Integrated Flood Risk Analysis
and Management Methodologies

FLOODsite

FLOODsite Pilot Studies

MESSAGES FOR POLICY MAKERS

Date	April 2009
Report Number	T35-09-16
Revision Number	1_0
Task Leader	HR Wallingford

FLOODsite is co-funded by the European Community
Sixth Framework Programme for European Research and Technological Development (2002-2006)
FLOODsite is an Integrated Project in the Global Change and Eco-systems Sub-Priority
Start date March 2004, duration 5 Years

Document Dissemination Level

PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Co-ordinator: HR Wallingford, UK
Project Contract No: GOCE-CT-2004-505420
Project website: www.floodsite.net

SIXTH FRAMEWORK PROGRAMME

DOCUMENT INFORMATION

Title	**FLOODsite Pilot Studies: Messages for Policy Makers**
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Distribution	**Public**
Document Reference	T35-09-16

DOCUMENT HISTORY

Date	Revision	Prepared by	Organisation	Approved by	Notes
01/05/09	1_0_Pn	David Ramsbottom	HR Wallingford	Paul Samuels	

ACKNOWLEDGEMENT

The work described in this publication was supported by the European Community's Sixth Framework Programme through the grant to the budget of the Integrated Project FLOODsite, Contract GOCE-CT-2004-505420.

DISCLAIMER

SUMMARY

FLOODsite is a major EC research programme intended to develop integrated methodologies for flood risk analysis and management for river basins, estuaries and coastal process cells. As part of the research programme, seven pilot studies were carried out in order to implement some of the new technologies. The pilot sites were:

- The River Elbe Basin, most of which is located in Germany and the Czech Republic. It has a catchment area of about 150,000km^2.
- The River Tisza Basin which includes Slovakia, Ukraine, Romania, Hungary and Serbia. It has a catchment area of about 160,000km^2.
- Four flash flood basins, in Italy (Adige River), France (Cévennes-Vivarais Region), Spain (Besos River and the Barcelona Area) and a transnational river basin in the Ardennes area covering the Netherlands, Belgium and Luxemburg.
- The Thames Estuary in the UK, which has a floodplain area of about 350km^2.
- The Schelde Estuary in Belgium and the Netherlands, which has a floodplain population of about 1.3 million people.
- The Ebro Delta on the Spanish Coast, which has an area of about 320km^2.
- Part of the German Bight coast including the community of St. Peter-Ording. The flood risk area is about 40km^2.

The purpose of this report is to identify messages from the pilot studies that might be helpful to Policy makers who are responsible for the implementation of the EC Floods Directive.

The Floods Directive (Directive 2007/60/EC) includes the following requirements for all Member States:

- Preliminary flood risk assessments (required by 22 December 2011)
- Flood hazard maps (required by 22 December 2013)
- Flood risk maps (required by 22 December 2013)
- Flood Risk Management Plans (required by 22 December 2015)

Messages have been identified from the pilot studies based on the above requirements. They have been categorised as follows:

- General planning
- Application and integration of knowledge
  - Flood hazard maps
  - Flood risk maps
- Environmental pollution from flooding
- Managing flood risk:
  - Prevention (of flooding)
  - Protection (against flooding)
  - Preparation (for flooding)
- Engagement with stakeholders
- Next steps for application in practice

The main requirement identified in this review is the need to develop guidance for methods to implement the Floods Directive based on the results of the FLOOD*site* pilot studies and other relevant work. Whilst tools and techniques have been demonstrated, it will be important to ensure that the most appropriate methods are applied taking account of local conditions, required outputs, data requirements and available resources.

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ABBREVIATIONS

Abbreviation	Meaning
AIB	Application and Implementation Advisory Board
Commission	Commission for the European Communities
CORDIS	The Commission research programme website www.cordis.lu
Defra	Department for Environment Food and Rural Affairs (a British Government Department)
DEM	Digital Elevation Model
DG	Directorate General
DOW	Description of Work (Annex 1 of the EC contract)
EA	Environment Agency of England and Wales
EC	European Commission (i.e. the Commission)
ERA-NET	European Research Area Network Action (a funding mechanism of FP6)
EU	European Union
Floods Directive	The European Directive on the assessment and management of flood risk Directive 2007/60/EC
FP5	The Fifth Framework Programme of Research and Development (1998-2002)
FP6	The Sixth Framework Programme of Research and Development (2002-2006)
HO	Hydrometeorological Observatory
IP	Integrated Project (a funding mechanism of FP6)
MT	Management Team (called the FLOODsite Executive Management Team in the DOW)
NoE	Network of Excellence (a funding mechanism of FP6)
SAS	Structured Algorithm System (of Task 15)
STAB	Scientific and Technical Advisory Board
STREP	Scientific and Technological Research Project (a funding mechanism of FP6)
WFD	The European Water Framework Directive, Directive 2000/60/EC
WPD	Work package description (the WPD tables in the DOW set out the Consortium's programme of research)

1. Objective

FLOOD*site* is a major EC research programme intended to develop integrated methodologies for flood risk analysis and management for river basins, estuaries and coastal process cells. As part of the research programme, seven pilot studies were carried out in order to implement some of the new technologies.

The objective of this report is to draw out messages for Policy Makers from the work carried out in the FLOOD*site* pilot studies. This report has been produced as an additional project output to meet the request of the *Commission* representative on the FLOODsite Project Board that the key messages from the Pilots should be widely available, particularly to the membership of Working Group F, which is considering the implementation of the EC Floods Directive. The messages have therefore been developed based on the requirements of the Directive. The report also served as input to the final reporting of FLOODsite, specifically the book text on the pilots and the second volume of the Integrated Science and Application Report (FLOODsite document T35-09-02)

An introduction to FLOOD*site* is given in Section 2 and links to external projects and other initiatives are outlined in Section 3. A summary of the EC Floods Directive is given in Section 4, and an overview of the pilot studies in Section 5. The messages are contained in Section 6.

2. Introduction to FLOOD*site*

2.1 Background

2.1.1 Terms of reference - The FP6 call and research proposal

In late 2002, the European Commission Directorate General for Research issued the first call for research in the Sixth Framework Programme priority on Global Change and Ecosystems with the Call Identifier FP6-2002-Global-1. The work programme, paragraph 1.1.6.3.IV.2.b, called for one of the two "new instruments" - an Integrated Project (IP) or Network of Excellence (NoE) - to tackle the following priority topic:

> "*Integrated strategies and tools for hazard, vulnerability and risk assessment, prevention and mitigation of flood risks in the river basin, coastal zone and the estuaries. Development of innovative design of sustainable flood defences and risk mitigation measures. Operationalisation of methods and technologies developed as well as their efficiency and cost of implementation. Understanding and prediction of coastal flood related extreme events, their interaction and synergetic effects with coastal morphodynamics. Exchange and dissemination of related information to user communities.*"

The FLOODsite partners submitted a proposal in April 2003 for an IP to respond to this call and formed a consortium to undertake the research. The Consortium negotiated a programme of work with DG Research and the FLOODsite project was one of the first IP's to commence work on 1st March 2004, with project duration of 5 years.

2.1.2 Scope and ambition of FLOODsite

FLOODsite was designed to produce improved understanding of specific flood processes and mechanisms and to develop integrated methodologies for flood risk analysis and management ranging from the high level management of risk at a river-basin, estuary and coastal process cell scale down to the detailed assessment in specific areas. FLOODsite addressed the research challenges on risk mitigation for rivers, estuaries and the coasts identified by the EC Research DG in the context of the more generic research called in the FP6 Work Programme. Progress was planned specifically on the following issues:

- Understanding and statistical appraisal of extremes which generate river, estuary and coastal flood hazards and the hydrometeorology of flash flood hazards in small basins

- Improved understanding of the vulnerability of the public and assets to flood damage
- Improved understanding of complex flood defence systems, their failure modes and their interaction with morphodynamic processes.
- Identification, design and appraisal of sustainable flood mitigation measures
- Consistent and integrated flood risk assessment and management procedures
- Improved disaster preparedness, evacuation and emergency management procedures and social resilience.

In May 2005, a major international conference was held on flood management at Nijmegen the Third international Symposium on Flood Defence. This drew an audience of over 300 researchers, experts and professionals engaged in flood management worldwide. The move from flood protection and defence to integrated flood risk management and "making room for rivers" was evident in many national contexts and in the policy of the EU as presented by DG Environment. This change in philosophy is at the heart of the FLOODsite objectives and research plan. FLOODsite has explored the proper system representation and societal understanding of flood risk management as the context within which the scientific and technological research advances will be implemented.

As described in Section 4 below a fundamental change in the external context over the past year is the entry into force of the EU "Floods" Directive. The wording of the Directive allows for considerable flexibility in its implementation in national law, respecting the national and regional context in which flood risk management occurs through the Subsidiarity Principle. Accordingly FLOODsite has provided a set of Integrated Methodologies for use in flood risk management practice not a single methodology, thus respecting the diversity of practice in each Member State

2.1.3 Organisation and governance of the research

The proposal and subsequent contractual Description of Work (DOW) for FLOODsite arranged the work into seven "Themes" which were divided into a total of 35 Tasks. Four of these themes covered the development of the project science and three covered generic activities including dissemination, training, networking and management and coordination; Figure 2.1 shows their interrelationship.

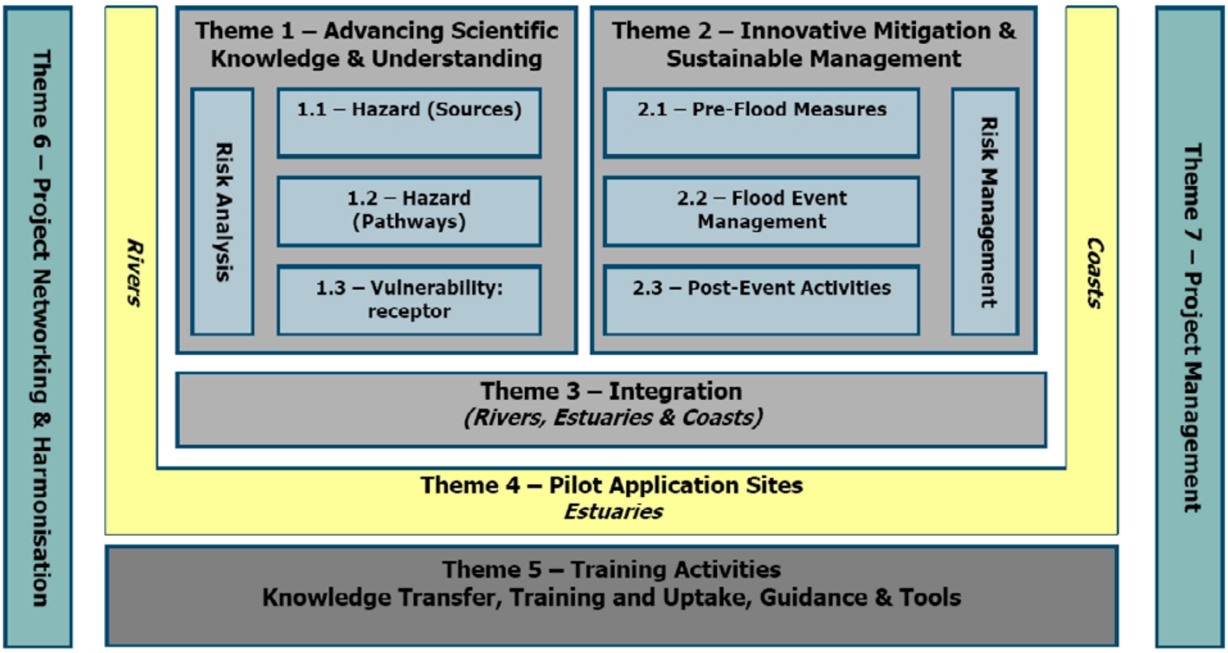

Figure 2.1 Overall project structure

The project governance structure included a Management Team responsible for the day-to-day running of the project, and three boards to provide assessment, review and advice, see Figure 2.2. There were two expert advisory boards (on scientific and technical issues and on application and implementation) and an oversight project board under independent chairmanship which reported annually to DG Research. In addition the FLOODsite Consortium reported annually on the scientific progress of the project to DG Research who commissioned an independent evaluation of the reports. The Scientific and Technical Advisory Board (STAB) reviewed the project science on several occasions, taking reports from and questioning the task leaders; the STAB then recommended means of improving some Task outputs. The Applications and Implementation Advisory Board (AIB) also met annually, making recommendations on the take-up of the project science. The AIB recommendations resulted in the Management Team organising a dissemination meeting with WG-F (see Section 4 below) and producing fact sheets which provide an easy entry into the project outputs for practitioners.

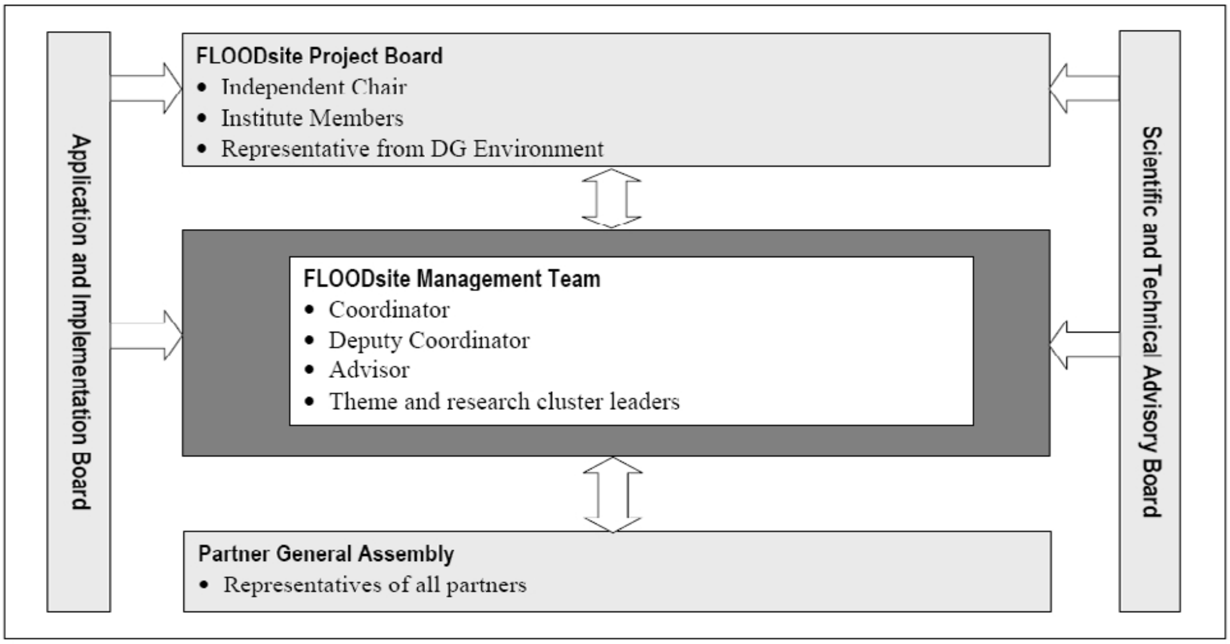

Figure 2.2 Project governance structure

2.1.4 Specific Objectives of the FLOODsite Themes

The objectives of each of the seven project themes were set out in the Description of Work as follows:

Theme 1 – Risk analysis: Scientific knowledge and understanding

- To improve understanding of the primary drivers of flood risk (waves, surges, river flow etc.) through research targeted at key issues and processes that significantly contribute to current uncertainty in flood risk analysis.
- To improve understanding, models and techniques for the analysis of the performance of the whole flood defence system and its diverse components, including natural and man-made defences (e.g. seawalls, embankments, dunes) and the extent of inundation.
- To understand the vulnerability and sensitivity of the receptors of risk and to improve and harmonise the methods to evaluate societal consequences and to estimate flood event damages

Theme 2 – Innovative mitigation and sustainable flood risk management

- To evaluate flood risk management measures and instruments *ex-post* and to develop sustainable flood risk management strategies and evaluate these *ex-ante* under consideration of a wide range of different physical and societal conditions.
- To improve flood risk mitigation measures that are applied during the flood event, through improved technology for flood warning in small flash-flood catchments and through measures for emergency evacuation.

