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end date

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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Rationale for BSM

The key phrases defining the rationale of BSM are contained in the Penning-Rowse Report (MAFF/EA 1997) which refers to the threat that *'...the huge investments made in the past may be under threat from climate change'* It goes on to highlight the *'... need to understand the frequency, extent and severity of coastal erosion and fluvial flooding likely in the future if we are to devise appropriate counteracting policies and schemes'*, and concludes that *'...we need to develop models that facilitate this understanding at a strategic scale of the catchment and the coastal cell...'*.

The BSM ROAME A statement

The rationale of BSM is set out in the ROAME A statement, from which the policy and scientific objectives are given below:

Policy Objective

The policy objective of BSM is to improve mathematical models in such a way that would:

1. enable Defra/EA to meet its policy aim of reducing risks to people and the developed and natural environment from flooding, through gaining an understanding of the large scale, medium to long term risks posed by such driving influences as climate change and cumulative anthropogenic change;
2. discourage inappropriate development in areas at risk of flooding or coastal erosion;
3. inform Defra/EA as to the interaction between policies or strategies in such areas as planning, land use, agriculture, catchment management and flood defence itself, and flood risk.

Research Objectives

There are a number of objectives related to broad scale modelling that may be considered to be common and more generic to coastal, estuarine and fluvial areas. These are related to determining the large scale, medium to long-term consequences of natural change such as climate change or anthropogenic intervention.

Predictive tools that take into account the multi-faceted interactions between different physical processes and their feedback effects, as well as the ecological, biological and socio-economics are required to support policy formulation and the decision-making process as it relates to future planning. The scientific research objectives for this programme are to provide tools, methods and understanding which will allow Defra and EA to:

1. Determine large scale, medium to long-term natural evolution of river, estuarine and coastal systems and the influence that anthropogenic intervention may have on the process of flooding and flood and coastal defence, whether physical, biological or ecological, the consequential impact on management strategies and corresponding management response;
2. Determine the relative influence of climate change phenomena on these processes;
3. Understand the importance/ role of variability in climate influences on vegetation, sediment transport and morphological evolution;
4. Determine the regional and national socio-economic impacts leading to prioritisation of scheme development; optimisation of available resources; better informed planning policy and improved catchment management;
5. Similarly determine the broad scale regional and national impacts on ecological system integrity
6. Provide tools to ensure the benefits of flood defence at one location do not lead to unacceptable consequences elsewhere or for other functions;
7. Provide tools to enable assessment of the impacts of alternative planning scenarios, catchment management practices and river engineering on the effectiveness of existing flood defences;
8. Provide tools to enable formulation of flood defence and flood plain zoning policy in relation to both structural and non-structural flood defence responses;
9. Provide tools to assist in the determination of acceptable locations and scales of new development.(the particular effect of development in a specific location falls under other themes such as engineering).

BSM theme development

The theme has a number of strong integrative strands but can conveniently be broken down into three 'physical' topic areas plus a fourth cross-cutting group of topics which goes across all the three physical topic areas. This matches the disciplinary skill groupings among researchers while emphasising the need for integrated modelling of impacts on the human and natural systems. The topic areas are:

- Catchment modelling
- Estuarial modelling
- Coastal modelling
- Cross-cutting topic areas – ecological and socio-economic modelling and decision support systems

Research within these topic areas has been shaped by research plans commissioned in catchment, estuarial and ecological modelling under the previous BSM management contracts, FD1802 and 1809. During the contract period, contracts were let for a batch of three projects in the Estuaries Research Programme Phase 2 (ERP2) and of phase 1 of the ecological modelling research plan. A further project (FD2113) was let in the family of projects relating to continuous simulation of rainfall and runoff. In addition planning work has been carried out on coastal BSM.

