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Position Review of Data and Information Issues within Flood and Coastal Defence

R & D Technical Report FD2314/TR

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R&D Technical Report FD2314/TR

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This technical report contains the results of a study to put forward a position statement on issues related to the use, capture and dissemination of data and information relating to flood management within Defra and the Environment Agency (Agency). The study is written for Agency/Defra staff though will be of use for other key stakeholders involved in managing, storing or producing information of relevance to the planning and management of flood and coastal defences in England and Wales.

Keywords
Data and Information, flooding, role and responsibilities, audit, storage, metadata.

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EXECUTIVE SUMMARY

This study has arisen from a previous Defra/Agency research (Overview of Data Management Issues in Flood and Coastal Defence -W5G-007). Its looks at data as a central item with the purpose to understand the efficiency of current data and information practices and what opportunities exist to improve the flood and coastal defence process through better data management. Focussing specifically on flood issues (fluvial, estuarine and coastal), the output of the project is to determine where limitations can be matched with quick fixes and improved uptake of ongoing research and initiatives.

The key findings of the project focus upon the five key principles of data.

Data Understanding: To improve the supply of data to support FCM decision making, an"ontology" of FCM data needs to be determined. Clearer communication is required on the needs of the FCM community and to help this, an ontology could be developed to map responsibilities and initiatives that are being undertaken to improve FCM data management.

Roles and Responsibilities: There needs to be a distinct improvement in encouraging better engagement of wider stakeholders in FCM. The study recommends encouraging partnerships with local stakeholders when managing datasets.

Process and Procedures: As the FCM community is primarily dealing with geo-spatial data, the FCM community should look to develop, maintain and service a FCM profile of ISO19115 (common standards). The FCM community should also embrace the diversity of data standards existing within FCM and to manage this establish a registry of FCM data standards and the associated mapping between these standards. This includes common dictionaries for terminology.

Enabling Technology: The FCM community is generally very quick to look at new technology and (lack of uptake) of new technology is a minor issue, not currently limiting FCM progress. What is often the limiting factor is the integration between 'requirements' and 'technology' to ensure the appropriate uptake and use of technology. Recommendations are therefore based on minimizing this gap through improved communication of technology development plans and to make explicit (e.g. provide guidelines) on the integration of the technology with FCM process workflows.

Audit: There is no mechanism in place to regularly appraise the data needs of FCM. There is also a requirement to ensure a continual feedback from current FCM initiatives (eg: PAMS) to others such as the NFDDDMS.The FCM community does not have an effective learning mechanism in place to understand what information is valuable and what information is not. The existing Agency Knowledge Management Strategy does provide a framework from which to prepare a FCM specific document.

A series of recommendations and actions to complement existing initiatives/activities are included within the report.

CONTENTS

ABBREVIATIONS

ABI	Association of British Insurers
ACAG	Anglian Coastal Authorities Group
Agency	Environment Agency
BRIMS	British Radioactive waste Inventory Management System
CASI	Compact Airborne Spectral Imager
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFMP	Catchment Flood Management Plan
CIRIA	Construction Industry Research and Information Association
Defra	Department for Environment, Food and Rural Affairs
DGPS	Differential Global Positioning System
DIEU	Data & Information Exploitation Unit
EC	Engineering Council
EIA	Environmental Impact Assessment
ESA	Environmental Services Association
FCD	Flood and Coastal Defence
FCM	Flood and Coastal Management
FoIA	Freedom of Information Act
GIS	Geographic Information Systems
GMES	Global Monitoring for Environment and Security
GPS	Global Positioning System
HRW	HR Wallingford
IACMST	Inter-Agency Committee on Marine Science and Technology
ICZM	Integrated Coastal Zone Management
IFM	Indicative Floodplain Mapping
IPR	Intellectual Property Rights
KM	Knowledge Management
LA	Local Authority
LiDAR	Light induced Detection And Ranging
MEDAG	Marine Environment Data Action Group
MDSF	Modelling and Decision Support Framework
NFCDD	National Flood and Coastal Defence Database
NFDDDMS	National Flood Defence Data and Data Management Strategy
NHS	National Health Service
ODPM	Office of Deputy Prime Minister
OS	Ordnance Survey
PAMS	Performance Based Asset Management System
POL	Proudman Oceanographic Laboratory
PR	Project Report 1
PSI	Public Sector Information Directive
R&D	Research and Development
RASP	Risk Assessment of Flood and Coastal Defence for Strategic Planning
RDA	Regional Development Agency
ROAME	Rationale, Objectives, Appraisal, Monitoring, Evaluation
SAR	Synthetic Aperture Radar
SATIS	Scientific & Technical Information Services
SCOPAC	Standing Conference on Problems Associated with the Coast
SEA	Strategic Environmental Assessment
SIG	Coastal Special Interest Group
SMP	Shoreline Management Plan
SMURF	Sustainable Management of Urban Rivers and Floodplains
TR	Technical Report 1
UKHO	United Kingdom Hydrographic Office
VAR	Value Added Resellers
WFD	Water Framework Directive
WSA	WS Atkins

1. INTRODUCTION

1.1 Project Background

The planning, design and implementation of effective flood and coastal defences, and the establishment of an efficient and effective flood warning service, are all dependent on the availability of accurate, relevant and up-to-date data. Data are interpreted to provide information. The understanding of fluvial, estuarine and coastal processes, which underpins government policies in these fields, cannot be improved unless we continue to collect data and process them to provide relevant information, and ensure that that information about data sources is widely available.

Data underpins the management decisions to support all aspects of Flood and Coastal Management (FCM). However, in order to understand how 'better data' can lead to 'better decisions', the way data is used in FCM needs to be clearly understood. Those responsible for FCM require a sound working framework. This also needs the capacity to allow the assessment of risks associated with a flood defence system to provide ways of identifying the optimum programme of management interventions. Such a framework may then achieve the required outcomes (i.e. some desirable reduction in flood risk). Understanding how 'data' impacts on this system, however, is difficult to conceptualise because the existing framework or "system" is complex, with multiple components contributing to the response during a fluvial or coastal flood event.

To investigate this issue further, a study was commissioned in 2002 (Atkins 2001) to investigate the current ROAME statement (see Abbreviations) on Data and Information (see Appendix A) and to initially document the systems in place to collect data and process information within the Agency, other governmental bodies and the public sector. That scoping study recommended that further study was required. The joint Agency/Defra R&D programme subsequently agreed to fund a follow up research project under the Risk Evaluation and Understanding of Uncertainty Theme. The aim of the project is to develop a strategic approach to FCM data and information, covering the whole 'cycle' of collection, dissemination and use of data for decision-making. Its purpose is to support existing work being carried out by the Agency (Environment Agency 2003d).

The project applies generically to fluvial, estuarine and coastal flood risk data. No differentiation between these three have been set out in terms of how data and information need to be managed in the future. Coastal erosion aspects are not concentrated upon in detail within this report.

1.2 Scope and Purpose of this Project

The purpose of the research project is to assist Agency/Defra to understand the current efficiency of data and information practices and to highlight the opportunities that exist to improve the flood and coastal defence process. The output of the project seeks to determine key limitations within the FCM industry relating to data and information

management and from this, identify quick fixes to improve uptake of ongoing research and initiatives.

This project aims to reflect and challenge new thought processes on this topic area, to support and promote policy development, process and operations, taking full account of existing data collection programmes and archives. The report is prepared for Agency/Defra, though can relate to users, other Research Themes, external providers (water companies), academics, internal drainage boards, current data managers and those who are involved in wider policy issues on data access both in England and Wales and further afield (Europe). The report has, however, been written with Agency /Defra as the key audience.

1.3 Position Statements

The study was asked to consider six topic areas related to data and information management within FCM. The subjects to be covered include:

- Data Needs.
- Data Accessibility.
- Data Acquisition.
- Knowledge Management.
- Involvement of Stakeholders in Data Collection.
- New Technology.

When compiling Position Statements on each topic, it was clear that whilst they represent a summary on that issue, this final integrated report (TR) needed to consider each of the findings in terms of the information principles it is trying address. The approach taken has been followed to reduce the confusion and overlap that might otherwise has arisen between the six topic areas. Figure 1.1 maps the topic of the six Position Statements onto the information management principles used in this study (numbered 1 to 5). Solid colour indicates a strong mapping, shading indicates a partial mapping.

	1) Data Understanding	2) Roles and Responsibilities	3) Processes and Procedures	4) Enabling Technologies	5) Audit
A) Data Needs					
B) Data Accessibility					
C) Data Acquisition					
D) Knowledge Management					
E) Stakeholder Involvement					
F) New Technology					

Figure 1.1 Five Principles of Data Management and Position Paper Titles

As an example, the involvement of stakeholders in data collection can provide useful information on flood consequences and pathways. The technology is mature enough to support the process, but procedures and responsibilities need to be better defined.

Based on a set of specific key objectives for the project (Atkins 2001), a series of specific Position Statements were produced and used internally to inform the Project Steering Group on key points for further elaboration. To produce these Position Statements (presented in FD2314 2004a) the project gathered views and opinions from industry data managers through questionnaires, consultation (face to face and telephone), workshops and literature surveys. Consideration was given to a range of ongoing data and information related initiatives that are either totally, or in part, reviewing the status of future data management in the UK. These include:

UK Initiatives (see Glossary for full title)	**Lead Responsibility**
NFCDD development	Agency
SATIS	Agency
SMURF	Agency Project
Agency Data Management Strategy	Agency (Bill Rodham)
SMP2	Defra
CFMP	Defra
MDSF	Defra
RASP	Agency
PAMS	Agency
Broad Scale Modelling Estuaries Projects (ERP1 and 2)	Defra/Agency
Flood Forecasting and Warning research	Agency/Defra
ICZM in the UK Stocktake Exercise	Defra
Coastal Data Co-ordinator remit	Defra
MEDAG/IACMST Data initiative[1]	Defra

European Initiatives	**Lead Responsibility**
INSPIRE	EC (DG Environment)
EUROSION	EC (DG Environment)
GMES	EC/ESA
FP5/FP6 R&D projects	EC (DG Environment & Information. Society)
EC Directives	EC

1.4 Purpose of this Report

This report represents a coherent analysis and presentation of findings accrued during the period of the research project. It is structured accordingly to improve knowledge on two aspects:

[1] FD2314 (this project) has not reviewed the outputs of this work as they were not available at time of publication, although the broad aims of the study are known.

- Understand which aspect of the FCM process has the “biggest” data issues, e.g. is it associated with the understanding of the source of flooding or the impact of flooding?
- Understand 'what can be done' from a data management perspective to remedy things, e.g. are we dealing with technology issues, procedural issues or people issues?

A framework is also used to cross reference ‘risk management’ and ‘data management’ in the FCM process.

It is noted that some questions originally raised before the project (Atkins 2001) remain unanswered. However, the intention has been, where possible, to put forward suggestions for how data and information management may be improved through streamlining existing processes or by advocating changing working mechanisms. All points raised are derived from the work undertaken by the Project Team based on the evidence gathered during the project. It should be added that the purpose of this study is not to duplicate existing work, but to advise on the current position resulting from existing work.

The report framework includes seven main sections, each containing specific recommendations. Under this structure, the reporting on the separate Position Papers (see above) fits easily into the approach adopted.

Section 1 Introduction
Background to this study, its scope and remit.

Section 2 Information Cycle within FCM
Presentation of the framework used to appraise FCM information and data issues. Introduction to subsequent sections.

Section 3 Data Understanding
Appraisal of the fundamental data requirements to ensure they match the information needs for FCM.

Section 4 Roles and Responsibilities
Review of the responsibilities for providing and managing the data needs for FCM.

Section 5 Processes and Procedures
Consideration of the rules followed within an organisation that are part of the FCM data processing chain. Key issues considered include procedures for metadata, cataloguing and archiving.

Section 6 Enabling Technologies
Review of how FCM could be improved by using appropriate technologies to support storage, transmission and management of data. Key issues considered include mobile technologies, satellite technologies and visualisation technologies.

Section 7 Audit

An examination as to how FCM learns from the effectiveness of its outputs of FCM. Key issues considered include measuring the outcome of FCM and knowledge management.

Section 8 Conclusions

References

Appendices

2. INFORMATION CYCLE WITHIN FCM

2.1 Risk Management Principles

Agency/Defra's aim of flood and coastal management is *"to reduce the risk to people, property and environment and to encourage sustainable development"*. To this end, those responsible for FCM need a system that allows the assessment of risks associated with a flood defence system and one that provides a means of identifying the optimum programme of management interventions, to achieve a particular outcome (i.e. some desirable reduction in flood risk). However, understanding how 'data' impacts on this system is difficult to conceptualise because the FCM system is complex, with multiple components contributing to performance (or reliability) during a flood event.

To set a framework for this study and manage the complexity, FCM has been considered in the context of the Government's standard 'Source / Pathways or Barrier / Receptor / Consequence' (SPRC) approach to risk management as shown in the cross sectional diagram (Figure 2.1). This overarching framework provides for a more detailed consideration of the precise activities actually undertaken.

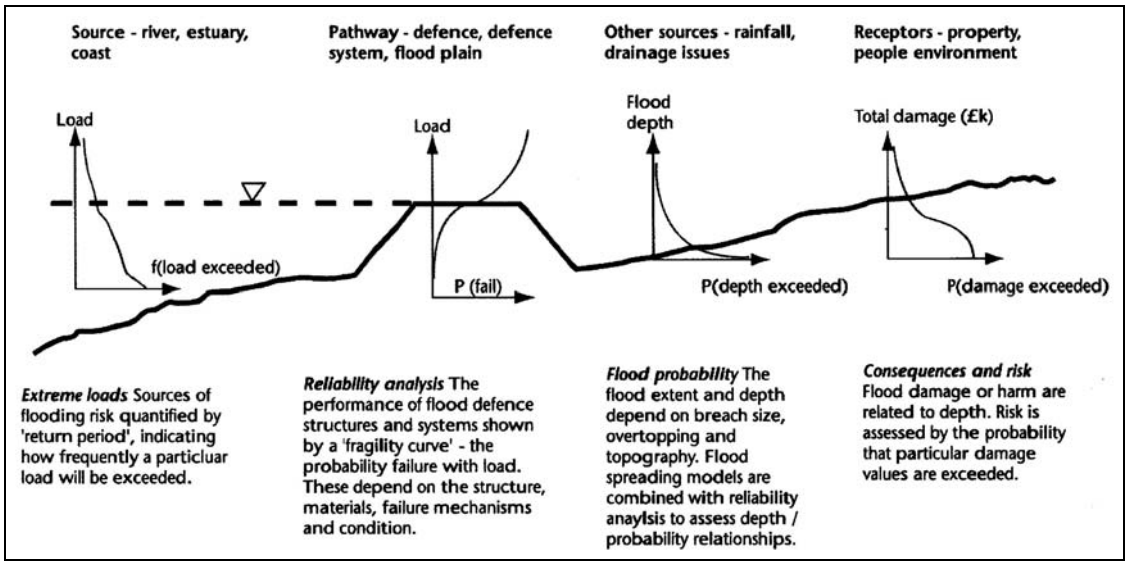


Figure 2.1 Source / Pathway / Receptor / Consequence (SPRC) model for FCM

Figure 2.2 shows some of the broad range of activities carried out within FCM. From this consideration, it becomes more straightforward to categorise the areas where information is needed. This is summarised in Table 2.1.