Theme 3 – Frameworks for technological integration

- To integrate the scientific, technological and procedural advances to support **long term** flood risk management decisions.
- To integrate the scientific, technological and procedural advances to support flood event management decisions.
- To develop a framework for the identification and quantification of the influence of uncertainty in the process of flood risk management.

Theme 4 – Pilot application sites

- To provide real sites with real and specific problems upon which tools, techniques and decision support systems may be developed and tested.
- To provide feedback into the research and development process from flood risk managers and river, estuary and coastal stakeholders.
- To ensure the FLOODsite deliverables are of real value, practicable and usable.

Theme 5 –Training activities (Knowledge transfer, training and uptake, Guidance and tools)

- To provide Best Practice Guidance based upon the research outcomes
- To disseminate, and support transfer, of knowledge to the stakeholder communities
- To provide educational material (paper, web-based, training course) for selected end users such as the public, professionals, school children, students etc.

Theme 6 – Project networking, harmonisation and monitoring

- To link with external research and policy development activities
- To provide internal coherence within the FLOODsite consortium (e.g. through the development of a common language of risk for flood management)
- To integrate review and assessment into the project activities

Theme 7 – Project co-ordination

- To ensure effective and efficient overall management of the project, including administrative and financial aspects, communication with the commission, exploitation of results etc.

2.2 Accessing the FLOODsite results

The FLOODsite team has produced a large number of publications; the “Final plan for using and disseminating the knowledge” (FLOODsite Report T35-09-09) identifies 636 publications at the end of the FLOODsite project:

- 155 Journal papers
- 16 Contributions to books
- 300 Conference papers
- 29 Institutional reports and theses
- 31 Posters
- 95 FLOODsite reports on the project science.

The **project website** www.floodsite.net has over 400 documents available for public download. Conference and Journal papers are only made available via the website once they have been formally published or presented and have been cleared of copyright restriction. The website contains pages (under “innovations and outcomes”) on each of the tasks, describing the background to the work, the research undertaken and how the results may be used in practice.

The content of many of the science reports are outlined in task **Fact Sheets** which are available for download from the website both from the pages that describe each task. They are also collected together as FLOODsite Report T32-09-02.

In addition to the fact sheets and the main FLOODsite science reports, most tasks have produced an **Executive Summary** report on their area of investigation. The Executive Summary reports were originally produced to assist the project STAB and AIB review the progress and outcomes of the project science, however, these summaries are additional outputs from the tasks, providing an overview of their activities, principal results and remaining gaps in knowledge. The task Executive Summaries are available from the project website and may be accessed both through the task pages and centrally from the database of publication.

3. Links from FLOODsite to external project and initiatives

3.1 Other projects and actions

FLOODsite has identified approximately 150 external projects that are related to flood risk management. The breadth of the projects identified reflects the considerable patrimony of research funded by the *Commission* on flooding as a natural hazard, on coastal science and on flood forecasting and Member States fund national programmes. Following the comments from the Evaluators on our progress reporting FLOODsite identified 88 active links between external projects and FLOODsite. The project links have been identified at a task level and these are collated alphabetically by linked project in Appendix A of this report.

In addition to these links where information and knowledge has been used or exchanged during FLOODsite, the project website also provides access to several external websites related to flood risk management research and practice; see: http://www.floodsite.net/html/useful_links_external.asp.

3.2 National Links

The German partners of FLOODsite have established close links to the research funding institutions such as the German Research Council (DFG) and the Federal Ministry of Education and Research (BMBF). Close links with end user groups both from the coast and the Elbe region have been maintained to keep potential end users informed and give them possibilities for feedback on ongoing research issues. In this context, some of the pilot sites in Germany are in constant discussion with administration and local authorities to make use from their expertise and needs.

In France, Météo-France is affiliated to the Consortium through INPG in recognition of its close ties to information used in FLOODsite and close cooperation in the research particularly on flash-flood forecasting; this close cooperation will lead to early adoption of advances made within FLOODsite. In Hungary, HEURAqua and VITUKI provided a close link to the national flood defence activities in both the Danube and Tisza rivers. In the Netherlands, Deltares has been working closely with the Rijkswaterstaat on long-term flood risk management issues following the work of Task 14. In Spain the work of UPC-LIM is closely aligned with spatial planning in the Ebro Delta.

In the UK, HR Wallingford maintains close links with national research and development activities in flood risk management, and the FLOODsite project themes and outputs form part of the national action on improving the scientific basis of flood risk management. Both Defra and the Environment Agency have been admitted as “affiliates” to the project consortium in recognition of the close flow of information to these stakeholders. The Environment Agency is undertaking a process of “benefits-planning” to ensure that the FLOODsite results are implemented appropriately into the Agency’s operations and the Coordinator will work with the Agency in the year after FLOODsite is completed to facilitate the transfer of project advances into national practice.

4. The European "Floods" Directive

4.1 Introduction

An important policy development that occurred during the FLOODsite project is the entry into force on 26th November 2007 of the European Directive on the assessment and management of floods (Directive 2007/60/EC; or the "Floods Directive"). Article 1 describes the objective as follows:

> *"The purpose of this Directive is to establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community."*

The Floods Directive applies to the whole Community territory, and therefore to flood risk management in both rivers and coastal areas. The new Directive is aligned with the *Water Framework Directive* (Directive 2000/60/EC; or the "WFD"). It sets out the need for assessments, maps and plans that cover the river basin district including the borders of the river basins, sub-basins and where appropriate associated coastal zones through:

- Preliminary flood risk assessment
- Flood risk maps
- Flood risk management plans

It is clear that FLOODsite is directly relevant to the needs of the Floods Directive and this was identified in the explanatory memorandum to the *Commission's* proposal for the Directive:

> *"European research policy has been supporting research into different components of flood risk management since the early 1980s through successive Framework Programmes. The Sixth Framework Programme is supporting the largest ever EU flood research project, "FLOODsite", which is developing integrated flood risk analysis and management methods. The proposed 7th Framework programme will continue to support research on flood risk assessment and management."*

Working Group F (WG-F) has been constituted by DG Environment under the Common Implementation Strategy (CIS) of the WFD and has two primary tasks:

- information exchange for example on research outcomes and current good practice, and
- support for the implementation of the Floods Directive within the CIS framework.

4.2 Contribution of FLOODsite to the implementation of the Directive

Within the boundaries of FLOODsite, the Integrated Project is delivering advances in several areas of direct relevance to the three main activities of the Floods Directive – preliminary flood risk assessment, the preparation of flood risk maps and the preparation (and implementation) of flood risk management plans. The procedures for undertaking these activities are being defined and agreed by the competent authorities in the Member States by a Working Group (WG-F) established under the CIS of the WFD. It will be important for the FLOODsite team to continue to interact with the WG-F so that the research outcomes can inform the development of the implementation plans.

4.2.1 Potential support for Preliminary Flood Risk Assessment

The preliminary flood risk assessments will be used to identify areas which need to be considered in more detail through mapping and potentially the preparation of flood risk management plans. In order to assess flood risk it is necessary identify both the probability and consequences of flooding. Much of the research in Theme 1 of FLOODsite is relevant in the assessment of flood risk. In terms of assessing the probability of the flood hazard, the outputs of Task 2 provide up-to-date statistical tools for looking at the probability of extreme events both at a point and the variation spatially. Where raised defences are used as flood mitigation measures in an area, it is important to recognise in quantifying the risk of flooding that all engineered structures will have a finite probability of failure at less than the design loading but also may have a performance which exceeds the design standard. Thus Tasks 4, 6 and 7 provide underpinning knowledge and methods to examine the reliability of existing flood defences that can form part of a flood risk assessment.

However, the existence of raised defences may be taken as an indication that risk maps and plans need to be prepared. In that case the contribution of the science in Tasks 4, 6 and 7 will be directly in these subsequent activities. Likewise it is not yet clear whether the flood damage estimation guidelines developed in Task 9 or the estimation of loss-of-life developed in Task 10 will be needed in preliminary assessments. If the preliminary flood risk assessment requires initial drafting of flood inundation and consequence maps, then other FLOODsite results are also relevant as discussed in the paragraphs below on the preparation of Flood Risk Maps.

4.2.2 Potential Support for the preparation of Flood Risk Maps

There are many mapping technologies available – from advanced topographic survey such as LiDAR to commercial GIS to overlay flood outlines with socio-economic data. The Exchange Circle EXCIMAP has prepared current practice guidance on flood risk mapping and FLOODsite partners contributed to that group. FLOODsite is not undertaking research on the development of GIS but is making use of this as a commercially available technology. Flood risk mapping will require both the hazard and the consequences of flooding to be assessed and FLOODsite is contributing knowledge relevant to these activities. It is this greater clarity of approach to risk assessment and for some specific physical processes that FLOODsite will make its main contribution to the scientific basis of the flood risk maps. The contributions to knowledge will be developed and tested in the context of our pilot sites in Theme 4.

Task 1 has researched the hydro meteorological processes that govern flash flooding, in particular, the stationarity of storms and the hydrological behaviour of small mountainous catchments. This has led to new models of extreme flood response in ungauged basins, and, although the flash flood work in FLOODsite is directed at improved forecasting this understanding may also improve flood estimation for mapping the hazard in small mountainous catchments. As noted above the outputs of Task 2 provide up-to-date statistical tools for assessing the probability of extreme events. Task 3 is developing and testing a general procedure for building a European Flood Hazard Atlas (as opposed to risk maps) based upon the FLOODsite methodology; the testing will be mainly for coastal areas.

The project is developing a deeper understanding of the elements of risk and this will be available to support the flood risk mapping process. The understanding of reliability of defences from Tasks 4, 6 and 7 will enable a fuller assessment of risk to be prepared through factoring the likelihood of defence failures into the assessment of risk. In Task 8, models for flood inundation are being benchmarked, and this will lead to guidance on the suitability of hydrodynamic modelling approaches for hazard and risk mapping.

The work in Tasks 9 and 10 will be of direct relevance to flood risk mapping since this work supports the evaluation of the consequences of flooding. In particular, the risk mapping may use the flood damage estimation guidelines developed in Task 9 and the estimation of loss-of-life model and the GIS-based multi-criteria evaluation of risk developed in Task 10.

4.2.3 Potential Support for the preparation of Flood Risk Management Plans

The purpose of the flood risk management plans is to identify means of reducing the impacts of flooding. In addition to the using the project knowledge outlined above which supports the preliminary assessments and flood risk mapping, several other tasks are researching areas which will support the preparation of flood risk management plans. These include:

- The understanding of community preparedness and resilience from Task 11
- Identification, design and appraisal of sustainable flood mitigation measures from Tasks 12 to 14
- Emergency evacuation planning, coupling inundation and traffic models from Task 17

- Decision support for long-term planning and the selection of a portfolio of measures and instruments for flood risk management from Task 18

It should be recognised that the process models and decision support software will require further development for application in practice. The FLOODsite project will prototype methods and pilot their application but only to a pre-competitive level.

The project partners are keen to work with national authorities responsible for the application of the proposed directive and preparation of the assessments, map and plans. It is only through this dialogue will the emerging results of FLOODsite be mapped onto the requirements of the implementation process as it is developed within the working group.

4.3 Summary of requirements

The Floods Directive requires the following:

- Preliminary flood risk assessment (required by 22 December 2011)
- Flood hazard maps (required by 22 December 2013)
- Flood risk maps (required by 22 December 2013)
- Consideration of environmental pollution from flooding
- The need to avoid worsening flooding elsewhere
- Flood Risk Management Plans (FRMPs), required by 22 December 2015. These include:
    - Prevention (of flooding)
    - Protection (against flooding)
    - Preparation (for flooding)
- Updating of the Plans taking account of climate and other change (every 6 years)
- Fair sharing of responsibilities for flood risk management
- Sharing of information on international river basins
- FRMPs should include flood forecasting and warning, and also consider:
    - Sustainable land use practices
    - Improved water retention
    - Controlled flooding

There may be conflicts with the requirements of River Basin Management Plans (RBMPs) being produced under the EC Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council, dated 23/10/2000), which are concerned with improving the ecological and chemical status of water bodies. The ‘Competent Authorities’ for FRMPs and RBMPs may also differ in different Member States.

5. The Pilot Studies

The seven pilot studies of FLOOD*site* are summarised in this section. The pilot studies made significant use of work carried out in other FLOOD*site* tasks. The locations of the pilot areas are shown on Figure 5.1.

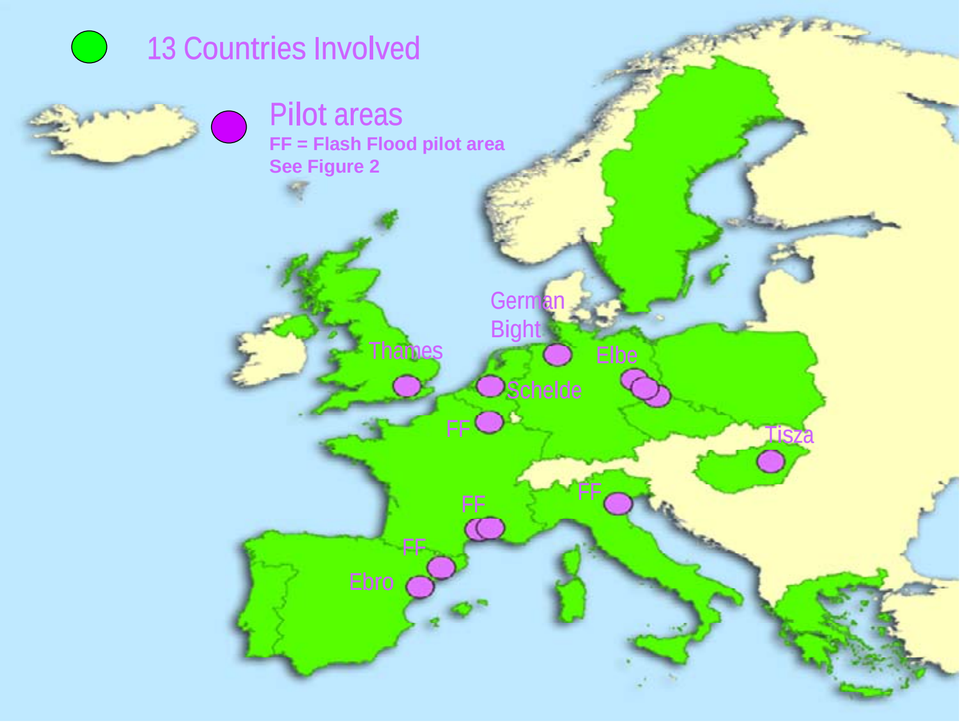

Figure 5.1 Locations of pilot areas

5.1 Elbe River Basin (FLOODsite Task 21)

The transnational Elbe River basin was chosen as a pilot basin in FLOODsite because of its wide range of different issues around flooding, which are typical for Europe. The Elbe is one of the major river catchments in Central Europe; it covers large areas of the Czech Republic and Eastern and Northern Germany and minor parts of the headwaters are located in Austria and Poland. International cooperation on water management in the Elbe basin is undertaken through the International Committee for the Protection of the Elbe (IKSE). The total length of the river is 1,091 km and the overall catchment area is 148,268 km², of which about two thirds lies in Germany.

The flood risks in the upland and lowland areas differ in nature. In the mountainous regions, the river processes are dynamic and in some cases the flood hazard are classified as flash flood; these cause high local hazards and risks in the narrow mountain valleys. The floods in the lowland plains rise more slowly and are more extensive than in the headwaters and these "plains" floods arise from a combination of flow from the tributaries and the Elbe River itself. The extreme discharge peaks (over 5000 m^3s^{-1}) in these slow rising flood waves can lead to very large inundation volumes. Flood-prone areas of river sections can be considered as both risk pathways and risk receptors depending on the existence and effectiveness of mitigation measures.