R&D Projects carried out during the contract period

Code	Title	Contractor	Start	End	Total cost £
Completed or ongoing					
FD2105	Improved methods for national spatial-temporal rainfall and evaporation modelling for BSM	Imperial College	Mar-02	Feb-05	683,250
FD2106	National river catchment flood frequency method using continuous simulation	CEH	Nov-01	Mar-05	436,026
FD2107	Development of hybrid estuary morphological models	POL	Jan-04	Jan-07	539,190
FD2112	Broad Scale Ecosystem Impact Modelling Phase 1- Toolbox	Cascade Consulting	Jan-04	Oct-05	129,925
FD2113	Spatial Temporal Rainfall Modelling with Climate Change Scenarios	UCL	Oct-03	Sep-06	153,961
FD2114	Review of impacts of rural land use and management on flood generation: short term improvement in modelling and research plan	Newcastle University	Jan-03	Mar-04	111,250
FD2116	ERP2 Interpretation and formalisation of geomorphological concepts and approaches	HR Wallingford	Feb-04	Feb-05	100,000
FD2117	ERP2 Development and demonstration of systems-based estuary simulators	ABP Mer	Apr-04	Mar-07	235,000
W5C(03)01	MDSF2 Inception Phase	HR Wallingford	Aug-04	Jul-05	25,000

		Wallingford	04	05	
New Starts 2005-06					
FD2118	Definition and framework for BSM and scoping study for a new catchment modelling capability	To be awarded			36,800
FD2119	ERP2 - Estuary Management System scoping and dissemination	To be awarded			100,000
FD2120	Analysis of historical data sets to look for impacts of land use and management change	To be awarded			150,000
FDE(05)01	MDSF2 Development Phase	To be awarded			360,000
	Total				3,060,402

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
- the scientific objectives as set out in the contract;
 - the extent to which the objectives set out in the contract have been met;
 - details of methods used and the results obtained, including statistical analysis (if appropriate);
 - a discussion of the results and their reliability;
 - the main implications of the findings;
 - possible future work; and
 - any action resulting from the research (e.g. IP, Knowledge Transfer).

Introduction

This report sets out the planned and completed activities that have been carried out to develop and undertake R&D within the Broad Scale Modelling Theme of the Defra / Environment Agency Flood and Coastal Defence R&D programme. Key supporting documents are listed in the References.

Rationale for BSM

The key phrases defining the rationale of BSM are contained in the Penning-Rowell Report (MAFF/EA 1997) which refers to the threat that *'...the huge investments made in the past may be under threat from climate change'* It goes on to highlight the *'... need to understand the frequency, extent and severity of coastal erosion and fluvial flooding likely in the future if we are to devise appropriate counteracting policies and schemes'*, and

concludes that ‘...we need to develop models that facilitate this understanding at a strategic scale of the catchment and the coastal cell...’.

The Foresight Flood and Coastal Defence project (OST 2004) has painted a picture of rising flood risks, from climate change, socio-economic and governance drivers, leading potentially to rises in risk of 2 to 20 times the present level by the 2080s. It has drawn attention to the need for more research into both individual drivers and responses and into strategic decision making, environment and sustainability. These all fit well into the BSM theme.

The BSM ROAME A statement

The rationale of BSM is set out in the ROAME A statement, version 4 dated April 2001, from which the policy and scientific objectives are given below for convenience:

Policy Objective

The policy objective of BSM is to improve mathematical models in such a way that would:

1. enable Defra/EA to meet its policy aim of reducing risks to people and the developed and natural environment from flooding, through gaining an understanding of the large scale, medium to long term risks posed by such driving influences as climate change and cumulative anthropogenic change;
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Funding

The ROAME A recommends that Defra/EA should support this research because it will supply the scientific basis to ensure that best practice guidelines encourage the provision of sustainable defence measures that are

technically and environmentally sound. Defra Flood Management division are aware of current international research and are confident that the research specified under this programme cannot be obtained by buying-in existing information from other countries.