Table 2.1 Information requirements and SPRC

Area	Examples of information requirements
Source	Extremes of rainfall (flash floods) and river flow, storm surges.
Pathway	Performance of beaches, defence performance, drainage (artificial/natural), and propagation in the flood plain.
Receptors	Quantification of areas and population at risk from flooding, information on vulnerable groups, transportation network, availability of emergency services.
Consequences	Quantification of Loss of life, property, personal assets (carpets etc) amenity and economic production, intangible heath indicators (stress etc).

Considering the system in terms of SPRC only takes the issue so far. A data management framework is required in order to help understand how the topics in FCM relate to data and information management.

The framework proposed for this study builds on work previously undertaken for the FCM industry on effective data management (CIRIA 2000, Agency 2002). These studies conclude that effective data management is the cornerstone to deriving maximum value from data. The data management framework embraces 'data management principles' to provide *pointers to action* on management issues and a data lifecycle framework to identify what existence state of the data requires improved management. These two items are discussed in the following chapters.

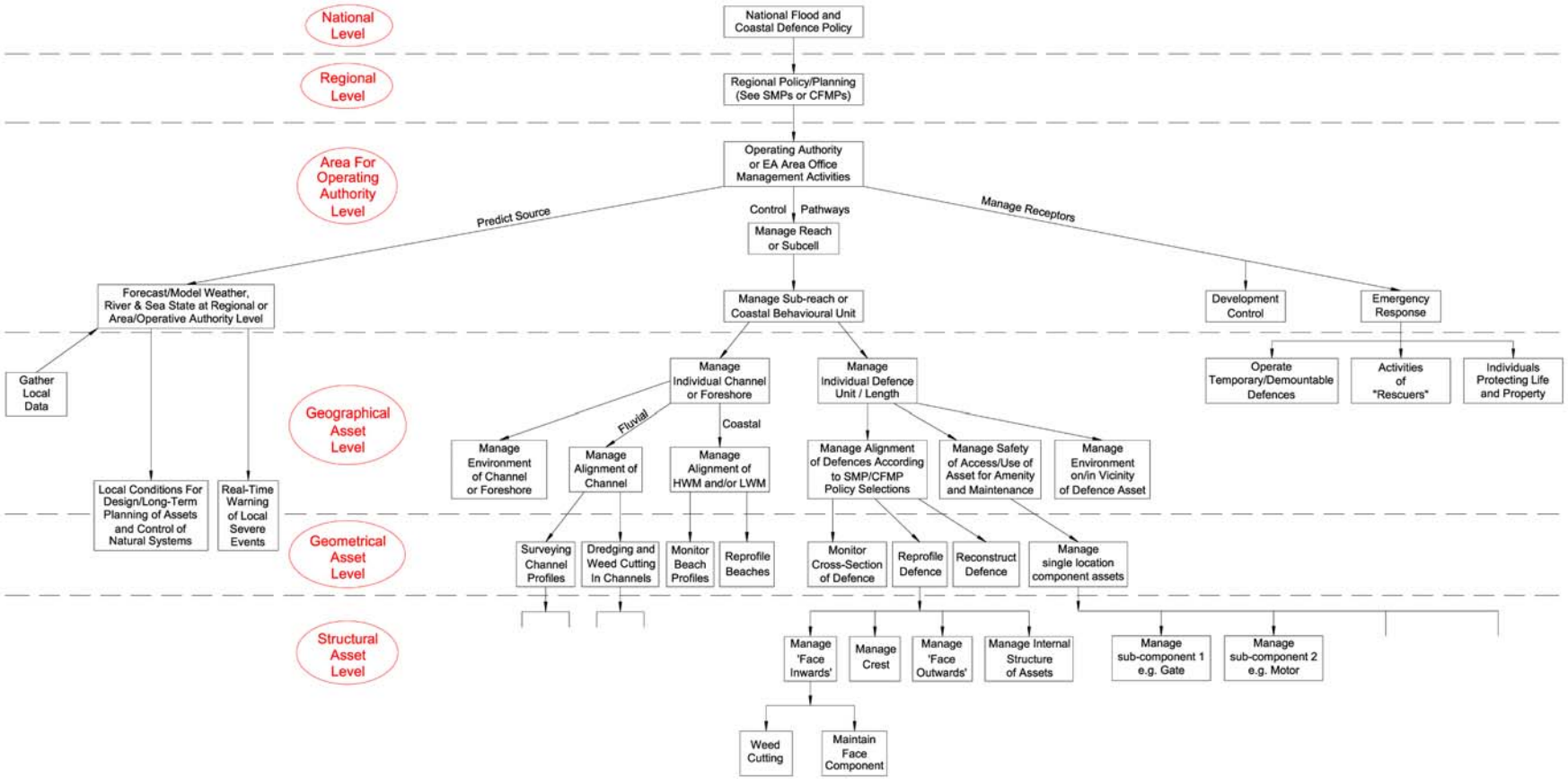


Figure 2.2 Activities Undertaken as part of Flood and Coastal Management (taken from EA).

2.2 Data Management Principles

Organisations involved within FCM do work together, yet operate different procedures and rules regarding data management. These often allocate roles and responsibilities to individuals in those organisations and define the data processing chain. However, when dealing across and between organisations at a strategic level it can be more effective to deal in terms of principles.

Principles provide the flexibility to enable organisations to use their own procedures in order to meet best practice standards. CIRIA (2000) recommended the adoption of five principles of good data management. These are based on principles adopted by the British Standards Institute for the management of electronic documents (Mayon-White and Dyer, 1997) and are essentially pointers as to how to manage the data lifecycle. These principles are technologically and politically independent, ensuring they will remain valid in the future. The five principles of good data management are shown in Figure 2.3.

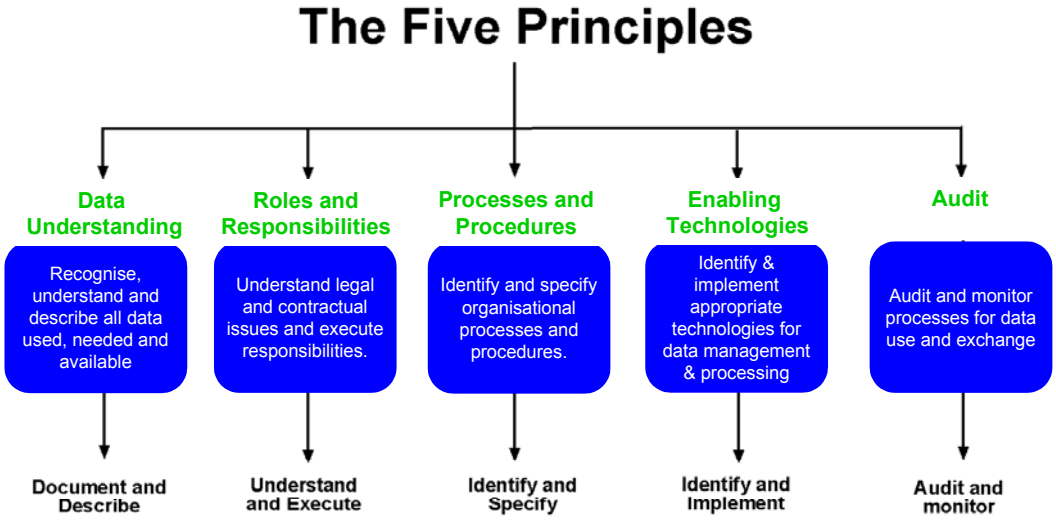


Figure 2.3 Five Principles of Data Management (Mayon-White & Dyer 1997)

2.3 Data Lifecycle

The data lifecycle considers what happens to an individual data item, such as a measurement, from its creation. A particular dataset, at a particular time, will be in one of six states that comprise the data lifecycle. These states are:

- Creation Capturing some real world phenomena.
- Storage Encoding the phenomena onto a media.
- Access. Reading the media to access the data.
- Update. Writing the media to update the data once reviewed.
- Retention. Maintenance of the media (to facilitate access and update).
- Deletion. Destruction of the data once a final review has taken place.

The order, duration and repetition of the states in which data exist at any one time will vary. However, the data life cycle always starts with 'creation' and always ends with 'deletion' (following audit review) and these two phases can only occur once[2]. It is important to note that whilst all stages of the lifecycle should be treated individually, consideration should be given to subsequent stages, particularly at the creation stage. Good data management is implicit in knowing the data lifecycle state at any time, and ensuring that deletion is only carried out as specified by a contract.

2.4 Using This Report

This document considers the five principles of good data management in the context of FCM. Each chapter considers the FCM data issues associated with each Principle in turn (specific tables covering generic data lifecycle issues and specific risk management issues. For each Principle, the document categorises the issues according to either the SPRC framework (if it is an issue related specifically to FCM) or the data lifecycle (if it is a generic data management issues). This matrix approach, which is consistently applied to each of the chapters, provides a powerful method of identifying and subsequently prioritising actions from this study.

Each issue that is associated with the SPRC or Lifecycle framework is discussed in more detail in the following sections, taking examples from case studies where appropriate. All case study information gathered for this project, where it is stating a fact that informs a position, is presented in a standalone grey box.

Recommendations for consideration are then put forward at the end of each section.

[2] Data can be duplicated, but then this is the creation of a new branch to the data lifecycle. The more duplicates that exist, the less chance that the data will be lost; although quality control becomes a greater problem.

3. DATA UNDERSTANDING

3.1 Generic Data Lifecycle issues

Table 3.1 shows generic 'information' aspects associated with the management of data in FCM.

Table 3.1 Generic Data Lifecycle issues

Lifecycle State	Issues to consider
Creation	There is presently no overall framework in place to determine which primary information is required to support FCM. Techniques for quantifying 'intangible' parameters such as 'environment' and 'well being' are generally immature.
Storage	None
Access	There need to be improved approaches on how secondary (i.e. collected for another purpose) information can be obtained. There is an increasing demand for improved interoperability between data and models.
Update	None
Retention	There need to be improved methods for establishing long term data sets.
Deletion	None

3.2 Specific Risk Management Issues

Table 3.2 shows specific 'information' issues associated with risk management[3]:

Table 3.2 Risk Management Issues

SPRC	Issues to consider
Source	Real time flood propagation. Extreme level return period estimates and methods. Improving accuracy of tidal predictions. Improved high flow flood gauging.
Pathway	High resolution "coastline" (work of ICZMap), bathymetry and flood plain. Defence crest height. Geographic representation of research and capital projects. Wave overtopping data. Urban flood propagation. Links between fluvial and sewer flooding.
Receptor	Records of properties affected by flooding. Databases of community and support groups. Improved data on people at risk rather than property.
Consequences	Socio-economic information about residents in flood areas. Post event data.

[3] Identified in FD2314 (2004a) - PR

	Valuation of intangible benefits (environmental, stress, leisure). Measurements of habitat quality.

3.3 Analysis of Specific Information Needs

The study has not been able to identify a formal FCM method for identifying missing data sets and then "signposting" users to where missing data should be sought. Whilst the list of parameters presented in Section 3.2 is a useful starter list for discussion, there is no mechanism at present to develop this aspect within FCM (see Section 7 on 'Audit'). Various studies such as SMP2 (Halcrow 2003a), Future Coast (Defra 2003b), NFCDD (Science Systems 2003), MDSF/CFMP (Halcrow 2003b), RASP (Environment Agency 2003b), ERP Phase 1 Dissemination Project (Posford Haskoning 2003) and NFDDDMS (Environment Agency 2003d) are all examining in detail what data are required for FCM. However, there is no mechanism to ensure that these initiatives talk to one another, even though the *de facto* common entity is NFCDD (See Box 3.1).

A recent review of the relationship between Projects such as PAMS, RASP and MDSF and NFCDD has identified that NFCDD should be improved to include the following data.

- Location of defences (currently being addressed at time of writing).
- Flood plain / channel roughness.
- Rating curves.
- Floodplain depths from EFO (Flood Zones).
- Coast extreme water levels.
- Coastal extreme wave conditions.
- River extreme water levels.
- Correlations between fluvial and coastal events.
- Probability of structural defence failure under a given load.

More information is provided in HR Wallingford and Halcrow (2003) on the data contained within NFCDD and the additional data required for RASP.

Box 3.1 Missing Parameters and NFCDD

Risk based approaches to data collection are not applied within FCM, but neither are they routinely used in other discipline areas (see Box 3.2). Risk assessment methods are well established in FCM to examine the consequences of certain actions or events occurring. As risk assessment is applied to the consequences of major decisions, it is implicit that risk assessments are also applied to the demand for data on which future decisions were based.

From the ENVALDAT (HR Wallingford, 1998) project it was found that explicit risk assessment methods applied to data demand were not used. Risk Assessment manifests itself in the choice of data to solve environmental problems in a number of ways:

- Incomplete understanding of environmental processes means that data requirements cannot be fully expressed.
- Ensuring continuity of data supply.
- Judgements over the quality of data to be used in decision making, or evaluating different data options.
- Limiting the amount of data collected (purchased) in line with budget requirements.

The lack of risk-based approaches is partly due to the fact that data customers regard data as something they have limited control over; i.e. 'data is available, or it is not'. Informal risk assessments are made on the quality of datasets of dubious origin in the form of an expert assessment. The cost of the data in relation to the benefits it delivers is not explicitly addressed.

Box 3.2 Risk Assessment and Data Management

This need for a high level view on data and information issues is echoed in the need for metadata (and associated relationships) on both R&D and capital projects. This information could be easily provided to the FCM community and would be a useful tool to map the evolution of FCM and its associated data needs. The current scientific interest in ontologies could provide the basis for developing this map (See Box 3.3)

The work on the semantic web has generated a large amount of interest recently in the subject of ontologies. An ontology (for anything) simply articulates how it exists or its nature of being. So, an ontology for FCM data would consider such issues including:
a) what data is required?, b) how certain are we of this requirement? c) where does it come from? d) where is it used? e) what data is needed in the future? f) what standards are used to maintain the data? g) what organisations are involved?
The ontology articulates the relationships between these concepts and the user determines what concepts are important to include in the ontology. There are freeware editors such as Protégé that can be used to generate ontologies. *(http://protege.stanford.edu).*

Box 3.3 Definition of Ontology for FCM

3.4 Intangible Parameters

Much work is being done on providing data on intangibles factors such as 'risk to people', 'well-being', 'environment' (Defra/Agency 2003). MDSF (see Abbreviations) developed the concept of the Social Flood Vulnerability Index (SFVI), and a people vulnerability index (PVI) is also being proposed. These techniques, however, are developed in a bottom-up fashion from available data and as such are 'data limited'. As this work is relatively new and evolving, it is not fully transferred to FCM procedures.

3.5 Long Term Datasets

There is no clear process to determine what the 'long term data sets' should be. In terms of shoreline management, there has been a recent approach taken by Defra to secure funding for longer term regional beach profile and shoreline monitoring for the south coast England from Dorset to Kent (SCOPAC). However, there is still debate as to how applicable and transposable this approach is for other Coastal Group areas (eg: the Anglian Coastal Authorities Group (ACAG) or North West Coastal Group – see FD2314/PR 2004). Strategies are, however, being put in place for the North West at present mirroring the SCOPAC approach (*pers comm*. Graham Lymbury 2003).

