experience of Phase 1. It has been assumed that 15% of outstations will require mains power.
PSTN	NRA are currently in discussion with BT over what is regarded as 'served premises' (nominal charge of £150). It is likely that in future a charge of **£3200** per site will be used.
Systems	Costs cover installation of the outstation, connection to the instrumentation and external services, testing and configuration. A figure of **£5,500** has been used, except for water quality monitoring stations which require **£6,500**.
Civils	Costs cover : Accommodation £3,000 Stilling Well £3,000 Gravel & ducting for raingauges £ 600 Sites involving more complex works have been considered by the Engineering Dept on a site by site basis.
Instrumentation	Costs depend on the signal type(s) required. eg. Shaft encoder £ 650 Raingauge £ 600 Gate position £1200 Digital signals £ 350

Estimates have been made of the costs for each proposed new outstation. These are detailed in Appendix 3 and summarised in Table 16.

The capital spend profile is shown in Table 17. Outstations can be purchased quickly. The limiting factor is NRA staff to supervise their commissioning.

Table 18 shows the cost of the Phase 3 outstation component in each option.

Ongoing revenue costs for site maintenance have been estimated to be 4% of the capital cost from year 4 onwards.

Table 16
Capital Costs (£ million) of telemetry outstations in Phase 3

Priority	Lincoln	Welland and Nene	Great Ouse	Norfolk and Suffolk	Essex	Total
High and Medium	1.301	0.601	0.279	0.507	0.288	2.976
Low	0.138	0.000	0.332	0.034	0.010	0.514
Total	1.439	0.601	0.611	0.541	0.298	3.490

Table 17
Capital Spend profile for Phase 3 outstations (those not requiring major civil engineering works)

Year	Spend
1	45%
2	45%
3	10%
Total	100%

Table 18
Capital Expenditure for the Phase 3 Outstation Component of each Option

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Total	0.000	0	0	0	2.976	3.490	2.976	3.490
Present value	0.00	0	0	0	2.70	3.17	2.70	3.17

5.4.3.3 The Construction of new gauging stations at Phase 4 Sites

Estimates have been made of the costs for each proposed new gauging station. These are detailed in Appendix 4 and summarised in Table 19.

The capital spend profile is shown in Table 20.

Table 21 shows the cost of the Phase 4 gauging station component in each option.

Ongoing revenue costs for site maintenance have been estimated to be 4% of the capital cost from year 5 onwards.

Table 19
Capital Costs (£ million) of Flow Gauging Stations in Phase 4

Priority	Lincoln	Welland and Nene	Great Ouse	Norfolk and Suffolk	Essex	Total
High and Medium	0.608	0.385	0.099	0.239	0.189	1.521
Low	0.449	0.000	0.000	0.000	0.000	0.449
Total	1.057	0.385	0.099	0.239	0.189	1.970

Table 20
Capital Spend profile for Phase 4 gauging stations

Year	Spend
1	0%
2	45%
3	45%
4	10%
Total	100%

Table 21
Capital Expenditure for the Phase 4 Gauging Station Component of each Option

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Total	0	0	0	0	0	0	1.520	1.969
Present value	0	0	0	0	0	0	1.31	1.69

5.4.4 Total Costs for Each Option

The capital costs for each of the components (Tables 13, 18 and 21) are totalled in Table 22.

Table 22
Total Capital Expenditure for all Options

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Phase 1								
Phase 2 Modelling			1.886	2.149	1.967	2.094	2.010	2.145
Phase 3 Outstations					2.976	3.490	2.976	3.490
Phase 4 Gauging Stations							1.521	1.969
Total	0.000	0.000	1.886	2.149	4.943	5.584	6.506	7.604
Present value	0.000	0.000	1.63	1.85	4.40	4.97	5.742	6.70

The capital costs can be combined with the annual revenue expenditures to obtain the total cost for each option over a 10 year period. The results are tabulated in Table 23.

Table 23
Total Present Value Expenditure for all Options

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Phase 1 - Revenue	0.000	7.564	7.564	7.564	7.564	7.564	7.564	7.564
Phase 2 Modelling - Capital - Revenue			1.886 0.287	2.149 0.287	1.967 0.287	2.094 0.287	2.010 0.287	2.145 0.287
Phase 3 Outstations - Capital - Revenue					2.976 0.833	3.490 0.980	2.976 0.833	3.490 0.980
Phase 4 Gauging Stations - Capital - Revenue							1.520 0.426	1.969 0.546
Total	0.000	7.564	9.736	9.998	13.626	14.411	15.615	16.983
Present value	0.00	5.57	7.39	7.60	10.72	11.39	12.343	13.486

5.5 Quantified Benefits

5.5.1. Introduction

Phase 1 of the ARTS project was approved in 1992 on the basis of the economic appraisal carried out by Sir William Halcrow and Partners (ref.2) which is summarised in section 2.5. These calculations are still valid. It is proposed to **retain the benefits as previously approved**, with only minor changes to update in line with inflation.

In 1992 benefits were totalled for the ARTS project as an integrated whole. In order to consider the options for the revised strategy it has been necessary to apportion the benefits to the various components of the project. The Halcrows analysis has been reviewed and the same logic and data used to apportion the benefits to the different options (ref.12). The analysis is reported here to an appropriate level of detail.

