Defra/Environment Agency
Flood and Coastal Defence R&D Programme

Development of a Decision Support system for a risk-based approach to catchment, estuary and coastal flood management planning (MDSF2)

Part 1: Inception Stage

Inception Report: SC050051

SCHO1005BJSM-E-P

defra
Department for Environment Food and Rural Affairs

ENVIRONMENT AGENCY

Defra / Environment Agency
Flood and Coastal Defence R&D Programme

Development of a Decision Support system for a risk-based approach to catchment, estuary and coastal flood management planning (MDSF2)

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June 2005

HR Wallingford
in association with Halcrow

Publishing organisation

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

Tel: 01454 624400 Fax: 01454 624409

Dissemination Status
Internal: Released Internally

Statement of use
This documents forms Part 1 of the development of a Decision Support system for a risk-based approach to flood management planning, and provides recommendations for the work to be carried out in Part 2, the Implementation Phase.

Contract Statement
This research was completed under the Broad Scale Modelling Theme of the Joint Defra/Environment Agency Flood and Coastal Defence R&D programme. The project reference is W5C(03)01.

Report Authors
David Ramsbottom, HR Wallingford
Paul Sayers, HR Wallingford
Jon Wicks, Halcrow

Research Contractor Contact Details
David Ramsbottom, Technical Director, HR Wallingford Ltd, Howbery Park, Wallingford, Oxon, OX10 8BA.
Email: dmr@hrwallingford.co.uk

Client Project Manager
Edward Evans, Independent Consultant, Project Leader on behalf of the Environment Agency, Rio House, Aztec West, Bristol.
Email: evansep@onetel.com

SUMMARY

The Modelling and Decision Support Framework (MDSF) was originally developed in 2001 to provide a tool for quantifying economic and social impacts of flooding at catchment scale for present day conditions, future scenarios and with flood management options.

Methods for assessing flood risk which take account of the performance of flood defences have been developed using the RASP (Risk Assessment for Strategic Planning) approaches. It has been decided to include these methods in the MDSF in order to provide a tool for risk-based flood management planning. The new version of the MDSF is currently called MDSF2.

This document describes the work needed to implement MDSF2. In addition to including the RASP approaches, the software will be 'future-proofed' as far as practicable by reducing dependence on any specific software. The original MDSF was developed based on ArcView Version 3.2 as this was the Environment Agency's standard GIS software at the time. ArcView 3.2 has now been superseded by ARC GIS.

The opportunity has also been taken to include other functionality in MDSF2, and an extensive consultation exercise was undertaken to determine the preferences of stakeholders. In addition to the items referred to above, MDSF2 will include some enhancements to the social impact tools and data handling. If additional funds become available, further enhancements were identified including improvements to the economic damage calculation.

The work to be included in Part 2 of the project (the Implementation Phase) is outlined together with costs and a programme for implementation.

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1. INTRODUCTION

1.1 Background

The Modelling and Decision Support Framework (MDSF) was originally developed in 2001 to provide a tool for quantifying economic and social impacts of flooding at catchment scale for present day conditions, future scenarios and with flood management options.

The MDSF uses results from external models to generate flood impacts. Broad-scale models are already applied for flood/erosion risk assessment as part of the Catchment Flood Management Plan (CFMP), Shoreline Management Plan (SMP) and strategy study process. However these methods generally use a simplified representation of the role of defences and do not include a method of analysis that takes account of defence performance in both the analysis of risks and their management. These are supported by the MDSF, which contains a simple method of assessing flood impacts in defended areas.

This document describes MDSF2, which is a development of the MDSF that incorporates the RASP (Risk Assessment for Strategic Planning) approaches that have been developed for the assessment of flood risk taking into account the performance of flood defences.

1.2 Objectives

An approach is needed to enable the Environment Agency, other operating authorities and their consultants to explore, with an appropriate degree of accuracy, flood risks under different scenarios and help identify suitable flood management policies at catchment, estuary, coastal cell and strategy level.

Existing methods are already being applied to CFMPs, SMPs and Strategy Plans, although the RASP methodology needs to be incorporated to provide a consistent approach for flood risk assessment. It is intended that the performance of flood defences and other flood defence infrastructure is explicitly recognised in future flood risk assessments at different scales. MDSF2 is intended to provide a system that supports this approach.

Significant progress has already been made in providing a system-based framework for the analysis of risk at a range of scales as part of the RASP development. The approaches developed as part of MDSF2 should as far as possible enhance this earlier work and bring together the two strands of research and experience. In particular, the approach should:

- Take advantage of the advances in flood defence analysis and risk assessment methods achieved in RASP;

- Provide an enhancement to the modelling methods currently in use that more explicitly enable flood systems to be analysed taking account of the performance of defences and other assets and improvements in data;

- Seek to achieve an acceptable balance between the amount of work needed to undertake a flood risk assessment and the quality and robustness of the results.

The specific objectives of the MDSF2 project are:

1. To improve the present version of MDSF by incorporating the RASP methodology to allow MDSF to assess defences better and thus support a full range of catchment, estuary and coastal planning and option appraisal tasks from high level planning via strategies down to individual defence systems in an efficient, consistent and transparent way.

2. To do this by building on the present MDSF and the work of the RASP Intermediate Level Method (ILM) and High Level Method (HLM+) to produce a fully tested item of software under an approved QA system which can be efficiently used by operating authorities and their consultants.

3. To put in links to other strategic systems and projects such as NFCDD, Flood Mapping Programme, and PAMS, and to consider future links to similar systems in land and water quality.

4. To facilitate the inclusion in option appraisal of softer options such as rural and urban land management, event management and flood loss reduction thus laying a foundation for a tool which can support the Agency's declared aim of integrated flood risk management.

5. To ensure that software development is 'future-proofed' by reducing to a realistic minimum its dependence on specific software; and to ensure that software development is modular, so that any individual element of MDSF can be used as required.

The development of MDSF2 will involve the following tasks:

- Incorporation of the system-based approaches developed through the RASP project within the MDSF. This will allow the MDSF to analyse defences better and thus support a full range of catchment, estuary and coastal planning and option appraisal tasks from high level planning via strategies down to individual defence systems in an efficient, consistent and transparent way.

- Reconfiguration of the MDSF tools to operate within a free-format GIS environment where possible and/or upgrade to ArcGIS.

- Continuation of stakeholder engagement.

- Development and proving of the methods and framework on a series of case studies, including river, estuarial and coastal situations.

1.3 Phasing of the Project

The MDSF2 project is to be implemented in two stages:

- Part 1: Inception Stage (the subject of this report)
- Part 2: Implementation Stage

The Inception Stage covers identification, prioritisation and requirements capture (with outline requirements and costs). Stakeholder contributions are essential at this stage. This Inception Report forms the basis of Part 2, the Implementation Phase.

Part 2 is expected to provide the development of a practical software-based system that can be readily applied by the Environment Agency, other Operating Authorities and their consultants.

1.4 Objectives of the Inception Phase

This Inception Report was commissioned by the joint Defra/Environment Agency R&D programme. The objectives of the Inception Phase were as follows:

1. To identify, consider, prioritise and propose costed options for R&D of wider catchment and coastal modelling capabilities to extend the current capabilities of MDSF, including incorporation of RASP ILM method, and spatial modelling of land use and flood generation.
2. To consider the relationship between the RASP country-wide implementation, NFCDD and the proposed MDSF2 in relation to present and future stakeholder needs, including maximising the use of outputs and algorithms of the former and opportunities for savings by double use of modules.
3. To consider and propose costed options for incorporating in MDSF2 improvements suggested in the peer reviews recently carried out on MDSF in connection with both CFMPs and SMPs, and the recommendations of the fast track River Teign CFMP.
4. To briefly consider (bearing in mind the recommendations of the Peer Review of MDSF for CFMPs) and propose costed options for mounting MDSF on Agency and other public authority stakeholder systems and/or making electronic plans available to stakeholder staff by other means such as a low-cost "viewer". This shall include consideration of the case for and the timing and cost of dispensing with the need for Arc View 3-D Analyst. (Note: Some of this work including dispensing with the need for Arc View 3-D Analyst was undertaken as part of the MDSF Support Contract in 2004/05).
5. To ensure integration between user need and technical development and a smooth and timely installation on Agency CIS and other stakeholder systems.
6. To ensure buy-in and uptake by Agency and other stakeholder staff through setting up a structured system of stakeholder and user consultation.
7. To produce outline requirements for the implementation phase, with complete costings and programme. This shall include options where appropriate, taking account of the objectives of Part 2, and a dissemination and uptake plan."

1.5 Context

The Environment Agency is currently investing in modelling for flood risk management for various purposes and at various spatial scales. The aim is to maximise the value of these investments through the integration and multiple use of the models. The 2003 Flood Mapping Strategy changed the focus of flood modelling from the "without defences" scenario to that which focuses on modelling the actual watercourses (and coastal zones) and their flood defence systems.

There are currently five strands (initiatives/programmes) of modelling underway, namely:

(i) Areas benefiting from defences under the Flood Mapping Programme. This is using a range of methods including increasing amounts of 2D modelling that takes into account the location of flood defences to determine the actual flood outlines assuming the defence systems work as designed.

(ii) National Flood Risk Assessment (NaFRA). This takes into account the location, type and condition of flood defences, and determines the actual probability (and also consequences) of flooding to impact zones within the floodplain.

(iii) Detailed flood modelling for options appraisal and scheme design. This uses a range of modelling methods including increasing amounts of 2D modelling and takes into account the location of defences and considers possible breach scenarios in calculating flood extents.

(iv) Flood forecasting modelling. This programme is developing a national flood forecasting system using a "shell" to host models that can then be run in real time using data from NFCDD and also real time data from rain gauges/weather forecasts.

(v) Strategic Flood Risk Assessments. These are generally using 2D modelling as appropriate taking into account flood defences and breach scenarios to determine the residual risks within the floodplain to support development decisions.

There is a need to converge these programmes to ensure that the return on the investment in modelling, data and analysis is maximised and improves decision making in Flood Risk Management. The development of a decision support tool will enable the outputs from these programmes to be shared, and in due course the programmes themselves to be streamlined and reduced to one multi-purpose programme of modelling.

The original MDSF was designed to permit the use of results from any model, to provide maximum flexibility for the User. The Environment Agency regards the development of MDSF2 as an important step in this programme of model convergence.

MDSF2 provides an opportunity to support the process of convergence of models and data in order to provide a more consistent approach to undertaking, with an appropriate degree of accuracy, flood risk assessments under different scenarios to explore and identify suitable flood management policies for catchments, estuaries and coastal cells, and also the optimum mix of responses at strategy plan level.

The RASP programme has developed the flood risk assessment methodology thus providing a system-based framework for the analysis of risk at a range of spatial scales.

A key issue to be considered in the future development of modelling and mapping methods is that the methods already being applied for CFMPs, SMPs and Strategy Plans do not take full account of the RASP methodology. The intention must therefore be to evolve and converge modelling and mapping methods in such a way as to make best use of existing methods and also to incorporate the RASP methodology. This will provide a more consistent approach for flood risk assessment.

Whilst MDSF2 is primarily aimed at strategic planning, experience has shown that MDSF can be applied at a more detailed level providing suitably detailed local data are used. The performance of flood defences and other flood defence infrastructure will be considered using a detailed RASP method incorporated into the Performance based Asset Management System (PAMS). The development of MDSF2 should therefore not preclude the incorporation of PAMS into MDSF at a later stage of development.

The approaches developed as part of MDSF2 should therefore take the following into consideration:

- How the five strands of modelling activity could be converged
- How different existing models used for decisions in planning and delivering Flood Risk Management (FRM) could be supported by MDSF2
- How MDSF2 might support a possible move towards single river and coastal cell models that could be used for multiple purposes in delivering FRM
- Development of a framework for undertaking Flood Risk Assessment, focussing particularly on CFMPs, SMPs and Strategies
- Development of the RASP analysis and risk assessment methods so that they are consistent with the outputs required from the Flood Mapping Strategy

It is recognised that different models serve different purposes, and there is likely to be a practical limit to the extent of model convergence. For example, it would not be appropriate to apply a detailed 2D model to a high level flood risk assessment covering a whole catchment. Not only would the modelling approach be unsuitable, but also the data requirements would be unacceptable.

1.6 Policy and Process

A crucial issue to consider in the development of MDSF2 is the way in which links are established with the policies and processes adopted by Defra and the Environment Agency for Flood Risk Management. Policy defines what is to be done, and therefore guides the functionality required for tools that support Flood Risk Management. Process provides guidance on how things are done, and therefore the methods used in the tools.

For example, in the case of flood risks to people, a policy decision is needed to decide whether to include flood risks to people in the appraisal process. A process decision is needed to guide how this should be done.

This is of particular importance when planning a decision support system such as MDSF2, as the functionality in MDSF2 must support policy decisions and provide a method that is acceptable from a process point of view.

This issue arose during the development of the MDSF, which includes calculation of the Social Flood Vulnerability Index (SFVI). Whilst providing useful information on the social impacts of flooding, the SFVI did not support any specific appraisal policy and there was therefore no guidance on how it should be used in the appraisal process. (This situation is expected to change in the future, with the move to appraising softer options and a higher priority for social issues in the appraisal process.)

This example illustrates just how important it is to ensure that the functionality of MDSF2 supports the policies and processes used by Defra, the Environment Agency and other Operating Authorities.

1.7 Outline of this report

The requirements of the RASP approach to flood defence performance are described in Section 2, leading to a summary of the main requirements of the approach in Section 2.4.

Section 3 covers stakeholder consultations. A Peer Review of the MDSF was carried out by the consultants who are using the MDSF for strategic planning, and the findings of this review are contained in Section 3.1.

A consultation workshop was held in February 2005. A summary of feedback from the consultation is given in Section 3.2.

Section 4 summarises the requirements for MDSF2 for both the RASP implementation and other purposes. Section 4 also includes the main issues to be considered in the development of MDSF2.

Following the initial consultation, a list of functional requirements for MDSF2 was developed. This was sent to key stakeholders, inviting them to prioritise their preferences for the functionality to be contained in MDSF2. Section 5 lists the functional requirements for MDSF2, prioritised by stakeholder preferences. The full breakdown of stakeholder responses is given in Appendix D. Section 5 also

summarises costs for the options available for the development of MDSF2, with more details of costs being contained in Appendix E.

Information on stakeholder preferences and costs were presented to the Project Board on 19 May 2005 in order to decide which functionality should be included in MDSF2. The conclusions of this discussion are also presented in Section 5.

Section 6 considers the workplan for Part 2, including a programme for the implementation phase and an outline dissemination and uptake plan.

2. FLOOD RISK MANAGEMENT PLANNING

2.1 General philosophy

Significant advances have been achieved in understanding the concepts underpinning a risk-based approach to flood management, for example the Defra / Environment Agency R&D Report, FD2302/TR1, entitled *Risk, Performance and uncertainty in Flood and Coastal Defence – A Review* (HR Wallingford, 2002). FD2302 established the concept of a tiered approach to risk-based decision-making with an interactive suite of tools, models and data addressing the national, catchment / coastal cell, and local levels. It also translated the Source-Pathway-Receptor conceptual model (widely used to assess and inform the management of environmental risks across Government) for specific use within the Flood and Coastal Defence community to provide a common philosophy of approach across all tiers of decision making. This translation is summarised in Figure 2.1 below.