There is a need to ensure that non FCM specific datasets (eg: demographic statistics, land use data, hydrometric and meteorological data) are made available over the long term. This issue needs to be set out clearly within a FCM ontology to clarify specific needs as they arise (see Box 3.3).

3.6 Access to Secondary Information

Not all data needed for FCM is available from central sources such as NFCDD and needs to be accessed from third parties. Studies such as SMP2 (Halcrow 2003a) and NFDDDM (Agency 2003d) have highlighted the range of data needed for FCM and improvement to setting up "signposts" for where stakeholders can access data is an action that is required (see Box 3.4). This issue was perhaps the main issue of coastal stakeholders at a series of ICZM Workshops carried out around the UK during September 2003[4] (Atkins 2003).

If a dataset is supplied nationally from a single supplier, the Agency can arrange that the dataset is supplied (as a "signpost") to all consultants to a specified standard. This saves money and time by avoiding the duplication of effort. Such datasets already form the basis for the standard data package in MDSF for CFMPs. MDSF for CFMPs comes preloaded with nationally negotiated datasets such as topography and socio-economic datasets – however not all of which are sufficiently accurate and need to be quality controlled. The use of a 'Standard Data Package' has also been proposed for the new round of SMPs (Halcrow, 2003), though this concept is far from being universally accepted by the Agency (at the time of writing this TR). The SMP2 Procedural Guidance Note (Halcrow 2003) recommends that the coastal extension to MDSF '*be developed as part of the standard data package'*. This would provide a co-ordinated source for core datasets (which could originate in different organisations). There would still be a need for consultants to collect local data as 'Standard Data Packages' are likely to be for national datasets only.

Box 3.4 Accessing Data via the 'Standard Data Package'

[4] ICZM in the UK: A Stocktake – (Atkins 2003). Whilst not directly specific to FCM, the sentiments were clear that stakeholders from all sectors and levels, would prefer to have clear advice on who the holders of certain sectoral datasets are and where data can be accessed.

3.7 Interoperable Modelling Systems

Interoperability within modelling systems will become increasingly important to support end to end data processing and 'operational flood and coastal management'. Box 3.5 presents some possible flood forecasting (as an example only) of interoperability issues. Achieving interoperability is a function of Process, Procedures and Technology. It is considered in more detail in these sections.

Type	Likely developments in the next 5-10 years
Meteorological	Improved weather radar resolution (number of radars, grid size), real time radar adjustments using Agency/Met Office rain gauge data, improved forecasting of convective events, ensemble rainfall forecasts more widely available, higher resolution meso-scale model outputs.
Fluvial	Increased use of real time 1D hydrodynamic models, real time integrated catchment models, real time inundation mapping and property at risk assessments, real time distributed (grid based) hydrological modelling, real time 2D modelling in complex/high risk locations, decision support tools for early warning of extreme rainfall events, use of Met Office MOSES product for estimating antecedent conditions, improved modelling of snowmelt, groundwater influences and runoff from ungauged catchments, more real time optimisation of flow control systems (washland, reservoir systems), improved coverage for ordinary watercourses (local authority, Agency), increased application to full flow forecasting (water management, drought, pollution incidents etc), wider use of urban drainage models.
Estuarine	Significant improvements in model sophistication, agreed coastline "positions" and better integration of fluvial and coastal forecasting models, improved models for key estuaries (eg: Thames, Humber, Mersey etc).
Coastal	Real time offshore-nearshore-inshore modelling, real time wave overtopping and inundation mapping, harbour modelling, shingle beach modelling, local influences (seiche etc), improved modelling for secondary depressions, improved CS3D model and STFS forecasts.

Box 3.5 Likely developments in flood forecasting in the next 5-10 years

3.8 Recommendations

There are a large number of studies reporting on the information required for FCM, but limited procedures for developing these needs into data collection programmes. The NFCDD is becoming a central focus for data and information issues related to FCM, but this cannot provide all data needed for FCM and links to other communities are required. The proposed actions are as follows:

- Develop an ontology for FCM Data Management activities (research and operation) covering such facets as “what, where, who, why” and serve this to the FCM community. Tools are readily available to do this, but responsibility needs to be assigned to various parties involved. This will effectively be a “map” for the FCM process.
- From the above, manage and update (on behalf of the FCM community) an ontology of FCM data that includes facets on what the data is, data purpose and responsibilities for maintenance and ownership.
- Develop improved mapping between ‘data’ and ‘process’ and serve this to the FCM community. This should embrace risk-based approaches to managing the data lifecycle and make explicit the quality of data required to support the quality of information that can be generated from a workflow. NFDDDMS is addressing some of these issues and needs to be supported to improve research findings uptake.

It should be noted that the above points should not be regarded as one-off projects, but new procedures for the Agency to adopt to improve effectiveness and reduce costs in the FCM process.

4. ROLES AND RESPONSIBILITIES

4.1 Generic Data Lifecycle Issues

Table 4.1 shows generic 'roles and responsibilities' issues associated with the management of data:

Table 4.1 Data Lifecycle Issues

Lifecycle State	Issues to consider
Creation	Wider use of stakeholders for data creation.
Storage	Storage "hubs" for technical datasets.
Access	Legal compliance on data access (PSI, FOIA etc.). Public domain issues.
Update	None
Retention	Responsibilities for long term data retention. Funding responsibilities for long term data retention.
Deletion	None.

4.2 Specific Risk Management Issues

Table 4.2 shows specific 'roles and responsibilities' issues associated with risk management.

Table 4.2 Roles and Responsibilities

SPRC	Issues to consider
Source	None
Pathway	None
Receptor	Communication to stakeholders (flood warnings)
Consequences	Use of stakeholders to report on flood events

4.3 The Roles of Stakeholders within FCM

There is a broad range of activities undertaken within the FCM industry and thus the range of responsibilities that exist (see Figure 2.2). In addition to activities undertaken by Government Departments, there are important, yet "external" providers within FCM, such as communities, academia, support services, data distribution services (eg: Agency Data Distribution Centre in Leeds) and aspects of the private sector (eg: insurance industry). Attention thus needs to be focused on roles of other stakeholders within the process, scrutinizing how they can be encouraged to take greater ownership of issues, as many individuals, civic organizations, and private companies can take the initiative to recognize flooding risks and impacts (eg: the work of the National Flood Forum).

Possible examples of how these "secondary" bodies and groupings could assist in better FCM data and information management are highlighted for discussion. A rigid evaluation of current Agency/Defra practices (eg: NFCDD) is not

undertaken as these are undergoing constant review outside of this research project. However, reference is made here to the existing Agency Data Policy Team who are responsible for implementing Agency-wide data management policy, ensuring consistent ways of working and delivering quality data that underpin the Agency as an effective communicator and efficient operator.

A list of "secondary" stakeholders together with their roles and responsibilities in major flood events (excluding Agency and Defra) and in capturing or storing relevant data and information (if known) is given in Table 4.3. This identifies stakeholders who are involved in flood management or managing activities associated with floods at the local level.

4.4 Proposed Improvements for FCM Data Management

The following section highlights possible areas of improvement within FCM in terms of stakeholder roles and responsibilities within the industry. Cases are backed up with examples where possible.

4.4.1 Procedural Compliance for Data Collection

It is apparent from Table 4.3 that whilst many organisations are involved in, for example flood emergency response, the information derived from such events is rarely consistently captured, thus potentially losing valuable information that may be used to improve emergency response during future events (primary and secondary data).

It is also recognised that there are too many uncoordinated projects to collate data for different purposes (essentially secondary data). The issue of being able to re-use information and data for better effect needs improved coordination.

The benefit in broadening the roles of stakeholder groups in capturing flood related information is agreed in concept by most policy decisions makers, yet a key issue in relation to using local community groups in flood data collection is ensuring data quality. It is appreciated that sound engineering decisions need to be made from data and information that is robust and credible. However, it is apparent that in cases of post flood event recording (see Box 4.1), arguably the best people to gather such data (or at least add to this) are those communities on the ground and not the insurance companies or the Agency.

There are examples where inaccurately collected data is compiled on a number of properties affected by flooding (false situations). Such data is often collected from reputable sources (Agency/consultants/insurance industry). A particular example of this was raised in Bewdley where the number of properties apparently affected by flooding was grossly underestimated (National Flood Forum *pers comm*. 2003).

Box 4.1 Bewdley Post Event Appraisal Information

Table 4.3 Stakeholders (excluding the Agency) and their roles and responsibilities during a flood event (4 pages in length)

Stakeholder	*Current Roles*	*Responsibility in flood events*	*Statutory responsibility in managing flood related data for Govt Depts*
Householders /business owners, other landowners	Property ownership, maintenance, etc. Residents rarely prepare their own flood emergency plan including an evacuation plan. Residents are responsible for obeying municipal and other agencies warnings, instructions and directions as they are received.	Make themselves aware of the action which they should take in the event of flooding, Move property (cars) to higher ground upon receiving a flood warning. Stay aware of developing conditions by listening to media broadcasts.	none
Coastal and non coastal Local Authorities	Planning. General duties of care, Ordinary watercourses, flood defences (coastal and Ordinary watercourses), roads, amenity and recreation.	Flood alleviation and dealing with flooded roads/issuing of sandbags. Emergency care during flood events including providing accommodation/food for those evacuated. Emergency transport for personnel, equipment and sandbags and evacuation if necessary. Coordinating the voluntary response.	Incorporate flood plain management information in statutory plans. Post storm event data and beach profile data collection is not mandatory.
Railtrack	Railways.	Maintenance of floodplain structures.	None.
Highways Agency	Trunk roads.	Maintenance of floodplain structures.	None.

Utilities (see also Water Companies below)	Services (electricity, gas, water supply, sewerage, etc).	Provision of services. Safety of services.	none
Internal Drainage Boards (IDBs)	Watercourses and flood defences in Drainage Districts.	Assistance in flood emergencies. Maintenance of rivers and flood defences in Drainage Districts.	none
Public Utility Companies and Water companies	Stormwater drainage.	Maintenance of adopted drainage systems. Repair services disrupted by flood events. Advise LA's and media when disrupted services will be reinstated. Restoration of services (sewage clean up etc).	register of flooded properties
Regional Development Agencies (RDA's)	Land use planning for a designated region.	None.	none
Developers	New developments.	Developments conform with flood management requirements (PPG25).	none
British Waterways	Assistance to public in navigation on waterways.	Protect its own structures. Help to warn the public of risks using its own navigation system. Provide specialist equipment, materials and other resources as appropriate.	none
Insurance companies	Insurance of properties in floodplains.	Provision of insurance where appropriate. Conditions for provision of insurance.	none

Loss Adjusters	Specialists in the control and repair of damage. They are usually appointed by insurers to act as their agents in handling claims, particularly those of potentially high value.	Review "after event" claims and situations. Could be a useful source of post event information for the Agency if advice is channelled from the Agency on what information to collect (confidentiality clauses apply here).	None.
Flood Defence Committees	Flood defence expenditure.	Allocation of flood defence funding.	None.
LGA	Formed to promote better local government and work with the Government to improve public services.	To better address coastal issues important to coastal local authorities the LGA formed a Coastal Special Interest Group (SIG) which acts on behalf of coastal LAs in lobbying government and raising awareness of coastal issues.	None.
ADA	IDB co-ordination.	Co-ordination on flooding matters.	None.
ABI	Representative body for insurance companies.	Co-ordination on flooding matters.	Separate GIS system on flood risk associated with post code
Association of Chief Police Officers (ACPO)	Law and order.	Co-ordinate emergency response. Assisting in the saving of lives and property protection. Establish cordons to help other emergency services. Process casualty information.	None.

Chief and Assistant Chief Fire Officers Association (CACFOA)	The local Fire and Rescue service has responsibility primarily for saving life, but they can also help by pumping out properties following flood, which will aid drying out. Sometimes a charge is made for this service.	Emergency response including rescue. Minimise effects of major flooding on the community.	None.
Ambulance Service	Focal point for all NHS/medical resources	Treatment and care of those injured at the scene of a flood. Determination of priority evacuation routes and receiving hospitals.	None.
Communications Media	News reporting and communication	Disseminate flood warnings received from the Agency to agreed standards. Disseminate updated information during a flood event. Disseminate stand down messages received from the Agency to agreed standards.	None.
Professional bodies	Professional standards Technical advances.	Promote good practice .	None.
Met Office	Provision of heavy rainfall warnings, severe rainfall warnings, weather radar data etc.	None	None.

Engaging local action groups to facilitate accurate information on actual flood aspects presents a real opportunity for the Agency. Questionnaires have, for example, been prepared by some flood action groups, to assist in gaining specific details on which houses or rooms were flooded and why. In addition, capturing local historic flood event information can be gathered at the same time. Nevertheless, gathering anecdotal information is fraught with subjectivity, however if the questions posed attempt to compare recent with past flood events as far as possible on a like-for-like basis, such information may be of value to the Agency in determining a change in flood characteristics (see Box 4.2).

The Post Event Appraisal project (Bullens 2003) suggests that quality assurance procedures are not widely used at present and need to be developed for post event monitoring and data collection to ensure both consistency in data densities, formats, accuracy etc and to achieve quality control of the data collected. Attention also needs to be given to data format. Recommendations are put forward for future specifications that require survey results to be provided in Access® database formats. This can provide a wide scope for interpretation though has been found to result in incompatibility of data from different sources and events. In addition to consistency and compatibility, the formats must be able to accept data from field collection with the minimum of intervention, which can be time consuming and therefore expensive.

Box 4.2 Standardising Post Event Recording

The findings from this (FD2314) research re-iterate the findings from Bullens (2003). Semi structured interviews and questionnaire replies identify several areas in which the conduct of future studies (quality and standard) can be improved. Particular areas that have been identified include:

- Preparation of a clearly defined specification, (format, quality and standard of data, equipment).
- Staff training, (including prioritisation of data collection issues).
- Preserve continuity from previous projects/initiatives.
- Maximising the data collection opportunities during initial site visits.
- Liaison between Operating Authorities and stakeholders at various levels.
- Checking quality assurance of data, definition of deliverables and associated formats, dynamic feedback.

4.4.2 Establishment of a Central Information "Hub"

Defra is providing high level strategies on data and information management (IACMST ongoing work) to underpin their broad data and information management strategy. Whatever is advocated needs to complement the range of ongoing initiatives in place. Box 4.3 identifies one possible quick win solution.

One possible approach maybe to introduce a central data co-ordinating "hub". This "hub" can take a range of forms, though it needs to be separate from other

stakeholders as it needs to focus on "services" rather than "data", thus playing a facilitator role. This approach seeks to harmonise the roles of stakeholders within FCM to help facilitate access to data, identify priority information products and importantly, "broker" financial and copyright related issues which currently are crippling progress within FCM within England and Wales. The Hub would therefore *enable* stakeholders within FCM to cooperate more efficiently. Figure 4.3 outlines the current framework for the Agency's National Flood Defence Data Management Group (Agency 2003d). This outlines a positive approach to establishing this "hub" concept within an organisation. The concept of this now needs to be promoted to a broader stakeholder base currently operating within the FCM industry.