An extreme flood event in mid August 2002, which resulted in damages of more than €12 Billion, highlighted shortcomings in the existing flood protection provided in the basin (Socher & Böhme-Korn, 2008). Against this background, the pilot study considered the issues in a risk-based approach considering the whole cascade of flood risk generation and a scenario-based long-term management. The results have the potential to assist in developing future flood risk management strategies, especially for developing the flood risk management plans required by the EU Floods Directive. The basin was not treated as a single unit in the pilots study; rather, different spatial levels of investigation gave details in five pilot areas (see Figure 5.2). These also provided an overview for the entire Elbe River basin in terms of the sources, pathways, receptors and consequences of floods.

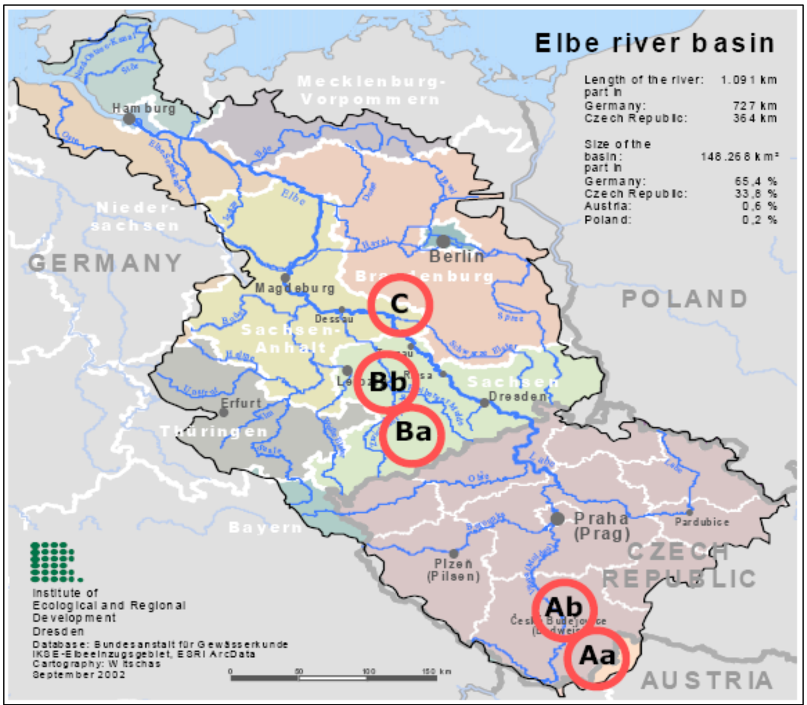

Figure 5.2 Map of the Elbe river basin showing pilot site locations

Data was provided by a large number of public authorities in Germany and the Czech Republic and detailed risk analysis in the pilot sites covered social, economic and ecological impacts, and to understand the interrelation between different sites. Risk perception, risk assessment and risk reduction measures and instruments were also investigated as part of integrated flood risk management strategies being developed within the river basin. Examples of specific research topics include:

- The effects of regional climate change;
- The influence of land-use change on runoff generation;
- Multi-criteria risk evaluation;
- Hydraulic investigations of flood polders; and
- Approach to scenario planning.

The pilot study for the Elbe River was directed at a comprehensive development and testing of the FLOODsite methodology under the condition of a large and transnational European river basin. This basin was chosen because of its wide range of different issues of flooding, which are of special European relevance. Flood risks widely vary depending on the site-specific nature and probability of flood hazards and the regional patterns of rural and urban land use according specific natural and societal conditions. Thus, flood risk management approaches in the Elbe River basin need both a differentiation of certain sites with their meaning as sources, pathways and receptors on the one hand and a consideration of interrelations between different sites on the catchment scale on the other hand. The development and testing of the FLOODsite methodology was carried out within five selected pilot areas. These pilot areas are located in Germany and the Czech Republic. The two states cover more than 99 % of the catchment size and represent an old and a new Member State of the European Union. Varying societal conditions provide the prerequisites for a supplementary comparison of flood risks and flood risk management approaches.

The pilot areas were:

- Moldawa river (Czech Republic)
  - Horní Stropnice river
  - Trebon Basin
- Mulde river (Germany)
  - Zwickauer Mulde river
  - Vereinigte Mulde river
- "Lowland part of the Elbe river" (Germany)

Task 21 emphasised the integration of all aspects of flood risk management according the comprehensive methodology of FLOODsite. The flood hazards were simulated using meteorological, hydrological and hydraulic models. Social, economic and ecological vulnerability were calculated with different damage models. Risks were assessed by multi-criteria approaches (MCA) considering all dimensions of sustainability. Criteria and methods are included from Tasks 10 and 12. To support integrated flood risk management relevant models were coupled in some pilot areas. In addition, the results of these models were incorporated within a DSS in close cooperation with Task 18. Mitigation measures and instruments and long-term scenarios were implemented based on the results of Task 12 and Task 14.

5.2 River Tisza (FLOODsite Task 22)

The River Tisza is the largest tributary of the Danube and stretches across five countries (Slovakia, Ukraine, Romania, Hungary and Serbia). The river basin covers 157,000 km^2 and has a total length of 966 km. The communities along the River Tisza are at significant risk from flooding. In Hungary alone there are over 400 communities housing 1.2 million people on a floodplain of approximately 16,000 km^2, which is protected by nearly 3,000 km of flood defences. The upper parts of the river suffer from flash flooding, while the middle and lower parts suffer from very high and long lasting flooding caused by the combined effects of upstream flows.

An unprecedented series of extreme floods hit the Upper- and Middle Tisza River between November 1998 and March 2001 after a relatively long dry period. During this 28 month period four extreme floods occurred, as a consequence of which the total duration of flood alerts reached 24 month. Within this, extraordinary alerts lasted 9 month. The November flood in 1998 as well as the March flood in 2001 brought new records in flood peaks along the Upper-Tisza; the latter caused even dike breach there. However, these floods due to the attenuation of the single flood waves resulted in a high, but not extreme flood on the Middle-Tisza section which is subject of the FLOODsite investigation, being the selected pilot site downstream Szolnok (See Figure 5.3).

The selected study area is situated in a rural environment at the confluence of Tisza and Hármas-Körös rivers. It covers the inner area of four settlements (*Tiszaug, Tiszasas, Csépa* and *Szelevény*) and the outer area of *Tiszainoka, Tiszakürt* and *Kunszentmárton*. The population of the flood area is in the range of 5,000 while the endangered assets in the settlements are of the magnitude of €100 million and for agriculture €20 million. The pilot study focused on the following issues:

- Development of precautionary and sustainable flood management strategies for the river basin, based on the investigation and analysis of previous floods;
- Fostering international co-operation especially in the fields of monitoring, data exchange and methods of flood forecasting and warning; and
- Application of general vulnerability analysis techniques (using flood hazard mapping) developed by other FLOODsite tasks, to identify the effectiveness of flood management strategies.
- Impact of flooding on pollution sources on the floodplains based on recent events.

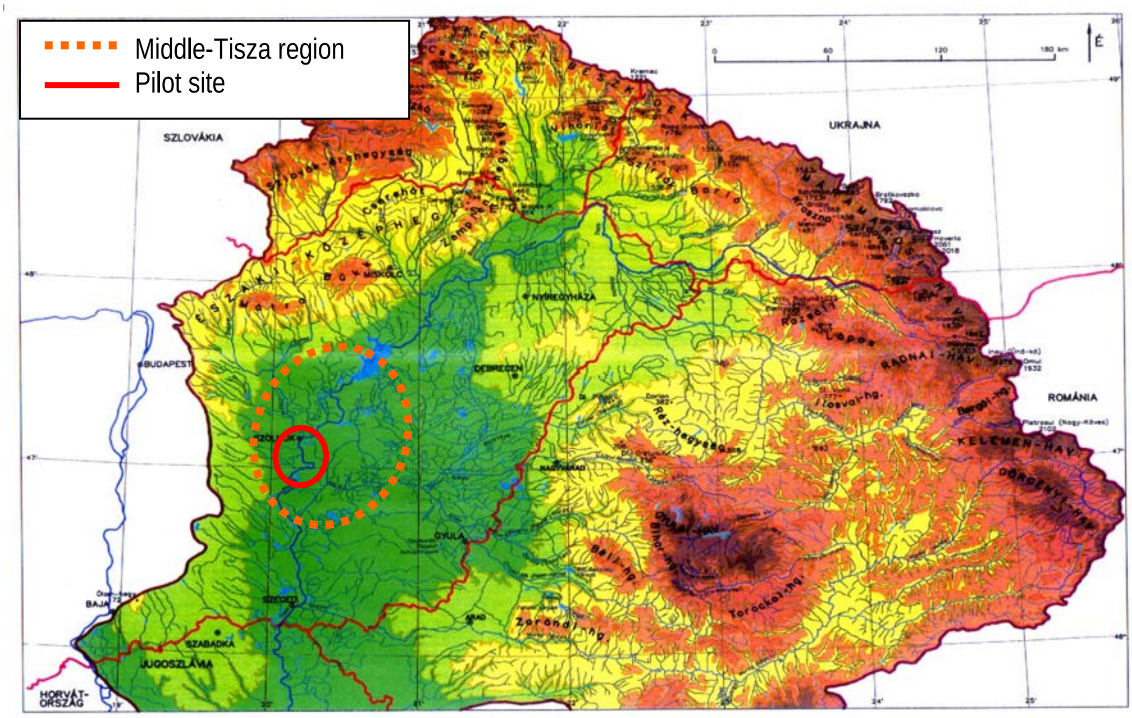

Figure 5.3 The Middle Tisza Region and pilot site in the larger Tisza catchment

5.3 Flash Flood Basins (FLOODsite Task 23)

Lack of observation data has hampered advances in understanding the hydrological processes at work during flash floods, and consequently, in forecasting catchment responses to extreme precipitation. The objectives of this pilot study were to illustrate and assess flash flood risk mitigation strategies in close collaboration with operational organisations, local communities and stakeholders at four sites. Observational limitations mainly stem from the fact that flash floods develop at spatial and temporal scales that conventional observation systems of rain and river discharges are not able to monitor. As these events are locally rare, they are also difficult to capture during traditional field-based experimentation, designed to last a few months over a limited area. The four pilot areas to study these issues were chosen for their especially high incidence of flash floods; giving reasonable expectation of encountering some events during the duration of FLOODsite. The areas were:

- Cévennes-Vivarais Region (France)
- Adige River (Italy)
- Besos River and Barcelona Area (Spain)
- Ardennes Region (transnational).

The locations of the pilot areas are shown on Figure 5.4.

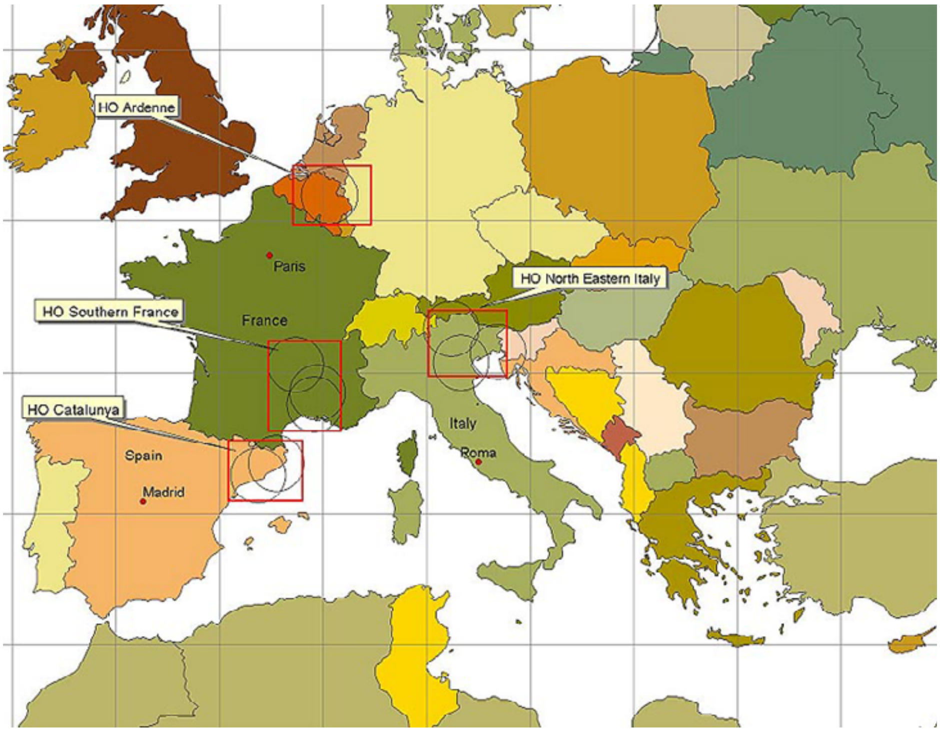

Figure 5.4 Flash flood pilot areas

(HO means 'Hydrometeorological Observatories')

Specific objectives of the flash flood pilot study were:

- Development of the concept for the monitoring of flash flood events and the systematic archiving of physical and socio-economic data concerning major flash floods. The aim was to identify the requirements for the coherent monitoring of rainfall and discharge data for flash-flood events. Furthermore, this activity provided the outline of a methodology aimed at collecting complementary information from field investigations carried out during the days following the event.
- Testing the flash flood forecasting system developed in Task 15 and 16, both off-line and in near real time. The validation phase was carried out in both off-line and near-real-time mode.
- Investigating the warning program for communicating and alerting general public about flash floods. This Activity was developed in close collaboration with Task 11 on risk perception of the "public" and how this relates to the vulnerability and resilience of communities. This work had a specific focus on the Adige rive basin in Italy.
- Systematic archiving of physical and socio economic data for flash floods.

5.4 Thames Estuary (FLOODsite Task 24)

The Thames Estuary is a large estuary with a floodplain of about 350km^2. The floodplain is highly developed and contains part of the City of London. London is the UK's largest centre of economic activity contributing around €300 Billion annually to the UK economy. Significant portions of the business and financial service sectors are located within the floodplain at, for example, the "Docklands". As well as the financial institutions there are a large number of buildings of historical and cultural (some are designated as world Heritage sites) significance within the floodplain.

The Environment Agency of England and Wales (EA) is the flood defence authority and has estimated there are over 3000 hectares of culturally significant sites within the floodplain area that are highly sensitive to flooding. Whilst placing a value on these buildings is difficult, the EA note that London's "sense of place" is defined by its cultural assets and provide an illustrative indicator, in terms of the annual revenue from tourism, which is approximately €180 Billion.

The Thames Estuary (in particular the outer estuary) is also home to a wide range of landscapes of high environmental value. These include national and international sites designated for protection such as saltmarsh, mudflats, freshwater grazing marsh and reed-beds. These areas support diverse species and provide habitats for wildfowl and waders, for .example. The implications of flood risk management interventions on these areas are a primary consideration for the development of future plans.

Flood risk arises on the Thames Estuary from a number of different sources: occurrences of high surges in the North Sea; fluvial flooding on the Thames and fluvial flooding on tributaries of the Thames. By far the greatest potential risk arises from tidal surges and in 1953 such an event caused widespread flooding, damage and significant loss of life along the Thames floodplain. The floodplain is shown on Figure 5.5.