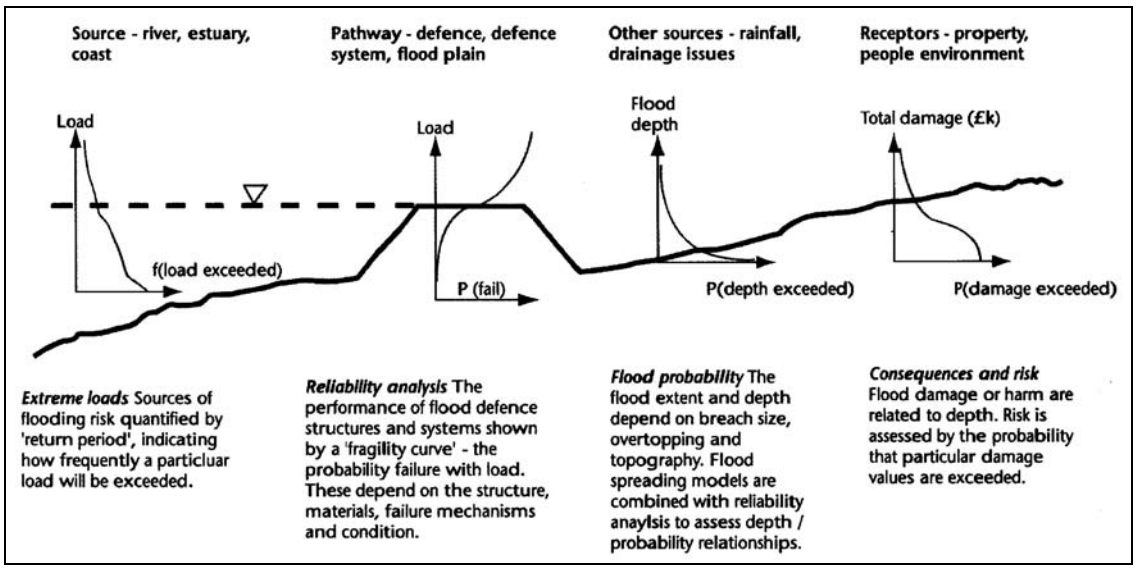

Figure 2.1 Source / Pathway or Barrier / Receptor model for flood and coastal defence (FD2302, HR Wallingford, 2002)

In tandem with this common approach to the assessment of risks, the Agency has structured its business processes to deliver an integrated response to flood risk as shown in Figure 2.2.

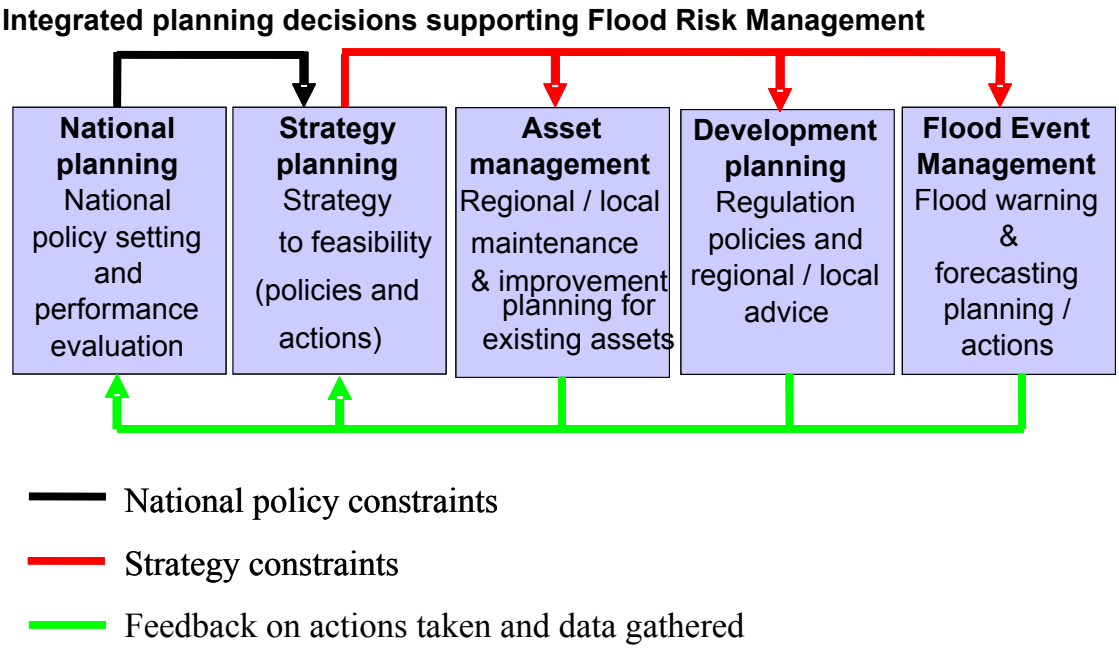

Figure 2.2 Integrated planning decisions supporting Flood Risk Management

The role of each decision within the context of integrated approach to flood risk management is summarised below:

- ***National policy development*** – At a national level decision makers need to have a national *picture* of risk; including national exposure and the general spatial distribution of risks. To provide effective policy guidance, national policy makers need to explore the effectiveness and efficiency of a wide range of strategic alternatives (regulation, protection, flood warning etc) in terms of implementation costs and the associated risk reduction. Inherent within good policy making there is therefore a need to identify approaches that are robust to future change (climate and socio-economic etc) and address issues of sustainability.

- ***Strategy planning*** –Strategy planning needs to be based on an exploration of the effectiveness, efficiency and sustainability of a wide range of strategic alternatives (regulation, protection, flood warning etc) and the preferred combination of interventions and actions identified and enshrined within a costed programme. Inherent within good policy making is therefore a need to identify approaches that are robust to future change (climate and socio-economic etc) and address issues of sustainability. It should be noted that there is no difference in type of analysis as it tiers down to sub-catchment or coastal strategies and ultimately down to individual feasibility studies, only progressively increasing detail to reduce uncertainty as the sequence approaches the implementation phase.

- ***Asset management planning*** – Asset managers seek to manage our asset infrastructure based on a whole life philosophy that includes design, construction, maintenance and eventual removal / replacement of an asset. Asset managers take their lead from national policies and aim to ensure that assets are managed to meet

specific policies or measures for each location as set out within the higher level strategy plans. Where these policies include management or improvement of assets on their current alignment (or similar) asset managers seek to ensure that these are implemented (in the best way) to ensure the overall policies (as encoded in SMP/CFMP/strategies) are met in the most efficient and effective manner. It will also be important that the added-value provided by asset managers (through data collection and detailed analysis) is fed back to the higher level tools to inform future decisions.

- ***Development planning*** – Regulation and development control represents a fundamental option in managing future flood risk. The response of the Agency to development proposals and needs will be guided by higher level policies and strategies. Specific information gathered through, for example, Strategic Flood Risk Assessments and more detailed Flood Risk Assessments will feed back to inform future strategies and policies.

- ***Flood event management*** – Reliable forecasting and effective warning are likely to play an increasingly important role in future flood risk management. Strategy planning should provide the flood event manager with a clear articulation of the role of flood forecasting and warning within a specific area and the level of service that is expected. Within this context flood event managers will seek to maximize risk reduction and the efficiency and effectiveness of the flood warning process.

The Environment Agency has combined the functions of Strategy Planning and Development Planning within their organisational structures.

As demonstrated above ***strategy planning*** (including CFMPs and SMPs) is a key element of the overall framework and provides the regional policy and planning lead for the Agency's delivery of flood risk management through flood defence asset operation /management /improvements, development planning and flood event management functions. In turn, the strategy plans take their lead from clearly articulated national policies that are based on reliable evidence of national exposure to risk and perceived societal preferences. As more detailed analysis is completed under the asset management, development and flood event management planning, revised and more detailed information is fed back to the higher level planning processes. This process of tiered analysis and management is shown schematically in Figure 2.3.

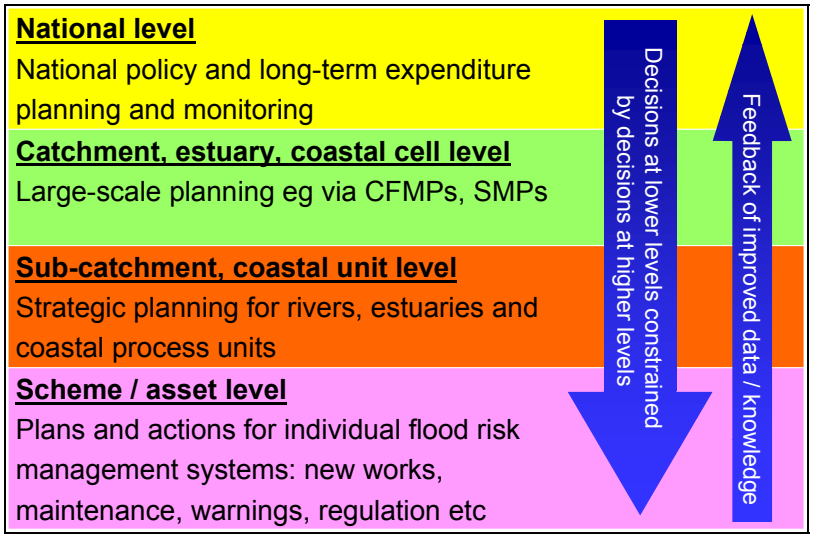

Figure 2.3 Tiered risk assessment and management planning

2.2 A tiered set of FRM planning tools

A key aim of the Agency's Environmental Vision is to reduce flood risk. Through their Corporate Strategy and Strategy for Flood Risk Management 2003/4 to 2007/8 the priorities to achieve this aim and deliver the targets set by Government are set out. Fundamental to this strategy, is the adoption of a risk-based approach to flood risk management. This is a proactive approach where resources and efforts are targeted at the locations or communities where greatest benefits can be achieved.

Through the joint Defra/Agency science programme a hierarchy of risk assessment methodologies, ranging from broad scale to detailed have been developed; the so-called RASP methods (HR Wallingford, 2004). Within this hierarchy of methods the broadest scale method (the so-called High Level Method – HLM) was proposed for national applications, the Intermediate Level Method (ILM) for catchment/coastal cell and the Detailed Level Method (DLM) for individual asset systems. By working together with Defra and Agency business managers and staff a set of IT tools have been identified that utilise the RASP methods in support of the Agency's integrated business processes and are shown in Figure 2.4 and discussed below.

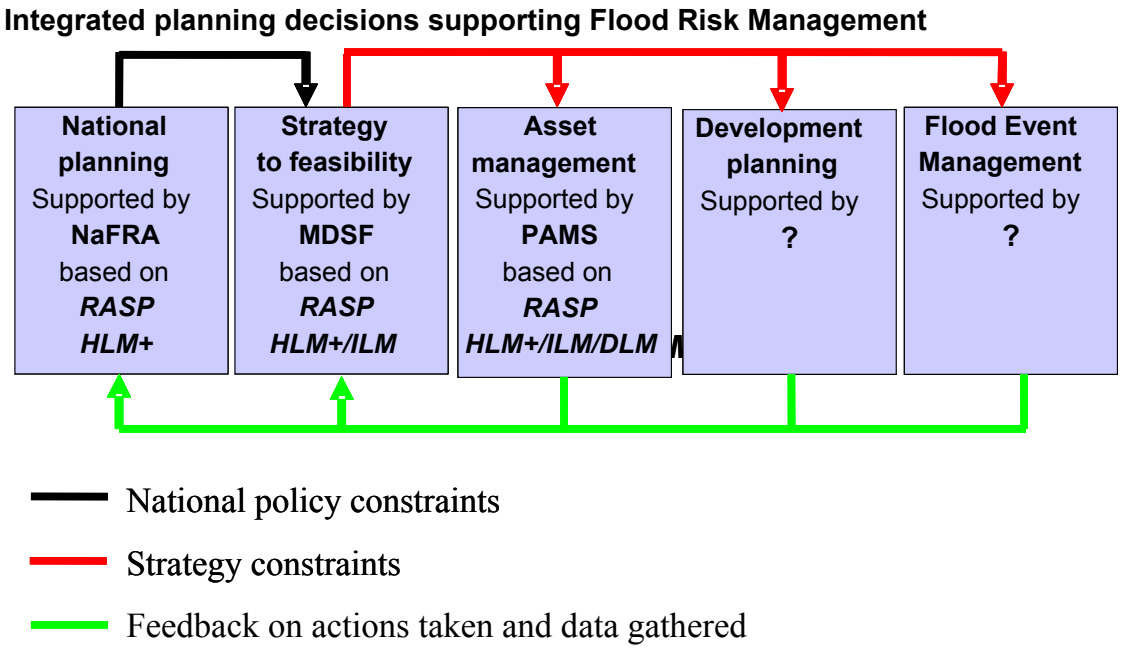

Figure 2.4 IT tools developed or under development to support the tiered concept of planning illustrated in Figure 2.2

2.2.1 NaFRA – National assessment of risk for the monitoring of targets and setting policies

The National Flood Risk Assessment (NaFRA) is an application of the RASP High Level methods at a national scale in a self contained single "model" that:

- Estimates load conditions (including joint wave and water level coastal loads)
- Assesses defence system performance based on input fragility curves for individual defences
- Spreads floodwater on floodplains using a simple parametric model that relies on knowledge of flood depths and extents in the absence of defences (derived from external modelling activities – in NaFRA 2004 these data were derived from the Extreme Flood Outline models)
- Calculates the risk metrics of choice – The NaFRA tools facilitates the estimate of depth probability curves for each Impact Zone. This information is easily converted to expected annual damages for example using standard methods (for example as undertaken in NaFRA 2002).
- Calculates investment costs – A bespoke NaFRA tool was developed to support the National Assessment of Defence Needs and Costs (NADNAC), 2003. This included a simple processes of whole life costing and discounting of benefits and costs over the appraisal period (with costing information based on the national database of unit costs developed by Ove Arup).

The tools used in the development of NaFRA 2004 are necessarily constructed to use datasets available at a national scale and assumes no resources are available for specific data collection. The NaFRA tools have been used, and continue to be used, to

provide a country-wide snapshot of flood risk at a common resolution of the floodplain (for NaFRA 2004 this was set at 100m).

In addition to the analysis code itself, the NaFRA tools include a series of data pre-processing tools that convert the raw input datasets from NFCDD for example, to the required format. (It is likely that these base tools will have utility in the development of similar tools to support the MDSF.)

The NaFRA is constructed to be run by the developers of the system and not external users. However, the aim is to provide the NaFRA tools in a semi-package format for running by multiple SFRM consultants from 2006/8 onwards.

2.2.2 Modelling Decision Support Framework and associated tools

Unlike the tools used in the development of NaFRA 2004, MDSF supports the development of integrated strategies and must be flexible and capable of distinguishing the performance of different options and operating at a range of levels of detail (reflecting the demands of a particular situation).

The tools used in the development of NaFRA 2004 are capable of exploring only relatively simple management options through "proxies". The option appraisal process implicit in CFMPs/SMPs and strategies demands a better understanding of the impacts of a range of options for the location(s) under examination. For example, in a catchment study, an understanding of the contribution to flood risk from different tributaries and (depending on the level of study) an exploration of the trade-off between engineering solutions, flood warning, infrastructure and property resilience, regulation etc. The tool to support such decisions therefore needs to be capable of distinguishing the performance of different options and provide the user with an interactive 'what if' tool to explore both flood risk and responses under a range of scenarios and management options.

It is important to realise that different CFMPs/SMPs and strategies will present different levels of complexity to the risk manager and cover a range of spatial scales. Therefore, unlike the NaFRA tools which provide a prescribed methodology within a single model, the tools that support CFMPs/SMPs and strategies (and possibly, in future, other studies) must be flexible and capable of operating a range of levels of detail. This flexibility is already build into MDSF and will be maintained in MDSF2 – allowing different hydrological/hydraulic models to be used, more or less complex descriptions of defence performance and more or less accurate input data.

It follows that, unlike the tools used in the development of NaFRA 2004, it is not possible to prescribe any specific level of detail that is universally appropriate to CFMPs/SMPs or strategy studies. MDSF2 should therefore be capable of working at whatever level of detail is required – with the defining issue relating to the nature of the decision and the need to explore multi-response strategies and trade one response against another. The MDSF and associated tools were designed to be run by the Agency, other Operating Authorities and their consultants.

2.2.3 PAMS – Performance-based asset management system

The maintenance and management of flood defence assets has hitherto been a largely ad hoc process and it could perhaps be said to be behind flood management planning in its use of IT. The PAMS system has therefore been proposed and is currently being scoped. Its aim is to relate asset management to flood risk in a more transparent and justifiable way. The necessity for this applies whether the dredging of a single reach is being considered or whether one is looking at enhanced maintenance as an option at a CFMP or SMP level.