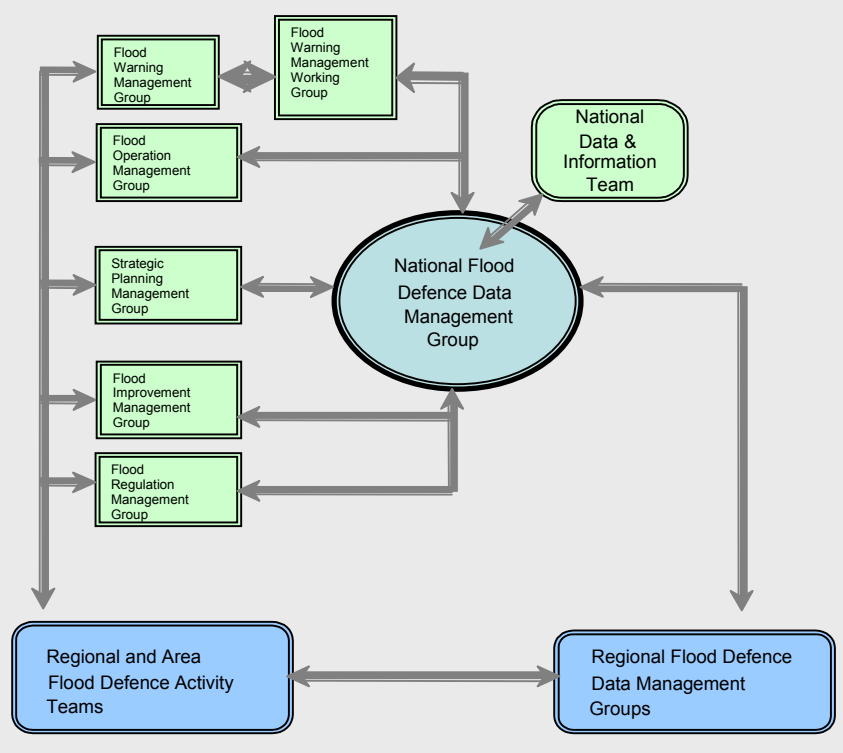


Figure 4.3 Data Hub concept adopted by NFDDDMS

4.4.3 Improved Clarity on Legal Compliance for data

4.4.3.1 Intellectual Property Rights

The vast majority of data required for FCM requires the issue of licensed use and Intellectual Property Rights (IPR) to be addressed. Where information is combined into large datasets, multiple ownership of the original material brings a raft of complexities in terms of agreements and licences. Box 4.4 identifies one mechanism that could be used to mitigate against the complexities involved.

Ordnance Survey and ODPM have negotiated a Pan-government Service Level Agreement under which all government bodies may access OS map data at extremely advantageous fee rates – the Agency is currently saving significant sums each year as a result of joining the scheme. The case should be set for UKHO bathymetric data to adhere to a similar approach.

Box 4.4 Pan Govt Service Level Agreement

This issue ultimately affects data access. The licences purchased for much of the data used in the first round of Shoreline Management Plans (SMPs) meant that the databases could not be maintained after the end of the project. This issue is currently being addressed by Agency/Defra and updates to the current SMP2 Interim Guidance are to be expected.

Additionally, some licences are limited in the number of terminals, which restricts distribution. Therefore, modifications may be needed to standard licences to allow them to be used in the dynamic development of plans such as Catchment Flood Management Plans (CFMPs) and SMPs in the future.

Licensing of the datasets should acknowledge the specific uses, the reproduction, publication and subsequent distribution of the resulting information and potentially the development of web based products. Modification to standard licence arrangements (through an agreed body) may be required to provide for the type of use envisaged by the programme.

Value Added Resellers (VARs) provide a key service to the public by obtaining Agency data under an appropriate agreement and repackaging it in a variety of different ways for their own target audience. The Agency has a policy of charging royalties on profits made from the use of Agency data and information in this manner. The Agency also reserves the right to receive back from VARs upgraded data which has been amended as a result of the additional checking and processing which the VARs carry out. It is not clear how VARs are being or likely to be used in future FCM. This issue needs to be more clearly reflected and communicated into FCM to assist all stakeholders and policy decision makers in the future.

4.4.3.2 Acknowledging European Legislation

Several important pieces of legislation have been initiated at European level and are expected to potentially influence future FCM data management. They include:

- The Water Framework Directive (due for implementation from 2004).
- The Access to Environmental Information Directive (to be implemented through a statutory regulation which is currently being finalised by Defra and which replaces the existing 1992 Regulations). (see Box 4.5).
- The Re-Use and Exploitation of Public Sector Information Directive (to be introduced in 2004). (see Box 4.6).
- INSPIRE – the Project for the creation of an Infrastructure for Spatial Information in Europe. (current decisions on this are being discussed - see Box 4.7).

- EC Directive on Environmental Liability adopted by the European Commission on 23 January 2002.

A new EU Directive on Public Access to Environmental Information was adopted in December 2002 to replace Directive 90/313/EEC (which underpinned the UK's 1992 Regulations). The aim of this legislation was to take account of developments in technology and socio-economic conditions within the EU, and also to reflect the requirements of the UNECE Aarhus Convention which the UK signed in 1998. Aarhus, for the first time, makes a specific link between environmental information and human rights, and guarantees the citizen access to information, participation in decision-making and access to justice.

Section 74 of the Freedom of Information Act (FoIA) 2000 enables the making of regulations to provide for implementing the information provisions of Aarhus, for dealing with matters arising from this and for the issue of a Code of Practice. Policy-wise, although disclosure under FoIA and EIR is subject to the public interest test, public authorities are encouraged to be proactive with their information by putting as much as possible into publication schemes and making useful information available on web sites.

Box 4.5 Environmental Information Regulations (EIR)

The Public Sector Information Directive (PSI) is expected to be adopted by the European Council in November 2003 and will be entered onto the EU Statute book shortly after. The member states of the EU (all 25) will have 18 months to implement the PSI Directive. The overall elapsed time from when the EU initially agreed the PSI strategy will have been 17 years by which time it will still not be clear whether public sector information has been opened up for reuse and exploitation across the EU

The EC will monitor the implementation of the PSI Directive annually and report to the European Parliament. The intention is to review the effectiveness of the PSI Directive three years after its implementation, i.e. in 2008.

The proposed Directive aims to ensure that in relation to the reuse of public sector information the same basic conditions apply to all players in the European information market that more transparency is achieved on the conditions for reuse and that unjustified market distortions are removed. It will offer legal certainty for the market players and establish deadlines for changes, while leaving the Member States to choose the precise way in which its provisions would be adapted to local circumstance. The terms of access to Public Sector Information are left to the Member States to implement.

Box 4.6 The Re-use and Exploitation of Public Sector Information Directive

The Environment Agency has played a significant part in helping to develop the European Commission's INSPIRE programme, formerly named the Environmental European Spatial Data Infrastructure (E-ESDI) project, which has already impacted many information management programmes throughout Europe by virtue of having laid down some important principles. INSPIRE will not, however, directly affect Member States until 2007-8 at the earliest, although key organisations are advised to start their preparations as early as possible, given the potentially far-reaching nature of some of its proposals.

The INSPIRE Framework Definition Support Working Group's Report (which included the findings of an Extended Impact Assessment study) considered several policy options for INSPIRE and recommended that the initiative should aim towards a broad framework of common principles, standards and best practice backed by an EU Directive based on the subsidiary principle of devolved management to Member State level where obstacles may be effectively addressed in a step-by-step manner.

Following acceptance of the above, the European Commission developed the draft INSPIRE Directive ready for the EC to consider and adopt before submitting it to the co-decision process for adoption by the EU. (European Parliament and European Council).

It is understood from a variety of sources (at the time of writing) that INSPIRE has now been put on hold and that the UK (ODPM, OS-GB, Defra) made an intervention both written and verbal against the recommendation of the Impact Assessment reported above. It is understood that the UK prefers a voluntary implementation. If this UK position is confirmed then it has knock on consequences for all UK SDI initiatives.

Box 4.7 INSPIRE

4.4.4 Improved Role of Specific Groups

4.4.4.1 Regional Development Agencies (RDAs)

Regional Development Agencies (RDAs) may have an enhanced responsibility for co-ordinating public sector business support and advice in certain flood data management and dissemination activities. This applies in particular to post flood event recovery initiatives. RDAs could, for example, take direct responsibility for capturing or being the repository of certain datasets from business. They should also take steps to improve the quality and consistency of data on flood issues to support and advise business and support services. These issues require more detailed discussion with key organisations in the future.

The potential of Rural Community Councils as partners in community or "catchment" based delivery is underestimated and should be enhanced. The concept of "Watershed Management" partnerships overseas is not new and there are good examples where such initiatives have helped to formalise data management issues within a watershed (or catchment). Often in Flood

Management initiatives, the local perspective is lost and valuable information is not relayed back to Regional and National offices. Lessons from the ongoing (at the time of writing) ICZM in the UK Stocktake exercise (Atkins 2003) suggest that establishing information and setting data "portals" at the catchment or partnership level is often most appropriate, so long as there is a standardised framework that this links to and avoids fragmentation of responsibilities. For FCM, it is proposed that local Flood Forums need to more closely liase with RDA's about issues on the ground and the local delivery of national policy.

4.4.4.2 Roles and Responsibilities of the Private Sector

Using an example from outside FCM, Defra has developed the British Radioactive Waste Inventory Management System (BRIMS) which brings together information on UK radioactive waste holdings including quantities, physical and chemical properties. In addition, information on individual waste packages, storage locations and ownership has been included to provide a comprehensive database for the UK national inventory bringing together information from all the major UK radioactive waste producers.

Private sector customers in general (within FCM) therefore need to be involved in defining priorities for data collection, participate in choosing appropriate "systems" for data storage (to appropriate standards) and to also participate in disseminating data resources. An immediate challenge that faces the Agency and Defra is how to demonstrate the benefits and to encourage the involvement of specific industries and groups into sharing data and information across sectoral and business groups. Water companies (for local sewer flood data) and the insurance sector is particularly important in the FCM debate and are key potential providers of information though understandably, are reluctant to sign up to an "open data exchange" relationship.

4.4.4.3 Roles and Responsibilities of Local Groups

Local residents and recreational clubs (eg: angling and canoe clubs) can often provide valuable information. This can include knowledge on the extent or depth of flooding in their locality (often mainly anecdotal) or through highlighting locations and properties flooded (provision of photographs). Longer term residents may have knowledge of previous floods as well. At some locations it may be possible to enlist the help of local Flood Wardens to provide a record of the flood event and to mark maximum flood levels. This could help to maximise data collection whilst resources are stretched, though quality control (linked to accuracy of this information) needs to be a key issue here. Often, it is perhaps more appropriate to use this data to confirm evidence of flooding found at a site (photographs etc).

The Flood Forum groups, for example, have captured the interest of those directly affected by flooding. One possible way forward may be for the Agency to better communicate incentivised schemes to encourage such groups to collate data in specific areas. These could be grant assisted by the Agency for appropriate and timely delivery of data and information that adheres to High Level Defra/Agency targets.

An often overlooked potential resource of data provision is that of the Emergency Services. Whilst the Police maintain primacy in all civil emergency response situations, and generally lead the arrangements for establishing an Emergency Command and Control Structure, they also provide a potential source of information for FCM. This can include support services for water companies (sewage related) and also to inform Defra/Agency on their perception of community vulnerability for an area.

Local Authorities are a good source of information on flood events. Leeds City Council, for example, maintain archives of events and commissioned the maintenance of a website of flood photographs which proves of great use to emergency services, operating authorities and consultants alike.

As stressed throughout this report, data quality and standardisation in approach is paramount, and such initiatives presented here should only be undertaken in addition to other data collection methods as a means of clarification or where competent authorities (Defra/Agency) provide sufficient back up advisory services (internal or seconded).

4.4.5 Long Term Funding

The research has highlighted that one of the top constraints to effective data management in the FCM industry at present is the unwillingness to fund long term collection and management and the resistance to collect data because its potential use cannot be envisioned. Climate change and demographic datasets, for example, are costly datasets to compile with limited (if any) short term value to decision makers. The reduction in the number of rain gauges, for example, in inaccessible areas (mountainous areas) is a case in point leading to data sparsity where it is often most needed.

There is a need for open forward thinking on this topic to where possible:

- Identify future problems that will need new data.
- Provide convincing arguments to authorities/funders for its collection – lead institution, willingness, management, funding, and prioritisation.
- Make recommendations for arranging its storage/dissemination.

4.4.6 Planning for Changes in Roles and Responsibilities

This report does not advocate the need for a major change to current roles and responsibilities within the industry. Some activities within FCM (such as event data recording – Bullens 2003) are inevitably non-programmed activities and must be initiated at short notice when organisations and their staff are under considerable pressure responding to flood and erosion events. The advanced planning of activities for monitoring and recording during and after an event is, therefore, an important and essential pre-requisite to effective post event analysis.

Operating Authorities for example, could be requested to develop plans (based on their local knowledge of the likely impacts of events) which fully recognise the need to provide information that is important to other parties. It will be essential

to anticipate that unexpectedly severe flooding (or erosion) can require a rapid review of pre-established priorities for data collection.

Extreme events also provide opportunities to capture additional data (e.g. wave overtopping, check gaugings, velocity profiles, etc.), but may also test installations at design limits. It is acknowledged that the Agency already have high flow gauging teams ready to go out on site during events, however, the issue of budgeting remains a key issue in the long term implementation of this activity. To assist this task, nominated staff (for relevant bodies including the Agency and those responsible for networks) could be deployed, during an event, to capture extra transient information (especially for high flow spot gauging) and to check equipment is fully operational.

Setting up adaptive planning for priority information is therefore needed, identifying who captures it and where it needs to be stored (and in what format). For example, there is no formal requirement to install instrumentation to monitor performance (levels, CCTV etc) in new coastal or fluvial defence schemes which could be implemented for a small additional cost to the capital scheme costs.

Pre-planning and call-off contracts (outsourcing) will be required to ensure rapid mobilisation, which is essential to capture many features of the event. Plans for post-event data collection must ensure that identified staff are allocated to these and other time-critical data gathering activities and not diverted to the operational response. Both the time available and the resources that can be mobilised (including external resources) may limit data collection activities, when priorities are the protection of life and property. Consequently a hierarchy of data collection needs to be established.

The requirements of users and stakeholders will change with time; therefore, procedures must be set up to review data collection plans on a regular basis. For example, data to support future investment planning includes:

- Locations where schemes are in place.
- Locations where the need for schemes has been identified.
- Other sensitive locations (e.g. on main river and critical ordinary watercourses, such as undefended flood warning zones) and areas identified in local plans for development.
- Data for Catchment Flood Management Plans and Shoreline Management Plans.

Pre-planning must also extend to the specification (at the design stage of schemes) of the data needed to assess their performance (including levels, flows, wind, tide etc). Defra should include this requirement in future project appraisal procedures.

4.5 Recommendations

The following actions are proposed. These have been kept generic to avoid specific alterations to roles and responsibilities unless a particularly strong case for change has been put forward through the consultation process of this project.