5.5.2 General Considerations

In order to estimate the benefits of options which cover only parts of the total scope of the project, the number and priority of outstation sites has been used as the key indicator. In some functions (such as flood control) more specific measures have been used.

Table 24 shows the number of outstations added to the system within each phase of the development, categorised by site priority. The MC16 column refers to the

telemetry system which was replaced by ARTS and is only included to ensure that the apportioning rules used here are consistent with the 1992 economic appraisal.

Table 24
Numbers of Telemetry Sites in each Phase

Priority	MC 16	Phase 1	Phase 2		Phase 3		Phase 4		Total
			H & M	All	H & M	All	H & M	All	
Top	343	0	0	0	0	0	0	0	343
High	0	128	0	0	152	152	18	18	298
Medium	0	39	0	0	45	45	8	8	92
Low	0	30	0	0	0	35	0	5	70
Total	343	197	0	0	197	232	26	31	803

To apportion the benefits between the options it has been assumed that some of the benefits arise from the **monitoring** of sites in real time and some arise from the added value of **modelling** which provides forecasts. It is assumed that the benefits of monitoring are in proportion to the priority of the site, so site priority is used to weight the benefits attributable to each phase. Modelling, however, involves the integration of all available data, so weighting by site priority is not appropriate. The weightings to be applied to outstation priority are given in Table 25.

It is then estimated that (in general) outstations at flow gauging stations make a greater contribution to real time monitoring and flow forecasting than other types of site by a factor of 4. This is subjective, but felt to be very conservative.

Table 25
Outstation Priority Weighting Factors

Site Priority	Weighting for Monitoring	Weighting for Modelling
Top	1.5	1.0
High	1.0	1.0
Medium	0.8	1.0
Low	0.3	1.0
Gauging Stations	4.0	

If the numbers of outstations in Table 24 are accumulated, weighted by the factors from Table 25 and then apportioned to each phase, the proportion applicable to each option may be calculated. The results are shown in Table 26 and will be referred to in later sections when calculating the value of benefits attributable to the components of each option.

Table 26
The proportion of outstation points (priority weighted) associated with each option

Priority	MC 16	Phase 1	Phases 1 & 2		Phase 1, 2 & 3		Phase 1, 2, 3 & 4	
			H & M	All	H & M	All	H & M	All
Monitoring	0.738	0.832	0.832	0.832	0.936	0.942	0.991	1.000
Modelling	not used	not used	0.731	0.752	0.869	0.914	0.941	1.000

5.5.3 Flood Warning

The 1992 economic appraisal identified potential annual benefits from flood warning of £11.55 million. It concluded that the old MC16 system realised 24% of these benefits and forecast that the ARTS project would increase this to 40%.

A flood warning system depends upon both the monitoring of real time data and modelling in order to produce forecasts. In order to apportion the benefits attributable to flood warning between the different options it has been estimated that 75% of the benefit is due to monitoring and 25% is due to modelling. If these percentages are applied to the proportions in Table 26 the flood warning benefits (ranging from 0.24 to 0.40) may be distributed between each option as shown in Table 27.

Table 27
The Proportion of Flood Warning Benefits Attributable to each Option

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Priority	MC16	Phase 1	Phases 1+2		Phases 1+2+3		Phases 1+2=3+4	
			H & M	All	H & M	All	H & M	All
Monitoring Table 26 *75% *40%	0.221	0.250	0.250	0.250	0.281	0.283	0.297	0.300
Modelling Table 26 *25% *40%	0.019	0.019	0.073	0.075	0.087	0.091	0.094	0.100
Total	0.240	0.268	0.323	0.325	0.368	0.3749	0.391	0.40

When the £11.55 million is inflated to September 1994 prices the annual benefit attributable to flood warning becomes £12.35 million. The proportions in Table 27 are used to apportion this amount between the options. Present values are calculated by assuming that ;

1. The benefits in the first 2 years are just the benefits of Phase 1
2. The benefits of the development options apply to years 3 to 10.

The results of this calculation are shown in Table 28.

Table 28
Present Value Benefits of Flood Warning (£ million)

	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Year		Phase 1	Phases 1+2		Phases 1+2+3		Phases 1+2+3+4	
			H & M	All	H & M	All	H & M	All
1		3.310	3.310	3.310	3.310	3.310	3.310	3.310
2		3.310	3.310	3.310	3.310	3.310	3.310	3.310
3		3.310	3.989	4.014	4.545	4.630	4.829	4.940
4		3.310	3.989	4.014	4.545	4.630	4.829	4.940
5		3.310	2.989	4.014	4.545	4.630	4.829	4.940
6		3.310	2.989	4.014	4.545	4.630	4.829	4.940
7		3.310	2.989	4.014	4.545	4.630	4.829	4.940
8		3.310	2.989	4.014	4.545	4.630	4.829	4.940
9		3.310	2.989	4.014	4.545	4.630	4.829	4.940
10		1.848	2.228	4.014	4.545	4.630	4.829	4.940
Present Value	not used	24.369	28.089	28.231	31.170	31.598	32.777	33.370

5.5.4 Flood Control

The benefits of flood control which were identified in the 1991 Economic Appraisal (ref.2) arise from the improved monitoring of tidal flood control gates and pumping stations, and from an increase in the number of sites being monitored.