Evaluation criteria

The ROAME A recommends that the programme should be evaluated by asking the following questions:

1. What models have been developed that provide acceptable representations of large scale, medium to long-term evolution processes?
2. To what extent can these models be used to influence management response?
3. How have these models been developed and used to improve the understanding of climate change phenomena and seasonal variation effects?
4. Has the influence of anthropogenic intervention been assessed and quantified?
5. Are these models at a sufficiently reliable level to be used for assessing alternative broad scale planning scenarios and the cumulative effects of works on the surrounding environment?

Theme Organisation and structure

Structure of the overall programme

The Penning-Rowsell Report (MAFF/EA 1997) proposed a number of priority research areas – risk and uncertainty; data and information; fluvial, estuarine and coastal processes; broad-scale models; climate change; economic and community impacts; performance evaluation; flood forecasting and warning; engineering; integration with environmental needs; preventive options; institutional change; biodiversity, conservation and sustainability, and community interface. This wide-ranging set of topics was condensed in the Implementation Report (MAFF/EA, 1999) into six "themes":

Defra - led

1. Fluvial, Estuarine and Coastal Processes
2. Policy Development
3. Broad-Scale Modelling

Environment Agency - led

4. Flood Forecasting and Warning
5. Risk Evaluation / Understanding of Uncertainty
6. Engineering

While themes 1, 3, 4 and 5 were carried through with their original scope, the smaller topics were grouped into themes 2 and 5.

Relationship between the themes

The Penning-Rowsell proposals set out to reshape the research areas, which had formerly been defined by physical areas such as estuaries, and to make them more closely aligned with Defra and EA policy and business areas. The danger in this is that instead of research being fragmented in a policy sense it will be fragmented in relation to physical areas. Thus the new thematic grouping creates a challenge in managing programmes such as the Estuaries Research Programme (ERP). In order to overcome this discussions were held between the theme leaders and the programme coordinators and a matrix was drawn up expressing the relationships.

The success of the approach is now becoming apparent in the ERP Phase 2, with the ESTPROC project, run by the Processes theme, producing its outputs in the form of algorithms which can be used by the BSM estuarial projects which commenced in early 2004.

Theme advisory Group (TAG) membership

The membership of the BSM TAG includes representatives of the major stakeholders, Defra and EA, and leading experts covering the theme topics. They are shown in Table 1, with their affiliations and topic areas.

Table 1 BSM TAG membership

Name	Affiliation	Topic area
Peter Allen-Williams/Dr Andrew Parsons	Defra	Estuarial and coastal engineering
Shirley Greenwood	Environment Agency	Modelling policy
Prof. Howard Wheeler	Imperial College London	Catchment modelling
Ian Townend	ABPmer	Coastal and estuarial

		modelling
Dr. Jon French	University College London	Coastal and estuarial geomorphology
Prof. Edmund Penning-Rowsell	Middlesex University Flood Hazard Research Centre	Social and economic impacts
Prof. Andrew Watkinson	Tyndall Centre/UEA	Environmental modelling
Prof. Edward Evans	Visiting professor Glasgow University	Theme Leader/ catchment planning and modelling

BSM topic areas

The theme has a number of strong integrative strands such as hybrid and probabilistic modelling, new mathematical methods, ecological and process modelling and decision support systems encompassing socio-economic impact modelling and GIS frameworks. However, it can conveniently be broken down into three 'physical' topic areas plus a fourth cross-cutting group of topics which goes across all the three physical topic areas. This matches the disciplinary skill groupings among researchers while emphasising the need for integrated modelling of impacts on the human and natural systems. The topic areas are:

- Catchment modelling
- Estuarial modelling
- Coastal modelling
- Cross-cutting topic areas – ecological and socio-economic modelling and decision support systems

Theme development

Basis of development

At the inception of the thematic programme BSM had available to it a number of relevant research planning documents:

- A catchment modelling scoping study (Naden et al 1997)
- A scoping study report for estuarial morphology research (HR Wallingford 1997). This was implemented via the Estuaries Research Programme (ERP) of which Phase 1 was completed in December 2000 (EMPHASYS Consortium 2000), and included among its outputs a long list of research priorities.