- Communicate Best Practice Better – Within the Agency, the Flood Defence Data Management Group is working closely with the SATIS team on FCM data needs and acquisition plans. This needs to acknowledge how best to

communicate what is required by consultants/academics/planners. It is recommended that this issue is developed, identifying clear routes and methods for third parties to be encouraged (as part of a structured data strategy) to provide value to the industry. This can focus on a variety of issues, such as establishing provenance and /or copyright issues. It may be implemented through coordinated workshops between private public sector with potential incentives for attendance and delivery (eg: a beneficial Key Performance Indicator – KPI)

- Establish a Single Point of Contact (SPC) - The objectives of SPC are the removal of work duplication for both the Agency and external data providers, in turn reducing the resource implications in the provision of data and the improvement of data management. This needs to be clearly communicated to all range of stakeholders to ensure the message of SPC (wherever this may be) is clearly understood.
- Better appreciate the role of VAR's within the FCM industry.
- Tap into Local Information Sources (including Academia) - Little attempt seems to be made by responsible authorities within FCM to set a policy that taps into the local knowledge that is still held by those who work on rivers and coasts. Specific examples have been presented on how local flood groups received their flood related information.

5. PROCESSES AND PROCEDURES FOR FCM

5.1 Generic Data Lifecyle Issues

Table 5.1 below shows generic 'process and procedures' issues associated with the management of data:

Table 5.1 Process and Procedures Data Lifecyle Issues.

Lifecycle State	Issues to consider
Creation	Data capture specifications.
Storage	Procedures for community metadata standards. Procedures for community data standards.
Access	None
Update	None.
Retention	Guidelines for post-project data retention.
Deletion	None.

5.2 Specific Risk Management Issues

Table 5.2 below shows specific 'process and procedures' issues associated with risk management

Table 5.2 Process and Procedures Specific Risk Issues

SPRC	Issues to consider
Source	None.
Pathway	None.
Receptor	None.
Consequences	None.

5.3 Data Capture Specifications

Whilst it is acknowledged that many organisations within FCM undertake their own data checks, often, any noted changes to datasets or errors noted do not always get fed back to the organisation providing the data. Hence there may be multiple versions of the same dataset all with different levels of quality assurance performed and not fully documented.

Presently it is not clear within FCM where and how data capture specifications are documented (i.e. how is it determined whether data are suitable for FCM). There are procedures being established for data exchange between tools such as NFCDD, MDSF[5] and PAMS and the Agency has National Standard Contracts and Specifications for Surveying Services, but these presume existence of the data capture specification.

[5] MDSF is an example where a procedure has been developed into tool that provides the basis for defining data standards for integration within a common data analysis tool.

Related to the above, it has not been possible to identify any widespread adoption for data Quality Assurance (QA) regarding their suitability in FCM. Paradoxically however, there is also no documented demand either from users for formal QA other than for establishing data provenance (see Box 5.1). Indeed, most demand for QA seems to be driven by internal requirements (see Box 5.2). INSPIRE, for example, has considered data quality issues and specified data quality procedures (Box 5.3).

Data provenance is vital to successful FCM management. Often uncertainties cluster around the following points:

- Who collected the data originally and how?
- Who is responsible for its update now?
- Can it be used in the context a different stakeholder needs?
- Who are the suppliers of the data and are they different?

This information is required in basic metadata standards so the procedure does exist to supply it.

Box 5.1 Data Provenance

Data quality is an issue that continuously exercises Agency resources. The commercial activities of DIEU within the SATIS group generate a significant amount of "external" income the greater proportion of which is directed towards supporting the data quality improvement programme. This is an important issue to contemplate in future reviews or action plans for better re-use of data and information within the industry.

The Agency Data Policy team is responsible for implementing Agency wide data management policy, including taking a lead role in the identification, assessment, prioritisation and resolution of data quality issues. It is good that responsibility for this is assigned, but it was found that organisations working on FCM projects for Defra/Agency have no visibility on how this impacts their working practices.

Box 5.2 Data Quality and the Agency.

Recommendations on quality assurance procedures, as set out by INSPIRE, state:

- The quality of the reference data should be known.
- To adopt ISO19113 quality principles and ISO19114 quality evaluation procedures.
- To document the results of the quality measurements in dedicated ISO19115 fields.
- However, the setting of data quality parameter levels will require further study.

Box 5.3 INSPIRE recommendations on data quality.

5.4 Community Standards for Metadata and Data

The FCM community[6] would benefit from improved metadata and data interoperability so data could be shared more effectively. Unfortunately, given

[6] As discussed in Section 3, the FCM community contains stakeholders from different discipline areas.

the diversity of the FCM community it is not simply a case of stating 'everybody use this standard now!' (Box 5.4). This is the same situation faced by the marine community and work is presently underway as part of the MarineXML project[7] to develop procedures whereby heterogeneous communities can communicate in an open way (Box 5.5).

There are large numbers of metadata standards in use by the FCM community. Key ones include Dublin Core, FGDC, NGDF, e-GIF (Dublin Core Profile) although mostly bespoke approaches are used. ISO-19115 is the standard geo-spatial metadata (superseding NGDF and FGDC) and it would be beneficial to establish an ISO-19115 compliant metadata profile to serve the FCM community. The present application of the FGDC profile in the South Coast Observatory and the South North Sea Phase II Transport Study would provide a good starting point here.

Community standard data models are in existence such as those used within NFCDD). E-GIF is also advocating the adoption of open source data formats such as GML. There is also a range of proprietary data formats for databases, GIS and numerical models. The NERC Data Grid team has developed ISO compliant data and metadata models to facilitate virtualisation of scientific and engineering data. These models are being used by the MarineXML community and could easily be adopted by the FCM community. FCM terminology details can be confirmed through a specific FCM "ontology" and re-fed back to projects/initiatives such as NFCDD.

Box 5.4 Data and Metadata Standards.

Interoperability requires that relevant sources of data are accurately and easily identifiable, and messages exchanged between the sources and the requestor of information is understood. There are different situations in which interoperability is provided:

- predefined/closed versus open processing environment.
- closed/proprietary interoperability rules versus open interoperability standards.

In a predefined/closed processing environment, all the known parties agree on a set of closed/proprietary rules and build interoperability around them. In an open processing environment in which parties come and go, (as is the case with the FCM community) closed/proprietary rules are not appropriate. In the FCM community, there is a strong trend to move towards open interoperability rules, but over many years most of the FCM community have accumulated data under closed/proprietary interoperability rules. For these organisations moving away from closed/proprietary sets of interoperability rules is not an option as it would entail a massive conversion effort. Instead they require an opportunity to subscribe to open interoperability standards with mapping mechanisms to the existing formats.

Box 5.5 Community Data Interoperability (from Millard 2003).

[7] www.marinexml.net

Given that there is a large number of different data standards and formats in use with the FCM community, FCM would benefit from establishing a 'standards registry' to serve data standards to the community with information on what standards exist and exchange between them. This should link to other communities' registries as required. However, even if standards for metadata and data are in place, it needs to be determined how they are complied with and compliance is enforced (See Box 5.6). For this reason the value of metadata needs to be communicated to the FCM community, i.e. compliance by 'carrot' rather than 'stick'.

Volume 3 of Bullen (2003) Post Event Appraisal – (Outline) Best Practice Guide Monitoring, Recording and Analysing Events, provides a formal approach to understanding the importance of various stakeholders in FCM operating to a common standard to gather and re-use information that is collected after a flood event. Of interest is a statement that suggests that most Agency regions have not adopted the national standards developed for flood data collection by Thames Region (Bullen 2003). As a result records are kept in a variety of formats and media, which makes data transfer and sharing between organisations inefficient and often labour intensive; this also leads to difficulties in analysis and appraisal.

Box 5.6 Compliance (exemplified by current Post Event Appraisal methods).

5.5 Post-project Data Retention

The researchers were unable to deduce the exact mechanisms in place for managing post-project data retention, i.e. passing the data back to the Agency. It is appreciated and acknowledged that the accountability for Data Management in Flood Defence rests with Strategic Planning and that the Agency's Strategic Planning Management Group has established a National Flood Defence Data Group to oversee data management on its behalf (Agency 2003d). This Strategy demonstrates good working principles and it is envisaged that further revisions and actions dictated by the March 2003 Strategy (which has been slightly updated) shall be addressing this issue from the Agency's perspective.

Defra Flood Management are placing greater emphasis on post project data retention through the joint R&D programme. However, there is a clear difference between retention of data "in house" and retention of data for re-use by third parties. Current debate is underway for the re-use and retention of data generated for the second generation SMP process and this is likely to be replicated for the onset of the CFMP process currently underway following the production of Pilot CFMPs (Halcrow 2002).

5.6 Recommendations

The FCM now has an excellent opportunity to take advantage of the internal standards development to strengthen (and rationalise) the processes and procedures that support its activities. In this area little research is required - it is simply a case of 'getting on with it'. The sound work of the Agency, currently underway as part of the NFDDDMS (Agency 2003d), represents a solid platform

for the Agency to work from, though additional particular actions for the industry as a whole may include the following:

- Establish an ISO-19135 compliant FCM data standards registry. This can be regarded as going hand in hand with the recommendation under 'Information' for an ontology of FCM activities (see Section 3.8).
- Establish an ISO-19115 compliant FCM metadata standard. This can be established in conjunction with the NERC data grid team using the experiences gained from the marine community.
- Introduce standard text that can be included into all Terms of Reference for Defra/Agency projects (NCPMS or research contracts) to ensure standardisation of data collected, stored and disseminated. To some extent this is undertaken on some Agency flood risk mapping projects, but it certainly doesn't appear to be a common practice within FCM as a whole.

6. ENABLING TECHNOLOGIES FOR FCM

6.1 Generic Data Lifecycle Issues

Table 6.1 below shows generic 'technology' issues associated the management of data:

Table 6.1 Enabling Technologies Data Lifecycle Issues.

Enabling Technology	Issues to consider
Creation	Using new or existing technologies to create data is only beneficial if it assists in achieving a required high level target.
Storage	Data format interoperability and 'end to end' processing. Data semantic interoperability.
Access	Internet-based approaches for distributed data access. Ontological approaches to query multiple faceted data. GSM/wireless approaches for data access.
Update	Use of mobile devices for field data collection and update.
Retention	Technology migration.
Deletion	None.

6.2 Specific Risk Management Issues

Table 6.2 below shows specific 'enabling technology' issues associated with risk management.

Table 6.2 Enabling Technologies Specific Risk Management Issues.

Enabling Technology	Issues to Consider
Source	Databased forecasting techniques. Real time via web or satellite access to tide gauge data.
Pathway	Hand-held computing technology provide cost-effective and more accurate updating of defence assets. Technological solutions can be subject to vandalism, power outages and slack maintenance.
Receptor	Remotely sensed terrain mapping techniques (such as LiDAR, SAR etc) to reduce costs in flood risk mapping.
Consequence	Mobile phone technology be used to provide better flood warning and reduce the consequences of flood events. Visualisation technologies to improve risk communication. Knowledge Management tools.

6.3 Data Creation Technologies

The research has clearly demonstrated that the UK is at the forefront of using the latest available technology (where appropriate and cost effective) to assist in

gaining better information on flood issues. Box 6.1 demonstrates (in summary) how specific satellite techniques and technologies are being used to best effect.

Kinematic GPS

Kinematic Global Positioning System (GPS) provides the opportunity to capture data with a vertical accuracy of approx. ±2 to 3cm and horizontal positioning at approx.±5cm. A minimum of two GPS receivers, linked by radio, are required. One receiver acts as a base station. The EU Galileo system will provide an alternative to the US GPS positioning system in a few years.

Earth Observation

Satellite monitoring frequency of coverage is currently poor, although Topex/Poseidon are now used to provide information on wave heights. Moreover, satellite Synthetic Aperture Radar (SAR) detail is improving as it can give ground elevations to an accuracy of less than a metre. Although satellite SAR does not give absolute elevation, comparing the results of successive surveys could be used to give changes in elevation. Satellite SAR surveys could be mapped onto aircraft-based SAR surveys (or other ground truthing) to provide absolute elevations.

DGPS Tide Gauges

Differential Global Positioning System (DGPS) tide gauges are currently being used for measurement of water levels and crustal/eustatic movement. (see http://www.pol.ac.uk/ntslf/).

Box 6.1 Satellite Techniques.

Aircraft remote sensing techniques are more common place, and as technology is advancing (Pope *et al* 1997; Wozencraft 2003), it is clear that its use is providing decisions makers with good advice. It is recommended that the specific needs of a project (whether data be of LiDAR or SAR quality) is linked back to a project "ontology" (see Section 3.8). Box 6.2 demonstrates how such techniques are being used to best effect.

LiDAR

Light Detection and Ranging (LiDAR) is an airborne mapping technique that uses a laser to measure the distance between the aircraft and the ground. The Agency has a LiDAR system which it has installed in a survey aircraft along with its other operational remote sensing instruments, including the Compact Airborne Spectral Imager (CASI), a thermal imager, high quality VHS video camera and a digital camera. With LiDAR, Individual measurements are made on the ground at 2 metre intervals with a vertical accuracy of ±0.25m.

The Agency's Flood Defence function has a requirement under the Water Resources Act 1991 to monitor the flood plain. LiDAR is being used to measure land topography and assess coastal erosion and geomorphology. The Agency has generated a map of LiDAR and SAR datasets which is available on their website. Routines are also established to allow for the removal of surface features from the data sets including vegetation and buildings. A large and extensive archive of LiDAR data files are available and is searchable using the downloadable database.

Compact Hydrographic Airborne Rapid Total Survey

Compact Hydrographic Airborne Rapid Total Survey (CHARTS) is a new system that was field-tested in summer 2003 (Wozencraft, 2003) and combines three sensors in a single system:

a) 1000 Hz hydrographic LiDAR

b) 10 MHz topographic LiDAR

c) Digital camera.

CHARTS has a 10 MHz topographic LiDAR to enhance data-collection over land. The system offers the potential to survey an entire catchment using a single system, including river beds and shallow lakes. CHARTS is also designed to be accurate to IHO Order 1 specifications.

Orthorectified Aerial Photos

Aerial photographs have been used in the past, for example in some SMPs, to illustrate geomorphic features and to derive datasets. Geo-referenced orthorectified aerial photographs can be incorporated within a GIS to provide the basis for displaying features. Two main sources for these images exist: UK Perspectives and Millennium Mapping. Other data sources should be appraised before a license is purchased. For example, some remote sensed data (Landsat or CASI) may be available. Defra holds a restricted license for England from UK Perspectives, which would not currently allow for use within a SMP.

SAR

The application of the recently built MDSF (Modelling and Decision Support Framework) to the development of CFMPs and SMPs has triggered the need to acquire more appropriate flood plain/area topographic data than that produced by LiDAR. It has led to the Agency co-funding (with Norwich Union) the collection of SAR data (by a Canadian Earth Observatory company called NextMap) as a basis for developing a DEM (digital elevation model) of fluvial flood-plains and coastal flood prone areas. The accuracy of the new jet-flown SAR DTM should be 1m in all regions except region 8 (the SE of England) where it will be ~0.5m. The survey has been flown and the data processed. Checking of the data is underway.