The PAMS suite of tools and guidance (currently under development and due for completion in 2007) will improve both the way defence information is collected and maintenance and improvement decisions are made. It will also be important that the added-value provided by PAMS through detailed site specific analysis is able to be fed back to the higher level tools to inform future decisions. The primary vehicle for the transfer of information is likely to be NFCDD, with PAMS providing the underpinning defence data for all other tools.

In particular the PAMS suite of tools will provide the most detailed analysis of defence reliability taking account of multiple failure modes (based on joint analysis of limit state equations) and, ultimately, asset deterioration processes. Significant effort will also be devoted to determining both the asset and asset element contribution to risk.

Unlike the tools used in the development of NaFRA 2004 or MDSF, PAMS is being constructed with the goal of providing a tool primarily for use directly by Agency staff. As such it is likely that PAMS will include a series of prescribed "closed" models and hard links to NFCDD and other datasets.

2.2.4 Regulation (tool yet to be defined)

The decision support framework associated with the Agency regulation function are currently being developed as part of the "Flood risk for New Developments" project led by HR Wallingford. This project adopts the source-pathway-receptor and the notion of a hierarchical assessment utilising the RASP methodologies.

2.2.5 Flood event management (tool yet to be defined)

A number of scoping studies have been completed that set out an approach to flood warning that utilising the risk information provided by NaFRA. More detailed tools for both flood warning and flood forecasting that utilise the source-pathway-receptor concepts within a system-based analysis have been outlined. However at present these are not being progressed.

2.3 A common analysis approach supporting all planning tools

As shown in Figure 2.4, one or more of the RASP methods feature in support of each defined decision-specific tool. These approaches have been developed through the Risk Assessment for Strategic Planning (RASP) project (HR Wallingford, 2004) and

in turn adopt the *source-pathway-receptor* concept. The general framework of analysis supported by RASP is shown in Figure 2.5 below.

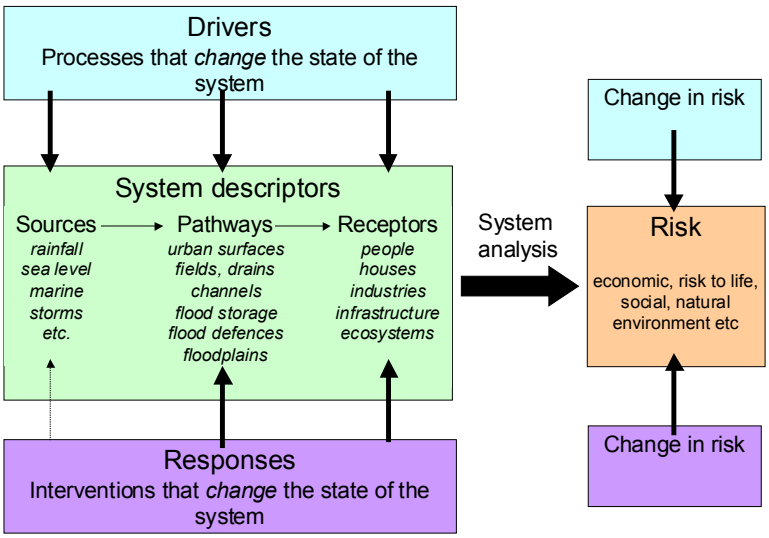

Figure 2.5 Systems-based view supported by the RASP approaches

The availability of data and the resources available/considered appropriate to explore the components of probability and consequences for a particular decision dictate the detail of the analysis. This has always been the case. However, within RASP the ability to vary the level of detail to reflect the decision in-hand has been for the first time formally recognised in a hierarchy of approaches reliant on varying degrees of data input. It is not, however, the formal recognition of this hierarchy that is innovative within RASP but rather the progressive nature of analysis from one level of analysis to the next.

Therefore, although the methodologies applied to each of the source, pathway and receptor terms shown in Figure 2.5 vary between the levels of detail – and the associated complexity and detail of the data used – the generic steps within the RASP analysis remain the same (as outlined in Figure 2.6). In particular, all tiers of the RASP methodology deliver:

- Failure probabilities for individual defences
- Failure probabilities for the defence "system"
- Total flood risk for an identified "impact zone"
- An indication of the risk associated with each defence
- Associated uncertainties – reflecting data quality and the modelling methods used.

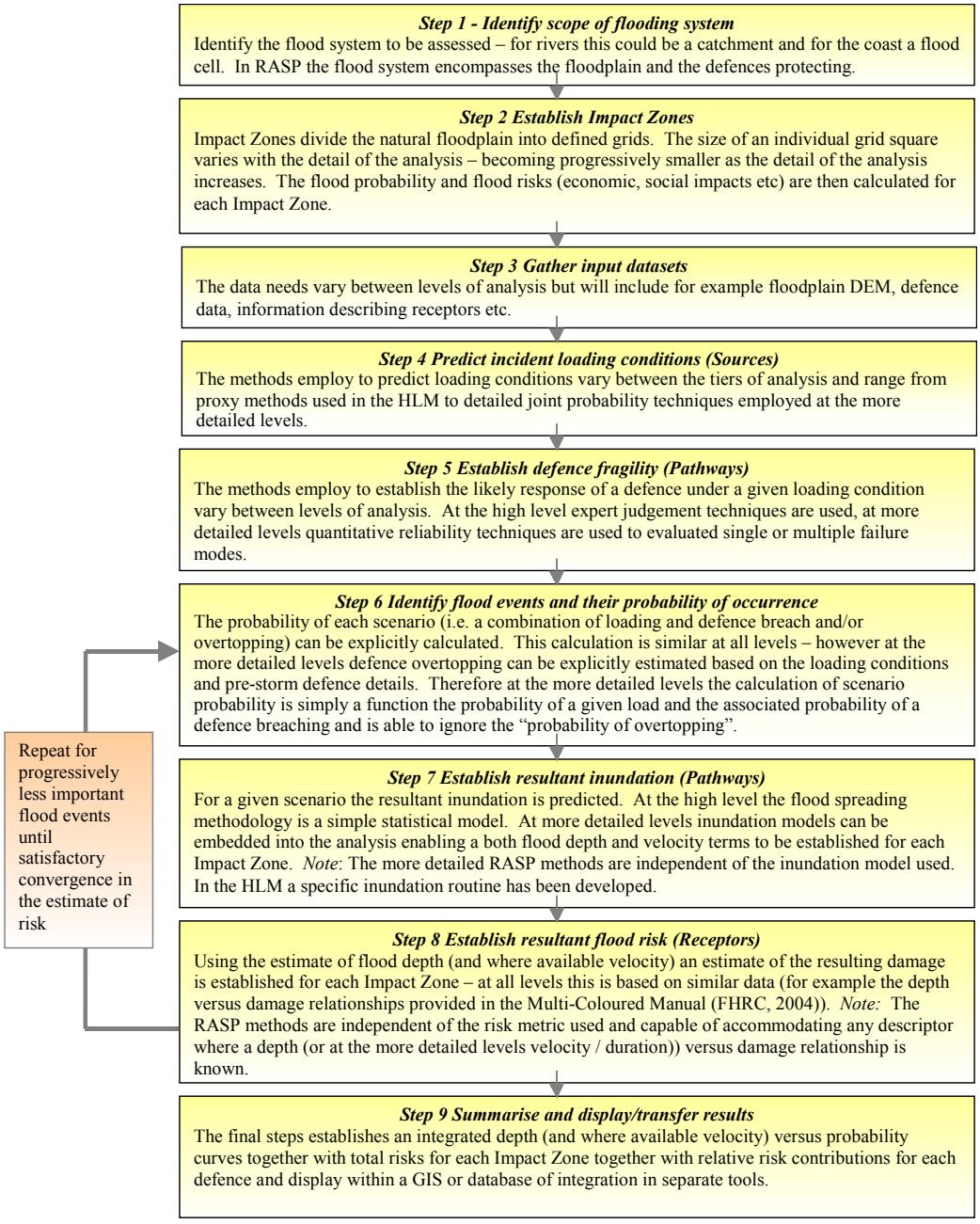

Figure 2.6 Generic process of analysis common to all tiers of the RASP hierarchy (HR Wallingford, 2004)

The concept within RASP is that where possible all data is provided from and returned to nationally accessed databases. This may be outline or offline access, but the principle of common data usage and continual improvement of data quality remains.

2.4 Development of MDSF2 – Technical issues

It is envisaged that the existing MDSF tool will be developed to incorporate the RASP concepts. The purpose of this section is to outline the proposed changes in the method for flood risk assessment in MDSF2 compared with the MDSF.

The primary change will be in the way data is prepared (including continuous defence lines, defence systems and impact zones) and the way in which defences are represented and the possible flooding scenarios determined and integrated. A simple flow chart of the framework to be developed in MDSF2 is outlined in Figure 2.7 – this will need to be expanded and specific methods developed during the implementation phase. A discussion of the more important elements of Figure 2.7 is provided below.

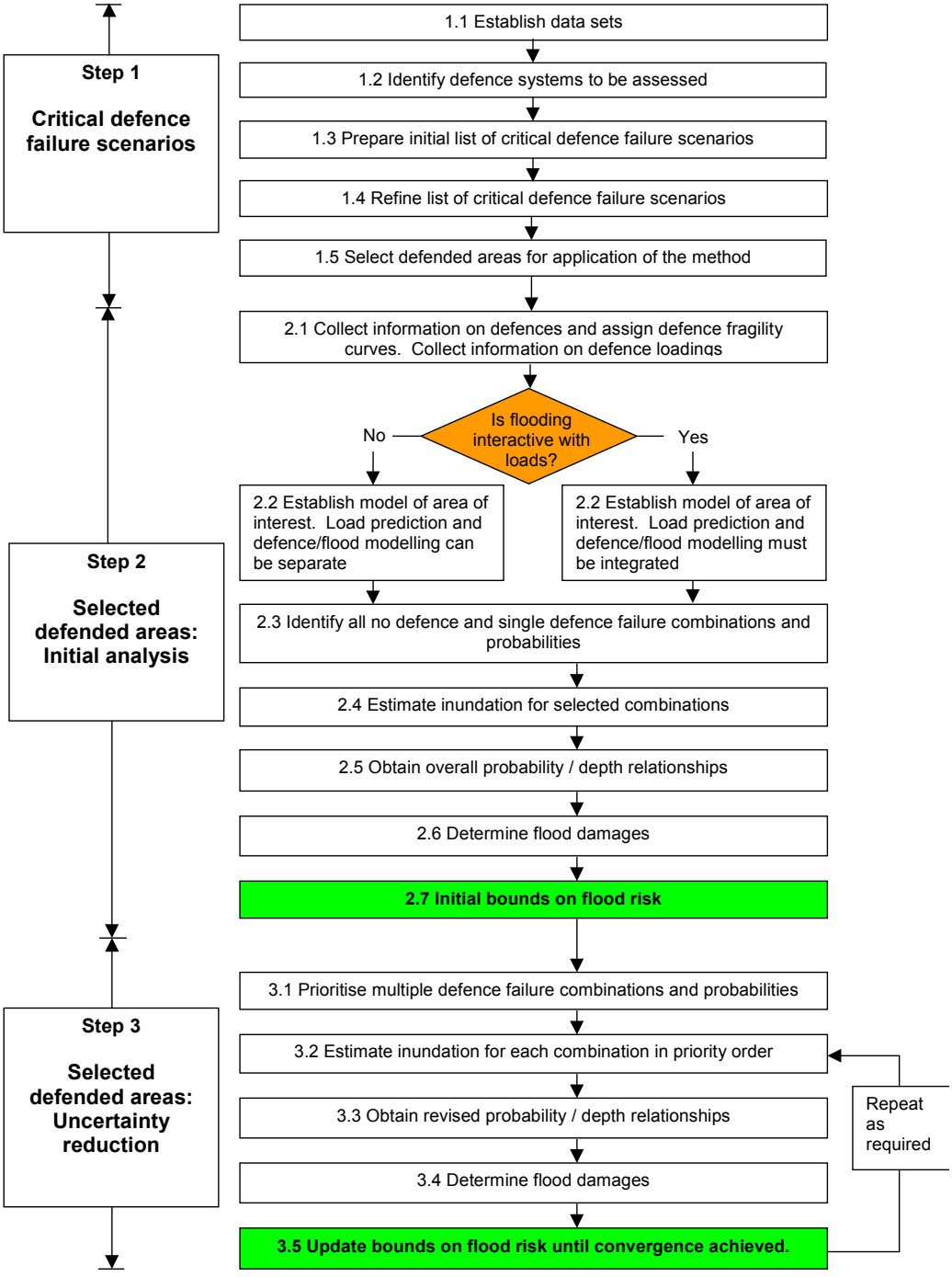

Figure 2.7 Outline of approach to integrating RASP analysis methods

2.4.1 Data preparation

Although not prescriptive regarding the analysis models (i.e the flow model, defence performance model etc) RASP does prescribe the basic data needs and the form of the data. In particular it requires, for example:

- ***Continuous defence lines*** – Information on the boundary between the river / coast and the land is required through the model space. At present the NaFRA tools consider only the primary linear defences. This may have to be extended within MDSF2 to include both *major* and *minor* linear defences. Data on defence lines is being collected under the Agency's Asset Data Action Plan.

- ***Defence location, type and geometry*** – To enable the performance of the defences under load to be determined certain basic information characterising each defence is required. Within NaFRA missing data is infilled using simple "judgement" rules. Within MDSF2, however, it is likely that critical missing data will be collected and returned to NFCDD (for example defence crest level).

- ***Impact zones*** – Impact Zones are used to discretise the floodplain. These facilitate the RASP analysis and provide for simple calculation of risks based on integrated flood probabilities.

2.4.2 Representing the protection afforded by and performance of flood defences – breach probability

The main enhancement to methods developed as part of MDSF will be the enhancement of the way in which flood defences are taken into account in the analysis of flood risk. The MDSF currently treats defended areas as areas that only flood if water levels (or flood frequency) exceed defence levels (or defence standard). When defended areas do flood, they are assumed to flood to the same water level as areas outside the defences. The method takes no account of breaching of defences or the actual water levels that occur during overtopping.

The methods developed as part of the RASP project will be utilised. In particular this will include the concept that defences behave as systems and that their performance relates load to probability of failure (the so called fragility curves). A comparison between the implied assessed of defence performance currently within MDSF and approach prompted within RASP is given in Figure 2.8.

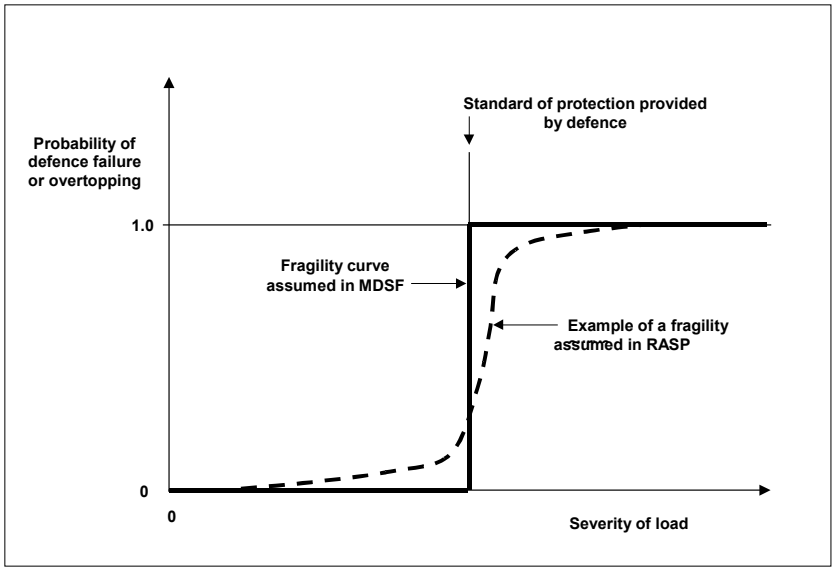

Figure 2.8 Fragility curves implied in MDSF and used in RASP

In general terms, the physical mechanisms that lead to failure of flood defences are often poorly understood. There is therefore significant uncertainty in any attempt to understand the performance of a defence under load. The approaches developed in RASP enable this uncertainty to be capture explicitly and provide a powerful tool in directing effort towards gather an improved understanding. This uncertainty is typically represented through upper and lower bounds on the fragility curve.