Table 29 shows the annual benefits per flood control gate and pumping station, as defined in 1991, but increased by 6.9% in line with inflation. In 1992 MAFF felt that the flood control benefits were too high and reduced them by 75% (ref.3). Table 30 shows the numbers of these sites monitored in each phase. Note that the marginal benefits of telemetry take into account the probability of a timely response with no monitoring.

Table 31 combines all of these calculations to show the benefits to flood control apportioned between the options.

Table 29
Flood Control Benefits (£ million per site)

Annual Benefits	per gate	per P.Stn
No monitoring	0.0043	0.0074
MC16	0.0603	0.0220
ARTS	0.0811	0.0293

Table 30
Numbers of Flood Control Sites

	MC 16	Phase 1	Phases 1 & 2		Phase 1, 2 & 3		Phase 1, 2, 3 & 4	
			H & M	All	H & M	All	H & M	All
No. of gates	20	44	44	44	50	50	50	50
No. of P. Stns	28	40	40	40	50	50	50	50

Table 31
Benefits to Flood Control

	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
		Phase 1	Phases 1+2		Phases 1+2+3		Phases 1+2+3+4	
			H & M	All	H & M	All	H & M	All
Gates		0.898	0.898	0.898	1.013	1.013	1.013	1.013
PS		0.311	0.311	0.311	0.366	0.366	0.366	0.366
Ann. Total (Yrs 1-10)		1.209	1.209	1.209	1.379	1.379	1.379	1.379
PV		8.90	8.90	8.90	9.84	9.84	9.84	9.84

5.5.5 Water Resources

The water resources benefits have been distributed between the options in proportion to the numbers of outstations (Table 24). In a similar manner to that used for flood warning benefits it is necessary to consider the relative contributions of monitoring and modelling. A ratio of 4 to 1 has been used.

The marginal annual benefit of the ARTS system is £1.03 million (ref.2). MAFF calculated that the pre-existing annual benefit was £1 million pa. These figures are inflated to September 1994 prices (£2.171 million) before apportioning between the options. Table 32 shows the result of these calculations.

Table 32
Water Resources Benefits (£ million)

	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
		Phase 1	Phases 1+2		Phases 1+2+3		Phases 1+2+3+4	
			H & M	All	H & M	All	H & M	OAll
Annual Benefit		1.168	1.485	1.493	1.971	2..067	2.058	2.171
PV over 10 years		8.594	10.348	10.398	13.032	13.558	13.516	14.136

5.5.6 Water Quality

The water quality benefits are calculated in exactly the same way as for water resources.

The annual benefits of MC16 was £0.132 million and it was estimated that ARTS would double it (ref.2). Inflating this total and apportioning between the options gives the results shown in Table 33.

Table 33
Water Quality Benefits (£ million)

	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
		Phase 1	Phases 1+2		Phases 1+2+3		Phases 1+2+3+4	
			H & M	All	H & M	All	H & M	All
Annual Benefit		0.151	0.192	0.193	0.255	0.268	0.266	0.281
PV over 10 years		1.113	1.341	1.347	1.688	1.757	1.751	1.831

5.5.7 Total Quantified Benefits

The present value of benefits arising from each function (Tables 28,31,32 and 33) are totalled in Table 34.

Table 34
Total Present Value Benefits (£ million)

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Flood Warning		24.369	28.089	28.231	31.170	31.598	32.777	33.370
Flood Control		8.900	8.900	8.900	9.840	9.840	9.840	9.840
Water Resources		8.594	10.348	10.398	13.032	13.558	13.516	14.136
Water Quality		1.113	1.341	1.347	1.688	1.757	1.751	1.831
Total PV	0.000	42.876	48.678	48.877	56.729	56.753	57.884	59.177

5.6 Unquantified benefits

The Halcrows economic evaluation considered only those benefits which are "quantifiable in a reasonably accurate manner". There are many other benefits of telemetry and flow forecasting which were not included, for example ;

- Improved response time when dealing with emergencies.
- Reduced damage from operating fluvial flood control structures and washland areas.
- The increased efficiency of flood defence operations.
- Reductions in mortality and morbidity following the flooding of property and the loss of personal possessions.
- Reductions in damage to the environment through the improved monitoring of abstractions.
- More effective enforcement of water quality consents.
- More effective management of fisheries.
- More effective management of navigation.
- Reductions in lost recreational opportunities.
- Improved efficiency of data collection for long term planning in all of the NRA's core functions.
- Enhanced public confidence in the NRA's river management capability.

5.7 Environmental Factors

There are no environmental disbenefits brought about by the development of a telemetry and flow forecasting system. The local environmental impact of outstation and/or gauging station construction is usually minimal and is addressed on a site by site basis.

There are many intangible benefits, including some of those listed above in section 5.6.

5.8 Risks

5.8.1 Development of the Flow-Forecast Modelling System

Assessment and minimisation of the technical and contractual risk was considered in detail in a Technical Note (ref.13). Risks have been minimised by adopting a design with a simple and well understood interface between systems.

Networked computers overcome the possibility of a single point of failure in the system, and provides flexibility to adapt to organisational changes or to changes in the user requirements.

The design includes a margin for expansion.

A wide range of skills will be required in the supply of a computer infrastructure, modelling algorithms, interfacing to ARTS, data take-on and model fitting. The proposed approach of letting a single contract (probably to a consortium) minimises the contractual risk.