Box 6.2 Aircraft Remote Sensing Techniques.

6.4 Data Access Technologies

6.4.1 Internet-based approaches and GIS

The worldwide web remains a powerful tool for the FCM industry. However, the quality of information available often requires close scrutiny for its appropriateness. The main GIS systems in usage at the moment are from ESRI (Arc family) and MapInfo. Examples of GIS usage in FCM include the coastal extension of Multicriteria Decision Support Framework (MDSF) GIS tool.

This report does not go into detail on the design of GIS within the FCM industry. This is a large topic area that is being rigorously assessed through ongoing

Agency/Defra projects (Environment Agency 2003d, Halcrow 2003). The outcome of the IACMST project is viewed as the most appropriate report for GIS related future technical strategies for marine related data. Specific tools/techniques such as RASP, MDSF and PAMS are used to demonstrate the GIS related situation (see Box 6.6). It is with interest to note similar generic statements being concluded as part of the recent Irish Sea Pilot project (JNCC 2004) as well as the ICZM in the UK A Stocktake initiative (Atkins 2003). Perhaps the main recommendation of relevance to this project is the point that there is a request for

"Improved co-ordination of data collection activities…., including in relation to research activities, in order to better meet the needs of society and to make the most efficient use of available resources. This should include much clearer identification of the specific data collection responsibilities of public bodies. In the UK, Defra should take the lead in developing improved co-ordination, including in relation to co-ordination with neighbouring countries. A greater degree of collaboration between survey organisations should be promoted and encouraged".

In terms of making use of web based technologies, there are many sound examples of good practice which demonstrate clearly how well FCM is utilising this technology for better information dissemination. Good examples of web-portals for data that should be used as best practice include (but are not specific to FCM) the Multi Agency Geographic Information for the Countryside (MAGIC) which is supported by Defra and has many environmental datasets accessible via its web site (at the time of report writing, is was not understood to be linked to NFCDD). The issue of database "traffic" competing with other intranet/internet traffic, reducing fast access to databases, requires close consideration in the future. Too many users on one central system can create considerable access issues at times of need, for example.

Issues associated with data streaming from hubs (see concept being adopted by NFDDDMS in Box 4.3) need developing and streamlining as appropriate to local needs. In addition, the potential of Agency/Defra providing a search tool for data and information within FCM (similar to a Google search engine) may be beneficial to the industry as whole.

In addition, using technologies to improve risk "visualisation" ("Games") is one area that potentially requires attention. Some good academic work is being carried out at present to support this area, though it is felt that more focused best practice research into its potential use for a range of stakeholders needs to explored. Virtual reality software packages to present "what if" scenarios are valuable in putting worst case situations across to the public. This work does need, however, to be couched within an appropriate participation/consultative framework to avoid presenting incorrect messages to stakeholder groups.

An additional issue of relevance to data access technologies in the future is linked to the use of public access internet sites with password protected private areas for customers sponsoring data acquisition The purpose here is to enable data sharing and rapid updating of existing data sets and to gain a sense of "ownership" which should be broadened within the FCM industry. This issue perhaps needs closer attention.

It is widely appreciated that a number of organisations have established information systems to address their own individual data and information requirements. Whilst some have resulted in successful collaborations between organisations in most cases, there has been limited communication between them and they have been developed in isolation. As a result many data project portals tend to be specialised and do not always take into consideration the needs of other interested parties. This also has often resulted in duplication of effort. Outside of the FCM industry, it is apparent that a range of GIS platforms are set up to store different datasets (eg:Highways Agency). This needs to be mitigated against within FCM and the work by IACMST is paving the way for an appropriate strategy for marine related datasets (report awaited during 2004 – see Box 6.4).

Box 6.3 Risk of Effort Duplication.

Defra in 2003 commissioned IACMST, through its Marine Environmental Data Action Group (MEDAG), to investigate:

- Generic issues in current activities (drivers, problems and constraints, co-ordination issues, use of standards, interoperability, sustainability, user community needs, options for visualisation, QA, business case for data activities, future directions).
- Best practice (data, mapping, UK, Europe, elsewhere).
- Emerging developments which impact on data collection and use.
- Generic themes for a future strategy which has the broad objective of recommending rationalisation of existing practices, where economies may be achieved, and establishing the principles of an outline business case for greater effort in this area.

A preliminary draft report has been produced and the concept of a Marine Data Gateway accepted by IACMST members in September 2003. This will be a neutral, central resource, signposting and providing access to relevant datasets. An 'expert' group comprising interested government bodies and agencies are now examining the options for implementation and management. It is anticipated that the alternative models for the long term sustainable management of this data including housing, archiving, etc will be discussed at the next IACMST plenary in January 2004 (outcome uncertain at time of writing).

Box 6.4 IACMST Marine Data Gateway.

The Agency's project "Checkmate" is currently examining hand-held data loggers and the current Agency North East Regions project is exploring the practical implementation of hand-held GIS systems in the field. These are still ongoing and may identify opportunities to streamline post event data collection. Their results should be reviewed and where appropriate incorporated into procedures for post event data collection.

Box 6.5 Project Checkmate.

6.4.2 Telemetric Technologies

Telemetry has been used for over 20years and continues to be an effective method to transmit data automatically to data centres where the processed data may become available in near to real time. Telemetry, still needs to verify calibration against more conventional recording systems such as tipping bucket rain gauges. Telemetry, aided by advances in instrumentation, has meant that staff time to check measuring apparatus is not required as often as it used to. The advantage of this is capital cost. The disadvantage is that systems are now often more difficult and expensive to repair than simpler systems. Internationally, phone (PSTN), radio, Metosat and more recently mobile technology (GSM) is, however, being used to good effect.

6.4.3 Data Interoperability

A particular gap in technology at present is that having collected the data in the field, there is a need to develop techniques to automate the processing of field data into floodplain maps and other deliverables such as databases and GIS. Khatibi *et al* (2003) focus on this issue in detail.

The FP5 project "HarmonIT", is a relevant example which appears to create internal intelligence within software systems to recognise third party datasets. In addition, the National Flood Forecasting Project (NFFP) is overseeing the development of an open shell forecasting system based on open architecture with the outcome of realising user-designed modelling systems. This system creates external data management intelligence through published interfaces and adapters. It is hoped that raw data can be packaged using categorisation and systems science approaches as appropriate tools. This is similar to the ARION project[8] that enables users to publish data and models that are distributed over the internet and build 'workflows' between them to generate data.

Using flood forecasting as an example, the following outlines ways in which management systems within FCM Data and Information management could be improved.

- Automated procedures for post event monitoring (flood warning performance against national targets).
- Improved procedures/techniques for the monitoring and evaluation for the performance of forecasting models.
- Improved availability of archived data and forecasts to researchers etc e.g. over the internet.
- Facilitating real time exchange of data and information between government Agencies – Agency, Highways Agency, Coastguard etc, local authorities and other operators (water, electricity).
- Internet/Intranet dissemination of real time data (levels, rainfall, CCTV etc).
- Knowledge based decision support systems for extreme events, complex flow control problems (washland operations, tidal gates/barriers etc), ensemble forecasts.

[8] www.arion-dl.org

- Automated historical event data retrieval and analysis to assist in operational decision making.
- Improved integration of coastal and fluvial forecasting systems which traditionally have been developed separately.

Box 6.6 Possible Technological Improvements within Flood Forecasting.

6.5 Recommendations

New technology often carries a high cost, but it can also result in major cost savings in data processing time and staff time during field data collection exercises. What is important to note is that all "cutting edge" technology may also (in certain circumstances) not be the most appropriate technology to use within FCM. To this end, a methodology must be developed for estimating the benefits to be gained from new technology (in terms of accuracy, resolution, coverage and new information) and balancing these against the data needs identified by users of data. There are a number of research programmes (particularly MDSF, RASP and PAMS) that are likely to set the framework for much of the work in FCM over the next 10 years. The methodologies developed for including uncertainty in RASP data could provide a suitable framework for identifying the greatest data needs.

The use of modern technology during surveys and for their subsequent processing could improve the effectiveness of data collection procedures. The use of hand held GPS systems linked to palm top computers would improve the efficiency of data collection during walkover surveys. This could easily be accommodated into current management strategies.

In addition, Agency/Defra need to be able to adapt to future technological change. Data and information strategies therefore need to be flexible enough to incorporate change in technology (primary and secondary data). The issue of storage requirements in the future needs to be taken into consideration as this will continue to emerge as a problem. This adds weight to the need to re-use data wherever possible.

Based on the research undertaken, the following are proposed as actions for the future:

- The results of investigations, by the Agency's NCEDS and the R&D project to test SAR, should be used to develop new procedures. This is especially pertinent to determining the viability of such techniques during extreme weather conditions.

- New techniques should be developed to help develop the automation/processing of field data into floodplain maps and other deliverables such as databases and GIS. Current best practice from consulting engineering firms working on flood risk mapping projects needs to be extracted to formalize an appropriate new approach for "field to office" mapping operations.

- Equipment used in the field must produce data in formats compatible with processing and storage technologies. A Pilot Study could be initiated to generate an appropriate framework for this.

- Review the role of Automation techniques (eg remote sensors, CCTV), changing remote sensing (satellite/aerial photography) techniques and how Digital photograph databases can be incorporated into day to day routine management (for example, simple digital cameras are now very cheap and can be very small – these could be carried by Agency staff and photos taken opportunistically and then uploaded with geo-referencing).

- Review current AgencyDefra systems for logging calls etc from external organisations / individuals and subsequently for recording/storing this info in such a way that it can be retrieved. A relatively low specification GIS-based system would facilitate this for example.

- Continue the research into mobile technologies, satellite technologies and importantly visualisation technologies to help communicate flood risk to all stakeholders.

- Promote concerted action into establishing and focusing "risk communication" software to demonstrate how powerful "virtual reality" or "games" software can be incorporated into FCM consultation.

- As a general point there is the need for the Agency to use GIS modelling in house (if not done already) to open up access to non FCM specific data sets, particularly for land use modelling and understanding the implications of land use for flood management. This will be particularly important when flood defence policies have to be considered alongside others to deliver WFD objectives.

- As there is an ever increasing volume and frequency of real time data (e.g. due to improved spatial resolution of Met Office forecast products), there needs to be a better system capable of generating and archiving stochastic modelling/ensemble forecasts, plus there needs to be improved resolution/frequency of STFS/CS3D forecasts and forecasts for specific estuaries.

- Improve technologies to better communicate flood warnings to 'mobile' addresses e.g. road users, tourists, campsites etc (text messages, RDS, road signs, coastal footpath signs etc).

7. AUDIT

7.1 Generic Data Lifecycle Issues

Table 7.1 below shows generic 'audit' issues associated the management of data:

Table 7.1 Audit Data Lifecycle Issues.

Lifecycle State	Issues to consider
Creation	Knowledge capture (especially tacit knowledge). Value of a particular data set to FCM.
Storage	How often stored data needs to be reviewed for its future re-use.
Access	Records of organisations that request data.
Update	Version control and compliance.
Retention	Effectiveness of data retention (including access and update).
Deletion	Ensuring no unplanned data deletion through 'data loss'. Value of retention, loss of opportunity after deletion

7.2 Specific Risk Management Issues

Table 7.2 below shows specific 'audit' issues associated with risk management:

Table 7.2 Audit Specific Risk Management Issues.

SPRC	Issues to consider
Source	None.
Pathway	None.
Receptor	None.
Consequences	Appraisal of outcomes verses outputs.

7.3 Appraisal of outcomes and outputs

Fundamentally the audit process needs to ensure that the actual outcomes of FCM tie in with the outputs of FCM and appraising the implications of this regarding data management practices. So for example, consider a town that is protected by a scheme to a 1 in 100yr standard, yet the town suffers flooding from the 1 in 75 yr event. The audit would need to consider if this failure (ie: the flood event) has happened due to deficiencies in the underlying data used to both select the most appropriate scheme option and/or suitable maintenance schedule.

The Post-Event Appraisal Study (Bullens 2003) stated the need to audit the outputs of the post-event appraisal and 'learn from them', but does not consider the feedback from the post-event appraisal onto the FCM process. In a similar vein, the Lessons Learned report (ICE 2001) did consider the 'outcomes' of FCM and associated data issues. Therefore, there is a need for both improved forecast information and the need for improved information communication on flood warnings.

The draft FCDPAG6 document provides guidance on monitoring and performance evaluation of plans, policies and projects to determine their effectiveness in delivering outcomes and FD2010/TR (HR Wallingford 2003) and provide indicative indicators that can be used to audit the FCM process (see Box 7.1). The current data warehouse concept of NFCDD offers the facility to hold post event data and make it widely available to all users, therefore, it could become the primary repository for post event data. This will require development of NFCDD into data areas not currently being considered.

Performance indicators for urban planning districts

- Flood-prone urban areas and towns where flood risk is adequately covered in Local Plans.
- Flood-prone urban areas and towns with completed flood emergency plans in place.
- Flood-prone urban areas and towns with a plan for implementing post-flood recovery activities, including the post-flood repair and reactivation of infrastructure.
- Flood-prone urban areas and towns with dedicated flood forecasting and warning systems in place.

Urban performance indicators may also include the ratio of:

- The current number of urban properties susceptible to flooding by a flood event(s) of nominated severity(s) to the number of properties susceptible in a nominated base year. This would measure the degree of success achieved in protecting urban properties.
- The current value of average annual potential or actual flood damage to the value in a nominated base year.

Performance indicators for rural planning districts

- Flood-prone rural areas where flood risk is adequately covered in Local Plans.
- Flood-prone rural areas with flood forecasting and warning systems in place.
- The area and type of farming activity susceptible to mainstream flooding by a flood event(s) of a nominated severity(s) to the area and type of farming activity in a nominated base year.
- Current value of average annual potential or actual flood damage to the value in a nominated base year.

Social and environmental performance indicators

There has been very little previous work carried out on the development of social and environmental performance indicators and further research is necessary before recommendations can be made.

Box 7.1 Indicators to audit the FCM process (from draft FCDPAG6)

7.4 Data Value Audit and Knowledge Capture

Presently, there are no tools to appraise data value. This applies to situations where there is both a continuous or latent (project-based) demand. Therefore there is a lot of subjectivity to answer questions on '*which new parameters are*

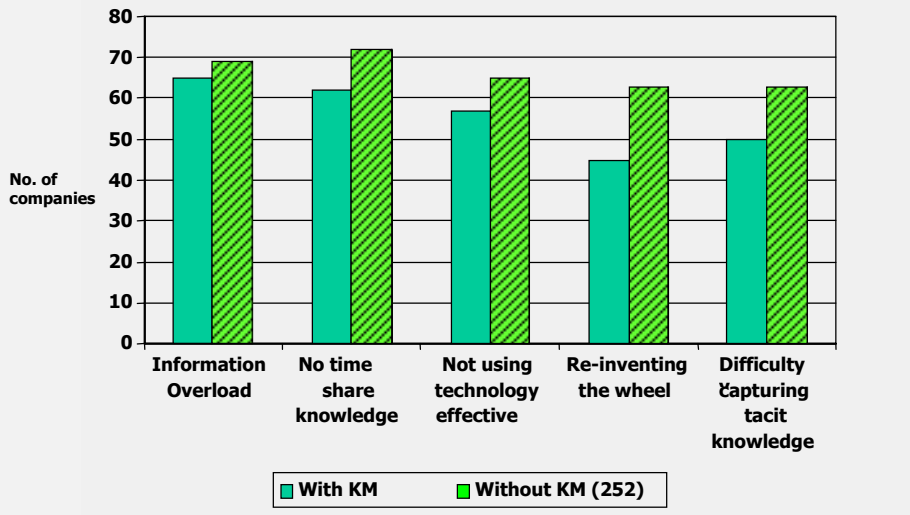
required' or '*which data sets should be maintained*'. There is work undertaken in this area (Millard 2003), but it is not directly applied in 'tool form' to FCM.