It is envisaged that the fragility curves developed for the RASP HLM+ will provide the basis for use within MDSF2. Where required it will be necessary to include a user defined fragility curve – derived from either specific reliability analysis or expert judgement.

Note: It is likely that once the PAMS projects are complete it will be possible to provide MDSF2 users with a standalone "fragility" module to explore and develop fragility curves for individual defences using limit state equations, associated defence condition and geometry data.

2.4.3 Representing the protection afforded by and performance of flood defences – breach size (wide and invert)

Breach probability only provides a limited story. Both breach size (wide and invert) and rate of growth provide critical constraints on the discharge into the floodplain. Within the RASP HLM+ a number of simplifying, but physically realistic, algorithms are provided to determine breach wide and invert. These will be utilised within MDSF2. However, where more detailed modelling is available – for example the application of the HR BREACH model, MDSF2 should be capable of including a growth time series (or perhaps more simply a discharge hydrograph).

2.4.4 Selection of events for analysis

For practical purposes, it is important to limit the number of combinations of source, pathway and receptor behaviour to those that provide a non-negligible contribution to

flood risk. Fundamental to both NaFRA and PAMS is an ability to limit the number of scenarios to those that really matter. Various techniques have already been demonstrated as part of the RASP R&D project and offer an efficient approach to optimising runtimes. However these will need to be developed in the context of MDSF2.

In setting up runs for MDSF2 an important step will be to screen the scenarios to eliminate the ones that make a negligible contribution to risk. These can be achieved through a number of crude approaches such as limiting the number of multiple breaches considered and/or eliminating those failure combinations with a probability below a defined threshold (eg 10^{-4} per annum). CFMPs/SMPs and strategies will however have recourse to the results from the latest NaFRA analysis and the RASP HLM+. The NaFRA results could inform the selection of runs, or alternatively the RASP HLM+ could be embedded within MDSF2 and rerun using any refined data. For example, only those scenarios contributing a defined percentage to the total risk – as estimated using the RASP HLM+ module / NaFRA results – would be run.

Beyond these coarse filters a more sophisticated approach will need to be embedded within MDSF2. The RASP R&D project has shown that joint probability analysis techniques can be used to reduce the number of runs required to achieve robust structure functions and hence results. The development of "intelligent sampling" enables further runs to be targeted towards areas of the scenario space that are ill defined by the initial structure function. However direct use of joint probability analysis has proven to be difficult in the past and therefore, within MDSF2, care will be needed to determine the appropriate level of user control over this element.

Users will also be able to directly intervene in the selection of scenarios to run thus allowing 'soft knowledge' and 'engineering judgement' to be applied.

Each scenario is run using a flood spreading model to spread the floodwater and produce a flood depth (and if required velocity) within each Impact Zone under a given loading and defence system state scenario. The flood depth information can be used to determine associated consequences (for example economic damages). Combined with knowledge on the scenario probability, a simple integration over all scenarios provides an assessment of the overall flood risk.

2.4.5 Case management

The case management facilities in MDSF provide a useful building block for MDSF2. However, as the number of cases proliferates (with options and scenarios) a simple unstructured database of cases will become unwieldy. It is inevitable, even with intelligent scenario selection, that a move to embed the RASP methods will lead to a large number of model runs to manage.

Furthermore, there need not be a one-to-one mapping between cases and model runs. Smart case management could enable cases to be reused for uncertainty analysis and testing of scenarios that change the probability of a boundary condition but not the defence conditions themselves.

The systematic case management approach developed in EUROTAS is now being developed further in Floodsite (by HR Wallingford and others in Task 19) and the Flood Risk Management Research Consortium. This will be explored in MDSF2 with a view to minimising the number of runs.

2.4.6 "Interactive" and "non-interactive" flood defence and floodplain modelling

When modelling defended areas, there is an important distinction to be made between areas which, when they flood, cause a change in the source of flooding and those which do not. This distinction and the associated definitions are as follows:

- No feedback between flooding on the floodplain and the source of flooding (for example, tidal inundation on the coast). This is referred to as the ***non-interactive*** case;
- Feedback between flooding on the floodplain and the source of flooding (for example, embankment failure on a small river where a large proportion of the flow enters the floodplain, thus reducing the water level in the river and therefore changing the load). This is referred to as the ***interactive*** case.

The reason why this distinction is important is that the interactive case requires more complex modelling (such as a coupled river and floodplain model). In the non-iterative case the loading can be decoupled from the inundation model.

In practice, the majority of flood defence systems will be of the non-interactive type, particularly those on coasts, wide estuaries and on rivers where the defended areas are relatively small. Examples where interaction will be important are large floodplains on perched rivers (for example, the lowlands of East Anglia and Yorkshire) and narrow estuaries (for example, parts of the Thames). In such cases, a breach at one location could reduce the chance of a breach elsewhere because of a reduction in loading.

Even in the interactive cases, a non-interactive method may provide sufficiently accurate results and will be used as a quick screening tool. For example, the non-interactive method could identify critical failure locations and limit the number of subsequent interactive simulations needed.

The test for the "interactive" case is to analyse the volume of water in the breached area in an initial "non-interactive run", which is then compared with the discharge in the river.

It is intended that floodplain modelling for the 'non-interactive' case is included in MDSF2 to facilitate rapid calculation of flood hazard without the need to run external models for the potentially large number of cases needed for a RASP analysis. It is accepted that the 'interactive' case will require external modelling to avoid trying to introduce the complexities of river and coastal modelling into the MDSF2 software.

2.4.7 Prediction of inundation extent, depth and velocities

The method will take account of the overtopping and breaching of flood defences in the following ways:

- Where overtopping occurs and the defence remains intact, flooding occurs as water enters the floodplain. This is based on a hydraulic calculation of overtopping rate driven by the head over the defence/bank. The water level in the defended area is generally lower than the source water level.

- Following a breach, overtopping or breach flow can occur. The discharge into the floodplain will depend on the rate of growth and size of the breach. These can be considered offline or online. It is likely that within MDSF2 the size of a breach will be determined outside of MDSF. A default method could be included in MDSF2, together with guidance on application.

The difference between the methods of representing flooding in the existing MDSF (using the in-built simple flood spreading algorithms) and the RASP approach is shown on Figure 2.9.

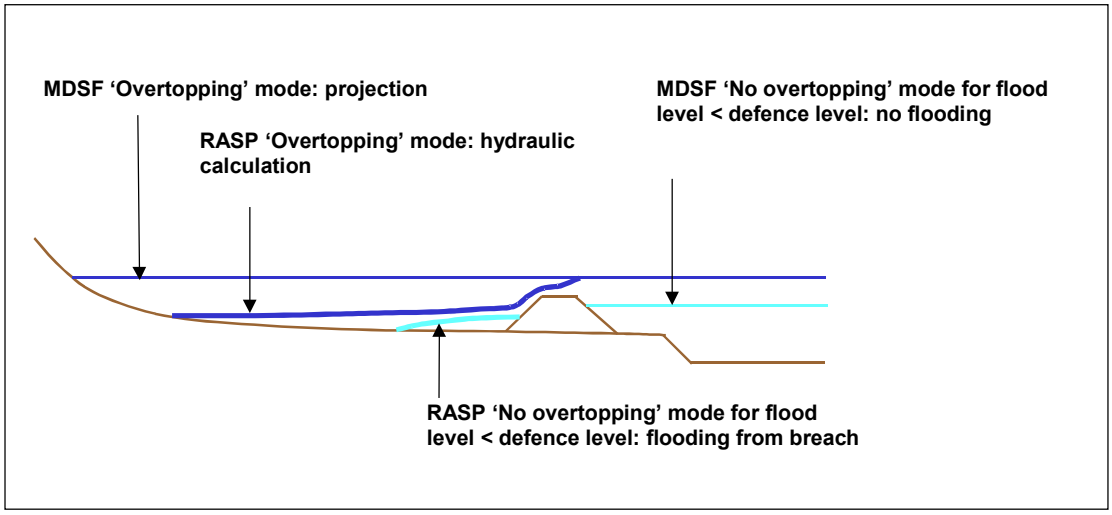

Figure 2.9 Modes of flooding in existing MDSF (using in-built method) and RASP

For reasons of efficiency an embedded flood spreading tool is beneficial, but this should be implemented such that users can understand the methodology and check results. In addition, the software architecture should also facilitate the use of external flood spreading tools (eg input files to the flood spreading module(s) should be generated in a format that could be used/modified for using in an external spreading tool).

A key issue in the development of MDSF2 is the selection of a modelling approach that is consistent with the Agency's desire to converge modelling and avoid as far as possible the introduction of new types of modelling that are likely to give different results to existing models. Some of the issues to be considered are as follows:

- RASP requires models that run rapidly, and are therefore likely to have less detail than models in current use.
- Existing models have been developed with varying levels of detail according to application. However the majority of existing models are relatively detailed compared to the needs of a RASP analysis.
- The most efficient way to undertake a RASP analysis is to batch a large number of runs. However, this requires a stable model. Some existing models are not stable over the wide range of scenarios likely to be required for a RASP analysis.

A possible approach to floodplain modelling for MDSF2 is as follows:

- Use results from existing detailed models to set limits on flood extent and depth (as is already done in the tools developed for NaFRA 2004).
- Use a floodplain model that is of the same type as existing floodplain models, but with simplified definition for quick running (for example, larger cell size than the equivalent detailed model).

This issue will be considered further at the beginning of the implementation phase.

2.4.8 Investment costing

An important element of determining strategy is to maximum benefits and minimise costs by trade-off of different possible management approaches. Within MDSF2 a simple but appropriately robust investment module could be developed to assist in estimating approximate costs associated with particular options.

2.4.9 Calculating risk metrics

The main functionality of MDSF is for numerical integration of the loss/probability curve. Introduction of the RASP methods elaborates on this merely by including another (discrete) variable over which the probability distribution is integrated (i.e. the indicator variable for breach scenarios). Inclusion of RASP in MDSF2 therefore does not change MDSF in principle. It is still a tool for numerical integration.

The RASP approach calculates flood water level against probability at any location in the defended area by considering overtopping events for the defence system and breaching scenarios for each element of the defence system. The resulting flood depth/velocity versus probability curves are provided for each Impact Zone. This is a slightly different concept to MDSF and should simplify the calculation of risk using the economic damage calculation procedure in MDSF.

The method for calculating flood risk in MDSF2 will be based on the RASP approach whilst utilising the existing functionality in MDSF for linking different datasets. In particular this will include:

- Economic risk
- People risk
- Other metrics to be determined during Phase 2. For example, multi-criteria analysis will become increasingly important in determining strategy. MDSF2 could be adapted to support such an analysis fairly readily.

2.4.10 Time-dependent variation in flood risk

An important element in the risk calculation process is how time-dependent changes should be taken into account. These include:

- Changes that can occur annually but may also have longer-term trends, for example the lowering of the foreshore in front of a coastal flood defence or the build up of vegetation in rivers. These affect the loads on the defences.
- Changes that can occur over longer time scales, for example climate change or land use/development change. These affect the loads on the defences (and consequences of flooding, if development takes place in the flood risk area).

The MDSF scenario manager will be extended to include multiple time slices, representing possible futures externally identified by the user (eg current, 2050 and 2100 as applied in the Thames Estuary 2100 project or any other given time horizons).

For each time horizon, basic changes could either be postulated by MDSF directly (perhaps based on a given climate scenario) or provided externally by the user.

Experience of FloodRanger and FloodRanger Professional concepts will be utilised here.

2.4.11 Uncertainty analysis and decision robustness

The uncertainty analysis in MDSF is a useful approach for looking at the key uncertainties. There is a limit however to the extent to which the approach is scaleable to uncertainty and sensitivity analysis for larger numbers of not necessarily independent variables.

Users are obviously nervous about the implications of introducing the RASP methods. It is therefore important that there are good diagnostics to show the effect of uncertainty of the variables (e.g. fragility curves) that they may be nervous about. This sensitivity analysis is not straightforward. It will need to be supported i.e. the sampling design for the sensitivity analysis and the post-processing of results to generate sensitivity indices.

Concepts of decision robustness are not well understood. This is not just to do with whether options are still desirable when subject to a sensitivity test of key uncertainties. It is to do with the *rate* at which options lose performance when the future departs from expectations. The exploration of decision robustness will be supported by MDSF2.

At the CFMP stage strategic options are thought of only in approximate terms, yet in MDSF they may be given precise definitions for implementation in the hydrodynamic model, for example. An attractive alternative would be to propagate approximate option definitions through models and avoid converging too rapidly to a precisely defined solution, which is not in the spirit of CFMP. Although this will not be included in MDSF2 this may feature in future improvements.

2.4.12 Coastal erosion risk – special issues

Coastal risks, both for flooding and erosion risks, are significantly influenced by the time-dependent processes of shoreline evolution through time needs to be taken into account. This may also be a case in river systems with active morphology or other deterioration processes. In coastal situations it is critical – beach lowering is a key initiator of failure and depends on long term shoreline evolution. Clear advice and associated methodological procedures will need to be provided from the Risk Assessment for Coastal Erosion project to help deal with these issues.

2.4.13 Issues arising from development of the original MDSF

Experience from the development of the original MDSF must be taken into account in MDSF2. Some specific issues are discussed below.

Data availability
Data for use with the MDSF was originally supplied from a single national source. This responsibility has now been devolved to the Agency Regions. It is vital to ensure that the data sets required by MDSF2 are carefully managed so that they are available when required and kept up-to-date. A particular issue has arisen with the application of the MDSF to SMPs led by Local Authorities. In this case, the Operating Authority does not have direct access to the data sets needed for the MDSF, and this has caused difficulties with the assembly of data.

Testing of the system
MDSF2 will require alpha and beta testing before being released for general use. In the development of the original MDSF, the system was beta tested on pilot CFMPs by consultants who had not been involved in the development of the MDSF. In addition, adequate support arrangements were not established for several months after the MDSF had been completed. These problems led to wasted effort, as the consultants tried to overcome problems with a limited amount of support.

It is recommended that some of the beta testing is carried out by the development team, as this will provide rapid assessment and fixing of problems arising from the practical application of MDSF2. It will also prepare the development team for responding to queries raised by other beta testers, and subsequent users of the system.

3. CONSULTATION

3.1 MDSF Peer Review outcomes

Following the development and initial application of MDSF, an independent Peer Review was carried out to consider the suitability of the MDSF to the development of CFMPs, and recommend improvements.

Underlying the outcome of the Peer Review was the recognition that **the MDSF is a tool that is suitable for a range of applications at different scales, not just CFMPs**.

The MDSF has since been applied to Strategy Plans and SMPs in addition to CFMPs.

In view of this, the MDSF documentation has been made 'non-CFMP specific'. The conclusions of the Peer Review are given below, together with comments and actions taken.

1. The MDSF software is a suitable tool for application to CFMPs. It is not the only tool which will be needed for efficient production of the CFMPs.
   Dissemination and training for the MDSF has stressed what the MDSF will do (and what it will not do).

2. The MDSF encompasses advice and functionality that will potentially aid the CFMP process but it should be regarded as a "slave" and not used to dictate a particular approach. It is based on data sets that are most useful when considering the policy implication of flood risk at a catchment scale. Provided its limitations are understood it can be used as a platform to structure the CFMP process.
   See comment under 1 above.

3. The MDSF software should remain in its present form for the time being.
   The present software will be maintained while MDSF2 is under development. Backward compatibility will be provided the existing version of the MDSF.

4. A formal support arrangement for the software should be put in place.
   This has been provided.

5. The MDSF Procedures need major revision to enhance their effectiveness and focus towards supporting decision-making in a CFMP.
   Underlying this conclusion was the recognition that the MDSF can be applied more broadly than just CFMPs. The MDSF Procedures have been revised to make them 'non-CFMP' specific and sections specifically relating to CFMPs removed. The revision was also intended to enhance the effectiveness of the Procedures in supporting decision making in CFMPs and other studies.