Development of the BSM work plan was initiated under the earlier contract FD1802 through a workshop in January 2001, in which experts and practitioners from a wide range of backgrounds participated. In addition BSM participated in Concerted Actions managed by the Processes theme on hydrology and coastal research.

It was decided that in order to produce a coherent programme of BSM research it was necessary to have prioritised and costed research plans, related to user needs and with outline project specifications in hydrology (Calver and Wheeler 2002), ecosystem modelling (Cascade Consulting 2002) and estuaries (French, Reeve & Owen 2002). The latter was carried out in cooperation with the Processes and Engineering theme leaders and had the objective of producing a proper cross-theme programme from the very long list of potential topics identified by ERP Phase 1. A proposal to commission a coastal BSM research plan was not approved but BSM participated in the Concerted Action noted above. Recently, however, a BSM Coastal mini-vision was written by TAG member Ian Townend. A similar mini-vision for socio-economic aspects has been written by Prof. Edmund Penning-Rowsell.

Two more recent programmes are relevant to BSM, the EPSRC/NERC/Defra/EA - funded by FRMRC, and the EU Framework 6 FLOODsite project, for which co-funding is being provided by Defra. Both projects will have an important impact on the future of BSM and offer significant opportunities for leveraging more funding. The EPSRC/Defra/EA FRMRC has two topics relevant to BSM:

- Land use and flood generation. The FRMRC project will not be able to fund all the necessary programme in this field, and a further potential new project is therefore the first stage of the research programme which will emerge from FD2114;
- Whole system modelling.

The BSM Theme Leader has maintained close liaison, particularly with the FRMRC in order to ensure that synergies and linkages are exploited to their maximum.

The ongoing and approved BSM projects are listed in the Executive Summary. For projects completed under the previous BSM management contracts FD1802 and FD1803 please refer to the complete list given in the CSG15 for the latter. An account of each topic area follows.

Catchment modelling

The key table from the Hydrology Strategic Plan is shown below, updated with completed and ongoing projects shown in **blue**. Project FD2120 'Analysis of historical data sets to look for impacts of land use and management change', which is a follow-up to FD2114, is scheduled to start in 2005-06.

Table 2: Components of the BSM Hydrology Strategic Programme with indicative cost levels and linkages in time (after Calver and Wheeler Table 5.2)

HSP COMPONENT	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2002-07 budget £ m
C1 Definition of strategic agenda	FD2104 (completed)			** Stage 3		* Stage 4					0.1
C2 Maintenance of current practice	FD1913 (ongoing-Processes theme)			*	*				*	*	0.5
C3 National spatial-temporal rainfall modelling (1a)	FD2105 (ongoing)			**	**		*	*			1.0
C4 National continuous simulation runoff modelling (2a)	FD2106 (completed)			**	**		*	*			1.3
C5 Modelling impacts of land use and land management change (3a, 3b, 3c)	FD2114 (completed) + FRMRC		**	FD2120 (new start 2005-06)				**	*		2.4
C6 Climate impact modelling (1b)	*	FD2113 (ongoing)						*			0.3
C7 Building a new modelling capability		FRMRC									
(a) generic modelling techniques						*		*		*	0.8
(b) data and data assimilation	*					***	*	*	*	*	1.0
(c) IT framework	*					***		*		*	0.8
C8 Software production		*	**	**	*	*	**	*	*	*	1.2

Estuarial modelling

The key table from the ERP2 Research Plan is shown below, updated with completed and ongoing projects shown in **blue**. FD2119, 'ERP2 – Estuary Management System scoping and dissemination', is scheduled to start in 2005-06.