Related, to the above, there are no procedures to ensure that 'everything that is of value' about FCM is captured and used. This includes issues of incorporating tacit and explicit knowledge capture (See Box 7.2). The draft FCDPAG6 looks at 'learning' in the FCM process and provides concepts and high-level guidance, but not tools or quantification of best practice. There is plenty of work on knowledge management and the value that it adds to organisations (See Box 7.3), but these practices are not widely applied to FCM. The Agency has a generic Knowledge Management Strategy (Environment Agency 2000) and although it is primarily an internally focussed document, it could be used as a template for a specific FCM knowledge management strategy.

PAMS will deliver a transitional system revising the Environment Agency's Flood Defence Management Manual (FDMM) and Management System (FDMS). In the long term, full operational delivery of a software-supported, performance based asset management system (to include training, documentation, software interface, etc.). For more information, see www.pams-project.net. The PAMS project highlighted the need for Knowledge Management (KM) based approaches to learn from experience about the performance of flood defence assets.

Box 7.2 Knowledge Management and PAMS

Can the value of KM be measured? Studies have shown that there are cost savings, but many benefits are not quantified such as allocation of cross-functional benefits, avoidance costs (better decision making and reduced risks) and benefits to organisational survival (necessary to compete). Studies conducted by KPMG in 2000 based on a cross section of industry sectors revealed organisations are more effective with Knowledge Management Process in place, in particular less 're-inventing the wheel'.



Source: KPMG Knowledge Management Report 2000

Box 7.3 The value of Knowledge Management (from KPMG 2000)

7.5 Processes and Procedures of Long Term Storage

Presuming the data are deemed to be of value (see Section 7.4 above), benchmarks for archives need to be established to demonstrate how good an archive system is in terms of access and update to ensure data quality. Within FCM in general, problems have been encountered with present approaches (See Box 7.4).

At the time of writing, the draft FCDPAG6 states the importance of establishing long term data sets, but it does not consider how this can be effected. Future revisions of this document may address this issue more fully. Essentially, long-term storage systems need to be *proactive* rather than reactive to ensure datasets are effectively managed and preserved.

There is anecdotal evidence of projects bypassing official data distribution channels as more up to date information is available from unofficial sources *(pers comm to Project Team member)*. This clearly points to the need to introduce basic audit procedures, not just to ensure that data held is the latest version (approved quality), but to be able to 'prove' this to users.

The Agency has a programme for monitoring environmental change indicators, using various data items (water quality, rainfall, flow, high-tide levels) already collected as routine. It is presumed that long-term records, and their quality, are maintained to the highest levels, to provide indicators identifying impacts of climate change, land-use change, etc. It has, however, been noted that problems with basic data, e.g. flow measurement consistency, is limiting the value of processed data sets on annual maximum flood series.

Box 7.4 Agency and long term indicators.

7.6 Recommendations

Audit has been found to be the weakest element of the FCM data management process and is deficient. There are insufficient mechanisms in two areas. Firstly, to audit whether data needs to be collected at all, and secondly, to check that the data is being effectively managed. One of the difficulties in realising audit effectiveness is linked to the lack of tools for strategic decision making. In part these do not exist (e.g. data value tools) but in the main the key issue is uptake. Specific actions include:

- The benefits of a specific Knowledge Management Programme for FCM need to be formally appraised to see 'how it could work'.
- This study has used a simple framework to 'audit' data and information issues related to FCM. (see Appendix A to D as a series of examples). This approach could be adopted into an internal Agency procedure to monitor data management issues.
- Emergency exercises should include post event data activities to test the initiation of data collection procedures and allocation or deployment of resources, from either government departments or from other stakeholder sources.

- Linked to the above, there is a need to develop a national database on post event results for use by researchers and operational staff for studies on model performance and flood warning system performance.
- Research is required to develop and test screening tools to appraise data value.

8. CONCLUSIONS

The aim of the project is to map out ways in which Agency/Defra FCM can lead in the development of wider data management polices and identify areas of good practice both within and outside of the FCM industry where this would be helpful. Crucially this indicates the need for a framework to understand the value of information to FCM and this has been the basis of this study.

The emphasis of this report focuses on flood risk aspects of the FCM industry. Issues associated with coastal erosion, in particular, have been addressed in more detail within the Defra Future Coast project (Defra 2003) and data/information aspects have been reviewed at a European level through the Eurosion project (2004) (http://www.eurosion.org/reports-online/reports.html). A new project may be required to determine whether a separate study is needed to cover all pertinent issues associated with data management issues for coastal erosion projects in England and Wales.

8.1 Generic Data Lifecycle Issues

The first set of conclusions examines the relationship between the information management principles and the data lifecycle to appraise where the key data management issues lie in the data supply chain. This is summarised in Table 8.1.

The table indicates that most gaps in data management centre on the lifecycle state of 'retention' and the principle of 'audit'. In essence, new approaches are required to check that 'the right things are being done' in relation to managing FCM data. In addition, new approaches are required to determine;

- what data needs to be retained in long term archives,
- who should be responsible for this,
- what procedures they should be following and compliance to these principles.

The overall issue of improved communication between Agency/Defra divisions, private sector companies and other groups (eg: Internal Drainage Boards) needs to be set as a priority task.

On a positive note, procedural issues are well developed and the FCM community can both consolidate on its internal and external approaches and uptake on best practice. The same is true for technology issues. These "quick wins" are articulated in more detail in Section 8.3.

Lifecycle State	Data Understanding	Roles and Responsibilities	Processes and Procedures	Enabling Technology	Audit
Creation	C	N	U	U	N/U
Storage	NA	NA	U	NA	NA
Access	U	NA	C	C	N
Update	NA	NA	U	C	NA
Retention	N	N	N	NA	N
Deletion	NA	NA	N	NA	N

U	Uptake	There is agreed consensus (not necessarily arrived at within FCM) of best practice that need adopting.
C	Consolidation	There is a large amount of (conflicting) work that requires consensus and tailoring to FCM.
N	New Thinking	New approaches need to be considered.
NA	Not Applicable	No issues reported for this area.

Table 8.1 Generic Data Lifecycle Issues

8.2 Specific Risk Management Issues

The second set of conclusions gives an overview as to where data and information issues are significant in relation to the FCM process, articulated by the SPRC framework. This is shown in Table 8.2. This table shows that 'consequences' (i.e. the impact of the flood) of FCM generally has the least well-managed data. In general, most of the data required for FCM are known and exist, but consolidation is required to ensure what constitutes 'best' data is understood and communicated accordingly. In summary, FCM is best improved by managing data on the consequences of FCM risks more effectively.

SPRC	Data Understanding	Roles and Responsibilities	Processes and Procedures	Enabling Technology	Audit
Source	C	NA	NA	NA	NA
Pathway	C	NA	NA	U	NA
Receptor	C	NA	C	C	NA
Consequences	C	N	C	N	N

U	Uptake	There is agreed consensus (not necessarily arrived at within FCM) of best practice that need adopting
C	Consolidation	There is a large amount of (conflicting) work that requires consensus and tailoring to FCM
N	New	New approaches need to be considered
NA	Not Applicable	No issues reported for this area

Table 8.2 Specific Risk Management Issues

8.3 The Way Forward

8.3.1 Data Understanding

What is 'FCM data? may seem an easy question, but it is difficult to determine. Therefore, to improve the supply of data to support FCM decision making, an ontology of FCM data needs to be determined. Some data such as information on flood defences and beach profiles can be clearly and relatively assigned as 'FCM data'. However information such as 'designated areas' or 'demographics' required to inform FCM is not restricted to 'FCM data' *per se*. In these cases, FCM needs to be clearly communicating to the owners of these datasets the needs of the FCM community. Again this is something that can be readily built and provided to both the FCM community, but also members of the FCM supply chain. Related to this, an ontology could also be developed to map responsibilities and initiatives that are being undertaken to improve FCM data management.

In the future there will be increased demand for "end to end" data management enabling more time to be spent on analysis than data processing. This will increase the requirement for data quality as the process becomes more data reliant. To embrace this, information needs to be clearly associated with its generating data workflow and the approaches used within the MDSF project should be more widely adopted.

8.3.2 Roles and Responsibilities

There needs to be a distinct improvement in encouraging better engagement of wider stakeholders in FCM. For example, information on factors such as flood propagation and flood impacts at a local level are arguably best recorded by local people. These people can also provide valuable audit information on the effectiveness of FCM.

The study recommends encouraging partnerships with local stakeholders when managing datasets. Defra/Agency can be more proactive and clear in how best to combine resources (internally and externally) when undertaking consultation and information dissemination. Whilst partnership adopting is seen as a positive approach, it is also key to clearly nominate a lead organisation that is responsible for establishing responsibilities and protocols for collecting data on the extent and impacts of all flooding. (The Environment Agency may be best placed to undertake this role under its supervisory role.) Operating Authorities and Professional Partners should be encouraged to collaborate in developing protocols for those items in which they have a joint interest.

It is evident that existing mechanisms are in place for capturing information of flood events or beach profile related data. What is missing is clarity between regions in terms of data collection. Wherever possible, the Agency/Defra need to review regularly existing mechanisms of involving stakeholders in data collection to assist local communities, rather than setting up duplicatory processes or systems that do not provide a service to local communities in times of need. Staff in all Operating Authorities should be informed that they have a "duty of care" to data. Protocols should be established for the retention of data to ensure the

preservation of valuable records. Outside "confirmed" stakeholders may be used to ensure this issue is adhered to.

Finally, organisations within flood groups with local experience and expertise in community involvement and consultation need to be utilised effectively whenever possible. Whilst not necessarily "expertise" (and subject to appropriate quality control measures), it is recommended that Agency/Defra investigate other approaches, such as using school resources, to undertake historical flooding research.

8.3.3 Process and Procedures

The key conclusion regarding process and procedures centres on data standards. In particular there are gaps on which standards are used, communicating this to the FCM community and supporting compliance to these standards. Addressing these issues is within the planned remit of the Agency data strategy team in SATIS (FD2314 PR (2004) and it is anticipated that our recommendations will support their efforts.

The wider FCM community is looking towards metadata standards based on ISO19115 and Dublin Core (e.g. e-GIF). As the FCM community is primarily dealing with geo-spatial data, the FCM community should look to develop maintain and service a FCM profile of ISO19115. Using this metadata standard should be mandatory for all EA FCM activities. The FCM community should embrace the diversity of data standards existing within FCM and to manage this establish a registry of FCM data standards and the associated mapping between these standards. This includes common dictionaries for terminology.

Once standards are agreed and effectively communicated, then procedures and policies to support their compliance can be issued.

8.3.4 Enabling Technology

The key conclusion from this study is that the FCM community is generally very quick to look at new technology and (lack of uptake) of new technology is a minor issue, not currently limiting FCM progress. Indeed the UK is generally a leader in all aspects of the application of new technology to FCM. This includes enabling technology for data collection, processing and dissemination.

What is often the limiting factor is the integration between 'requirements' and 'technology' to ensure the appropriate uptake and use of technology. Recommendations are therefore based on minimizing this gap through improved communication of technology development plans and to make explicit (e.g. provide guidelines) on the integration of the technology with FCM process workflows. For example using SAR data to develop a CFMP.

8.3.5 Audit

There is no mechanism in place to regularly appraise the data needs of FCM. In this study, data gaps were identified from the four case-studies used as part of this study (See Appendices A-D) and this is a useful 'snapshot' to inform policy development. What is more important is a mechanism to ensure a continual feedback from these studies to initiatives such as the NFDDDMS. This study used a matrix approach to capture where data issues occur and it is recommended that this should be used as a standard reporting pro-forma for all future R&D studies. This captures more than just 'what data are needed', but also what are the data management issues.

The benefits of data collections also need to be appraised alongside data needs as this ultimately appraises its value. This presupposes that there is sufficient information about the data to enable such a value judgement to be placed. If not, then the question is really one of the value of metadata. It is recommended that a simple screening tool is developed that takes as input 'what is known' about a dataset and from this infer a statement of its value/management needs.

What is less clear, however, is who is responsible for acting on the information provided by this audit process. The FCM community does not have an effective learning mechanism in place to understand what information is valuable and what information is not. The existing Agency Knowledge Management Strategy does provide a framework from which to prepare a FCM specific document.

Finally, the FCM process can only be audited on its outcomes and the study has identified there is insufficient data on this. Accordingly, recommendations are made to improve this, in particular a database of flood events.

8.4 Proposed Implementation Plan

The key recommendations from this study are summarised in table 8.3 below along with information on their importance (high/medium/low)[9], dependency (which tasks need to be in place first before that recommendation can start) and resources required (high/medium/low).

Table 8.3 is presented in Principle order (see Figure 1.1), i.e. issues to do with *process and procedures* should be approached before issues to do with *enabling technology*. Responsibilities for implementing these recommendations are not addressed in Table 8.3. Recommendation numbers do not reflect section numbers set out in the report.