6. The Procedures should include greater emphasis on the need for judgement, most particularly in the identification of fundamental catchment processes and the adoption of appropriate hydrological and hydraulic modelling techniques. MDSF users should be given greater encouragement to use information and techniques that give credible results.

This has been addressed in the latest version of the MDSF Procedures

7. All developments of MDSF should be directed by a Steering Group having an Agency champion and involving prospective users from consultants and the Agency.
   This has been provided.

The Peer Review did not include specific recommendations for improving the functionality of the MDSF.

3.2 Stakeholder consultation

A workshop was held on 18th February 2005. The participants at the workshop are listed in Appendix A. They were divided into three groups and asked to consider the following eight questions.

1. Do you have any comments on the concept of MDSF2?
2. Are there broader uses of MDSF2 outside flood risk management planning?
3. Should broader option appraisal facilities be included in MDSF2 to support the Agency's move to integrated flood risk management and Multi Criteria Analysis? If so, what?
4. Do you have comments on data requirements and availability for MDSF2?
5. Are we missing any opportunities to increase the value of MDSF2 without excessive additional effort?
6. Do you have any other ideas for improving the functionality of MDSF2?
7. Do you have any concerns about the practical implementation of MDSF2?
8. Are there any lessons we can learn from the development of the original MDSF?

The responses are given in Appendix B.

Some of the issues arising from the consultation workshop that affect the design of MDSF2 are as follows:

- Need to be clear about who will use MDSF2, and for what purpose. There should be wide access to MDSF2.

- Needs to be clear what MDSF2 should be used for, and how.

- MDSF2 should be simple to use, as it will be one of several tools used by practitioners.

- Need to consider additions that improve the appraisal capability of MDSF, including costs, environmental impacts, broader economic impacts, current appraisal approaches (including priority scoring), and MCA approaches.

- Need to consider future requirements of the Environment Agency and Operating Authorities, for example with respect to the Water Framework Directive and other developments.

- Need to provide visualisation facilities for the presentation and communication of information to stakeholders including the general public

- Take advantage of the GIS capability of MDSF to provide other spatial information for flood management, including locations of hospitals, schools, emergency services, rests centres, etc.

A further requirement of MDSF2 is the ability to assess the impacts of future developments and strategic plans. This can be accommodated to a large degree by existing MDSF functionality, for example by adding new developments to property data sets. However specific guidance on how to assess impacts of new developments using MDSF2 will be provided in the User Manual and Guidance.

4. TECHNICAL ISSUES

4.1 Requirements for RASP implementation

The specific requirements of the RASP implementation are discussed in Section 2.4 above and summarised below.

- Links with NFCDD data
- Development and manipulation of fragility curves to represent defence performance
- Import or selection of breaches
- Guidance on event selection to converge flood risk bounds
- Link number of cases with number of model runs, as there could be many model runs for one 'case'.
- Non-interactive modelling (interactive case by external modelling)
- Flood spreading tool
- Costs capital and maintenance work
- Calculation of risk metrics (economic, people, other)
- Time dependent variation in flood risk including long-term variation (for example, deterioration of flood defences and coastal erosion issues)
- Improved handling of uncertainty.

Some of these items are essential for the RASP implementation whereas others would be 'nice to have'. Priorities are considered in Section 4.7.

4.2 GIS platform

ArcView was the Environment Agency's preferred GIS system in 2001. As such, the original MDSF was developed to interface with ArcView 3.2a using DDE. ESRI, the developers of ArcView have since superseded ArcView by a new range of ArcGIS products including desktop, server and mobile GIS packages.

The Environment Agency is currently migrating legacy GIS systems onto an ArcGIS 8.x implementation and consequently there is a need to upgrade the MDSF to enable users to employ the power of the new software systems.

Within the ArcGIS Desktop collection there are four products; each adds a higher level of functionality.

- ArcReader is a free viewer for maps authored using the other ArcGIS Desktop products. It can view and print all maps and data types. It also has some simple tools to explore and query maps. It is likely that ArcReader will be made available to all Environment Agency staff as part of the standard desktop. ArcReader effectively replaces the legacy MapExplorer 2 software.

- ArcView provides extensive mapping, data use, and analysis along with simple editing and geoprocessing capabilities. It is likely that ArcView will be made available to many Environment Agency users as the primary GIS system.

- ArcEditor includes advanced editing for shapefiles and geodatabases in addition to the full functionality of ArcView. It is likely that ArcEditor will be made available to a number of 'power users' in the Environment Agency.

- ArcInfo is the full function, flagship GIS desktop. It extends the functionality of both ArcView and ArcEditor with advanced geoprocessing. It also includes the legacy applications for ArcInfo Workstation. It is likely that ArcInfo will only available to a small number of specialist users in the Environment Agency.

All ArcGIS Desktop products share a common architecture, so users working with any of these GIS desktops can share their work with others. Maps, data, symbology, map layers, geoprocessing models, custom tools and interfaces, reports, metadata, and so on, can be accessed interchangeably.

The latest release of ArcGIS (at the time of writing) is version 9.1 with version 10 in development. It is likely that the Environment Agency's preferred GIS system will be further upgraded in the future. Although currently unlikely, the possible future use of an alternative system from a different supplier should not be ruled out. Some consultants to the Agency and many Local Authority users have licenses to and experience of alternate GIS systems (primarily MapInfo). Consequently, it is important that MDSF2 be developed as independent of GIS system as possible.

It is proposed that MDSF2 be developed with all GIS functionality provided as a 'plug-in' that can be developed or upgraded separately as users require. Initially, an ArcView or ArcEditor plug-in should be provided. MDSF should continue to operate fully (although with reduced visualisation functionality) if no GIS system is available. Plug-ins should be constructed to support visualisation of grid or TIN data only if the appropriate extensions are available.

Creation and access to GIS data should also take place through the plug-in layer such that underlying datasets can be stored (and possibly converted) from one GIS format to another. In addition, geodata components should be kept separate from the visualisation components such that they can be re-used between different visualisation modules (MapExplorer, ArcView, ArcGIS and ArcIMS would all use the same underlying geodata formats). It will be important to define robust interfaces between the components early in the MDSF2 project.

4.3 Approach to modular software and flexibility

MDSF2 should be designed as a modular system. User interface and scientific calculation modules should be kept separate to enable re-use of the technical aspects in other applications in the RASP family, such as PAMS.

Cohesive blocks of similar calculations should be packaged as distinct units (or modules) allowing for efficient future maintenance, improvement or replacement. Dependencies (or module coupling) should be avoided where possible whilst ensuring that code duplication is kept to a minimum. Common functionality required by many modules should be identified early in the development process and lifted into one or more 'core' packages.

Components should be designed with clearly defined and documented interfaces that facilitate their re-use in other software, possibly coded in different languages. The use of well-defined interfaces also helps in the avoidance of excessive unit coupling.

There are potentially significant cost and functionality benefits available from some third-party components and their use should not be ruled out. However, third-party modules should be avoided where licensing issues associated with their use may hamper redistribution or open source code access. Equally, any proposed third-party components should be evaluated for compatibility with Agency systems (possibly requiring CIS input). Components should be evaluated on a case-by-case basis by the developers, reviewed by CIS as appropriate and only used following approval by the Agency.

4.4 Other functionality

A range of other functionality was identified in the stakeholder consultations, and some of the main categories are listed below. Some of these arise from recent and ongoing research projects, where issues for strategic planning and broader approaches to appraisal are being addressed. Some key recent R&D projects are listed in Appendix C. Decisions are required on which additional functionality to include in MDSF2, and which to leave out.

Other possible functionality for MDSF2 includes:

- Improved property damages including better floor area data; categorisation of residential properties, etc.
- Broader economic damages and benefits, for example infrastructure damage, disruption, benefits of flood warning, etc
- Improved appraisal including link to FCDPAG3 and priority scoring, and the proposed MCA approach in the future
- Environmental impacts, including BSEIM outputs (FD2112), see Appendix C
- Land management change scenarios, based on FD2114, see Appendix C
- Risks to people, based on FD2321, see Appendix C
- Functionality to facilitate the implementation of the Water Framework Directive
- Functionality to facilitate water resources work, although this is not directly linked to flood management
- Mapping of social information including hospitals, schools, etc, to enhance social impact assessment and planning
- Compliance with CIS standards (see Section 4.5 below)

4.5 Access for Agency and Local Authority users

In order to facilitate full access to MDSF2 for Agency users it will be necessary to comply with appropriate clauses of the CIS Technical Standards. Version 5.7 of the Standards has been reviewed and an initial meeting held with CIS (Will Hall – Project Architect).

It was agreed that, although Java is the primary development language within the Environment Agency, this may not be appropriate for this particular project given the volume of MDSF code currently residing in other languages (eg Visual Basic 6),

availability of associated modules developed in other languages, relative benefits of other languages and knowledge of Java within potential contractors.

If the MDSF is to be used by local authorities and Agency consultants the system must be flexible enough to work in a wide variety of computing environments. The plug-in approach to GIS is a key element in the system's flexibility (although it is not proposed to write MapInfo geodata or visualisation components as part of the first release version of MDSF2). In addition MDSF2 should be designed for compatibility with the most common stakeholder operating systems.

A key requirement of the CIS Technical Standards is that the software operates successfully in a Windows 2000 environment. In addition, there is an ongoing evaluation of the possible use of Windows XP within the Environment Agency. XP is widely used by the Agency's primary CFMP and Strategy consultants. As such MDSF should be fully tested under both Windows 2000 and XP. A review, perhaps based on information gathered from the MDSF support team, should be undertaken to determine the extent of usage of other operating systems with a particular focus on Windows NT4 and Windows 98/ME systems. It is not proposed to design specifically for compatibility with these legacy systems unless a strong need is identified during the review.

4.6 Associated Issues

In order to ensure the successful development, uptake and longevity of the proposed MDSF2 system it will be important that the Environment Agency and Defra address the following issues:

- Clear ownership/championship of the software with the Agency
- Clarity of roles, with a link to a project co-ordinator within the Agency
- Clear championship of the software by key non-Agency users including consultants, Local Authorities and other public sector users
- Pro-active management of the take-up of MDSF2
- Acceptance testing of the tools (both 'science' and IT)
- Organise appropriate support and maintenance arrangements
- Organise integration testing of the MDSF2 software for Agency systems
- Roll out the software to the Agency (both IT and awareness)
- Enable the roll out of the software to other operating authorities
- Enable the roll out of the software to consultants
- Ensure Agency users have access to any necessary supporting software (ArcGIS with spatial analyst is the most likely supporting software)
- Ensure users have access to appropriate hardware (eg large hard disks and backup devices)
- Ensure availability of necessary data and production of guidance manual for data preparation
- Training for 'project managers' and for technical users
- Continued internal promotion of MDSF2 (perhaps, but not limited to, pages on the Agency intranet site)
- Change management processes including creation / update of relevant Process Documentation

5. OPTIONS, PRIORITIES AND COSTS

5.1 Options for functionality to be included in MDSF2

A Requirements Specification is provided in Appendix D, which contains about 100 items that could be included in MDSF2. Many of these are 'must have', as they are either already an essential part of the existing MDSF or because they are essential for implementing the RASP approach. The priorities for the others are either 'should have' (ie include if possible) and 'could have' (ie desirable but not essential).

5.2 Essential options and user priorities

The Requirements Specification has been developed to match the primary requirement of MDSF2, which is to include the RASP methodology in MDSF. The other main 'must have' item is the need to be GIS system independent, another key requirement of the project brief. Hence the main 'must have' requirements as shown in Table 5.1 relate to the satisfaction of the project objectives as set out in the specification. These are set out in Section 1 of the report.

There are a large number of other enhancements that could be made including improved management of data and results, improved user access, improved economic and social information, costs, appraisal methods, and new developments.

The process used to decide which functionality to include in MDSF2 was as follows:

- Stakeholders were requested to indicate their preferences.
- Preferences were collated, and approximate costs assessed.
- Selection was then made by the Project Board based on the preferences and the available budget.

The work covered by the above bullet points is described in this section.

Stakeholders were requested to enter their preferences for the development of MDSF2 on a copy of Table 5.1 using the following numbers:

2 = Highly desirable. Strong business case for this justifying additional funding if necessary.

1 = Desirable. Good business case for including this within the existing budget if headroom is available after the 'Must Haves' and 'Highly Desirables'.

0 = Not important

The results for all stakeholders are shown in Appendix E, Table E.1. A total of 15 stakeholders responded to the questionnaire. Results for a selected group of stakeholders representing Defra, the Environment Agency, Local Authorities and Consultants are shown in Appendix E, Table E.2. These organisations will be either direct Clients or regular users of MDSF2. Table D.2 contains results for 7 stakeholders.

Interpretation of the results from Tables E.1 and E.2 are given along with the Must Have items in Table 5.1. The overall rating given in the right hand column is based on a somewhat subjective review of the responses. In most cases there is a clear division between those items that are 'highly desirable' and those that are desireable.

However the definition of 'desirable is less clear. The criteria adopted were an average score per stakeholder of at least 0.9 in Table E.1, and a combined average score per stakeholder of at least 1.9 from the results in Tables E.1 and E.2 added together.

Table 5.1 Main development options for MDSF2

Ref	Item (or groups of items) **Policy requirements are indicated in the descriptions below (see Note 1)**	Appendix D reference IDs	Priority
Implement RASP Methodology			
R1	Import and assign data required for RASP analysis, includes defence data, fragility curves, breach dimensions *EA Policy requirement*	9, 10, 11, 12	Must have
R2	Import loading data (eg water levels, flows) *EA Policy requirement*	8	Must have
R3	Module(s) to generate failure probabilities, manage RASP simulations and results, including guidance and tools for selection/screening of required simulations *EA Policy requirement*	3, 15, 16, 17, 18, 19, 40, 66	Must have
R4	Implement rapid flood spreading module (for non-interactive flooding) including export of results for checking *Convergence required with existing and future EA modelling approaches*	32, 58	Must have
R5	Easy viewing (and possible editing) of input data within MDSF2 (eg fragility curves, defence data)	13, 48, 49, 50, 52	Highly desirable
R6	RASP methodology implemented for non-linear defences, eg pumps, sluices *EA Policy requirement*	51	Desirable
R7	Include time dependent variation in flood risk, eg deterioration in flood defences		Desirable
R8	Improve uncertainty analysis (eg using upper/lower fragility curves)	66	Desirable
GIS 'upgrade' and other IT/generic requirements			
G1	MDSF2 to be as GIS-system independent as practical and work with ArcGIS v8 *EA Policy requirement*	27,	Must have
G2	Software to be robust, well tested, 'fit for purpose', efficient to use, modular, generates metadata, enables efficient data import/export, scale independent. *EA Policy requirement*	20, 33, 37, 44, 56	Must have

Ref	Item (or groups of items) **Policy requirements are indicated in the descriptions below (see Note 1)**	Appendix D reference IDs	Priority
G3	Compliant with relevant CIS technical standards, suitable for operating on standard Agency Desktop PCs (of sufficient 'computer power'), easy installation. *EA Policy requirement*	21, 35, 36, 43, 67	Must have
G4	Agency to own code and IP. Code developed to be modular, well structured and documented and suitable for 'open source' release. *EA Policy requirement*	62, 63, 64	Must have
Other requirements			
O1	Provide/maintain MDSF1-type methods, ie case management, data import, simple flood mapping, economic damage calculation, coastal erosion impact calculation, social impact calculation, simple sensitivity analysis, results aggregation and export.	1, 2, 4, 5, 6, 7, 25, 28, 29, 30, 31, 39, 41, 42	Must have
O2	Provide suitable user manual and technical background documentation – facilitating transparency in calculations	23, 24, 38	Must have
O3	Enhanced damage calculation 1: calculate AAD for all provided return periods, use new VOA-derived floor area data, easier summaries of impacts (eg count of flooded properties by area), facilitate review of properties contributing high % of overall risk (eg using Data Quality Score), better use of the 'GroundLevel' field in the NPD, calculate asset value within floodplain, use 2005 MCM depth-damage curves, cap property damages at asset value, add description of property classes to look-up tables	26, 53, 54, 55, 59, 84, 87, 76, 77, 78	Desirable
O4	Minor improvements to MDSF1 case management approach suggested by users: improved case management, more flexibility in case numbering, reuse of simulation results for multiple cases	45, 46, 47, 74	
O5	Maintain support for the MDSF Wizard (allows MDSF results to be easily distributed by CD and viewed without access to GIS software)	60	
O6	Minor improvements to the social impact assessment, including easing the joining process of social data and spatial data	61	Highly desirable
O7	Minor improvements to the use of externally generated flood depth grids: improve ease of loading, allow perturbing of flood grids for sensitivity analysis, merging of multiple flood depth grids, 'spreading the edge' of imported broad scale flood grids over high resolution DEMs	57, 65, 94, 95	