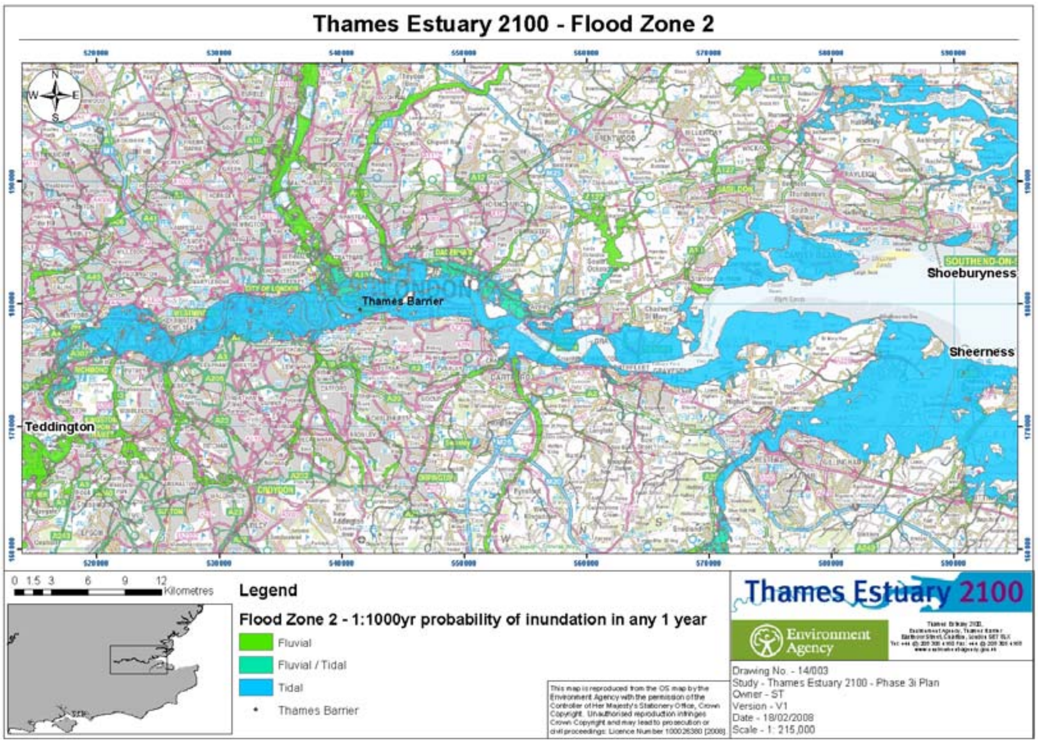

Figure 5.5 The floodplain of the Thames Estuary

This floodplain would be liable to tidal flooding without the existing defences, which have been established over many years. Most recently, these defences were constructed or improved in the late 1970s and early 1980s as part of the Thames Estuary Flood Prevention Scheme which accompanied the construction of the Thames Barrier (Figure 5.6). As well as the Thames Barrier, which became operational in 1982, nine other surge tidal excluding barriers have been constructed, downstream of the Thames Barrier, where tributaries join the Thames. Forecast and real time data on the tidal conditions in the North Sea are used to ensure these barriers and the Thames Barrier are closed simultaneously, prior to extreme tidal flood events in the Thames Estuary.

There are approximately 280 km of raised flood defences on the Thames with approximately 200 km of tributary defences. These static defences vary in type, the most common are earth embankments, steel sheet piled vertical walls and concrete/brick structures. The defences generally have been designed to last until about 2030 and the Environment Agency has recently undertaken a review of their future strategy for managing flood risk in the Thames Estuary in order to ensure that it is in place before large-scale works are required.

Figure 5.6 The Thames Barrier

The Thames pilot study in FLOODsite has produced a new flood risk analysis model that enables a rational quantification of flood risk. The model facilitates the production of maps of both probability of flooding and flood risk, expressed as Expected Annual Damage (EAD). The modelling method utilises the Source, Pathway, Receptor, Consequence conceptual representation of the flood system. The primary scientific advances of the model are:

- Development of a new computationally efficient flood spreading model;
- Development of an efficient Monte-Carlo sampling procedure for simulating multiple flood defence failure scenarios; and
- Development of a method for attributing residual risk to flood defences.

5.5 Schelde Estuary (FLOODsite Task 25)

The trans-national Schelde estuary (Figure 5.7) extends from the upper reaches near Gent in Belgium to the lower reaches and the mouth at Vlissingen in The Netherlands.

Figure 5.7 Map of the Schelde Estuary

The Dutch part of the estuary, called the "Westerschelde", is characterized by meandering multiple channels, with intertidal islands and areas on the inner side of channel bends. The Belgian part, called the "Zeeschelde", is characterized by a single meandering channel, with intertidal areas along the channel margins. Throughout the estuary the higher intertidal areas host fauna and flora-rich salt-, brackish- and freshwater marshes. The lower intertidal flats are important feeding grounds for birds and resting areas for the increasing population of seals.

The study area is home to around 300,000 people in the Netherlands and less than 1 million people in Belgium (Zeeschelde area). This includes the city of Antwerp with a population of around 450,000 (2003). The estuary is of economic importance as a major shipping artery, hosting the harbour of Antwerp, as well as providing an access route to the harbour of Rotterdam via the Rhine-Schelde canal. In 1999 to 2001, breaking with a 300 year tradition of conflict over the Schelde, the Dutch and Flemish developed a joint long term vision for the Schelde estuary. In this broad policy document the triple functions of shipping, safety from flooding and the ecosystem are emphasized. Since then many policy-related activities have been undertaken under the auspices of a joint Dutch-Flemish project bureau tasked with the implementation of the measures necessary to achieve this long term vision.

Figure 5.8 shows the complexity of flood risk management in full. Insight in the sources, pathways, receptors and impacts of a flood is required as well as in the feasibility of a wide range of potential measures. In deciding on a preferred risk management strategy all combinations need to be analysed in principle. The various ongoing projects, studies and research activities lead to a respectable body of knowledge, albeit in a rather fragmented and partially integrated way. But even more problematic for a sound risk assessment is that these activities take place almost exclusively in the (applied) science and policy area, largely ignoring the public. This prompted us to focus on the role of local citizens and stakeholders within the flood risk management process.

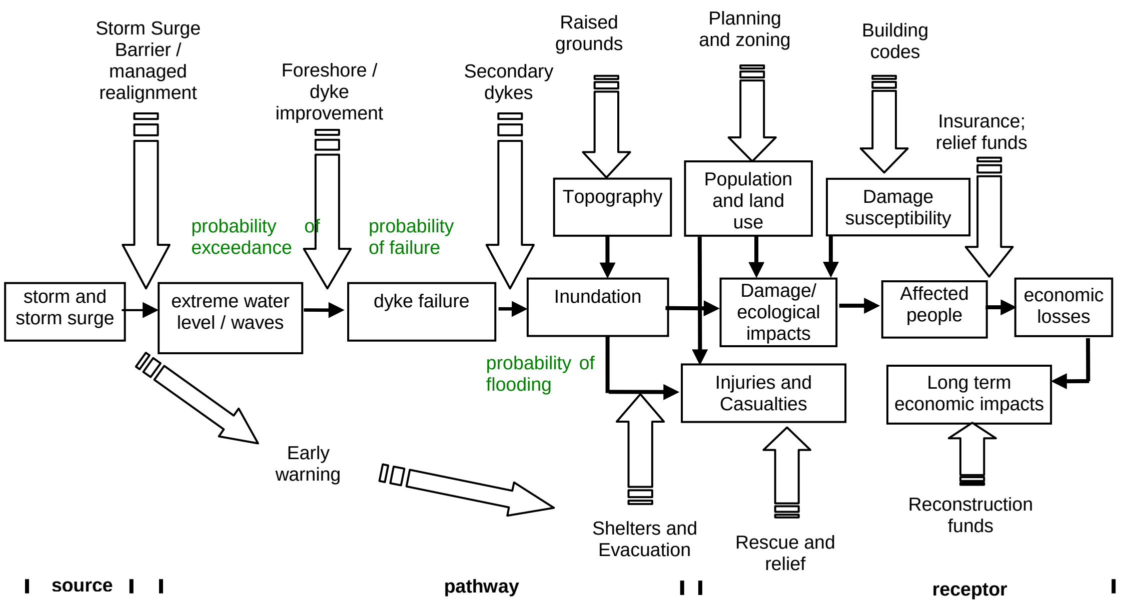

Figure 5.8 Schematic representations of the flood risk components along the Schelde estuary

5.6 Ebro Delta Coast (FLOODsite Task 26)

The main objective of the Ebro Pilot Study was to examine vulnerability, risk and defence needs against flooding (of marine origin) at the Ebro delta coast. It also includes the analysis of the associated coastal erosion which is usually the starting event for late flooding.

The Ebro delta is located on the Spanish Mediterranean coast about 200 km southward of Barcelona. It has an approximate surface area of 320 km^2 and a coastline length of about 50 km including the inner coast in the two main lagoons (see Figure 5.9).

Figure 5.9 The Ebro delta.

It is an ecologically rich environment and it includes a Natural Park of 7,802 ha giving administrative protection to the areas of highest environmental value, including habitats like freshwater, brackish and saline lagoons, salt marshes and coastal and small dune sandy areas.

Around 66% of the area is exploited for rice cultivation with a further 10-15% used to grow other crops. Approximately 50,000 people depend on the delta for their homes or directly for their livelihoods. Despite the potential for significant flood impacts associated with these factors, previous work has only focussed on coastal evolution rather than flood impacts.

Coastal flooding and erosion result from the action of eastern storms in the Catalan Sea through the combination of high waves and storm surge. Typically, the wave-induced run-up is significantly larger than the storm surge. The Ebro Delta Coast is an unprotected sandy coast exposed to storms where the beach and dune row (if present) acts as a dynamic flood defence. Therefore, to estimate the flooding of the hinterland properly, the beach and dune evolution during the storm was included.

The Ebro delta is a low-lying coastal area of about 320km^2. It is threatened by increasing storminess and sea level rise. The research consisted of a flood risk analysis that took account of stakeholder perceptions and concerns. Specific topics included:

- Impacts of increasing storminess and sea level rise on flood risk.
- Impacts on flooding of storm induced changes to beaches that occur during a storm event.
- Social and environmental impacts of increasing flood risk.
- Discussion of future flood management measures.

5.7 German Bight Coast (FLOODsite Task 27)

St. Peter-Ording is one of the largest communities at the Schleswig-Holstein North Sea Coast with the character of a tourist seaside resort. Furthermore, the municipality has an important regional and national function as health centre with various hospitals and other health companies. The community is located very exposed on the west coast of Eiderstedt peninsula (Figure 5.10). The size of the study area is approximately 6000 ha; of these about 4000 ha are potentially flood-prone. In addition, flooding of the municipality could spread far into the hinterland of Schleswig-Holstein.

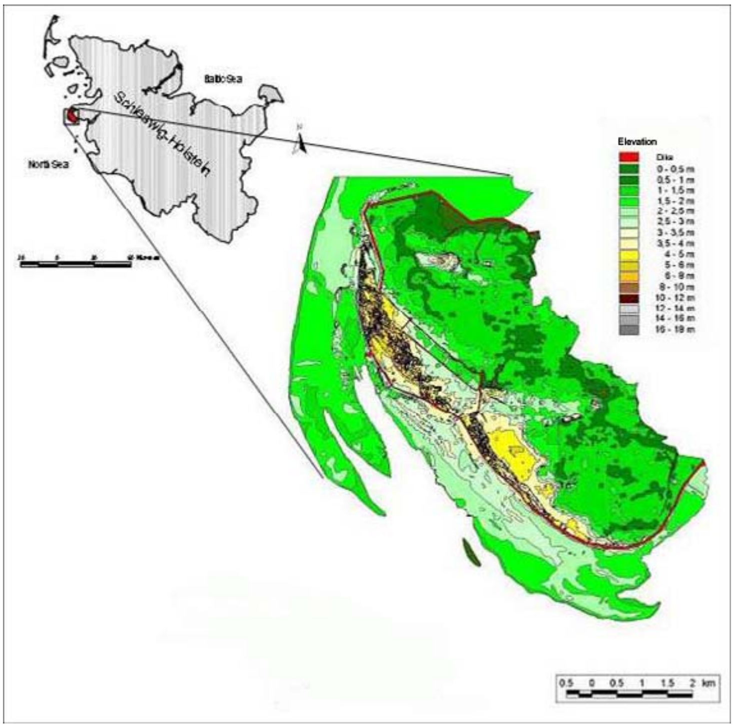

Figure 5.10 Map of the German Bight Coast pilot

The community covers about 2,800 ha and has about 6300 inhabitants. The major threats from the sea result from storm surges which may occur several times a year. Large storm surges have occurred in 1962 and 1976 where during the latter the highest storm surge water levels were recorded with a water level up to 4.8 m above normal sea level. Three other storm surges in 1962, 1981, and 1999 exceeded 4.0 m above sea level; there is concern over an increase of storminess in recent last decades.

The defence structure of the pilot site German Bight is a complex coastal defence system (Figure 5.11). It is divided into a foreland, dune structures (>2.5 km, about 10 m and up to 18.0 m high), a major dike line and a second dike line. The major dike line is 12.5 km long and about 8.0 m high. Furthermore, there is a 2 km long so called overtopping dike. This type of dike is designed to withstand wave overtopping and wave overflow. It is therefore considerably lower than standard dikes and is protected by a very solid asphalt cover layer. The height of the dike line is not constant.

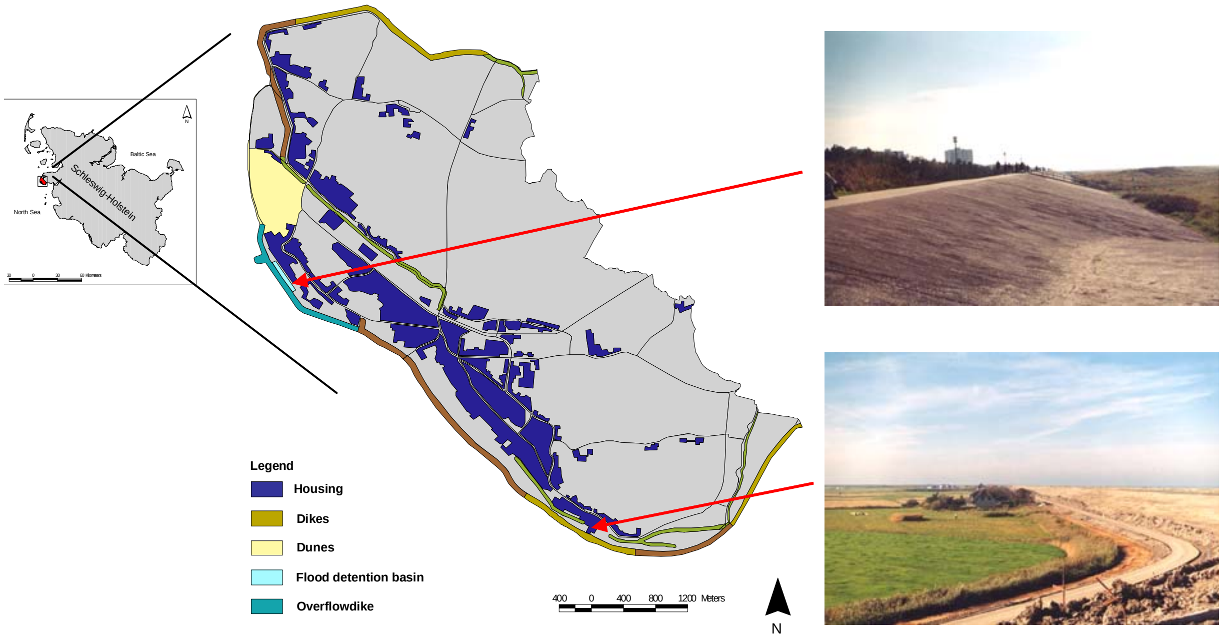

Figure 5.11 Coastal defences of the German Bight pilot site

The overall aim of the Pilot Study “German Bight Coast” was to develop and test special parts of the flood risk management (FRM) methodology of FLOODsite for a coastal site by conducting a detailed risk analysis for the community of St. Peter-Ording.