Considerable effort has gone into the estimation of costs and there is a high degree of confidence in their accuracy. The least reliable component is in the cost of adapting design hydrodynamic models for real time use. Estimates are conservative and should be adequate.

This sub-project will require significant manpower resources for model calibration (estimated to be almost 17 person years) in addition to those provided by the main contractor. It is envisaged that most of these will be provided by specialist consultants. However, if NRA staff are to develop adequate familiarity with the models there must be a high level of involvement.

5.8.2 Installation of the additional outstations

This is felt to present a low risk as a large number of outstations have already been successfully installed during Phase 1.

Similarly, cost estimates are believed to be accurate as they are based on recent experience.

The number and locations of the proposed outstations have been defined by Area and Catchment staff based on current knowledge. It is possible that some of the proposals which are linked to flow forecasting may be refined in the light of planning for Phase 2.

5.8.3 Construction of new gauging stations

This is felt to present a low risk as there is considerable experience of constructing new gauging stations within the NRA and the proposals involve proven technology.

Cost estimates are approximate at this stage. They will be refined for the Engineers Report but are felt to be sufficiently robust for use in this document.

The number and locations of the proposed gauging stations have been defined by Area and Catchment staff based on current knowledge. It is possible that some of the proposals which are linked to flow forecasting may be refined in the light of planning for Phase 2.

5.9 Evaluation of the Options

Table 35 summarises the costs and the quantified benefits of each option in the format prescribed by MAFF.

The preferred option is Option 6, with a total present value cost of £12.3 million. The present value of the quantified benefits are £57.9 million, giving a benefit : cost ratio of 4.7. This is the least cost option which meets the objectives of the project.

The average benefit : cost ratios vary between 7.7 and 4.4. The major difference between the options reflects the relative effectiveness of ;

1. Developing a flow forecast modelling system.
2. Installing telemetry outstations (but no new gauging stations).
3. Constructing new gauging stations.

Options 0 and 1 are rejected because they would not improve the existing inadequate flood warning system.

Options 3, 5 and 7 (which include low priority sites) are rejected because they have lower benefit : cost ratios than the equivalent options 2, 4 and 6 (which include only high and medium priority sites).

Option 2 and 4 are rejected because they would not provide cover for all property known to be at risk of flooding from main river. Option 2 would result in flood warning and flood control arrangements remaining inadequate at 223 high and medium priority sites where property is at risk. Option 4 would leave a large number of properties without adequate protection. The additional gauging stations are needed primarily to provide data for flood forecast modelling. Without these sites forecasts would be impossible or inadequate for many flood risk zones.

Option 6 has a benefit : cost ratio of 4.7. It is the least cost option which aims to provide a service to all known property at risk from flooding from main river. The incremental benefit : cost ratio (over option 4) is 1.2. This is likely to be conservative as the benefits of Option 6 do not account for all the multifunctional benefits of river flow gauging, including the intangibles listed in section 5.6. (The benefit : cost ratio usually associated with river flow gauging stations is 2.3 (ref.14)).

The preferred option is therefore option 6. It will provide an integrated system which includes ;

- **Development of a flow forecast modelling system for all high and medium priority flood risk zones.**
- **The installation of 223 additional outstations for high and medium priority sites.**
- **The construction or improvement of 26 gauging stations at high and medium priority sites.**

Table 35
The costs and benefits of all Options (£ million)

	Do Nothing	Do Minimum Maintain Phase 1 but no more development	Phase 1 + further development of Phase 2 only		Phase 1 + further development of Phases 2 and 3		Phase 1 + further development of Phase 2, 3 and 4	
			H+M priority sites only	All priority sites	H+M priority sites only	All priority sites	H+M priority sites	All priority sites
	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
PV Costs	0.00	5.57	7.59	7.60	10.72	11.39	12.34	13.49
PV Flood Damage	164.9	131.6	127.9	127.7	123.9	123.4	122.2	121.7
PV Flood Damage Avoided		33.3	37.0	37.1	41.0	41.4	42.6	43.2
PV Other Quantified losses	19.7	10.0	8.0	7.9	4.9	4.3	4.4	3.7
PV Other losses avoided		9.7	11.7	11.7	14.7	15.3	15.3	16.0
PV Benefits	0.00	42.98	48.68	48.88	55.73	56.75	57.88	59.18
Net Present Value	0.00	37.41	41.29	41.28	45.01	45.36	45.54	45.69
Ave Benefit : Cost ratio		7.7	6.6	6.4	5.2	5.0	4.7	4.4
Incremental Benefit : Cost Ratio (wrt. to the previous option)			3.1	0.9	2.2	1.5	1.2	1.1
Incremental Benefit : Cost Ratio (wrt. to the equivalent sub option of the previous phase)			3.1 wrt. 1	2.9 wrt 1	2.1 wrt 2	2.1 wrt 3	1.3 wrt 4	1.2 wrt 5

Footnote :

- *The row for PV costs corresponds to Table 23*
- *The row for PV benefits corresponds to Table 34*
- *The PV Flood Damage for option 0 derives from ;*
  - *Annual damage with no Flood warning = 12.351 (from section 5.3.3)*
  - *Annual damage with no Flood control gates = 6.7 (from ref.2 Annexe E2 with p(respond) = 1)*
  - *Annual damage with no Flood control pumps = 3.4 (from ref.2 Annexe E3 with p(respond) = 1)*

  reduced to PV over 10 years.
- *The PV Flood damage avoided is linked to tables 28 and 31.*
- *The PV of other losses avoided for option 0 derives from ;*
  - *Water Resources = 2.171 annually (from section 5.3.5)*
  - *Water Quality = 0.5 annually (from ref.2 annexe F with p(respond) = 1)*

  reduced to PV over 10 years.