Ref	Item (or groups of items) **Policy requirements are indicated in the descriptions below (see Note 1)**	Appendix D reference IDs	Priority
O8	Allow multi-user access to MDSF database	68	
O9	Provide on-line context sensitive help	69	
O10	Deliver the 'Risk assessment of coastal erosion' R&D outputs (FD2324) *Need should be based on Policy requirement*	70	Desirable
O11	Provide/facilitate estimation of costing for capital and maintenance work	71, 72	
O12	Direct interaction with NFCDD (eg for defence data and fragility curves in future)	14, 73	Highly desirable
O13	Enhanced economic damage calculation 2: infrastructure damage, transport disruption, damage avoided by flood event management/building resilience and recommendations from MCM revision (FD2014), eg flood duration varying damages *EA Policy requirement*	75, 86, 88	Desirable
O14	Enhanced economic damage calculation 3: easy graphing of depth-damage curves from MDSF2, easy access to property flood areas and threshold, ability of adjust threshold levels by defined polygon, calculate present values, improved calculation/assignment of asset value.	79, 80, 81, 82, 83, 85	Desirable
O15	Mapping of key social and emergency response data including hospitals, schools, flood warning areas, etc *Need should be based on Policy requirement*	89	Highly desirable
O16	Provide or build in future capacity to add Broad-scale Ecosystem Impact Modelling habitat potential analysis tool (incorporate FD2112) *Need should be based on Policy requirement*	90	
O17	Improve links to appraisal methods: MCA (incorporate FD2013), populate PAG3 spreadsheet, provide data for Defra priority score *Need should be based on Policy requirement and ability to achieve sufficient detail in MDSF2*	91, 97, 98	Highly desirable
O18	Linkages to integrated urban drainage plans (would need significant further work to scope) *Need should be based on Policy requirement: keep option open for future incorporation*	92	
O19	Linkages to Water Framework Directive (would need significant further work to scope) *Need should be based on Policy requirement: keep option open for future incorporation*	93	
O20	Provide tool to assist implementation of FD2114 - land management impact on flood generation *Need should be based on Policy requirement*	96	

Ref	Item (or groups of items) **Policy requirements are indicated in the descriptions below (see Note 1)**	Appendix D reference IDs	Priority
O21	Provide a 'FloodRangerPro' type visualisation tool to enable stakeholders to better understand MDSF2 results	99	
O22	Include 'flood risks to people' calculation (flood hazard) (incorporate FD2321) *EA Policy requirement but methods must be suitable for practical application*	100	Desirable
O23	Improve use of spatial data sets: direct use of tiled DEMs, support image catalogues	101, 102	

Notes:

1. There is a need to ensure that the functionality of MDSF2 is consistent with Defra and Environment Agency policy. Those items where a policy decision is required are noted in the Table.
2. There is a need to ensure that the methods in MDSF2 are consistent with the methods and processes used by the Environment Agency. Liaison will be required on such issues as appraisal approaches, etc.
3. The above functionality will require access and support for national data sets including those required by the MDSF and those required for the new functionality of MDSF2. Appropriate licence conditions for data sets will be required.
4. A modular approach to development is proposed, to facilitate inclusion of additional functionality at a later date (for example O16, O18 and O19 above).

5.3 Costs of development and dissemination options

Estimated costs for the development of all the potential options for MDSF2 are presented in Appendix E. The costs are summarised in Table 5.2 below.

Table 5.2 Cost summary

Ref	Item **(See Table 5.1 for fuller description)**	Cost (£)	Priority (from Table 5.1) and comment
R1-R4	RASP: methodology development and software	120,000	Must Have *Modelling approach requires review, see Sections 1.3 and 2.4.7.*
R5	Easy viewing of input data	8,000	Highly Desirable
R6	RASP for non-linear defences (method and software)	20,000	Desirable
R7	Time dependent issues (method and software)	10,000	Desirable
R8	Improve uncertainty analysis (method and software)	14,000	Desirable
G1-G4	GIS platform change	25,000	Must Have
O1	Implement MDSF1 methods on new platform	56,000	Must Have
O2	User manual and guidance	18,000	Must Have
O3	Enhanced economic damage calculation 1	12,000	Desirable

Ref	Item (See Table 5.1 for fuller description)	Cost (£)	Priority (from Table 5.1) and comment
O4	Minor improvements to MDSF1 case management approach suggested by users	5,000	
O5	Maintain support for the MDSF Wizard	0	*Cost included in G1 to G4*
O6	Social impact assessment improvement	1,500	Highly Desirable
O7	Minor improvements to the use of externally generated flood depth grids	7,000	
O8	Allow multi-user access to MDSF database	3,500	
O9	Provide on-line context sensitive help	4,000	
O10	Risk assessment of coastal erosion	5,500	Desirable
O11	Provide/facilitate estimation of costing for capital and maintenance work	3,500	
O12	Interaction with NFCDD	5,000	Highly Desirable *Price indicator: more information required*
O13	Enhanced economic damage calculation 2	15,000	Desirable
O14	Enhanced economic damage calculation 3	10,500	Desirable
O15	Mapping of social and emergency response	1,000	Highly Desirable
O16	Provide Broad-scale Ecosystem Impact Modelling habitat potential analysis tool	-	*Not costed: more information required*
O17	Improve links to appraisal methods	4,000	Highly Desirable *Price indicator: more information required*
O18	Linkages to integrated urban drainage plans	-	*Not costed: more information required*
O19	Linkages to Water Framework Directive	-	*Not costed: more information required*
O20	Provide tool to assist implementation of FD2114	-	*Not costed: more information required*
O21	Provide a 'FloodRangerPro' type visualisation tool	15,000	
O22	Risks to people	4,000	Desirable *Assumes underlying data are available*
O23	Improve use of spatial data sets	7,700	
	Other costs		
	Project management	27,000	Must Have
	Internal (alpha) test of system	15,000	Must Have
	External (beta) test of system: CFMPs	30,000	Needed to support the final delivery, dissemination and uptake of MDSF2 *These items should be funded from outside the R&D Budget.*
	External (beta) test of system: SMPs	30,000	
	Interim dissemination workshop	7,500	
	Dissemination roadshow	10,000	

Ref	Item (See Table 5.1 for fuller description)	Cost (£)	Priority (from Table 5.1) and comment
	Guidance documents for application to CFMPs, SMPs and Strategy Studies	35,000	

5.4 Recommended work for Part 2

The options and costs were considered by the Project Board at a meeting on 19 May 2005. The conclusions reached by the Board on which items to put forward in the Part 2 project are listed in Table 5.3.

Table 5.3 Recommended work for Part 2

Priority	Ref	Item	Cost (£)	Cumulative cost (£)	Objective (see Section 1.2)
Must have	R1-R4	RASP: methodology development and software	120,000	120,000	1, 2
	R5	Easy viewing of input data	8,000	128,000	2
	G1-G4	GIS platform change	25,000	153,000	5
	O1	Implement MDSF1 methods on new platform	56,000	209,000	5
	O2	User manual and guidance	18,000	227,000	2
	O6	Social impact assessment improvement	2,000	229,000	4
	O12	Interaction with NFCDD	5,000	234,000	3
	O15	Mapping of social and emergency response	1,000	235,000	4
		Project management (including dissemination materials)	28,000	263,000	
		Interim dissemination workshop	7,000	270,000	
		Internal (alpha) test of system	15,000	285,000	
		Liaison with Beta testers and review of results	10,000	**295,000**	
Items required but not fully defined at present	R6	RASP for non-linear defences (method and software)	20,000	20,000	1, 2
	R7	Time dependent issues (method and software)	10,000	30,000	1, 2
	R8	Improve uncertainty analysis (method and software)	14,000	44,000	1, 2
	O3	Enhanced economic damage calculation 1	12,000	56,000	
	O10	Risk assessment of coastal erosion	5,500	61,500	3
	O13	Enhanced economic damage calculation 2	15,000	76,500	4

Priority	Ref	Item	Cost (£)	Cumulative cost (£)	Objective (see Section 1.2)
	O14	Enhanced economic damage calculation 3	10,500	87,000	
	O17	Improve links to appraisal methods	4,000	91,000	
	O22	Risks to people	4,000	**95,000**	4
Items required but funding may be outside R&D budget		External (beta) test of system: CFMPs	25,000	25,000	
		External (beta) test of system: SMPs	25,000	50,000	
		Dissemination roadshow	10,000	60,000	
		Guidance documents for application to CFMPs, SMPs and Strategy Studies	35,000	**95,000**	

The proposed overall costing for the Part 2 project is as follows:

Item	**Cost (£)**
'Must Have' functionality	295,000
Contingency on 'Must Have' functionality	30,000
Items not yet fully defined (PROVISIONAL SUM)	35,000
Sub-total: Recommended R&D Project budget	**360,000**
Items funded outside R&D Project Budget	95,000
Total: Overall project cost (excluding Agency internal costs)	**455,000**

There are a number of unresolved issues regarding the 'Must Have' items related to the method of rapid flood spreading, and data management issues related to the NFCDD. At this stage the contingency sum shown above is an essential element of the overall cost. The costing will be reviewed in detail at the beginning of Part 2, when the system design is undertaken.

6. PLAN FOR PART 2

Part 2 of the project consists of developing a new version of the MDSF (known as MDSF2) that includes the items listed in Table 5.3. These are summarised below:

- Implementation of RASP methodology.
- Change in GIS platform to make the system as independent as practical.
- Comply with Environment Agency systems and facilitate Agency ownership of the MDSF2 code.
- Improve and extend appraisal facilities both to improve outputs for economic appraisal and provide additional information for the appraisal of social impacts.
- Project management, testing and interim dissemination.

Issues to consider in the Implementation Plan for Part 2 include the following:

- Decision on modelling approach.
- Development of functional design.
- Liaison with the Environment Agency for integrating MDSF2 into the Agency's IT environment.
- Broader liaison with stakeholders, particularly with regard to items that are not fully defined at present.
- Implementation.
- Testing.

An implementation plan is shown in Figure 6.1.

With regard to dissemination and uptake, the following approach is proposed based on the successful support provided to MDSF during 2004 and 2005:

- Prepare dissemination materials for presentation purposes. The materials should clearly demonstrate what MDSF2 does and how it fits with the Agency's procedures for CFMPs, SMPs, Strategy Plans and other Flood Risk Assessments.
- Prepare training materials and apply them internally by non-MDSF staff to ensure that they are suitable for use by potential users.
- Establish dissemination and uptake arrangements similar to the current arrangements for the MDSF. This should be set up before the dissemination process begins to ensure that potential users have immediate support for dealing with queries.
- Undertake a roadshow to each Environment Agency Region to present MDSF2 to both Agency and Consultant staff.
- Support the use of MDSF2 by individual users, including 'hands-on' training.

It is recommended that the dissemination and uptake arrangements referred to above (as opposed to the management of the research and development work) are led by an Environment Agency Project Manager as this provides Client led direction for the use of MDSF2, and also facilitates liaison with other Environment Agency functions.

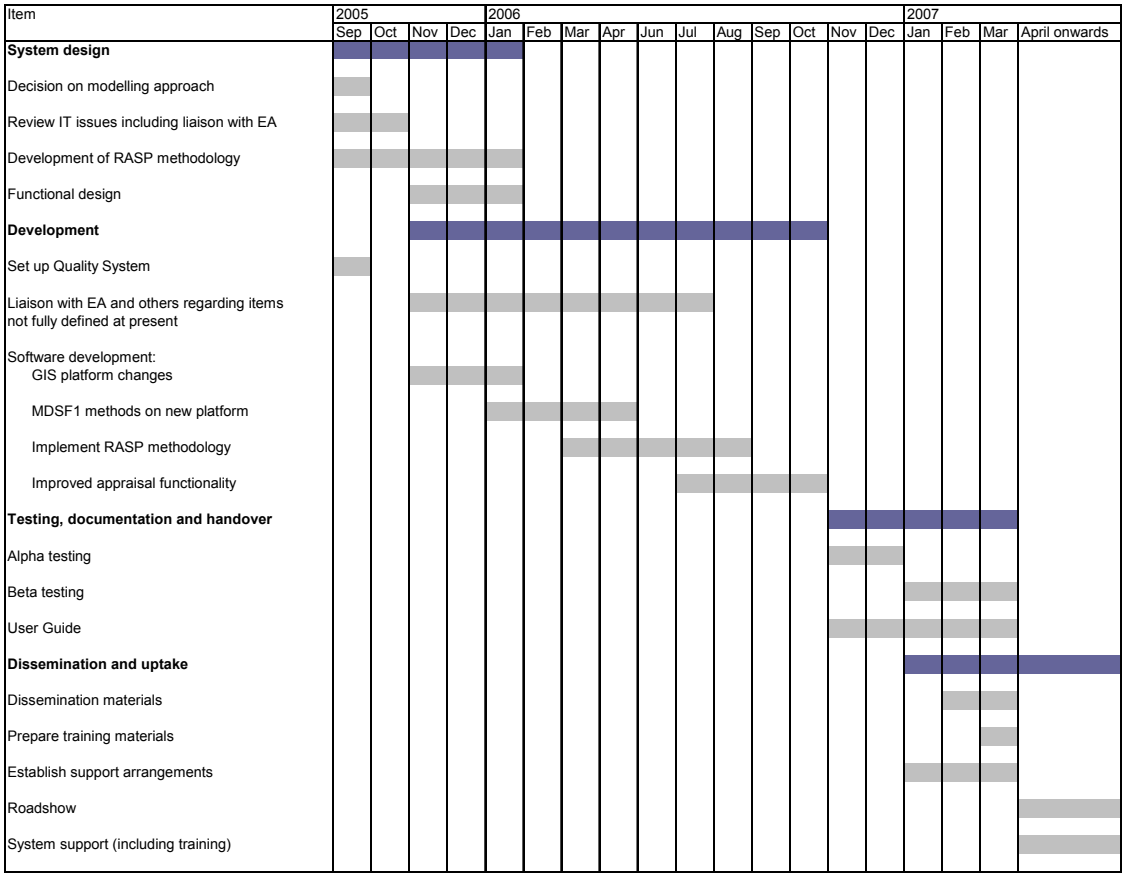

Figure 6.1 Implementation Programme

APPENDICES

Appendix A

Workshop on 19 February 2005: List of participants

Name	Organisation	Role
Lucy Ayers	Environment Agency	CFMP technical user
Peter Bailey	Environment Agency	Social Policy Unit
Steve Bosher	Environment Agency	CFMP technical user (Thames Region)
Jonathan Chapman	Environment Agency	Flood Risk Policy Advisor - Research
Rebecca Coles	Environment Agency	Water Framework Directive
Jane Corbett	ECI Oxford	Environmental issues
Edward Evans	Environment Agency (contract)	MDSF2 project leader
Ian Finnigan	Environment Agency	PAMS technical user
Ben Gouldby	HR Wallingford	PAMS contractor team leader
Carl Green	Wyre District Council	Coastal applications/SMPs
Shirley Greenwood	Environment Agency	Policy advisor flood data, mapping and modelling

Jim Hall	Newcastle University	MDSF2 project team (specialist in risk methods)
Adam Hosking	Halcrow	SMP guidelines
Karl Jeans	Environment Agency	EA delivery
Ian Meadowcroft	Environment Agency	RISK Theme Leader/RASP
Andy Parsons	Defra	SMPs
David Ramsbottom	HR Wallingford	MDSF2 project team
Tim Reeder	Environment Agency	TE2100 and estuary applications
Paul Sayers	HR Wallingford	MDSF2 project team
John Waddingham	Environment Agency	Water Framework Directive
Jon Wicks	Halcrow	MDSF2 project team
David Worth	Royal Haskoning	MDSF peer reviewer / consultant user
Paul Wyse	Environment Agency	Process technical user

Appendix B

Workshop on 19 February 2005: Responses to questions

Question 1.
Do you have any comments on the concept of MDSF2?