6. Messages

The messages from the pilot studies are set out in the following sections. They have been classified as follows, in order to mirror the requirements of the EC Floods Directive:

- General planning issues (Section 6.1)
- Application and integration of knowledge
    - Preliminary flood risk assessment (Section 6.2)
    - Flood hazard maps (Section 6.3)
    - Flood risk maps (Section 6.4)
    - Consideration of environmental pollution from flooding (Section 6.5)
- Managing flood risk:
    - Prevention (of flooding) (Section 6.6). This includes physical measures to reduce flood water levels (for example, detention basins) and land use planning (to avoid inappropriate development in areas that could flood).
    - Protection (against flooding) (Section 6.7). This is primarily concerned with flood defence structures.
    - Preparation (for flooding) (Section 6.8). This includes separate sections on flood forecasting and warning, and other issues (for example, evacuation).
- Engagement with stakeholders (Section 6.9).
- Next steps for application in practice (Section 6.10)

The FLOOD*site* research has concentrated on developments to improve flood risk management in line with current national and international initiatives to:

- Use flood risk as a basis for planning, covering economic, social and environmental flood impacts.
- Consider the full range of available measures to reduce flood risk including both structural and non-structural measures.

There is of course much established science and experience in flood risk management, and the intention is to build on current knowledge. For example, hydraulic models already exist that can be used to predict flooding. These have been used in the FLOOD*site* pilot studies to estimate flood hazard, but a wider range of receptors have then been used to estimate flood risk including social and environmental in addition to economic.

The FLOOD*site* pilot studies have also covered technical advances to improve understanding and practice in particular areas where improvement was needed, including the performance of flood defence structures and the forecasting and warning of flash floods.

Thus the FLOOD*site* pilot studies do not provide detailed information on every aspect of flood risk analysis and management, but have built on existing knowledge and experience to provide new information and methods for undertaking flood risk analysis and management.

Some of the FLOOD*site* findings confirm the results of previous research and flood risk management practice. Some of the messages are therefore not just the direct result of work carried out in FLOOD*site* but also take account of other research and experience.

6.1 General planning issues

General messages from the FLOOD*site* pilot studies are listed in Table 6.1.

The pilot studies have demonstrated that methods and tools are available to develop Flood Risk Management Plans (including flood hazard and flood risk maps), but there are significant issues to be resolved related to preferred approaches for different sizes of systems and different locations.

It may be advisable to use the pilot study results to develop guidance for preparing Flood Risk Management Plans that includes appropriate methods, data requirements and resource requirements. Whilst decisions on implementing the Floods Directive will be made at a national level, this guidance would suggest appropriate approaches for different areas, levels of detail and data requirements.

The value of local knowledge and public participation in developing flood risk management solutions has been identified, and different approaches to involving the public have been implemented. Whilst this provides helpful insight into how the public should be involved, it is also recognised that people in different countries have different expectations and ways of working. Therefore, whilst participatory approaches should be encouraged, the optimal method of engagement will vary depending on the country and local conditions.

Table 6.1 Messages for Flood Risk Management Planning

MESSAGE		PILOT STUDY	APPLICATION
1.	The FLOOD*site* pilot studies have included the assessment of flood hazard and flood risk for river, estuary and coastal sites at a range of scales. They have demonstrated that methods are available for preparing Flood Hazard and Flood Risk maps. There are however challenges in deciding how best to apply the available methods. Particular issues include the selection of future scenarios for planning, data requirements, suitability of methods at a range of scales, and acceptable accuracy.	Elbe, Tisza, Thames, Ebro, German Bight	Development of Flood Risk Management Plans
2.	The FLOOD*site* pilot studies have also made important advances in other areas of flood risk management including: – Flood forecasting and warning in flash flood areas, where lead times are short and the potential for loss of life is very high. – Flood forecasting and warning in transnational river basins, where international sharing of information and co-operation is essential. – Retention of flood water on river basins as a means of reducing flood risk.	Flash floods Elbe Tisza	Improvements in flood risk management
3.	There are important scale issues related to the Floods Directive and the pilot studies. Whilst a typical Flood Risk Management Plan might cover 10,000 to 15,000km^2, the pilot studies cover areas from 40km^2 to 160,000km^2 (although the pilot studies covering very large areas only covered aspects of the catchments).	All	Development of Flood Risk Management Plans

	MESSAGE	PILOT STUDY	APPLICATION
	There are a number of implications for Flood Risk Management Plans, as follows: • What level of detail is needed to achieve adequate hazard maps, risk maps and Plans? • What are the associated data requirements? • What are the associated resource requirements? • What scope is there for 'up scaling' results from 'micro-scale' analyses to larger areas? The FLOOD*site* pilot studies provide insight into these questions but further more formal guidance is suggested.		
4.	The FLOOD*site* pilot studies cover a selection of situations but do not cover every potential case. For example, the pilot study areas do not include rivers that form national boundaries, where policies for flood management on one bank may differ from those on the other bank (although they do include cases with a high degree of international co-operation).	All	This is a limitation of the FLOOD*site* pilots. Further work may be needed to fill gaps.
5.	There is a wide range of knowledge and experience in flood risk management throughout the Member States. FLOOD*site* has brought together much of this experience. However it is clear that experiences and practices vary considerably and there is a need to ensure that relevant experience for implementing the Floods Directive should be shared. Particular issues include: – Data collection techniques – Approaches to public participation – Modelling methods for different zones (coastal, estuary, rivers, high risk areas, low risk areas, etc).	All	Development of Flood Risk Management Plans
6.	Local knowledge is important. The depth of understanding amongst the people of the Schelde 'astonished' the researchers. Those with close contact with the water (e.g. a fisherman), showed an understanding of flooding comparable with that of the scientists. Furthermore, local knowledge of the consequences of flooding and the post-flood recovery went deeper than scientific understanding.	All (Schelde in particular)	Development of Flood Risk Management Plans
7.	Whilst the public in the Schelde polders have confidence in the defence system, they indicated that policy makers should do more to mitigate the impacts during and after a flooding event, yet still pay attention to primary defence.	Schelde German Bight Ebro Flash Floods	The need to take account of flood defences and other measures

	MESSAGE	PILOT STUDY	APPLICATION
	The creation of safe havens and inspection of the dikes were the most favoured flood amelioration measures. It was recognised that evacuation of large areas would not be possible. More generally, there is value in redundancy when combating a natural hazard because things can go wrong. This can be difficult to explain to the public (i.e. that we are providing defences but still require measures in case a flood occurs). This reflects initiatives elsewhere in the EC, where a more integrated approach to flood risk management is evolving which includes 'pathway responses' (e.g. flood defences) and 'receptor responses' (or 'non-structural responses', to reduce the consequences of flooding on the floodplains).		in flood risk management planning.
8.	The public are generally not involved in the design of the decision making process, which can limit the influence that the public could have. For example, some decisions may already have been made before the public have chance to comment. Citizens in the Schelde pilot expressed greater concern about the criteria for the decision process than the scientists. This indicates that public involvement in the design (of the planning process) could potentially lead to improvements in the quality of the planning process and its subsequent results.	This issue was specifically identified in the Schelde study.	Public involvement in flood risk management planning.
9.	People in different countries have different expectations about the role of Government in flood management. This implies that different approaches are suitable in different countries.	All	The need to take account of local differences in flood risk management planning.
10.	Current approaches to flood management are affected by the history of flooding in different locations. This is because flood management is often 'reactive' to flood events. For example, flood risk management in the Southern North Sea is still influenced by the devastating impacts of the 1953, 1962, 1976 storm surges.	All	Recognising the impact of historic floods on flood risk management planning.
11.	The results of the individual case studies are not necessarily applicable to other flood prone areas and situations because people and situations are different. However it is through a participatory approach that	All	The need for a participatory approach in order to identify local issues.

MESSAGE		PILOT STUDY	APPLICATION
	diversity in culture and local situations can be taken into account in flood risk management.		
12.	The Schelde is a transnational estuary and forms a single system for flood risk management. There is therefore a need for common knowledge and agreement on models and other analysis methods between the countries involved. A joint Dutch-Flemish agreement has been reached on managing the Schelde estuary including flood management, shipping and ecosystems. Whilst not a FLOOD*site* development, it represents a possible approach for working together to manage a transnational physical system.	Schelde	Transnational estuaries. Transnational systems.

6.2 Preliminary flood risk assessment

The Floods Directive provides the following description of the requirements of preliminary flood risk assessments:

"The preliminary flood risk assessment required under the Floods Directive is to be based on available or readily derivable information to provide an assessment of potential risks. The assessment shall include at least the following:

a. maps of the river basin district …… showing topography and land use;

b. a description of the floods which have occurred in the past and which had significant adverse impacts on human health, the environment, cultural heritage and economic activity and for which the likelihood of similar future events is still relevant, including their flood extent and conveyance routes and an assessment of the adverse impacts they have entailed;

and, depending on the specific needs of Member States, it shall include:

c. an assessment of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity, taking into account as far as possible issues such as ….. floodplains as natural retention areas, the effectiveness of existing man-made flood defence infrastructures, the position of populated areas, areas of economic activity and long-term developments including impacts of climate change on the occurrence of floods."

The FLOOD*site* pilot studies have involved the development and application of new ideas and methods in areas of *known flood risk*. However, the preliminary flood risk assessments are to be based on available or readily derivable information to identify areas of flood risk which will require further action under the scope of the Floods Directive. Messages have therefore not been developed from the FLOODsite Pilot specifically for the preliminary flood risk assessments. Section 4.2.1 above indicates how the results of the FLOODsite research task may be used in Preliminary Flood Risk Assessment under the Directive.

6.3 Flood hazard

Messages from the FLOOD*site* pilot studies related to flood hazard are listed in Table 6.2.

Methods for assessing flood hazard are generally available although the majority of modelling provides flood levels, flood extents and flood flows (but not flood velocities). Flood velocities are used to estimate some aspects of flood risk (for example, whether or not buildings might collapse during a flood). However models that predict flood velocity are more complex than models that provide flood levels and flood extents only, and may not be suitable for the large areas covered by Flood Risk Management Plans.

When assessing future flood hazard, estimates of future changes in river flow and sea level will be needed. Sea levels are rising relative to the land. This is a finding from independent research including, for example, climate change research for flood risk management planning on the Thames Estuary in the UK (the 'TE2100 Project').. Whilst future rates of increase are unknown, future planning should take account of rising sea levels and the fact that certain levels are likely to be reached at some point in the future. For example, the Ebro pilot study has shown large increases in flooded area for an increase in sea level of 0.5m. Whilst the exact date when this will be reached is unknown, it should be assumed for planning purposes that it will be reached at some point in the future.

The situation with river flows is much less certain. Whilst increases in future flood flows as a result of climate change are expected to occur, this is not always supported by available evidence. For example, fluvial flood flows on the Mulde catchment have decreased over the past 90/100 years. A similar observation can be made for fluvial flows on the River Thames by inspection of the flow data record at Teddington/Kingston in West London where the record length is over 100 years.

When assessing flood hazard it is important to concentrate on the processes that make the largest contribution to flood hazard and avoid the temptation to try to model everything. The reason for this is to minimise complexity, data requirements and cost. For example, it was shown on the Thames and German Bight pilot studies that defence crest level is a major factor in assessing flood hazard, and therefore good crest level data are needed.

There is uncertainty in the magnitude of some contributors to flood hazard, for example the probability of failure of flood defences. Whilst significant advances in assessing flood defence failure probabilities have been made in Tasks 4 and 7, there are significant uncertainties associated with the performance of flood defences.

There is also uncertainty in some of the methods used to estimate flood hazard. For example, the two coastal pilot studies both used inundation models designed for river applications, and there appears to be a need for a coastal inundation model or at least methods that account for the conditions that initiate flooding on the coast.

Table 6.2 Messages for preparing Flood Hazard Maps

MESSAGE		PILOT STUDY	APPLICATION
1.	Flood hazard assessments have been carried out in the Elbe (river), Tisza (river), Thames (estuary), Ebro (coast) and German Bight (coast) pilot studies. These have been used to assess flood risk for areas ranging from about 40 to 350km^2.	Elbe, Tisza, Thames, Ebro, German Bight	Methods for flood hazard mapping.
2.	When assessing flood hazard, an appreciation of the critical factors is needed in order to focus the analysis. In the case of the German Bight, sea water level, dike crest	German Bight Ebro	Developing flood hazard maps.

MESSAGE		PILOT STUDY	APPLICATION
	level and wave height are critical, as wave overtopping and breaching of embankments are the most important flood mechanisms. It is particularly important to adopt the simplest available method for flood hazard analysis that is capable of achieving the required results. For example, inclusion of changes to the coast during a storm event is a major additional complication. It should only be included if it has a significant impact on flood hazard (as demonstrated on the Ebro delta). This suggests that the sensitivity of flood risk to key parameters should be checked before undertaking a full flood hazard assessment.		
3.	The impacts of climate change on river and estuary flood flows are uncertain. The analysis of data on the Upper Mulde catchment indicates a decrease in extreme flood flows over the last 90 years. Care is needed when selecting records for analysis because of the natural variability in the climate. On the Thames in the UK, long term records show an overall decrease in flood flows with time whereas short term records show an increase.	Elbe Thames	Estimating future flood hazard.
4.	The frequency of weather conditions that could lead to flooding changes with time. Research on the Tisza river shows that the frequency of these weather conditions is increasing. Whilst this conclusion is particularly related to the Tisza, more general assessments of the impact of climate change on future rainfall have also concluded that storm rainfall (and hence fluvial flooding) is likely to increase.	Tisza	Estimating future flood hazard.
5.	Run-off from rainfall is very sensitive to the path of the frontal zones. Minor deviations in the location of rainfall can have a significant impact on the magnitude of floods. Whilst this conclusion is related to the Tisza, it applies more generally where there is heavy rainfall over catchment boundaries as the distribution of runoff between catchments is very sensitive to the location of the rainfall.	Tisza Flash floods	Uncertainty in flood hazard estimates.
6.	Whilst coastal storms can cause flooding by overtopping and breaching of defences, a serious long term threat to low-lying unprotected coastal areas is sea level rise. For the Ebro delta, sea level rise of 0.5m (within current	Ebro	Future flood hazard in coastal areas.

MESSAGE		PILOT STUDY	APPLICATION
	predictions of sea level rise by 2100) could lead to permanent submergence of 40% of the delta unless management measures are implemented.		
7.	There is significant uncertainty associated with some of the processes that contribute to flood hazard estimation. These include the prediction of embankment failure and hydro-morphological change in estuaries.	Schelde German Bight Thames	Uncertainty in flood hazard estimates.
8.	Morphological change on an estuary can increase flood levels (for example, reclamation on the Schelde caused increases in tidal water levels further upriver). It is a general observation that flood levels can also be increased on fluvial systems by morphological change and construction work. For example, constrictions such as a new bridge crossing can increase upstream levels, and flood embankments prevent flooding and can increase downstream levels. More generally, both morphological change and construction work can cause increases in flood risk.	Schelde Thames	Estimating future flood hazard.
9.	Beach and dune evolution during a coastal storm event has a significant impact on overwash and therefore the amount of flooding. The use of a 'static' representation of the coast in the modelling would result in an underestimation of overwash and flooding.	Ebro	Flood hazard in specific coastal areas
10.	The impact of successive storms on coastal flooding can be greater than expected because there is not enough time for the natural recovery process (following erosion during the first storm) to take place.	Ebro German Bight	Flood hazard in coastal areas
11.	The Ebro delta has suffered from a loss of fluvial sediment inflow over the years because of the construction of dams in the catchment. Accretion from fluvial sediments helps to mitigate the impacts of sea level rise. However the loss of sediment means that local flood risk has increased and will continue to increase as the sea level rises.	Ebro	Flood hazard in coastal delta areas
12.	The floodplain of the Thames Estuary is protected by a large system of fixed defences together with flood control gates. A system for estimating flood hazard has been developed and applied on the Estuary that includes the following: • Probability of defence failure for all defences	Thames	Flood hazard mapping

MESSAGE		PILOT STUDY	APPLICATION
	including barriers. • Deterioration of the defences. • Breach formation and development. • A rapid flood spreading method that permits fast run times and the evaluation of a range of scenarios. • Impacts of climate change • A method for assessing uncertainty. The method is data intensive but can be used with simplified data sets in order to identify priorities for future data collection.		
13.	Accurate flood defence crest level information is needed for reliable flood hazard assessment on large systems with defended floodplains. This is partly because it directly affects the amount of water overtopping a defence, but also because it affects the propagation of a tidal or fluvial flood wave and therefore flooding elsewhere in the system.	Thames German Bight	Estimating flood hazard.
14.	Modelling for the Ebro delta was based on models developed for riverine floods. A specific coastal inundation model is needed. This should take account of evolution of the coast during a storm. This problem also occurred in the German Bight pilot, where the model used does not include wave overtopping or coastal processes such as breaching.	Ebro German Bight	Flood hazard modelling for coastal areas.