5.10 Eligibility for Grant Aid

It is reasonable to allocate the costs of providing a real time data gathering and processing system to function areas according to the utilisation of the outstations in the system. Appendix 3 shows the uses of each outstation. The weightings are an assessment of the value of each outstation to the principal functions. Table 36 applies the summated weightings to the capital cost of the preferred option.

The cost of developing the flow forecasting system has been apportioned on the assumption that greater benefits would accrue to flood warning and flood control.

Table 36 shows that 52% of the capital costs (not discounted) would be eligible for grant aid.

Table 36
Eligibility of Capital Costs for Grant Aid

	Phase 2		Phase 3		Phase 4		Total	
Function	%	Cost (£m.)	%	Cost (£m.)	%	Cost (£m.)	%	Cost (£m.)
Design & Supervision		0.22		0.75		0.17	18	1.14
Contractors / Specialist Consultants		1.79		2.23		1.35		
Total		2.01		2.98		1.52		
Breakdown of Contractors / Specialist Consultants								
Grant Aidable								
Flood warning	60	1.07	37	0.83	51	0.69		
Flood Control	15	0.27	16	0.36	13	0.18		
Grant Aidable Sub-Total	75	1.34	53	1.18	64	0.86	52	3.38
Non Grant Aidable								
Flood Operations	10	0.18	28	0.63	17	0.23		
Water Resources	10	0.18	14	0.31	10	0.14		
Water Quality	5	0.09	5	0.11	9	0.12		
Non Grant Aidable Sub-Total	25	0.45	47	1.05	36	0.49	31	1.99
Sub-Total for C & SC	100	1.79	100	2.23	100	1.35		
Total							100	6.51

5.11 Future Developments.

It should be noted that Option 6 does not realise all of the benefits identified in the Halcrows economic appraisal. These (and others) may be realised through future projects to further improve the region's flood warning service, for example the improvement of weather radar coverage and a possible requirement to extend the flood warning service to non main river. Any future projects would be subject to a separate economic appraisal following NRA and MAFF guidelines.

6. THE PROJECT PLAN

6.1 Introduction

The overall approach which is being adopted for this project has been prescribed by MAFF. Plans are initially presented as part of the **Strategy** in order to obtain **outline approval. Detailed plans** for component phases are presented later in **Engineer's Reports** which enable **full approval** to commit expenditure. This section therefore presents the project plan at a strategic level.

The preferred option would be implemented as three sub-projects (phases) of the overall ARTS project. This reflects the different nature of the work involved and the project management skills which would be required. The project management structure is shown in Figure 1. All three phases would run in parallel (Figure 2).

The expenditure profile is shown in Table 37. The link between project years (Table 37) and the project plan (Fig.2) assumes that approval to start work on the Project Initiation Documents is obtained by July 1995.

Further details of each phase are given in sections 6.2 to 6.4. They each have a Technical and Resource Plan. The Quality Plan covers all phases and is described in section 6.5.