Comments as follows:

General concept

- Good concept
- Concept of incorporating RASP and HLM+ good starting point
- Concern about 'believability' of RASP results
- Allows wide range of sensitivities to be presented
- Fit for purpose use:
  - Desk top tool
  - Must clearly define uncertainty
- Clarity and transparency
  - Further development for specific decision making purposes
- Introduction of defence systems and flood spreading gives much improved functionality
- Like modular approach
- Addition of RASP is useful. Need visibility of calculation option to change
- More ecological info needed
- What level is it aimed at?
- Who is going to use it?

Timing

- Is there enough experience of applying MDSF?

- Deciding whether to wait for MDSF2 (SMPs)
- Initially for CFMP – MDSF2 will miss the current round of CFMPs and most of the SMP2s.

Other comments

- Does name distract – name change?

Question 2.
Are there broader uses of MDSF2 outside flood risk management planning?

General response was 'yes'. Ideas as follows:

- Coastal erosion
- Coastal erosion (SMPs) integrated into MDSF2
- WFD
- Water resources
- Spatial planning
- Design of agricultural environmental schemes
  - Defence v alternative land use
- Visualisation
  - Pre project – education and scope
  - Decision – explanation
- High level development tool
- Asset management tool (breach)
- Could it be used for other water management?
- Are there other tools that have already been started or are in use?

Question 3.
Should broader option appraisal facilities be included in MDSF2 to support the Agency's move to integrated flood risk management and Multi Criteria Analysis? If so, what?

General response was 'yes'. Suggestions as follows:

- Flood Risk Management measures need to be included
- Appraisal needs to be widened
- Needs to provide as much info as possible for developing appraisal techniques.
- Flood risks to people
- Flexibility to incorporate future risk matrix (social considerations)
- Flexibility in coping with future MCA approaches
- Production of PV outputs (and Priority Score?)
- Damages to infrastructure
- Linkage to environmental indicators – requires environmental output (eg BSEIM)
- Infrastructure information through GIS (eg hospitals, etc)
- Linkage of pre-modelled sewer flooding and output variables for joint probability
- Other joint probability
- Need Defra and Operating Authority buy-in to output for detailed schemes

Question 4.
Do you have comments on data requirements and availability for MDSF2?

Comments as follows:

- Essential to know during Inception phase what the data needs are
- Provide guidance on data as soon as possible so people know what to collect
- Prioritise so focus on collecting most important data
- Data collection for flood mapping – what else do we need?
- Collecting whilst doing other work to avoid making multiple data requests
- Extending beyond property data, for example critical utilities infrastructure

- Data on vulnerable groups plus other social/environmental/heritage data
- Heritage sites
- Availability of information for fragility curves
- There are issues regarding collection of core data sets including, for example, management and licensing of all required data sets
- NFCDD provides a key input
- NFCDD currently incomplete.
- Education/training needed on data requirements and quality including consistency of data and accuracy
- Central available data sets required, including:
  - Property
  - Habitat Mapping
  - Infrastructure
- Ensure variable resolution of data to suit application
- Must be possible to use different DTM data for different applications and variations in data availability.
- Flexibility to use better data if you have it.

Question 5.
Are we missing any opportunities to increase the value of MDSF2 without excessive additional effort?

Suggestions as follows:

- Ensure wide access (eg all potential users including consultants, the Agency and other Operating Authorities, etc)
- Provide visualisation tools
- Need good dissemination, training and support
- Training and education
  - Appropriate use
  - Clear communication
- Clearly explain why practitioners should use it
- Let other functions consider how they might use MDSF2

Question 6.
Do you have any other ideas for improving the functionality of MDSF2?

Ideas as follows:

- Keep it simple!
- Use it as a communication tool
- Link to Flood Ranger etc. with in-built interface. This approach is being adopted for the TE2100 project.
- Transparency
- Opportunities to skip stages (modular within MDSF)
- Sensitivity testing
- Direct interface with NFCDD and other data sources
- Suggested default data
- Run time indication
- Classification of error band
- Output consistent with priority scoring, although it was recognised that this may change in the future.

Question 7.
Do you have any concerns about the practical implementation of MDSF2?

Concerns as follows:

- Keep it simple and understandable to practitioners
- Appropriate use
  - Fit for purpose
- List skills required to use
- Availability and acceptance
  - Environment Agency
  - Local Authorities

- Local authority in-house use/consultant use. These organisations will have a range of systems and software.
- CIS acceptability within Agency
- Will users understand social impacts
- Who uses it for what?
- Needs to be fully integrated in internal Agency processes
- Challenge of GIS platform independence
- Common GIS across MDSF2 and NFCDD?
- Need for training and ongoing support
- Training for users and decision makers in Operating Authorities and consultants

Question 8.
Are there any lessons we can learn from the development of the original MDSF?

- Yes, see above
- Integration with existing and future systems
- Ensure distribution and explanation of benefits
- Link to Agency systems – CIS etc
- Don't oversell (ie make it clear what MDSF2 is and what it is not)
- Don't under develop – test! Ensure product is fully tested before release to Users.

Appendix C

Associated R&D Projects

Code	Title	Contractor	Dates	Links with MDSF2
FD2013	Developing a Multi Criteria Analysis methodology for application to Flood and Coastal Management Appraisals	RPA Ltd	January-03 to July-04	Extension of risk metrics to include MCA requirements
FD2014	Development of Economic appraisal methods for flood management and coastal erosion protection	University of Middlesex	February-03 to January-05 (delayed to mid 2005)	Update to the economic damage calculations (eg new depth-damage curves). More information required.
FD2112	Broad Scale Ecosystem Impact Modelling Phase 1- Toolbox	Cascade	January-04 to April-05	Habitat potential analysis and other outputs could be delivered through MDSF2.
FD2317	Flood risks to people	HR Wallingford	January-03 to June-03	Additional risk metric based on strategic-level assessment of fatalities (and injuries).
FD2321	Risks to people phase II	HR Wallingford	September-03 to January-05	
FD2318	Performance & Reliability of Flood & Coastal Defence Structures - Phase 1	HR Wallingford	September-03 to September-05	To provide initial default fragility curves – these could then be updated within the CFMP / SMP / CDS process where required and used in MDSF2.
W5B(02)05	Establishing a Performance-based Asset Management System for	HR Wallingford	December-02 to March-05	Guidance on the development of fragility curves to be translated

	Flood Defences, Ph 2			into the guidance to accompany MDSF2. Methods for identifying the asset contribution to risk and risk reduction for inclusion in MDSF 2.
SC010017 W5B-030 W5B(01)02	Risk assessment of flood and coastal defence systems for strategic planning	HR Wallingford	April-01 to March-04	The basic system analysis approach to form the basis of the MDSF 2 procedures. Note: this will need to be formalised into a specific approach for MDSF2 that utilises elements of both the HLM+ and ILM.
FD2324	Risk assessment of coastal erosion	Halcrow	ongoing	MDSF2 could be used to deliver the coastal erosion assessment methodology.
FD2114	Review of impacts of rural land use and management on flood generation: short term improvement in modelling and research	Newcastle University	January-03 to March-04	FEH tool could be used to estimate the impact of land management on flood generation.

Appendix D

Requirements Specification (Version: 8 April 2005)

ID	Item	**Functionality** non-functional maintain existing improve existing new	Module	**Suggested priority** Must have Should have Could have
1	Structured case management: climate, management options, receptor	Maintain existing	Case management	Must have
2	Import existing MDSF1 project	Maintain existing	Case management	Must have
3	Case management for RASP simulations	New functionality	Case management	Must have
4	Coastal erosion impact assessment (economics)	Maintain existing	Coastal erosion	Must have
5	Import base data (common data to be used in all cases)	Maintain existing	Data	Must have
6	Import case-specific data (e.g. properties including proposed development)	Maintain existing	Data	Must have
7	Share case-specific data between cases (reduced data storage requirements)	Maintain existing	Data	Must have
8	Import extended 'loading' data (eg flows, levels)	New functionality	Data	Must have
9	Load standard defence data (after export from NFCDD), eg condition grade, defence type (use same field names as NFCDD and standard NFCDD export formats, XML?) Load extra defence data width, crest level etc.	New functionality	Defence data	Must have
10	Provide and store default fragility curves (in standard format)	New functionality	Defence data	Must have
11	Assign existing fragility curves to defence(s)	New functionality	Defence data	Must have
12	Import of breach size data and assignment to specific defences (or types of defences) if flood spreading in MDSF2	New functionality	Defence data	Must have
13	Enable users to edit fragility curves (and save as new curve)	New functionality	Defence data	Must have
14	Export fragility curve to standard format (then can become new standard curve) and upload to NFCDD	New functionality	Defence data	Must have
15	Export list of proposed simulations (to make it easier to run these simulations outside of the MDSF and to facilitate future automation of running third party inundation models outside MDSF). List of proposed simulations to include metadata enabling automated import of sets of flood depth results back into MDSF (eg linking field or specific results file name).	New functionality	Defence failure scenarios	Must have
16	Implementation of algorithm to guide the selection of simulations needed to converge the flood risk bounds	New functionality	Defence failure scenarios	Must have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
17	Module to generate defence failure probabilities (from loading distributions and fragility curves) and produce automated prioritised list of proposed inundation simulations	New functionality	Defence failure scenarios	Must have
18	Screening of potential inundation runs to eliminate those that have negligible contribution to risk	New functionality	Defence failure scenarios	Must have
19	User interaction with automated prioritised list of proposed inundation simulations, eg deleting simulations, changing priority and adding simulations	New functionality	Defence failure scenarios	Must have
20	'Run times' should be short if possible. For calculations that are expected to last between 2 and 10 seconds, show a message indicating that work is taking place and ensure 'busy cursor' is used. For calculations that are expected to take longer than 10 seconds provide indication of run time (progress bar). Enable batching where applicable so unattended runs are possible.	Non-functional	Ease of use	Must have
21	Provide installer/uninstaller program – should be able to run silently to allow remote installation. Provide a minimal and typical installation where minimal contains only 'essential' components and 'typical' includes additional support material such as demo data.	Non-functional	Ease of use	Must have
22	Software must be robust, well tested and 'fit for purpose'	Non-functional	Ease of use	Must have
23	User manual, building on MDSF1 user manual (eg better description of error messages and resolution, maintain full description on input data formats)	Non-functional	Ease of use	Must have
24	Background documentation for users (MDSF2 revised user guidance / procedures) including addition of full details of the new RASP-based methodology as implemented in MDSF2	Non-functional	Ease of use	Must have
25	Direct damages calculation from properties, depth grid, MCM curves	Maintain existing	Economic impacts	Must have
26	Calculate AAD using all provided return periods (rather than just MDSF suite of 5)	Improve existing	Economic impacts	Must have
27	Make as GIS-system independent as is practical within project constraints. Note that Agency GIS strategy focuses on ArcGIS	New functionality	GIS system	Must have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
	(clarification required on extension availability including discussion with EA GIS Strategy team) where as local authorities tend to use MapInfo. It was also be very useful if MDSF2 could be used without the need for a third-party GIS system (note that this is different from the MDSF Wizard functionality which is designed to convert MDSF outputs into a format that can be viewed using Internet Explorer and MapExplorer). A possible solution is to isolate all 'GIS' analysis and 'GIS' viewing code (separately), then provide 'plug-in' modules to enable use of ArcGIS (v9?) , MapInfo (v?) and/or end-user licence-free GIS system. Initially only provide the ArcGIS compatibility.			
28	Import flood depth grids (formats to be supported to be determined)	Maintain existing	Inundation	Must have
29	Import flood extent polygons and convert to flood depth grid	Maintain existing	Inundation	Must have
30	Import water levels, and interpolate using mapping sections and polygons. Combine with a DEM to generate flood depth grids. Allow batching.	Maintain existing	Inundation	Must have
31	Remove protected areas from depth grid based on water level or return period	Maintain existing	Inundation	Must have
32	New rapid flood spreading module (for non-interactive flooding)	New functionality	Inundation	Must have
33	Meta data (to appropriate Standard) to be generated	Maintain existing	Misc	Must have
34	Allow users to continue to be able to use the current non-RASP methods	Maintain existing	Misc	Must have
35	Software to be compliant with relevant clauses of CIS Technical Standards (current and likely changes where appropriate)	Non-functional	Misc	Must have
36	To operate as a single user desktop tool (no requirement for simultaneous multiple user access to the MDSF2 project database) (see also ID 68)	Non-functional	Misc	Must have
37	Maintain scale-independence of MDSF software - data volume primarily limited by hardware rather than software. Smaller areas will support more detail.	Non-functional	Misc	Must have
38	Provide transparency in calculations (users must know what it is	Non-functional	Misc	Must have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
	doing before they will accept the results). Could provide an obvious 'how does this work' button or help entry for each calculation.			
39	Aggregate detailed results to user defined polygons.	Maintain existing	Results processing	Must have
40	New output processing to deliver the RASP-type results	New functionality	Results processing	Must have
41	Number of people at risk and SFVI	Maintain existing	Social impacts	Must have
42	Uncertainty analysis through water level perturbation	Maintain existing	Uncertainty analysis	Must have
43	Facilitate easy access to the MDSF2 software for appropriate Agency staff (see also ID35)	Non-functional	User access	Must have
44	Facilitate future support/maintenance and upgrading	Non-functional	Sustainability	Must have
45	Improve case management (better 'housekeeping').	Improve existing	Case management	Should have
46	More generic definition of case components (eg management options, climate, receptors)	Improve existing	Case management	Should have
47	Provide more flexibility in case numbering through version numbering.	Improve existing	Case management	Should have
48	Allow users to edit defence data within the MDSF2 system (access from GIS view and tabular view) – to resolve errors or look at sensitivity to specific data items	New functionality	Defence data	Should have
49	Allow users to view defence data within the MDSF2 system (access from GIS view and tabular view) – for checking purposes	New functionality	Defence data	Should have
50	View defence location data within the MDSF2 system (as polylines and points)	New functionality	Defence data	Should have
51	Support non-linear defences, eg pumps, flood storage reservoirs, barriers, sluices etc	New functionality	Defence data	Should have
52	Visualise fragility curve (eg click on defence (in table or on GIS view) and plot curve) to include picture, breach info (widths, levels), ground levels, crest levels, water levels.	New functionality	Defence data	Should have
53	Improved default average floor area data (from VOA-derived table)	Improve existing	Economic impacts	Should have
54	Output count of properties within flooded area (summarised by	Improve existing	Economic impacts	Should have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
	property type and output polygon)			
55	Assist user review of MDSF damage results through filtering/highlighting of high damage and key assets and 'encouraging' users to review the data and results for these properties that make/should make a significant contribution to risk. Eg highlight the top 20 assets (by damage) and all public buildings for greater scrutiny. Should be done on the AAD or PVd if available.	Improve existing	Economic impacts	Should have
56	Enable output to be used for further analysis by others (eg social policy and WFD)	Non-functional	Future potential	Should have
57	Improve ease of loading externally generated flood depth grids	Improve existing	Inundation	Should have
58	Export results of new rapid flood spreading module to standard format (for view and/or edit outside of MDSF and then be able to read back in)	New functionality	Inundation	Should have
59	Make it easier to summarise impacts (damages, property count, people affected count) by a range of polygons (eg flood risk area, river reach)	Improve existing	Results processing	Should have
60	Maintain support for MDSF Wizard use – may require expansion of wizard to support new datasets / processes depending on other options selected.	Maintain existing	Results processing	Should have
61	Improve the ease of use of the 'joining' process needed to link population point data, social impact point data and spatial extent data. Also, facilitate use of 2001-based census data which uses higher resolution polygons (Output Areas not enumeration districts).	Improve existing	Social impacts	Should have
62	Agency to own the code and IP of resultant software	Non-functional	Sustainability	Must have
63	Facilitate potential future release as "open source", well structured and commented code, programmers documentation. javadoc/xmldoc or equivalent as appropriate.	Non-functional	Sustainability	Must have
64	Make MDSF2 as modular as practical. Limit dependencies to enable flexible future independent development of sub-components.	Non-functional	Sustainability	Must have
65	Allow import of perturbed / uncertainty flood depth grids (currently	Improve existing	Uncertainty	Should have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
	you can only perturb stage data) or perturbation of existing flood depth grids (raise and expand flood bounds).		analysis	
66	Improved uncertainty analysis, including fragility curves upper/lower bounds	New functionality	Uncertainty analysis	Should have
67	Works on Standard Agency Desktop although possibly with some functionality limitations (dependent on availability of GIS software).	Non-functional	User access	Must have
68	Single server of data with multiple clients allowing CFMPs etc to be worked on by several people	Non-functional	User access	Should have
69	Online context sensitive help	Non-functional	Ease of use	Should have
70	Coastal erosion risk assessment (incorporate F2324)	New functionality	Coastal erosion	Could have
71	Support for flood defence construction costs	New functionality	Costs	Could have
72	Support on flood defence asset maintenance costs	New functionality	Costs	Could have
73	Load fragility curves from NFCDD (or rather facilitate future loading of fragility curves from NFCDD)	New functionality	Defence data	Could have
74	Improve case management structure, eg reuse of simulation results for different cases, defence failure combinations, uncertainty analysis runs	New functionality	Case management	Could have
75	Allow different flood damage rates for different flood durations.	Improve existing	Economic impacts	Could have
76	Calculate asset value within flooded area	Improve existing	Economic impacts	Could have
77	Cap property direct damages at asset value (AAD or PVd if available)	Improve existing	Economic impacts	Could have
78	Add description of property classes to the look-up tables	Improve existing	Economic impacts	Could have
79	Allow users to graph the depth-damage curves from MDSF	Improve existing	Economic impacts	Could have
80	Easier access to property floor area fields	Improve existing	Economic impacts	Could have
81	Easier access to property threshold fields	Improve existing	Economic impacts	Could have
82	Provide ability to adjust threshold levels globally / by defined shapefile	Improve existing	Economic impacts	Could have
83	Improved calculation of property valuation (where missing from NPD) – possibly make use of floor area if available?	Improve existing	Economic impacts	Could have
84	Maintain and propagate Data Quality Score (eg apply extra scrutiny	Improve existing	Economic impacts	Could have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
	to high ranking assets where the DQS is greater than 6)			
85	Calculate Present Values for damages PVd (may need to integrate AAD calculated at different time horizons, current AAD, 2050 climate AAD and 2100 climate ADD)	New functionality	Economic impacts	Could have
86	Enhance economic damage calculations: eg damage to transport infrastructure, transport disruption, impact on utilities, emergency services costs	New functionality	Economic impacts	Could have
87	Improve method used to deal with properties that may not be at ground level (better use of the 'GroundLevel' field in NPD)	New functionality	Economic impacts	Could have
88	Include method for calculating damage avoided from flood event management, eg benefits of flood warning, building resilience, etc	New functionality	Economic impacts	Could have
89	Mapping of key social and emergency response data including hospitals, schools, etc	New functionality	Social impacts	Could have
90	Broad-scale Ecosystem Impact Modelling (incorporate FD2112)	New functionality	Future potential	Could have
91	Multi criteria analysis, allow changing of MCA weights (incorporate FD2013)	New functionality	Future potential	Could have
92	Facilitate potential future linkages to integrated urban drainage plans	Non-functional	Future potential	Could have
93	Facilitate potential use for WFD	Non-functional	Future potential	Could have
94	Enable MDSF to merge multiple flood depth grids (eg from different models covering different areas)	Improve existing	Inundation	Could have
95	Spread the edge of imported broad scale depth grids over higher resolution DEM	Improve existing	Inundation	Could have
96	Provide tool to assist implementation of FD2114 - land management impact on flood generation	New functionality	Inundation	Could have
97	Produce damage calculation in a format compatible with Defra PAG3 (eg populate PAG3 spreadsheet) or latest update	New functionality	Results processing	Could have
98	Produce information in a format that can be used for the Defra priority score	New functionality	Results processing	Could have
99	Provide a 'FloodRangerPro' type visualisation tool to non-experts to understand the data and results	New functionality	Results processing	Could have