6.4 Flood risk

Messages from the FLOOD*site* pilot studies related to flood risk are listed in Table 6.3.

The FLOOD*site* pilot studies have demonstrated methods for estimating flood risk that takes account of economic, social and environmental impacts of flooding. There are however different approaches to assessing the impacts and the relative importance of different impacts, involving both scientific evidence and stakeholder engagement. Whilst the weighting of impacts is to some extent a local issue based on participation of stakeholders, it may be advisable to provide guidance on flood risk assessment including stakeholder engagement.

'Micro-scale' approaches to risk are normally adopted for flood risk assessment but these are unlikely to be practical for the large areas covered by Flood Risk Management Plans. It may therefore be necessary to simplify these methods so that they can be applied over large areas. It may also be advisable to apply different methods depending on the degree of flood risk, to avoid expending a large amount of effort in areas where the flood risk is small.

Table 6.3 Messages for preparing Flood Risk Maps

MESSAGE		PILOT STUDY	APPLICATION
1.	The FLOOD*site* pilot studies have demonstrated several approaches to estimating flood hazard and flood risk. Whilst these follow similar processes including data collection and modelling, there are differences in the methods and techniques applied.	Elbe, Tisza, Thames, Ebro, German Bight	Flood risk mapping.
2.	Methods have been developed for assessing flood risk that takes account of economic, social and environmental aspects. The weighting between these components is 'subjective', and can lead to non-intuitive conclusions. There is a need for a method of weighting that is agreed by the authorities (who make decisions on funding) and stakeholders. This appears to require a participatory approach.	German Bight Thames Elbe Flash floods Schelde	Assessment of flood risk
3.	National or international methods for multi-criteria analysis may be needed to ensure national (and possibly international) consistency between methods of estimating flood risk.	All	Assessment of flood risk
4.	There is a need to develop future climate change and possibly other scenarios for planning flood risk management. The scenarios should be consistent across whole river, estuary and coastal systems.	Elbe	Estimating future flood risk.
5.	Different future scenarios affect the viability of flood risk management options.	Schelde	Must be considered when developing a FRMP.
6.	A micro-scale approach is needed to provide sufficiently accurate vulnerability analysis together with a fully	German Bight	Assessment of flood risk

	MESSAGE	PILOT STUDY	APPLICATION
	probabilistic approach to determine flooding. However this is time consuming and expensive. It should be noted that the German Bight pilot covers a small area, where detailed work is possible (compared with some of the other pilot sites). The suggested approach in the German Bight pilot is a risk analysis tool to standardise the method of risk management.		
7.	There is a need to simplify micro-scale approaches so that they can be applied over large areas at reasonable cost.	German Bight	Assessment of flood risk
8.	Modelling results require an independent check to see whether they are 'realistic'. With new models and methods being developed (particularly for the assessment of non-economic risk) there is a risk that gross errors could occur.	German Bight Thames	Assessment of flood risk
9.	There is a need to integrate the calculation of economic, social and environmental impacts of flooding to facilitate flood risk estimation and mapping.	German Bight Thames	Assessment of flood risk
10.	Calculation of economic flood risk can be simplified by concentrating on the main receptors of the risk (particularly people and properties).	German Bight	Calculation of the economic component of flood risk.
11.	A flood risk assessment method should have the facility to test risk management approaches.	All	Development of Flood Risk Management Plans.
12.	The quality of a flood risk analysis is affected by the quality of data. Where data quality are poor, uncertainty increases. In the case of the Tisza, it was concluded that the uncertainties in flood risk estimation were too large to provide meaningful results for a relatively small part of the floodplain (120km^2) using the available data. Better data would therefore be needed. This is a common finding, and highlights the need to optimise data requirements so that reasonable flood risk assessments can be made at reasonable cost. It is recommended that guidance is developed for the required quality of a flood risk assessment, and the associated data needs. This could include screening approaches as applied on the Thames.	Tisza Thames	Data requirements for flood risk management planning.
13.	Seasonality of flooding has a major impact on flood risk in some areas (particularly agricultural and tourist areas	Ebro	Seasonal effects in flood risk

MESSAGE		PILOT STUDY	APPLICATION
	where activity is seasonal).		assessment.
14.	A multi-criteria analysis was carried out to assess the flood risk by combining economic, social and environmental risks on the Lower Mulde. Particular problems were experienced defining social vulnerability.	Elbe	Method of defining and estimating flood risk.
15.	The Elbe pilot study has made a significant step towards a Flood Risk Management Plan for the basin, but only deals with some aspects of flood risk. The Elbe is a very large catchment (148,000km^2). It is recommended that guidance is developed for undertaking flood risk assessments for large catchments. This could consist of a high level assessment for the whole catchment with more detail for sub-catchments.	Elbe	Flood risk assessment for large catchments.
16.	The floodplain of the Thames Estuary is protected by a large system of fixed defences together with flood control gates. A system for estimating flood risk has been developed and applied on the Estuary that includes the main flooding processes and the receptors of flooding Whilst this is a technically rigorous approach, it is data intensive. The approach may be justifiable because of the high level of potential flood risk on the estuary (including the centre of London). However it may not be justifiable in areas of lower flood risk. With regard to the Floods Directive, it may be appropriate to undertake detailed studies for areas where the consequences of flooding would be very high and much less detailed studies for areas where the consequences of flooding would be low (for examples, rural areas with little development).	Thames German Bight	Method of estimating flood risk.
17.	The flood risk management method applied on the Thames Estuary allows the testing of different flood risk management strategies by changing elements of the Source-Pathway-Receptor modelling system (including defence crest level, defence 'fragility', assumptions regarding flood damages and loss of life, future scenarios, etc).	Thames	Development of Flood Risk Management Plans.
18.	Information on flash floods is limited. Post flash flood studies should be undertaken and shared in order to build up knowledge of flash flooding. These studies should cover hydrology, hydro-meteorology, geomorphology, social and economic aspects.	Flash floods	Flood risk estimation in areas prone to flash flooding.
19.	A common methodology for data collection after flash floods should be developed and disseminated to encourage	Flash floods	Flood risk estimation in

	MESSAGE	PILOT STUDY	APPLICATION
	better understanding and information on flash flooding.		areas prone to flash flooding.
20.	Managed realignment to create replacement habitat (as required by the EC Habitats and Birds Directives) can be very controversial because it often involves giving up land that has been reclaimed from the sea in the past.	Schelde Thames	Replacement intertidal habitat on estuaries and coasts
21.	Sea level rise will have a strong impact on ecosystems in low lying coastal areas. On the Ebro Delta, a sea-level rise of 0.5m will lead to the "drowning" of most low-elevation habitats and salinisation of freshwater and brackish habitats, resulting in a strong increase of unvegetated, shallow flooded areas. The changes in vegetation patterns imply severe habitat loss for many characteristic bird species of salt marshes and freshwater habitats, because many of these species are highly dependent on habitat types at low elevations. This reflects a general problem facing low-lying unprotected coastal areas.	Ebro	Future risk to ecosystems in coastal areas
22.	There is a need to forecast the development of new habitat taking account changes in the flood and morphological regime.	Ebro	Future flood risk in coastal areas
23.	Coastal ecosystems can generally cope with occasional temporary inundation during storms (unless there is a significant increase in salinity). Sea level rise can potentially be a much greater threat depending on local circumstances.	Ebro	Future risk to ecosystems in coastal areas
24.	Changes in salinity in coastal areas (caused by sea level rise and increased storminess) will lead to changes in the ecosystems (for example, towards species that are more resistant or adapted to higher salinity values).	Ebro	Future changes to ecosystems in coastal areas

6.5 Environmental pollution from flooding

Messages from the FLOOD*site* pilot studies related to environmental pollution are listed in Table 6.4.

Whilst the amount of work on environmental pollution was limited, information was gained on the mobility and changes in concentrations of pollutants following flooding of pollution sources. The results demonstrated that pollutants can travel large distances, and further research is suggested to assess the spread of pollutants onto floodplains (and hence into food chains).

Increases in salinity on the coast caused by rising sea levels are dealt with in Section 7.4, *Flood Risk*.

Table 6.4 Messages regarding environmental pollution from flooding

	MESSAGE	PILOT STUDY	APPLICATION
1.	Pollution sources on floodplains present a serious problem because pollution can be spread over large areas in the event of a flood. In pollution incidents in the Tisza basin, it was found that toxic elements travelled large distances from the source of pollution. Cyanides caused a major fish-kill but only pose a short-term threat due to their degradability. However heavy metals were carried many kilometres down the river system and can cause a long-term threat to people and ecosystems. Modelling of polluted sediment on the polders of the Schelde estuary showed that there is great uncertainty regarding the distribution of toxic risk. Further research is suggested to assess the distribution of pollutants (particularly heavy metals) on floodplains, and the resulting impact on agriculture.	Tisza Schelde	Pollution from flooding in river basins
2.	Heavy metal concentrations reduce over time following pollution incidents. As they are not degradable, other mechanisms must have caused the decrease, for example subsequent floods.	Tisza	Pollution from flooding in river basins
3.	The use of flood polders for flood water storage can lead to water quality problems caused by organic material in the water body or on the land. Land use in the polder must therefore be considered when planning flood storage polders.	Elbe	Pollution of polders used for flood water storage.
4.	Environmental pollution can be caused when a source of pollution is flooded. Leading to a spread of contaminants. When the source of flooding is in a polder, there is the potential to contaminate the whole flooded area. This process was modelled but there was uncertainty in predictions of the spread of pollutant across the polder. This is related to the type of modelling and the properties of the pollutant.	Schelde	Uncertainty in the prediction of pollution of polders where the pollution source is within the polder.

6.6 Prevention of flooding

Messages from the FLOOD*site* pilot studies related to the prevention of flooding are listed in Table 6.5.

Flood storage on the floodplains of large embanked rivers reduces flood levels and therefore flood risk. However the Elbe pilot study indicated that the reduction in flood risk that can be gained by utilising existing reservoirs or changing land use is only significant for frequent floods (but not large floods). This finding has already been identified in previous research and practical applications.

There is a possibility of linking flood risk management more closely with land use planning, so that development is appropriate to the level of protection provided in different parts of the floodplain, and land is safeguarded for future flood risk management.

Table 6.5 Messages regarding the prevention of flooding

MESSAGE		PILOT STUDY	APPLICATION
1.	Polders that are allowed to flood during large river floods can significantly reduce peak discharges (and therefore flood levels and flood risk) on a large lowland river with defended floodplains. This was demonstrated by modelling of the lowland Elbe river and the River Tisza. On the Elbe a single large storage area reduced peak flood levels by about 0.2m, and on the Tisza eleven storage areas reduced peak flood levels by at least 1.0m. The analysis did not assess the costs or benefits of this approach.	Elbe Tisza	Flood reduction on large lowland rivers
2.	Where several flood storage areas are used in the same river basin to reduce flood risk, there is a need to optimise the operation so that the maximum reduction in flood risk is achieved. This should be linked to flood forecasting.	Tisza	Flood reduction on large lowland rivers.
3.	Reservoirs can contribute to flood risk reduction in some circumstances. On the Horni Stropnice River (in the Elbe headwaters), reservoirs reduce flood risk for frequent events but not large events. This result supports findings from previous work where storing water in existing reservoirs have been considered for reducing flood risk. The main factors in the effectiveness of reservoirs include the available storage volume compared with the overall flood volume, and the way in which the outlet flow from the reservoir is controlled.	Elbe	Flood reduction by storing water in existing reservoirs.
4.	Changing land use, for example introducing more forest, can theoretically reduce flood risk. On the upper Mulde River, this effect is limited to frequent events but not large events. This is site-specific and changes as the land use changes.	Elbe	Flood reduction by changing land use.

MESSAGE		PILOT STUDY	APPLICATION
	This result supports findings from other research, for example in the UK where work has been undertaken to determine flood reduction benefits of changing land use in sample catchments.		
5.	Flood risk can be reduced by removing obstacles from floodplains and creating a 'hydraulic corridor'. This includes removal of summer dykes and vegetation together with realignment of flood defences. Reductions in flood level of up to about 0.9m were predicted by modelling on the middle Tisza river. The costs (including land) and benefits of this approach were not assessed. This type of approach has been adopted in the 'room for the river' projects in the Netherlands.	Tisza	Flood reduction by removing obstacles to flow on floodplains.
6.	There is a trade off between private self interest and public safety. Development has been permitted in flood risk areas for a variety of reasons which has increased overall flood risk. One particular reason is lack of available land (in narrow valleys). This is a general problem, reflecting the fact that flood risk is one of many factors that must be considered when planning development.	Flash floods	Reducing flood risk by land use planning.
7.	Including flood risk in spatial planning could result in a less vulnerable situation, by keeping the most dangerous areas free from residential and industrial developments.	Schelde	Reducing flood risk by land use planning.
8.	There is a challenge to integrate flood risk management into sustainable regional development. For example, land that might be needed for flood management in the future should be safeguarded, and development should take account of present and future flood risk.	Schelde	Land use planning that incorporates future flood prevention measures.
9.	One strategic alternative for flood risk management is a 'Spatial Planning alternative', where there is spatially differentiated flood protection standards which determine land use development. The current land use determines which sub-areas receive the highest protection. Future land use developments are also directed towards these highly protected areas. This requires co-operation with spatial planners, and therefore flood risk management becomes a planning matter. The approach adopted in the UK is to have variable defence standards. However this is based on existing land use and is	Schelde	Spatial land use planning

MESSAGE		PILOT STUDY	APPLICATION
	not used to direct land use planning.		
10.	Potential problems identified with approaches that affect the level of flood risk in different areas include lack of knowledge, implementation hurdles, communication difficulties, resistance of citizens and institutional complexity. Spatial differentiation in safety levels is difficult to implement because it requires a decision process in which many government levels need to be involved as well as the public and stakeholders. This necessitates a transparent and objective communication of flood risk, which implies that somehow the differences in risk perception between stakeholders, policy makers and scientists need to be bridged.	Schelde	Spatial land use planning
11.	The Ebro Delta pilot site demonstrates that there is a difference between the demand for risk reduction on the one hand, and the “living with risk while striving for benefits” on the other. In a world with increasing flood risks, decision makers have to cope with that paradox if they want to implement an effective land use policy in flood prone areas.	Ebro	Spatial land use planning

6.7 Protection against flooding

Messages from the FLOOD*site* pilot studies related to the protection against flooding are listed in Table 6.6.

Much of the research on flood defences in FLOOD*site* was concerned with the performance of fixed defences and the probability that defences could fail. This could add significantly to the flood hazard. Whilst much work has been done to improve understanding of defence performance, there are still large uncertainties. Reasons for this include the great variability in defence systems, and the fact that failures can be caused by local features.

Table 6.6 Messages regarding protection against flooding

MESSAGE		PILOT STUDY	APPLICATION
1.	Defences can fail at lower water levels than the design level, thus lowering the level of protection. On the Schelde the concept of a broad dike is being investigated, which can tolerate more overtopping than traditional dikes before they breach.	Schelde Thames German Bight	Flood Risk management Planning.
2.	The probability of failure of flood defences forms an important component of the potential flood hazard in areas with flood defences. The concept of flood defence 'fragility' has been incorporated in models for assessing flood risk. One difficulty with this approach is the degree of uncertainty in the assessment of failure probability. The impact that this and other uncertainties have on flood risk estimates are dealt with by an uncertainty analysis.	Thames	Flood hazard and flood risk in areas with flood defences.
3.	Reliability analysis of flood defences provides improved methods of estimating the probability of flooding. Some further development is needed, for example to take account of the following: – Some failures do not result in a flood (e.g. a slip surface failure following a very high tide). – Some failures are caused by local features not identified in a reliability analysis.	Schelde Thames	Improving estimates of flood hazard and flood risk in areas with flood defences.
4.	Selection of defence failure scenarios in a flood defence system can be complex. In the Thames pilot study a complex approach was adopted in which the probability of overtopping and breaching of all defences was considered. In the German Bight pilot study, assumptions were made about where specific failures occurred for use in the flood risk analysis. This approach is pragmatic providing that the critical defences (that are most likely to fail) are identified. In practice, the optimal approach for each area will depend	German Bight Thames	Flood hazard and flood risk in areas with flood defences.