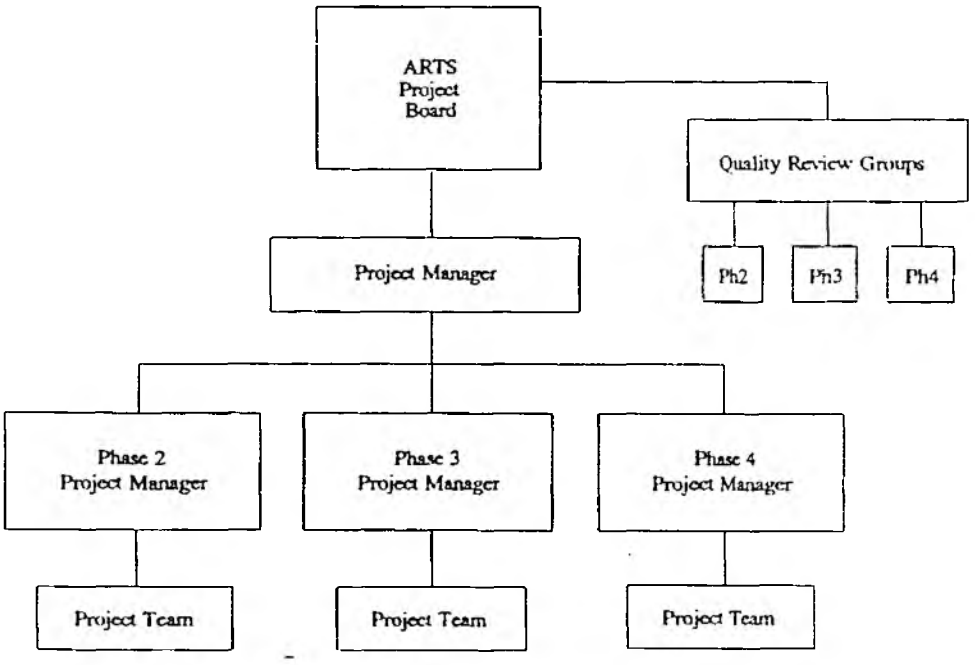


Figure 1
Project Management for the ARTS Project

Figure 2
The Project Programme

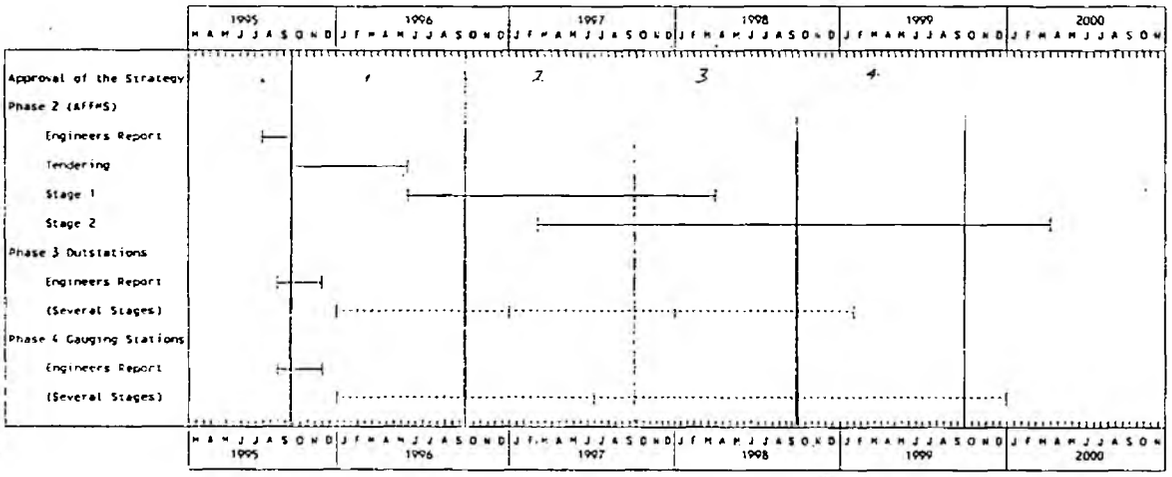


Table 37
Expenditure Profile

Year	Phase 1 Ongoing rev cost	Phase 2 (Modelling)		Phase 3 (addit. o/stations)		Phase 4 (add. gauging stns)		Total	
		Cap	Rev	Cap	Rev	Cap	Rev	Cap	Rev
1	0.756	0.180		1.339				1.519	0.756
2	0.756	0.900		1.339		0.684		2.923	0.756
3	0.756	0.525		0.298		0.684		1.507	0.756
4	0.756	0.405	0.041		0.119	0.152	0.061	0.557	0.977
5	0.756		0.041		0.119		0.061		0.977
6	0.756		0.041		0.119		0.061		0.977
7	0.756		0.041		0.119		0.061		0.977
8	0.756		0.041		0.119		0.061		0.977
9	0.756		0.041		0.119		0.061		0.977
10	0.756		0.041		0.119		0.061		0.977
Sub-Total	7.560	2.010	0.287	2.976	0.833	1.520	0.426	6.506	9.109
Total	7.560	2.297		3.809		1.946		15.615	
PV Total								12.343	

6.2 Phase 2 - Flow Forecast Modelling System

Planning for this phase of the project is well advanced. The Draft Project Initiation Document for Phase 2 (ref.6) provides more detail of the plan which is summarised below

6.2.1 Technical Plan.

The major stages of the project will be ;

- Specification and tendering
- Implementation Stage 1 (years 1-2) - the computer system and pilot take on, plus the transfer of all existing models from the old to the new system.
- Implementation Stage 2 (years 3-5) - expansion to the rest of the region.

In order to ensure unambiguous responsibilities for Implementation Stage 1, a single contract will be let for all of ;

- The integration of the computing system(s).
- The modelling software
- Fitting of models to a sufficiently large pilot area to demonstrate the system's functionality and useability.
- The take-on of existing rainfall-runoff forecasting models.
- Testing of the system.

Implementation Stage 2, the Anglian-wide development of further models, will be run as separate contracts. Users will have an important involvement in order to ensure the on-going success of the system.