Table 3: Proposed ERP2 core projects (1 - 8) and additional areas of basic research recommended for co-funding with Research Councils.(after French et al Table 4.1)

	Core R&D project title	R&D Theme	Status	Cost(k)
1	Uptake of ERP1 science	BSM/Risk	FD2110(completed)	172
2	Improved estuary data	Risk		450
3	Enhanced hybrid models	BSM	FD2107(ongoing)	600
4	Estuary physical, sedimentary and biological processes	Process	FD1905 (ESTPROC, run by Processes theme-completed)	750
5	Enhanced top down models: 5a) Formalisation and interpretation of geomorphological concepts 5b) Behavioural modelling of estuarine systems	BSM	FD2116 (completed) and FD2117 (ongoing)	275
6	Predictability of morphological systems	Process/BSM		120
7	Maintenance and dissemination of existing guidelines	Engineering		40
8	Delivery of ERP2 science	BSM	FD2119 (new start 2005-06)	150
			Sub-total Defra/EA	2485
	Budget for research council co-funding			
i	Mathematical analysis of long term estuary behaviour	Process/BSM		Co-fund with EPSRC
ii	Evaluation of spatial landscape simulation for estuaries	Process/BSM		Co-fund with NERC
iii	Formal testing of critical scientific concepts	BSM/Process		Co-fund with NERC
			Sub-total co-funding	250
			Total	2735

The projects listed above represent a substantial contribution to ERP Phase 2. The Estuaries Advisory Group has stressed the importance of managing the programme and dissemination of its outputs in a coordinated way, and it is hoped to commence project 8 on the table, ERP2 uptake and scoping, in 2005/06.

Coastal projects

The negative side of the good progress noted above in most topic areas only serves to highlight the lack of a coherent approach to coastal modelling, despite the Coastal Vision. The urgency of creating a good research programme in this topic area is confirmed by the findings of the Foresight FCD project, which shows coastal risks as those with the greatest potential increase.

A table of priority projects is shown below based on the BSM Coastal mini-vision (Townend 2004), taking into account work at the Tyndall Centre and other factors.

Table 4: Priority projects in coastal research

Ref	Project	Cost (£k)	Duration (years)	Timing
1.1	Coastal geomorphological behavioural models	400	3	2005-07
1.2	Characterise large-scale coastal exchanges	500	3	2005-10
1.3	Coastal intervention models (to represent influence/impact of management actions and engineering works)	600	3	2007-10
2.1	Climate change impacts on coastal forcing	300	2	2006-09
3.1	Risk based tools for assessing defence options	250	2	2009-11
4.1	Integration of coastal methods and models (including geomorphological, ecological and socio-economic developments)	300	3	2007-10

No starts have been made on any of the coastal projects owing to limitations on funding, but projects 1.1 and 1.2 in Table 4 have been included in the proposals for the BSM 2006-07 programme .

Cross-cutting projects

BS ecosystem modelling

The key table from the scoping study, FD2108, is summarised below, updated with ongoing projects shown in blue.

Table 5: Proposed ecosystem model development projects (summarised from BSEIM scoping study report Table 5.1)

Ref. No.	Proposed Project
Short Term - within 2 years	
FD2112 (ongoing)	Development of Initial BSEIM Guidance: BSEIM Toolbox Phase 1 including training, user support and exploitation of R&D
BSEIM 2	Hydrological, Hydrodynamic and Geomorphological Model Development
BSEIM 3	Development of Ecosystem Impact Modelling Approach Phase 1
	a) Development of Ecosystem Baseline Descriptions.
	b) Interaction and Dynamic Evolution of Aquatic, Riparian and Wetland Ecosystems
	c) Development of Ecosystem Modelling Approaches
This project as with the others identified in the Table must recognise and integrate with work to support the Habitats and Water Framework Directives in order to ensure minimal duplication of effort and encourage development of consistent and inter-related assessment tools.	
Medium Term – 2 to 5 years	
BSEIM 4	Updating of BSEIM Guidance: BSEIM Toolbox Phase 2
BSEIM 6	Mid-Term Review of Progress
Long Term - Up to 10 years	
BSEIM 7	Ecosystem Impact Model Development – Phase 3
	a) Development of Suitable Ecosystem Baseline Description and Interactions of Aquatic, Riparian and Wetland Ecosystems
	b) Development of Ecosystem Modelling Approaches

Of the three projects recommended for an early start BSEIM 1 commenced in 2003-04 and is due to finish in late 2005. It would seem wise to postpone any further starts until feedback on uptake and value can be obtained.