	MESSAGE	PILOT STUDY	APPLICATION
	on local features and the magnitude of the potential consequences of flooding.		
5.	The use of secondary dikes to create flood compartments was less favoured. The risk of deeper inundations at particular locations was mentioned. This is also a concern of flood managers in the UK, although secondary defences are used for key installations.	Schelde German Bight	Flood mitigation measures in FRMPs.
6.	Management of flash floods by structural means is difficult because of the small scale of individual flood risk areas, and the large number of areas potentially at risk. A similar theme occurs in the Tisza pilot study, where it has been identified that small changes in rainfall patterns can have a large impact on flooding.	Flash floods	Flood mitigation measures in FRMPs.
7.	A method has been developed for simulating multiple flood defence failure scenarios based on an efficient Monte-Carlo sampling technique.	Thames	Potential method for improving flood hazard estimates in areas with flood defences.
8.	A method has been developed for attributing residual risk to individual defences, in order to assist with the optimisation of defence maintenance and repair.	Thames	Potential method for prioritising defence improvements in FRMPs.
9.	A proposed adaptation strategy for the Ebro delta is to create a 500m wide buffer strip with a bank near the inner edge. This approach is favoured in stakeholder consultation in preference to a 'business as usual' approach.	Ebro	Flood mitigation measures in FRMPs.

6.8 Preparation for flooding

6.8.1 Preparation for flooding - Flood forecasting and warning

Messages from the FLOOD*site* pilot studies related to flood forecasting and warning are listed in Table 6.7.

Basin wide flood forecasting and warning on transnational rivers requires co-operation between the countries involved, including the sharing and transfer of information. A method of achieving this is proposed for the Tisza Basin using the Internet.

Detailed research has been carried out on the difficult problem of flood forecasting, warning and appropriate responses on rivers that are prone to flash flooding. As the available lead time in a flash flood is short, the research has concentrated on providing reasonably reliable and timely forecasts, understanding how people respond to warnings, and methods of communication. Recommendations are also made on how to improve information and knowledge on flash floods.

Table 6.7 Messages regarding flood forecasting and warning

MESSAGE		PILOT STUDY	APPLICATION
1.	In order to develop a basin wide monitoring, flood forecasting and warning system on a transnational river, data collection is required in more than one country and data must be transferred rapidly across national boundaries. Consistent approaches to data collection and storage are required, together with co-operation between the countries involved to ensure the rapid transfer of data. An approach based on the Internet is proposed where data can easily be accessed by each country (but has not been implemented).	Tisza	Flood forecasting and warning on transnational rivers
2.	Antecedent precipitation and water content of snow are more important than previously thought in the prediction of floods in the Tisza basin.	Tisza	Flood forecasting in catchments with snow.
3.	Detailed rainfall data are needed for flash flood analysis and forecasting, including a high density of rain gauges and frequency of data provision. A better alternative is to use weather radar. This is capable of providing distributed forecasts over river networks including ungauged catchments. Guidelines developed in Task 23 indicate that for rural catchments of the order of 20 km^2 data are required every 30 minutes with a spatial resolution of about 5 km. For rural catchments of the order of 100 km^2, the corresponding figures are about 45 min and 7 km respectively.	Flash floods	Rainfall data for forecasting flash floods.
4.	Knowledge of soil moisture is important for reliable flood	Flash floods	Soil moisture data

	MESSAGE	PILOT STUDY	APPLICATION
	forecasts, and this affects the amount of runoff. This is particularly true for flash flood conditions, but also applies in other river catchments.		for forecasting flash floods.
5.	Radar based forecasting techniques can increase the lead time provided by a warning system by between 20 and 80 minutes for a flash flood.	Flash floods	Forecasting flash floods.
6.	Space and time scales for flash floods vary depending on local circumstances. Therefore rules regarding lead times, warnings times, etc will vary depending on location. This is one aspect of a general issue, where warning times vary depending on the type and scale of flooding. Rapid flooding can also occur in urban areas from local runoff although this is generally far less devastating than a flash flood in a mountainous region.	Flash floods	Flood forecasting and warning for flash floods.
7.	The method of forecasting and warning on flash flood catchments depends on the relationship between the social response time and the catchment response time. When the social response time is shorter than the catchment response time, purely hydrological-hydraulic models may provide the forecast at the required lead time. However, when the social response time is larger than the catchment response time, the planning of the event management measures requires the use of rainfall forecasts. For small rapid response catchments, accurate real time radar rainfall information is the best way of initiating a flood warning.	Flash floods	Flood forecasting and warning for flash floods.
8.	Effective flood warning in flash flood situations depends on the response by recipients. Specific preparedness strategies should be developed to capitalise on improvements to flash flood forecasting systems.	Flash floods	Preparing for flash floods.
9.	More resources should be devoted to risk communication in flash flood situations.	Flash floods	Communications in flash floods.
10.	Recipients of flood warning messages do not normally respond as expected. There is concern about how best to disseminate warnings and the content of the warning message. People generally try to find more information before taking action. In many cases hydrological evidence is necessary before people will react (for example, very heavy rain or high flows in a watercourse).	Flash floods	Flood warning for flash floods.

	MESSAGE	PILOT STUDY	APPLICATION
11.	The public are sympathetic to false alarms, particularly where the fact that a 'near miss' has just occurred can be demonstrated and understood. Whilst a small group of people will change their behaviour as a result of false alarms, these are inevitable on the principle that 'it is better to be safe than sorry'.	Flash floods	Flood warning for flash floods.
12.	Information on flash floods is limited. Post flash flood studies should be undertaken and shared in order to build up knowledge of flash flooding. These studies should cover hydrology, hydro-meteorology, geomorphology, social and economic aspects.	Flash floods	Improving preparation for flash flooding.
13.	Archives of flash flood data and observations should be developed to facilitate the verification of flash flood forecasting systems and effectiveness of enhancements.	Flash floods	Improving methods for forecasting flash floods.
14.	A common methodology for data collection after flash floods should be developed and disseminated to encourage better understanding and information on flash flooding.	Flash floods	Improving preparation for flash flooding.

6.8.2 Preparation for flooding – Non-structural measures

Messages from the FLOOD*site* pilot studies related to non-structural measures are listed in Table 6.8. There are also relevant messages in other sections of this document.

The FLOOD*site* pilot studies have demonstrated that the way people react to flood risk is difficult to predict. For example, an increase in flood awareness does not necessarily mean that people will prepare for flooding. This suggests that care is needed when planning campaigns to raise awareness and engage the public and other stakeholders in flood risk management. Such campaigns should have clear objectives and ways of achieving them.

Choices of non-structural measures must involve participation by the organisations involved together with the general public. For example, stakeholders identified a preference for safe havens on the polders on the Schelde estuary (see the table in Section 5.1) in addition to maintaining the flood defences. The alternative of evacuation was not considered to be practical.

Flash flood management requires an integrated approach to forecasting, warning and response. This approach should be managed locally.

Table 6.8 Messages regarding preparing for floods

MESSAGE		PILOT STUDY	APPLICATION
1.	Non-structural measures involve participation by a range of stakeholders in addition to flood managers and decision makers. To achieve this, new partnerships and synergies will be required. Otherwise attempting to place greater responsibilities on private shoulders is unlikely to be effective. This issue is at the core of initiatives to involve a wider range of stakeholders including the public in flood risk management.	Elbe	Flood Risk Management Plans
2.	On the Lower Mulde catchment, social surveys showed that there is no automatic correlation between flood risk awareness and behaviour, particularly preparedness for flooding. Therefore, making people aware of the flood risk does not automatically mean that they will prepare for flooding.	Elbe	Public awareness raising in Flood Risk Management Planning.
3.	Flood awareness may lead to higher levels of worry. Worry may lead to higher preparedness (but not necessarily). Higher preparedness can lead to a decline in the awareness of the risk. In other words, the impacts of raising awareness are not immediately clear. Awareness raising should be accompanied by a programme of training in how to respond (including, for example, emergency exercises).	Schelde	Public awareness raising in Flood Risk Management Planning.
4.	On the Lower Mulde catchment, social surveys showed that there is no automatic correlation between community and personal preparedness for flooding. This will depend on a range of factors including the size and type of community, actions taken by the community and actions taken by individuals.	Elbe	Community and personal preparedness for flooding.
5.	Following the 2002 flood on the Lower Mulde catchment, the main measures adopted by individuals were insurance and minor adaptations to buildings. Flood Risk Management Planning should provide guidance on the most suitable measures.	Elbe	Personal preparedness for flooding.
6.	The Dutch authorities use preventive evacuation as a means for reducing flood risk. This type of measure should be considered in Flood Risk Management Planning.	Schelde	Evacuation to reduce flood risk to people.
7.	Evacuation models to be used for planning evacuations must be validated to establish their reliability using local knowledge available from local authorities and the public.	Schelde	Evacuation planning.

	MESSAGE	PILOT STUDY	APPLICATION
	Hence, a more active involvement of local stakeholders and citizens in the further development of such models seems both justified and feasible. The models should also meet the explicit needs of the end user.		
8.	Flash flood management requires an integrated approach of forecasting, communication of warnings, an understanding of how people respond to warnings, and an appropriate rescue service. Flash flooding is best managed by local authorities with active and effective involvement of local people.	Flash floods	Preparing for flash floods.
9.	The response to a flash flood is influenced by scale. In small catchments, communities and individuals take charge of the response whereas in larger catchments this is done by local authorities or emergency services.	Flash floods	Preparing for flash floods.
10.	Some flood risk management components have received little attention in research. These include flood resistant buildings, insurances, relief and reconstruction funds.	All	Further research needs to improve flood preparedness.

6.9 Engagement with stakeholders

Messages from the FLOOD*site* pilot studies related to stakeholder engagement are listed in Table 6.9.

One reason why stakeholder participation is so important is that many of the non-structural measures will require actions by stakeholders including the public. This will not be possible without appropriate engagement and ways of working together.

The FLOOD*site* pilot studies have adopted a number of different approaches to stakeholder engagement involving meetings, events, questionnaires and working groups. The benefits have been very positive including the provision of local knowledge and clear preferences for approaches to flood risk management.

Difficulties with stakeholder participation have also been identified, which will help to plan future participation in flood risk management. A particular issue is the way in which stakeholders should be involved in the decision making process.

Table 6.9 Messages regarding stakeholder engagement

MESSAGE		PILOT STUDY	APPLICATION
1.	Flood risk management requires new partnerships and synergies. Otherwise, placing greater responsibilities on private shoulders is unlikely to be effective. This issue is at the core of initiatives to involve a wider range of stakeholders including the public in flood risk management. One problem is that flooding is rare and, even where an organisation takes more responsibility for flood management, responses to flooding tend to be reactive rather than proactive.	Elbe	Guidance for preparing Flood Risk Management Plans.
2.	In the social surveys in the Lower Mulde catchment it was found that residents have traditional views about flood risk management, that it consists of physical defences which are the responsibility of public bodies. This perception varies depending on local circumstances but is very prevalent in flood risk areas.	Elbe	Stakeholder engagement in the development of Flood Risk Management Plans.
3.	The Floods Directive encourages the participation of stakeholders in flood risk management planning. However examples of good practice in participatory flood risk management are scarce. One problem is the use of different types of knowledge and perspectives in discussion (although a greater problem is the knowledge that flooding is a real risk, see below).	Schelde German Bight	Stakeholder engagement in the development of Flood Risk Management Plans.
4.	Participation has major potential benefits in the acceptance and implementation of solutions, particularly where the solutions have a major impact on stakeholders. This is likely to far outweigh the additional time and effort needed to undertake participatory approaches.	Schelde	Stakeholder engagement in the development of Flood Risk Management Plans.

	MESSAGE	PILOT STUDY	APPLICATION
5.	An important problem to consider when involving stakeholders is the relative rarity of flooding. It is interesting to contrast this with fire risk management (fire also being a rare event). Regular fire drills and the common understanding that fires can occur leads to relatively high awareness of the risk, plus the fact that it affects everyone.	General	Method of involving Stakeholders in Flood Risk Management.
6.	The public are often left out of the decision making process or have little influence over decisions. One problem on the Thames and the Schelde is that the probability of flooding is very low, and many people are not aware of the flood risk. In addition, these areas require major engineering works to prevent flooding and the scope for public debate is arguably limited in this case.	Schelde Thames	Decision making process for Flood Risk Management Planning.
7.	Three sources of knowledge were identified in the Schelde pilot: – The scientific domain where probabilities, models and uncertainties dominate. – The local citizens perception and experience of flood risk, that largely remains unused in decision making. – The policy and management institutions, where innovative approaches compete with vested interests, procedures and legislation.	Schelde	Stakeholder engagement in the development of Flood Risk Management Plans.
8.	Difficulties faced in stakeholder participation on the Schelde included: - Difficulties in communication because of differences in background, etc. - A lack of a comprehensive methodology to incorporate stakeholder knowledge with scientific methods. - Lack of trust between stakeholders. - The international dimension of the Schelde estuary, where certain agreements have already been made. These types of issues should be considered when deciding how best to involve stakeholders in FRMPs, preferably by discussion with stakeholders.	Schelde	Stakeholder engagement in the development of Flood Risk Management Plans.
9.	Good communication implies an open exchange of information based on recognition of equality and mutual trust. The lack of trust between stakeholders can be illustrated by the discussions on managed realignment along the Western Schelde. Over the past 15 years this	Schelde	Stakeholder engagement in the development of Flood Risk Management

	MESSAGE	PILOT STUDY	APPLICATION
	item of 'depoldering' appeared on the political agenda several times, but with different arguments. Safety reasons and nature compensation were alternating put forward and thus made people sceptical about the real reasons.		Plans.
10.	Solutions for flood risk management have traditionally been developed by scientists with limited involvement of stakeholders. This situation is changing and the role of stakeholders in influencing decisions is increasing. For example, some scientific recommendations might be unacceptable for social or other reasons. Scientists should therefore be considered as stakeholders and be involved in stakeholder discussions during the development of Flood Risk Management Plans.	Schelde	Planning the involvement of Stakeholders In Flood Risk Management Planning.
11.	The suggestion that flood defences could fail could cause undue alarm and anxiety amongst residents.	Flash floods	Sensitive explanation of issues to stakeholders and the public.
12.	Concern that the disclosure of flood risk maps could affect property values in high risk areas. There is pressure for decision makers to reduce the extent of areas that are designated as high risk.	Flash floods	Management of information in Flood Risk Management Planning.
13.	An advisory group was set up on the German Bight pilot consisting of about 10 representatives of different institutions and organizations including the community government, local dike and water boards, the regional (county) disaster preparedness unit, the regional office for water management and coastal protection planning the state government office for coastal protection, and the state government office for disaster mitigation. This type of advisory group has worked well in the UK for the implementation of an estuary strategy (the Humber).	German Bight	Stakeholder engagement in the development of Flood Risk Management Plans.
14.	Dissemination and communication events organised by the Flash Floods pilot include: – 'Open door' events to the relevant Government centres for hydrology and meteorology. – Involvement of schools. – Meetings with relevant practitioners and stakeholders including those responsible for civil protection, policy makers and members of the public. – Four focus groups involving local authorities. – Government agencies and the emergency services. – Questionnaires for people affected by floods.	Flash floods	Stakeholder engagement in the development of Flood Risk Management Plans.