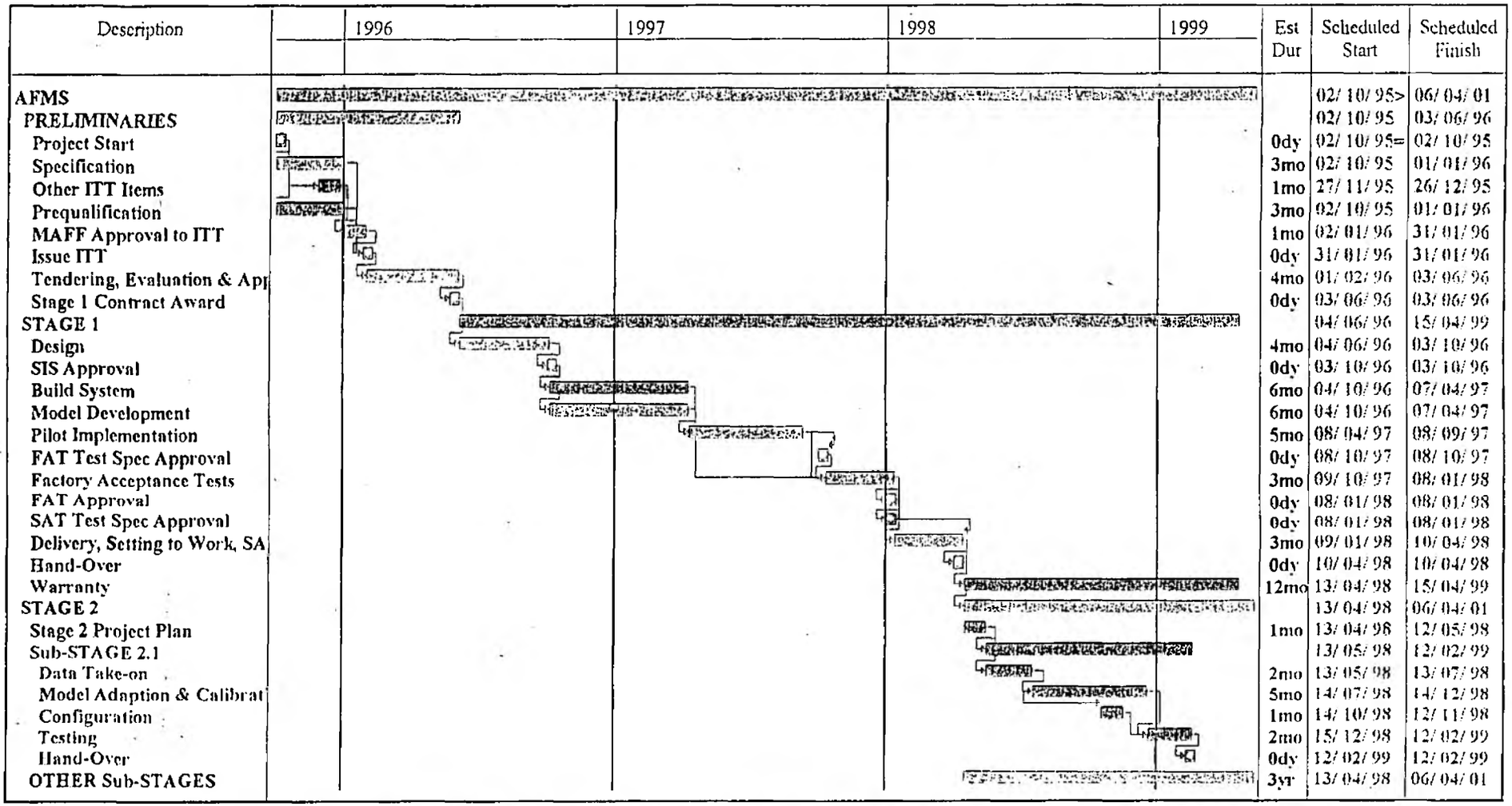
The major products will be ;

- Stage 1 invitation to tender document.
- A tender evaluation report
- The approved Systems Implementation Specification in which the contractor sets out his detailed design.
- The approved test specification for factory acceptance tests.
- The system delivered to the NRA after passing formal factory acceptance tests.
- The approved test specification for site acceptance tests.
- The system handed over to the NRA after setting to work on the pilot area and passing of site acceptance tests.
- The formal hand over from the project team to NRA users of each sub-project of Stage 2. (There will be a programme of Stage Plans for region wide implementation).

A provisional project programme is shown in Figure 3, based on a working assumption that full approval is obtained by October 1995.

FIGURE 3

AFMS TOP LEVEL PROGRAMME



Description	Est Dur	Scheduled Start	Scheduled Finish
AFMS		02/ 10/ 95>	06/ 04/ 01
PRELIMINARIES		02/ 10/ 95	03/ 06/ 96
Project Start	0dy	02/ 10/ 95=	02/ 10/ 95
Specification	3mo	02/ 10/ 95	01/ 01/ 96
Other ITT Items	1mo	27/ 11/ 95	26/ 12/ 95
Prequalification	3mo	02/ 10/ 95	01/ 01/ 96
MAFF Approval to ITT	1mo	02/ 01/ 96	31/ 01/ 96
Issue ITT	0dy	31/ 01/ 96	31/ 01/ 96
Tendering, Evaluation & Apj	4mo	01/ 02/ 96	03/ 06/ 96
Stage 1 Contract Award	0dy	03/ 06/ 96	03/ 06/ 96
STAGE 1		04/ 06/ 96	15/ 04/ 99
Design	4mo	04/ 06/ 96	03/ 10/ 96
SIS Approval	0dy	03/ 10/ 96	03/ 10/ 96
Build System	6mo	04/ 10/ 96	07/ 04/ 97
Model Development	6mo	04/ 10/ 96	07/ 04/ 97
Pilot Implementation	5mo	08/ 04/ 97	08/ 09/ 97
FAT Test Spec Approval	0dy	08/ 10/ 97	08/ 10/ 97
Factory Acceptance Tests	3mo	09/ 10/ 97	08/ 01/ 98
FAT Approval	0dy	08/ 01/ 98	08/ 01/ 98
SAT Test Spec Approval	0dy	08/ 01/ 98	08/ 01/ 98
Delivery, Setting to Work, SA	3mo	09/ 01/ 98	10/ 04/ 98
Hand-Over	0dy	10/ 04/ 98	10/ 04/ 98
Warranty	12mo	13/ 04/ 98	15/ 04/ 99
STAGE 2		13/ 04/ 98	06/ 04/ 01
Stage 2 Project Plan	1mo	13/ 04/ 98	12/ 05/ 98
Sub-STAGE 2.1		13/ 05/ 98	12/ 02/ 99
Data Take-on	2mo	13/ 05/ 98	13/ 07/ 98
Model Adaption & Calibrat	5mo	14/ 07/ 98	14/ 12/ 98
Configuration	1mo	14/ 10/ 98	12/ 11/ 98
Testing	2mo	15/ 12/ 98	12/ 02/ 99
Hand-Over	0dy	12/ 02/ 99	12/ 02/ 99
OTHER Sub-STAGES	3yr	13/ 04/ 98	06/ 04/ 01