Socio-economic modelling

Preparation was started for a BSM socio-economic modelling project in 2002-03, but this was subsumed within an ongoing Policy Development theme project. Following the Foresight FCD project and Making Space for Water a Socio-economic mini-vision was commissioned from Edmund Penning-Rowsell. A recommended project entitled 'Understanding public preferences, and the nature of social choices, to underpin flood risk management' has been included in the proposals for the BSM 2006-07 programme.

Decision support and integrative projects

The scoping study for MDSF2 (project W5C(03)01) was completed during the period. This will bring in the defence reliability analysis developed under the RASP project and make MDSF applicable for coastal and estuarial tasks. The main development stage FDE(05)01 is scheduled to start in 2005-06.

A brainstorming session held at a TAG meeting in 2003 showed a clear consensus in favour of a short project to define a vision for BSM. This is very timely, as BSM is beginning to generate some potentially very powerful and important projects and we need to ensure that we have a coherent vision of how they fit together and how they are aimed at satisfying user needs. The project, FD2118, is scheduled to start in and will involve both the BSM TAG and FRMRC team members.

Potential new projects 2006-07 plus

The following proposals have been submitted to Defra/EA for BSM 2006-07 new starts.

Table 5: Summary of possible BSM projects 2005 plus

Sector	Title	Costs: 06-07	07-08	08-09	Total
B/f from 05-06		565222	153000	0	718222
Catchments	No new projects				
Urban flood risk	Definition of research priorities for urban response to extreme floods (BSM HSP-3b)	25000	0	0	25000
	Scoping of methods for representing urban flood response in BSM at catchment scale (BSM HSP-3c)	20000	0	0	20000
	Groundwater flood risk maps and planning decisions.	100000	100000		200000
Estuaries	No new projects				
Coasts	Coastal geomorphological behavioural models to predict long-term change	120000	140000	140000	400000
	Characterisation of large scale coastal exchanges	160000	170000	170000	500000
Strategic planning tools	No new projects				
Socio-economic	Understanding public preferences, and the nature of social choices, to underpin flood risk management	120000	130000	0	250000
New Starts 2006-07		545000	540000	310000	1395000
Total by year		1110222	693000	310000	2113222

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Calver, A. & Wheeler, H.S. (2002) *Scoping the broad scale modelling hydrology programme*. Defra R&D project FD2104.

Cascade Consulting (2002) *Broad Scale Ecosystem Impact Modelling Tools: Scoping Study Final Report*. Defra R&D project FD2108.

EMPHASYS Consortium (2000) *Estuaries Research Programme, Phase 1, Interim Report*, for MAFF, EA, English Nature.

French, J.R. Reeve, D. & Owen, M. (2002) *Estuaries Research Programme. Phase 2 Research Plan*. Defra R&D project 2115.

HR Wallingford (1997) *Estuaries The case for research into morphology and processes*, Report SR 478.

MAFF/Environment Agency (1999) *Flood and Coastal Defence, Report of the Advisory Committee*, MAFF/ Environment Agency (1999) *Implementation of Recommendations from the Penning-RowSELL Report*.

MAFF (2000) *Terms of Reference for the Procurement of External Resources for the Development and Management of the FCD Research and Development Programme*.

Naden, P., Calver, A., Samuels, P., Ash, J. (1997) *Whole Catchment Modelling, the basis for an integrated approach to catchment management, Scoping Study*. Centre for Ecology & Hydrology

Townend, I.H. (2004) *Coastal Vision for Broad Scale Modelling*. BSM TAG communication

Penning-RowSELL, E.C., (2005) *A socio-economic "vision" for Broad Scale Modelling: Do we want it, or shall we forget it?* BSM TAG communication.