	MESSAGE	PILOT STUDY	APPLICATION
	Dissemination and communication will depend on the particular area and issues. Flash flooding can occur in many locations over wide areas, thus affecting many communities and local authorities. Communication should lead to the sharing of experience and the adoption of recommended actions by relevant authorities and the public.		
15.	Dissemination and communication events organised by the Schelde pilot include: – Interviews with stakeholders. – Workshops with policy makers and local stakeholders. – Questionnaires to local stakeholders	Schelde	Stakeholder engagement in the development of Flood Risk Management Plans.

6.10 Next steps for application in practice

Some suggestions for practical application of the results from the FLOOD*site* pilot studies are listed in Table 6.10.

The main requirement is to develop guidance for methods to implement the Floods Directive based on the results of the FLOOD*site* pilot studies and other relevant work. Whilst tools and techniques have been demonstrated, it will be important to ensure that the most appropriate method are applied taking account of required outputs, data requirements and available resources.

Table 6.10 Some recommended next steps

NEXT STEPS FOR APPLICATION IN PRACTICE	
1.	**Guidance on methods:** Guidance on the most appropriate methods for estimating flood hazard and flood risk, and developing Flood Risk Management Plans is prepared based on the FLOOD*site* pilot studies and other relevant work. This should take account of different scales, different levels of flood risk, data requirements and potential resource requirements.
2.	**FRM Plans:** There is a need to share knowledge and experience gained in FLOOD*site* in order to facilitate the development of Flood Risk Management Plans and improve flood risk management.
3.	**Stakeholder involvement:** The way in which stakeholders are involved in decision making requires consideration by Member States. The FLOOD*site* pilot studies provide examples of methods and benefits of stakeholder engagement, and also identified some of the pitfalls. Stakeholder participation is essential when considering measures that require actions by stakeholders including the public.
4.	**Scenarios:** There is a need to develop future scenarios for planning flood risk management. These should take account of sea level rise and changes in fluvial flood flows. The scenarios should be consistent across whole river, estuary and coastal systems.
5.	**Multi-criteria-analysis:** National or international methods for multi-criteria analysis will be needed to ensure national (and possibly international) consistency between methods of estimating flood risk.
6.	**Scale of approach:** Flood risk assessment often requires a detailed ‘micro-scale approach’ to obtain reasonably reliable results. However this is time consuming and expensive. There is therefore a need to simplify micro-scale approaches so that they can be applied over large areas at reasonable cost.
7.	**Data needs:** In addition to date needs for flood risk assessment, data are also needed for the verification of models and approaches. Examples of the types of models where data are needed for verification include: – Coastal modelling and risk assessment – Assessment of social and environmental impacts – Evacuation planning – Flash flooding It is therefore desirable to assemble data sets that can be used for this purpose.

NEXT STEPS FOR APPLICATION IN PRACTICE	
8.	**Coastal inundation models**: There is a need for a specific coastal inundation model that takes account of the evolution of the coast during a storm. Furthermore, the initiation of flood inundation modelling needs further improvement.
9.	**Environmental pollution:** Further research is suggested to assess the distribution of pollutants (particularly heavy metals) on floodplains, and the resulting impact on agriculture.
10.	**Ecological impacts:** It is desirable to evaluate the ecological impacts of flooding in terms of changes in ecosystem functions along the coast or river (i.e. not just change in habitats).
11.	**Social impacts:** Methods for calculating flood risk in FLOODsite consider risks to life and social vulnerability. However flooding has very severe impacts on everyone affected including stress and the need to move while homes are repaired. The way in which these impacts should be included in a flood risk assessment requires consideration by Member States.
12.	**Flood risk management components:** Further research is suggested to improve the understanding, benefits and disadvantages of some flood risk management components. These include flood resistant buildings, insurances, and relief and reconstruction funds.

APPENDIX A – External links from the FLOODsite Pilots

Project	*ACTIF*
Web url	http://www.actif-ec.net/
Actions taken Tasks 16 and 23	Investigation of flood processes at small time and space scales and development of threshold-based flood forecasting for flood watch at a regional level, according with indications offered by ACTIF.

Project	*AFORISM*
Web url	http://www.itia.ntua.gr/e/projinfo/2/
Actions taken Tasks 16 & 23	Enhancement of flood forecasting with consideration of small catchments (less than 500 km^2) which are frequently affected by flash floods. Used research outputs in Tasks 16 and 23.

Project	*AMPHORE (Interreg IIIC)*
Web url	*https://amphore.medocc.org/*
Actions taken Task 16 and 23	Organisation of Summer School on: Mediterranean storms driven flash flood (May 2006); Meetings with Sandrine Anquetin, contact point in AMPHORE, on dissemination plans.

Project	*CARPE DIEM*
Web url	*http://carpediem.ub.es/home/*
Actions taken Tasks 16 & 23	Analysis of uncertainty of radar rainfall estimates coupled with rainfall-runoff modelling. Used research outputs in Tasks 16 and 23.

Project	*COST 731*
Web url	*http://cost731.bafg.de*
Actions taken Task 16 & 23	Specific contact point: Anrea Rossa, CMT Teolo, Italy, COST 731 coordinator. Organisation of common meetings (February 2006, October 2006) for the analysis of specific case studies on north eastern Italy for the investigation of propagation of uncertainty of radar rainfall estimates coupled with rainfall-runoff modelling; Exchange of data for analysis of propagation of uncertainty for flash flood events.

Project	*Ebro delta National (Spanish funded) Projects*
Web url	*None*
Actions taken Task 26	Data and results obtained in several Spain-funded projects have been incorporated to the analysis of the field site.

Project	*EFAS*
Web url	*http://natural-hazards.jrc.it/*
Actions taken Task 22	Contacts at researchers' level in the preparation of modelling of the Tisza river

Project	*EFFS (European Flood Forecasting System)*
Web url	*http://grdc.bafg.de/servlet/is/2478/*
Actions taken Tasks 16 and 23	Enhancement of flood forecasting with consideration of small catchments (less than 500 km2) which are frequently affected by flash floods. Used research outputs in Tasks 16 and 23.
Actions taken Task 22	Contacts at researchers' level in the preparation of modelling of the Tisza river

Project	*ELLA*
Web url	*http://www.ella.org*
Actions taken Task 21	Knowledge exchange (J. Schanze).

Project	ESCAPE European Solutions by Co-operation and Planning in Emergencies (for coastal flooding)
Web url	*http://www.interregnorthsea.org/project-details.asp?id=1-16-31-7-526-02*
Actions taken Tasks 17, 19 and 25	• Contact person Durk-Jan Lagendijk • The ESCAPE DSS is planned to be applied in the framework of the benchmark of evacuation models for the Schelde pilot.

Project	EU-MEDIN and EU-MEDIN-SSA
Web url	www.eu-medin.org
Actions taken Tasks 12, 21 and 35	FLOODsite is represented formally in the project board of EU-MEDIN by Dr Jochen Schanze. The EU-MEDIN network covers disaster information on all natural hazards of which flooding is one. Several contributions from the FLOODsite project are scheduled in the is the book on disaster risk management currently in preparation by the FP6 Specific Support Action

Project	EXCIMAP (2004 ongoing)
Web url	None
Actions taken Tasks 22	Partner 7, is an active member of the drafting group of EXCIMAP contributing experience of the Tisza pilot and other rivers in Hungary
Actions taken Tasks 24 and 35	• Task 24 commented on the draft guidelines and participated in the exchange circle meeting in December 2006. • The Coordinator is in correspondence with the leader of EXCIMAP and comments on drafts of the guidance documentation

Project	*Fliwas*
Web url	*http://www.fliwas.eu*
Actions taken Tasks 17, 19 & 25	Contact persons Marcel van der Doef, Ludolph Wentholt and Kees de Gooier The Evacuation Calculator (EC), developed in the Dutch HIS project, will be applied by FLOODsite to the Schelde pilot. The Flood Information and Warning System (FLIWAS) is being developed by a cooperation of the EU funded projects NOAH and Viking. FLIWAS will use the EC to calculate evacuation times. FLOODsite and FLIWAS coordinate their activities in order to avoid overlap. An agreement has been reached that results will be mutually exchanged.

Project	FLOOD-ERA
Web url	Linked through www.crue-eranet.net/
Actions taken Task 9, 12 and 21	• This ERA-NET CRUE project is funded jointly by national Ministries in Germany, UK and Austria and runs from 2006-2008. It seeks to compare the effectiveness and efficiency of structural and non-structural measures in the involved partner countries. • The FLOODsite flood damage evaluation guidelines will be applied in this project for all evaluation tasks. • FLOOD-ERA started in 10/2006 • Contact: Dr. Jochen Schanze (IOER Dresden, coordinator)

Project	Flood Risk Management research Consortium FRMRC Phase 1 (UK)
Web url	www.floodrisk.org.uk
Actions taken Task 24	Managed through common staffing (HRW). Building on ideas for rapid flood spreading models in the floodplain. Transfer of concepts and knowledge from Foresight into FLOODsite Task 24 through common staffing.

Project	German national research projects on wave overtopping
Web url	-
Actions taken Tasks 6 and 27	The knowledge on wave overtopping which has been developed during the nationally funded projects has been used to describe wave overtopping processes for the preliminary model on breaching. Methods derived from these projects have also been used to design the tests in the small-scale and large-scale flumes at LWI and in the GWK of Hannover.

Project	HIPOCAS
Web url	*http://www.mar.ist.utl.pt/hipocas/*
Actions taken Task 26	Wave and water level data around the Catalonian coast have been incorporated to the analysis of the field site.

Project	*HIS*
Web url	*//www.hisinfo.nl*
Actions taken Tasks 17, 19 and 25	Contact persons Marcel van der Doef, Ludolph Wentholt and Kees de Gooier The Evacuation Calculator (EC), developed in the Dutch HIS project, will be applied by FLOODsite to the Schelde pilot. The Flood Information and Warning System (FLIWAS) is being developed by a cooperation of the EU funded projects NOAH and Viking. FLIWAS will use the EC to calculate evacuation times. FLOODsite and FLIWAS coordinate their activities in order to avoid overlap. An agreement has been reached that results will be mutually exchanged.

Project	*HYDRATE: Hydrometeorological data resources and technologies for flash flood forecasting*
Actions taken Task 16 and 23	• Development of the threshold approach for the flash flood forecasting problem; • Organisation of common Task meeting on October 3-4 2006. • Organisation of common Task meeting at EGU Vienna 2007

Project	Lange Termijn Visie (schelde estuarium)
Web url	http://www.scheldenet.nl/?url=/nl/dossiers/proses/ltv001
Actions taken Tasks 8 and 25	Lange Termijn Visie Schelde Estuarium (LTV) means Long-term vision for the Schelde Estuary. The project is funded by the Dutch and Belgian governments. Partners of Task 8 are involved in the research part of this project that among other things focuses on the inundation models that are used in the Schelde basin to determine the probability for flooding and the resulting flooding patterns. Information is exchanged between FLOODsite and LTV.

Project	MEDDELT
Web url	None active
Actions taken Task 26	Morphodynamic models and results obtained in this project have been incorporated to the analysis of the field site.

Project	MERK - Mikroskalige Evaluation der Risiken in überflutungsgefährdeten Küstenniederungen (Micro-scale evaluation of flood damages in flood prone coastal areas)
Web url	http://www.uni-kiel.de/ftzwest/ag4/PROJEKT/merk.htm
Actions taken *Task 27*	The German research project MERK has dealt with a micro-scale evaluation of damages in flood prone areas. The pilot site German Bight has been used as a test site within this project as well. CAU has actively contributed to MERK and many new methods were developed which are now embedded in the FLOODsite approach.

Project	*METEORISK (Interreg III B)*
Web url	*http://www.meteorisk.info/*
Actions taken *Tasks 16 & 23*	• Specific contact point: Dott. Marta Pendesini, Meteotrentino - Trento (Italy) • Coupling of radar rainfall estimates with hydrological modelling on the upper Adige river basin and common investigation of specific case studies; • Development of the flash flood case study of Val Canal (eastern Italian Alps).

Project	Modelling and Decision Support Framework (MDSF 2)
Web url	Coming soon to www.mdsf.co.uk (i.e. an update to existing MDSF website)
Actions taken *Task 24*	MDSF2 project has utilised the methodology developed in Task 24 to underpin the software product.

Project	*NAFRA (UK)*
Web url	*None*
Actions taken *Task 24*	• The Task 24 methods will potentially be utilised within the context of the UK National flood risk assessment project

Project	*NOAH*
Web url	*http://www.wldelft.nl/cons/appl/hydrology/noah.html*
Actions taken *Tasks 17, 19 & 25*	Contact persons Marcel van der Doef, Ludolph Wentholt and Kees de Gooier The Evacuation Calculator (EC), developed in the Dutch HIS project, will be applied by FLOODsite to the Schelde pilot. The Flood Information and Warning System (FLIWAS) is being developed by a cooperation of the EU funded projects NOAH and Viking. FLIWAS will use the EC to calculate evacuation times. FLOODsite and FLIWAS coordinate their activities in order to avoid overlap. An agreement has been reached that results will be mutually exchanged.

Project	ORCHESTRA Open Architecture and Spatial Data Infrastructure for Risk Management
Web url	*http://www.eu-orchestra.org/*
Actions taken *Tasks 16 19 & 23*	ORCHESTRA has developed web-tools for transport routing. Cooperation is sought with Christiaan Logtmeijer of JRC to adapt these for flood emergencies and to link those to the flash-flood road network warning prototype on the Gard region.

Project	PACE
Web url	Not active
Actions taken *Task 26*	Morphodynamic models and results obtained in this project have been incorporated to the analysis of the field site.

Project	PAMS (UK)
Web url	http://www.pams-project.net/
Actions taken Task 24	The Task 24 methodology will be used within the context of the Performance Based Asset Management System (PAMS) models to support decisions relating to asset management planning

Project	Performance and reliability (UK)
Web url	http://www.prfcd.org.uk/
Actions taken Task 24	Work on fragility curves undertaking within the Performance and reliability project is utilised within the Task 24 system model

Project	PRODEICH
Web url	None
Actions taken Task 6 & 27	Within the German ProDeich project LWI has developed a simple method to calculate the probability of breaching for sea dikes for use in probabilistic models. This approach has been used within FLOODsite in Tasks 6 and 7 for the calculation of expected time for breaching and the preliminary reliability analysis of the pilot sites.

Project	PROSES
Web url	*http://www.ontwikkelingsschets2010.nl/www/scripts/content.php?pageID=4&cBlockID=11*
Actions taken Task 25	Participation of Proses project director Mr. J. Claesens in first workshop

Project	*PROmO: Perceptie en Risicocommunicatie bij Omgaan met Overstromingsrisico's*
Web url	*www.omgaanmetoverstromingsrisicos.nl*
Actions taken Task 25	joint workshop held on 24 January 2008

Project	*RAPHAEL*
Web url	
Actions taken Tasks 16 & 23	Integration of meteorological and hydrological forecasts at small space/time scales.

Project	RASP (UK)
Web url	http://www.rasp-project.net/
Actions taken Task 24	Task 24 builds upon the concepts and principles established within the Risk analysis for Strategic Protection (RASP) research project

Project	*SARISK*
Web url	*http://www.ufz.de/btf*
Actions taken Task 21	Adjustments between hydraulic modelling and DSS development (M. Rode, J. Schanze, A. Sauer).

Project	Thames Estuary 2100
Web url	http://www.thamesweb.com/page.php?page_id=60&topic_id=9
Actions taken Task 24	Managed through common staffing (HRW). The Task 24 model is being utilised for economic appraisal and to support flood risk management decisions on the TE2100 project.

Project	Update of the Vásárhelyi Plan
Web url	*http://www.vizugy.hu/vtt/index.html*
Actions taken Task 22	Daily contact with the stakeholders and the designers

Project	VERIS Elbe
Web url	*http://www.veris-elbe.ioer.de/*
Actions taken Task 21	Adjustment of scenario development (J. Schanze, J. Luther).