Negative Float
Critical
Unassigned
Milestone
Critical Unassigned
Actual Milestone
Interrupted
Critical Interrupted
Actual
Noncritical

6.2.2 Resource Plan

The NRA Project manager for this phase would be the focus for planning, monitoring and controlling the project. A key role will be to ensure good communication between all of the parties who will be involved ; the Consultant, the Contractor, Sub-Contractor(s), Users throughout the Region and those employed to carry out model calibration.

A Consultant with skills and experience in the management of similar large projects would be employed to act as Engineer to the contract.

The personnel resources (other than those provided by the Contractor) which have been allowed for in the costs are detailed in Table 38. The resources required to configure and calibrate the models dominate. It is anticipated that this work will be carried out be Consultants, but with the close involvement of NRA Hydrologists.

Computer room facilities will be required, probably at two locations. Space will be available in the existing facilities at Kingfisher House and Brampton.

Table 38
Personnel Resources for Phase 2

Role	Total Resources (FTEs)
Project Manager	0.77
Project Board	0.23
Project Team	0.23
Quality Assurance	0.08
Configuration	0.99
Stage 2 Managers	1.31
Stage 2 Calibration	12.00
Stage 2 Testing	1.23

6.3 Phase 3 - Additional outstations

6.3.1 Technical Plan

The installation of additional outstations will follow the now well developed procedures which have been used for Phase 1.

A programme of works will be developed to take account of priority and cost effectiveness. This will be a rolling programme over a 4 year period.

6.3.2 Resource Plan

There will be a separate project manager for this Phase.

Outstations will be installed by a combination of existing NRA IS staff and contractors. Their costs have been allowed for in the Systems element of Appendix 3 and Table 15.

Any significant Engineering works on site would be carried out under the supervision of the Engineering Dept. Costs have been allowed for in the Civils element of Appendix 3 and Table 15.

6.4 Phase 4 - Additional gauging stations

6.4.1 Technical Plan

A programme for construction of the new gauging stations will be developed to take account of priority, geographical distribution and cost effectiveness. This will be a rolling programme over a 4 year period.

6.4.2 Resource Plan

There will be a separate project manager for this phase

The Engineering costs allowed for in Appendix 4 are based on recent experience elsewhere in the region.

6.5 The Quality Plan

Each product will have a Product Description which specifies the quality review criteria and method to be applied in respect of that product.

The quality plan will be based on the principle of formal reviews of each product by the project teams and the Quality Review Panel which will be established in accordance with the quality assurance provisions of the NRA Project management Procedures.

The Project Board will review and approve all major products and will receive reports on all major deliverables.

REFERENCES

1. NRA (1990). Project Appraisal 'Regional Telemetry Improvement Scheme' May 1990, Pettifor, Page & Baxendale.

2. Sir William Halcrows Ltd [for the NRA] (1991). The Regional Telemetry Replacement Scheme Engineers Report. Overall Scheme Summary incl. Summary Proposals Stage 1 and Economic Appraisal. Report for NRA Anglian Region.

3. MAFF (1995). Letter J.Preston to N.Fawthrop 30/1/95 with tables summarising the 1991 Economic Appraisal as approved by MAFF.

4. Servelec Ltd (1993). Anglian Flow Modelling System - Functional Specification.

5. Institute of Hydrology (1993). Anglian Flow Modelling System - Systems Analysis.

6. Kennedy and Donkin Systems Control Ltd (1994). Anglian Flow Modelling System - Draft Project Initiation Document. Report for NRA Anglian Region.

7. NRA (1992). Central Area Flood Report to Great Ouse LLDC, September 1992

8. NRA (1992). Notes of the September 1992 Flood Washup. Northern Area.

9. NRA (1993). Northern Area Flood Report to Lincolnshire LLDC, October 1993.

10. NRA (1993). Eastern Area Flood Report, October 1993.

11. Kennedy and Donkin Systems Control Ltd (1994). Anglian Flow Modelling System - User Requirements Specification.

12. Kennedy and Donkin Systems Control Ltd (1995). Revised ARTS Business Case - Technical Note.

13. Kennedy and Donkin Systems Control Ltd (1994). AFMS Project Appraisal and Planning Options Technical Note. Report for NRA Anglian Region.

14. Foundation for Water Research (1991). The Benefit-Cost of Hydrometric Data - River Flow Gauging. Report on research commissioned by the Department of the Environment.