ID	Item	**Functionality** non-functional maintain existing improve existing new	**Module**	**Suggested priority** Must have Should have Could have
100	Include 'flood risks to people' calculation (flood hazard) (incorporate FD2321)	New functionality	Social impacts	Could have
101	Direct use of tiled DEMs (either through merge on import or transparently in MDSF2)	New functionality	Data	Could have
102	Support image catalogues / batches of image tiles (simpler management of OS tiles)	New functionality	Data	Could have

Appendix E

Questionnaire responses

Table E.1 All responses

Item Number	Score Shirley Greenwood	Adam Hosking	David Worth	Mervyn Pettifor	Stephen Worrall	Andy Parsons	Carl Green	Paul Wyse	Ian Meadowcroft	Tim Reeder	Jeremy Benn	Lucy Ayres	Dave Denness	Iain Finnigan	EA Social Policy	Mark Diamond	Peter Spencer	Sue Reed	John Waddingham	Total		Score > 15	Score 15≥x>12
R1	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	R1		
R2	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	R2		
R3	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	R3		
R4	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	R4		
R5			2			2		2		2		1	2		1	0	0		0	19	R5	√	
R6			2		1	0.5	1			2	1	1	1.5	2	2	0	0		0	15	R6		√
R7			2	0		1	2			2	1	0	1	2	2	0	0		0	13	R7		√
R8			2	0		1	2			1	1	1	1	2	1	2	0		0	14	R8		√
G1	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	G1		
G2	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	G2		
G3	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	G3		
G4	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	G4		
O1	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	O1		
O2	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	O2		
O3			1.5	1		0	2		1	2	2	1	1	2	0	0	0	0	0	15.5	O3	√	
O4			2	1	0	2	1	1	1	1	1	1	1	1	0	0	0	0	0	12	O4		
O5			2	1	1	1	1	1	0	1	1	0	1	1	2	0	0	1	0	12	O5		
O6			1	0	2	2	2	2	1	1	1	1	1	2	2	0	0	2	0	18	O6	√	
O7			1	1	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	7	O7		
O8			0	1	1	0.5	1	1	0	0	0	1	2	0	2	0	0	0	0	8.5	O8		
O9			1	0	1	1	2	1	1	2	0	1	1	1	2	0	0	0	0	11	O9		
O10			2	0	2	2	2	1	2	0	1	1	1	1	0	0	0	1	0	15	O10		√
O11			0	0	1	1	0	1	0	1	1	1	1	2	0	0	0	0	0	9	O11		
O12			1	0	2	2	2	2	2	2	2	1	1	2	0	0	0	0	0	17	O12	√	
O13			2	0	0	2	1	1	1	2	2	1	2	1	0	0	0	1	0	15	O13		√
O14			1	1	0	2	2	2	1	1	2	1	1	1	0	0	0	0	0	13	O14		√
O15			1	0	2	1	2	2	2	2	1	1	1	2	2	0	0	2	0	19	O15	√	
O16			1	0	2	0.5	1	2	0	2	2	1	1	0	2	1	1	2	0	14.5	O16	√	
O17			1.5	2	2	0.5	2	2	0	2	2	2	1	2	2	0	0	2	0	23	O17	√	
O18			0	0	2	0	1	0	0	0	2	0	1	1	0	0	0	1	0	8	O18		
O19			0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	1	9	O19		
O20			0	0	2	1	0	1	0	2	1	1	1	1	2	0	0	2	1	15	O20		√
O21			1	0	2	0.5	2	2	1	2	2	0	1	1	1	0	0	1	0	13.5	O21		√
O22			1	0	2	0.5	2	2	1	1	1	1	1	2	2	0	0	2	0	17.5	O22	√	
O23			1	0	2	2	1	2	1	1	1	0	1	1	0	0	0	0	0	11	O23		
Note:	M: Must Have																						

Table E.2 Responses from key Defra, Environment Agency, Local Authority and Consultant staff

Item Number	Score									Total	Item Number	Score	
	Defra	Environment Agency				LA	Consultants						
	Andy Parsons	Shirley Greenwood	Mervyn Pettifor	Stephen Worrall	Ian Meadowcroft	Carl Green	Adam Hosking	David Worth	Jeremy Benn			≥ 9	9>x≥7
R1	M	M	M	M	M	M	M	M	M	M	R1		
R2	M	M	M	M	M	M	M	M	M	M	R2		
R3	M	M	M	M	M	M	M	M	M	M	R3		
R4	M	M	M	M	M	M	M	M	M	M	R4		
R5	2			1	2	2	2	2	1	12	R5	√	
R6	0.5			1	2	1	1	2	1	8.5	R6		√
R7	1			0	2	2	2	0	0	7	R7		√
R8	1			0	1	2	2	0	1	7	R8		√
G1	M	M	M	M	M	M	M	M	M	M	G1		
G2	M	M	M	M	M	M	M	M	M	M	G2		
G3	M	M	M	M	M	M	M	M	M	M	G3		
G4	M	M	M	M	M	M	M	M	M	M	G4		
O1	M	M	M	M	M	M	M	M	M	M	O1		
O2	M	M	M	M	M	M	M	M	M	M	O2		
O3	2			0	1	2	1.5	1	1	8.5	O3		√
O4	2			0	1	1	2	1	1	8	O4		√
O5	1			1	0	1	2	1	0	6	O5		
O6	2			2	1	2	1	0	1	9	O6	√	
O7	1			0	0	1	1	1	0	4	O7		
O8	0.5			1	0	1	0	1	0	3.5	O8		
O9	1			0	2	1	1	0	1	6	O9		
O10	2			2	2	2	2	0	1	11	O10	√	
O11	1			1	0	0	0	0	1	3	O11		
O12	2			2	2	2	1	0	1	10	O12	√	
O13	2			0	1	1	2	0	2	8	O13		√
O14	2			0	1	2	1	1	2	9	O14	√	
O15	1			2	2	2	1	0	1	9	O15	√	
O16	0.5			2	0	1	1	0	1	5.5	O16		
O17	0.5			2	2	2	1.5	2	2	12	O17	√	
O18	0			2	0	1	0	0	0	3	O18		
O19	0			2	0	1	0	0	0	3	O19		
O20	1			2	1	0	0	0	1	5	O20		
O21	0.5			2	1	2	1	0	0	6.5	O21		
O22	0.5			2	1	2	1	0	1	7.5	O22		√
O23	2			2	1	1	1	0	0	7	O23		√
Note:	M: Must Have												

Appendix F

Costs for MDSF2

	Version 1 13 May 2005 (Decisions by Project Board on 19 May not included)			
Project costs				
	Must haves only (£)	261000		
	Must haves + highly desirables (£)	290000		
	Must haves + highly desirables + desirables (£)	388500		
	All costed options (£)	529200		
Option costs				
	Basic cost -to achieve **Must Have** functionality (£)	261000		
	Additional cost to achieve **highly desirable** enhancements (£)	29000		
	Additional cost to achieve **desirable** enhancements (£)	98500		
Item ID	**Description**	**Cost (£)**	**Status**	**Comment**
1	**Methodological development**			
	Develop RASP HLM+/ILM methods for implementation within MDSF2 (supporting R1-R4)	£65,000	Must Have	Assumes parametric model utilising a limited set of externally run model results will be used for rapid flood spreading, similar to TE2100
	Extend RASP framework to include non-linear defences, eg. Pumps, sluices etc (supporting R6)	£15,000	Desirable	
	Develop efficient methods for handling time dependent issues (climate change, deterioration etc) (Supporting R7)	£5,000	Desirable	
	Improve uncertainty analysis (using quantitative bounds) (Supporting R8)	£10,000	Desirable	
2	**Software development**			
	Including RASP methods			
R1	Import and assign defence data (fragility, breach inverts etc)	£10,000	Must Have	
R2	Import loading data (eg water levels, flows)	£5,000	Must Have	
R3	Generate scenarios and associated probabilities and manage multiple simulations	£25,000	Must Have	
R4	Implement rapid flood spreading module (for non-interactive flooding)	£15,000	Must Have	
R5	Easy viewing (and possible editing) of input data within MDSF2 (eg fragility curves, defence data)	£8,000	Highly desirable	
R6	RASP methodology implemented for non-linear defences, eg pumps, sluices	£5,000	Desirable	
R7	Update handling of time dependent issues to produce Pvalues	£5,000	Desirable	
R8	Implement improved uncertainty analysis (eg using upper/lower fragility curves)	£4,000	Desirable	
G1-G4	**GIS platform changes**			
	Compete changes using GIS-system independent software; compliant with CIS standards; owned by Agency; open source	£25,000	Must Have	
	Other software issues			
O1	Update existing MDSF1 methods on new platform	£56,000	Must Have	
O3	Enhance damage calculation (through time - links with R7)	£12,000	Desirable	Reuse NaFRA modules
O4	Minor improvements to MDSF1 case management approach suggested by users	£5,000		
O5	Maintain support for the MDSF Wizard	£0		No cost: Covered in G1 - G4
O6	Minor improvements to the social impact assessment, including easing the joining process of social data and spatial data	£1,500	Highly desirable	
O7	Minor improvements to the use of externally generated flood depth grids	£7,000		
O8	Allow multi-user access to MDSF database	£3,500		
O9	Provide on-line context sensitive help	£4,000		
O10	Deliver the 'Risk assessment of coastal erosion' R&D outputs (FD2324)	£5,500	Desirable	
O11	Provide/facilitate estimation of costing for capital and maintenance work	£3,500		
O12	Direct interaction with NFCDD (eg for defence data and fragility curves in future)	£5,000	Highly desirable	Price indicator. More information needed.
O13	Enhanced economic damage calculation 2	£15,000	Desirable	
O14	Enhanced economic damage calculation 3	£10,500	Desirable	
O15	Mapping of key social and emergency response including location of hospitals, schools etc	£1,000	Highly desirable	
O16	Provide Broad-scale Ecosystem Impact Modelling habitat potential analysis tool		Not costed	
O17	Improve links to appraisal methods incl MCA and PAG3	£3,500	Highly desirable	Price indicator. More information needed.

O18	Linkages to integrated urban drainage plans		Not costed	Would need significant further work to scope
O19	Linkages to Water Framework Directive		Not costed	Would need significant further work to scope
O20	Provide tool to assist implementation of FD2114 - land management impact on flood generation		Not costed	
O21	Provide a 'FloodRangerPro' type visualisation tool to enable stakeholders to better understand MDSF2 results	£15,000		
O22	Include 'flood risks to people' calculation (incorporate FD2321)	£4,000	Desirable	Assumes underlying data are available
O23	Improve use of spatial data sets: direct use of tiled DEMs, support image catalogues	£7,700		
3	**Testing and proving**			
	Alpha testing by development team	£15,000	Must Have	
	Beta test on one catchment - to be identified	£30,000	Other funding sources?	
	Beta test on one SMP - to be identified	£30,000	Other funding sources?	
4	**Guidance and user manuals**			
O2	Provide suitable user manual and guidance documentation – facilitating transparency in calculations	18,000	Must Have	
	Updated CFMP Guidance	£10,000	Other funding sources?	
	Updated SMP Guidance	£10,000	Other funding sources?	
	Updated Strategy Guidance	£15,000	Other funding sources?	
5	**Dissemination**			
	Interim workshop	£7,500	Desirable	
	Final roadshows (8 locations - one in each Region)	£10,000	Highly desirable	
4	**Project Management**			
	Progress report and meetings	£7,000	Must Have	
	Interim Report	£5,000	Must Have	
	Project management	£15,000	Must Have	