[9] Ranking based on steering committee review of this work – See FD2314 PR (2004)

Table 8.3 Implementation of Recommendations

No		Importance	Dependency	Resource
Principle Number 1 - Data Understanding (from Section 3)				
1.1	Develop an ontology for FCM Data Management activities (research and operation) covering such facets as "what, where, who, why" and serve this to the FCM community.	H	None	L
1.2	Develop, manage and serve to the FCM community an ontology of FCM data that includes facets on what the data is, data purpose and responsibilities for maintenance and ownership. This could be related/linked to the above ontology.	H	None	L
1.3	Develop and publish improved mapping between 'data' and 'process' and serve this to the FCM community. This should embrace risk-based approaches to managing the data lifecycle and make explicit the quality of data required to support the quality of information that can be generated from a workflow, e.g. MDSF	M	1.2 required first	M
Principle Number 2 - Roles and Responsibility (from Section 4)				
2.1	Assign responsibility for improved (internal and external) communication of existing practices within FCM (Defra/Agency).	H	1.1	L
2.2	Clarify (internal and external) contact points for FCM responsibilities within Defra/Agency.	H	1.1	L
2.3	Test approaches for using wider stakeholder community to provide FCM data (academia, public, VAR).	M	1.2	M
Principle Number 3 - Process and Procedures (from Section 5)				
3.1	Establish an ISO-19135 compliant FCM data standards registry. This can be regarded as going hand in hand with the recommendation under 'Information' for an ontology of FCM activities and take account of e-GIF registries	H	None	L
3.2	Introduce standard text that can be included into all Terms of Reference for Defra/Agency projects (NCPMS or research contracts) to ensure standardisation of data collected, stored and disseminated.	H	Some progress on 3.1 required	L
3.3	Establish an ISO-19115 compliant FCM metadata standard. This can be established	M	None	M

	in conjunction with the NERC data grid team using the experiences gained from the marine community.			
Principle Number 4 - Enabling Technology (from Section 6)				
4.1	Look to improve communication on technology appraisal to both ensure more uptake	L	1.1/1.2	M
4.2	Improve communication on how new technology integrates into the FCM process, especially new data capture technologies.	L	1.3 and 3.1 support and facilitate this	M
Principle Number 5 – Audit (from Section 7)				
5.1	Look to develop a national database on post event results for use by researchers and operational staff for studies on model performance and flood warning system performance	H	None	H
5.2	Adopt simple framework used in this study to 'audit' data and information issues related to FCM projects (see Appendix A to D as a series of examples).	H	None (could be linked to 3.3)	L
5.3	Research is required to develop and test screening tools to appraise data value.	M	None	L/M
5.4	The benefits of a Knowledge Management Programme for FCM need to be formally appraised to see 'how it could work'	M	None (1.1/1.2 would be useful)	M
5.5	Emergency exercises should include post event data activities to test the initiation of data collection procedures and allocation or deployment of resources, from either government departments or from other stakeholder sources	L	None	M/H

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APPENDICES

APPENDIX A

ROAME Statement

Summary of the Policy Problem: Sub-Theme 5.3, Data and Information

The planning, design and implementation of effective flood and coastal defences, and the establishment of an efficient and effective flood warning service, are all dependent on the availability of accurate, relevant and up-to-date data. Data is interpreted to provide information. The understanding of fluvial, estuarine and coastal processes, which underpins government policies in these fields, cannot be improved unless we continue to collect data and process them to provide relevant information, and ensure that that information about data sources is widely available.

A move towards strategic and large scale planning, within the context of sustainability, places additional requirements in terms of availability of a wide range of data, from meteorology, land use, and physical characteristics to social, demographic and economics data. Historical data often provides an important basis for assessing future trends.

The lack of appropriate data can lead to flood and coast defence schemes being inappropriately designed and prone to failure or poor performance. It can also lead to over-design and excessive cost. Historical data is needed to detect change. Information about data sources is crucial to identify gaps, to maximise the use of data, and to avoid duplication.

MAFF and the Agency must also ensure that future data collection is cost effective and will meet the needs of future flood and coastal defence planners. The following policy problems will need to be addressed:

- What data is needed and information are needed both now and in the future?
- What are the benefits of having these data?
- To what extent are these data already available?
- How can the data be collected?
- Who else may benefit from their acquisition?
- In what form should the data be stored and presented?

This Sub-Theme will therefore seek provide a framework for identifying data needs, establishing costs and benefits of data collection / storage and monitoring, and risks of *not* collecting data, and alternative 'models' for data provision.

In recent years, there have been many technical developments that allow previously unattainable data, greater quantities of data, and cheaper data, to be collected. These developments are likely to continue and perhaps accelerate. These new data acquisition techniques have yet to be fully exploited in the field of flood and coastal defence. In order to ensure that these are fully exploited, MAFF and the Agency should seek to identify, develop and deploy new techniques for measurement, acquisition, storage and dissemination of data and information to support delivery of overall policy objectives. This is an area of continual change

and R&D is needed to ensure that MAFF and the Agency keep up to date on the availability, costs and benefits of new techniques.

The scientific objectives of this programme are to:

- Encourage co-operative effort so that the cost of data acquisition can be shared (eg between engineers and scientists, and engineers and environmentalists), which will lead to better flood and coastal defence solutions.
- Investigate the greater involvement of stakeholders, such as riparian owners, in data acquisition, to make use of a low-cost untapped resource and to promote awareness of flood defence issues in the wider community.
- Examine ways of improving data accessibility. This will include the use of the Internet, standardisation of archives, and the development of "lead data centres" where an organisation is charged with maintaining a specific database.
- Evaluate the benefits of data collection and develop appropriate techniques for more widespread application of value of information techniques.
- Identify data needs for policy, plan and scheme and operation purposes level, and review against data availability in order to identify needs.
- Develop and encourage application of new technology and new techniques for monitoring, data handling, archiving, dissemination and presentation where appropriate.

APPENDIX B

DATA AND INFORMATION ISSUES RELATED TO THE CFMP PROCESS

	Sources (rainfall, runoff, climate change, etc)	**Pathways** (rivers, flood-plains, flood defence systems)	**Receptors** (people, property, the environment)	**Consequences** (harm, damage, loss)
Data understanding Data needs, uses, and availability are set out in the CFMP guidelines	Good understanding of data Climate change scenarios are available and updated regularly	Good understanding of data Data on rivers and flood-plains are available and being updated continuously Flood defence data in NFCDD	Good understanding of data Data on receptors in the flood prone areas plains are available and being updated continuously (via national censuses) Receptor data in Address Point datasets	Good understanding of economic loss data Reasonable understanding of public safety data Growing understanding of environmental harm and opportunity data Need to improve awareness of data emerging from on-going R&D
Roles and Responsibilities The CFMP guidelines recognise legal and contractual issues and responsibilities but do not give detailed advice on these issues	Roles and responsibilities of CEH, research groups, EA and Defra are evolving to meet needs for CFMPs but need to assess whether effectiveness can be improved	Roles and responsibilities of EA Defra, and local authorities are evolving to meet needs for CFMPs but need to assess whether effectiveness can be improved	Roles and responsibilities of government agencies (eg OS), research groups, EA and Defra are evolving to meet needs for CFMPs but need to assess whether effectiveness can be improved	Roles and responsibilities of research groups, EA and Defra are evolving to meet needs for CFMPs but need to assess whether effectiveness can be improved
Processes and Procedures	Procedures for data provision to CFMP teams	Procedures for data provision to CFMP teams	Procedures for data provision to CFMP teams	Procedures for data provision to CFMP teams

The CFMP process works within current organisational processes and procedures, and identifies the need for procedures to deal with results (ie the CFMPs as they are developed)	needs to be strengthened Procedures required to ensure that data processed by CFMP teams and the resulting CFMPs are fed back into the broader FCM data management framework	reasonably strong (NFCDD and concept of Twerton acting as a data-hub) Procedures required to ensure that data processed by CFMP teams and the resulting CFMPs are fed back into the broader FCM data management framework	needs to be strengthened Procedures required to ensure that data processed by CFMP teams and the resulting CFMPs are fed back into the broader FCM data management framework Procedure needed for improving access to relevant third party data (eg Norwich Union data on flood risk mapping)	needs to be strengthened Procedures required to ensure that data processed by CFMP teams and the resulting CFMPs are fed back into the broader FCM data management framework Procedures needed to improve access to data and information held by stakeholders
Enabling Technologies CFMP guidelines work within current technologies but CFMPs may identify and provide a stimulus for the implementation new technologies where appropriate	Technology being used subject to continuous improvement but driven by broader needs than just CFMPs	Technology being used subject to continuous improvement (eg LiDAR and SAR) but driven by broader needs than just CFMPs	Technology (including that inherent in models such as MDSF and RASP) being used is subject to continuous improvement but driven by broader needs than just CFMPs	Technology being used subject to continuous improvement but driven by broader needs than just CFMPs
Audit The CFMP process assumes that procedures are in place for monitoring processes for data use and exchange – special procedures will be	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user)	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user)	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user)	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user)

required to monitor the results and effectiveness of each CFMP as it is produced	Meta data standard needs to be decided on and meta data should then be attached to all data	Meta data standard needs to be decided on and meta data should then be attached to all data	Meta data standard needs to be decided on and meta data should then be attached to all data	Meta data standard needs to be decided on and meta data should then be attached to all data

APPENDIX C

DATA AND INFORMATION ISSUES RELATED TO THE FLOOD RISK ASSESSMENT PROCESS.

	Sources (rainfall, runoff, climate change, etc)	**Pathways** (rivers, flood-plains, flood defence systems)	**Receptors** (people, property, the environment)	**Consequences** (harm, damage, loss)
Data understanding Data needs, uses, and availability are set out in a series of documents (HR Wallingford, 2003)	Good understanding of data requirements. More data on environmental variables such as rainfall, waves, water levels, reduces uncertainties on extreme value estimates and hence flood risk results. Numerical models of the loading variables (waves, water levels and river flows) take time/money to run. There is a trade off between cost and accuracy.	Good understanding of data requirements Data on rivers and flood-plains are available and being updated continuously Flood defence data in	Good understanding of data requirements. Data on receptors in the flood prone areas/plains are available and being updated continuously (via national censuses) Receptor data in Address Point databases	Good understanding of economic loss data Reasonable understanding of public safety data Need to improve awareness and understanding of data emerging from the project, as it is sometimes used for purposes it was not developed for and not appropriate for.
Roles and Responsibilities The Environment Agency and Defra are responsible for commissioning and making use of the RASP output. There are many	Roles and responsibilities of CEH, POL, university research groups, EA and Defra are evolving to meet needs for RASP but need to assess whether effectiveness can be improved.	Roles and responsibilities of EA Defra, and local authorities are evolving to meet needs for RASP but need to assess whether effectiveness can be improved. Need for development in	Roles and responsibilities of government agencies (eg OS), research groups, EA and Defra are evolving to meet needs of RASP but need to assess whether effectiveness can be improved.	Roles and responsibilities of research groups, EA and Defra are evolving to meet needs for RASP but need to assess whether effectiveness can be improved. Need for development in

avenues to explore with regard to uses of the data. Eg. Flood forecasting and warning, flood insurance, strategic planning		the dissemination of outputs from RASP to maximise the use of the results	Need for development in the dissemination of outputs from RASP to maximise the use of the results	the dissemination of outputs from RASP to maximise the use of the results
Processes and Procedures It is hoped the RASP approach will be adopted as standard practices within the EA.	Procedures for data provision to RASP teams are reasonable and improving. Procedures for obtaining measured water level data sets could be improved.	Procedures required ensuring that data processed by RASP teams are fed back to and available to the EA as a whole and the broader FCM data management community.	Procedures for data provision to RASP teams needs to be strengthened Procedures required ensuring that data processed by RASP teams are fed back into the NFCDD database. Procedure needed for improving access to relevant third party data (eg Norwich Union data on flood risk mapping)	Procedures for data provision to the EA needs to be strengthened Procedures are required to ensure that data processed is readily available for EA staff and the wider flood and coast defence industry. Procedures needed to improve access to data and information held by stakeholders.
Enabling Technologies RASP is a new research project and provides new methodologies. It is envisaged that the methodologies will undergo continual improvement, adopting new technologies that are	Technology being used subject to continuous improvement but driven by broader needs than just RASP	Technology being used subject to continuous improvement (eg LiDAR and SAR) but driven by broader needs than just RASP	Technology to improve the flood propagation modelling is currently being implemented and will continue to be developed.	Technology being used subject to continuous improvement but driven by broader needs than just RASP

appropriate when they become available.				
Audit Procedures to develop consistency amongst the different RASP tiers need improving. Procedures will be required to monitor the dissemination and effectiveness of the results	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user) Meta data standard needs to be decided on and meta data should then be attached to all data	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user) Meta data standard needs to be decided on and meta data should then be attached to all data	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user) Meta data standard needs to be decided on and meta data should then be attached to all data	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user) Meta data standard needs to be decided on and meta data should then be attached to all data

APPENDIX D

POTENTIAL DATA AND INFORMATION ISSUES RELATED TO THE ASSET MANAGEMENT PROCESS (PAMS)

	Sources (rainfall, runoff, climate change, etc)	**Pathways** (rivers, flood-plains, flood defence systems)	**Receptors** (people, property, the environment)	**Consequences** (harm, damage, loss)
Data understanding Data needs, uses, and availability are set out in a series of documents (HR Wallingford, 2003)	Good understanding of data requirements. More data on environmental variables such as rainfall, waves, water levels, reduces uncertainties on extreme value estimates and hence flood risk results. Numerical models of the loading variables (waves, water levels and river flows) take time/money to run. There is a trade off between cost and accuracy.	Fair understanding of data requirements Data on rivers and flood-plains are available and being updated continuously Flood defence data in NFCDD could be improved Better understanding of the relationships between inspection results, defence failure mechanisms, and probability of failure is required.	Good understanding of data requirements. Data on receptors in the flood prone areas/plains are available and being updated continuously (via national censuses) Receptor data in Address Point databases Access to other datasets (e.g. environmental, amenity, health and safety) should be improved	Good understanding of economic loss data Reasonable understanding of public safety data
Roles and Responsibilities The Environment Agency is responsible for commissioning the PAMS project and making use of the output.	Roles and responsibilities of staff within the EA organisational structure will need to evolve somewhat to meet the needs for PAMS	Roles and responsibilities of staff within the EA organisational structure will need to evolve somewhat to meet the needs for PAMS	Roles and responsibilities of staff within the EA organisational structure will need to evolve somewhat to meet the needs for PAMS	Roles and responsibilities of staff within the EA organisational structure will need to evolve somewhat to meet the needs for PAMS

Processes and Procedures It is hoped the PAMS process will be adopted as standard practice within the Environment Agency.	Procedures for data provision suitable for PAMS require improvement Procedures for obtaining measured water level data sets could be improved	Procedures are required to ensure that data processed by PAMS is the most up to date and consistent with appropriate inspection methodologies	Procedures for data provision for PAMS need to be strengthened Procedure needed for improving access to relevant third party data (e.g. environmental data)	Procedures for data provision to the Environment Agency need to be strengthened
Enabling Technologies PAMS is a new, ongoing research project providing a new system for flood and coastal defence asset management. The system will draw on existing R&D work while provide the ability for adaptation in light of future research.	Technology being used subject to continuous improvement and dependant on development within other R&D projects, such as RASP and Performance & Reliability	Technology being used subject to continuous improvement and dependant on development within other R&D projects, such as RASP and Performance & Reliability	Technology being used subject to continuous improvement and dependant on development within other R&D projects, such as RASP and Performance & Reliability	Technology being used subject to continuous improvement and dependant on development within other R&D projects, such as RASP and Performance & Reliability
Audit Procedures will be required to monitor the effectiveness and utility of the results.	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify) Meta data standard needs to be decided on and meta data should then be attached to all data	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify) Meta data standard needs to be decided on and meta data should then be attached to all data	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify) Meta data standard needs to be decided on and meta data should then be attached to all data	Individual data providers have in-house audit processes Data quality needs to be assured (difficult to verify by user) Meta data standard needs to be decided on and meta data should then be attached to all data

APPENDIX E

DATA AND INFORMATION ISSUES RELATED TO THE SMP2 PROCESS

(NB: Table text is not necessarily the view of the SMP2 Steering Group)

	Sources (coastal processes, beach data, climate change, etc)	**Pathways** (shorelines, coastal hinterland, coast protection/beach management systems)	**Receptors** (people, property, coastal businesses, the environment)	**Consequences** (harm, damage, loss, social deprivation)
Data understanding Data needs, uses, and availability are set out in the recent SMP2 guidelines (currently being reviewed and updated in terms of data and information issues.	Good understanding of data Climate change scenarios are available and updated regularly	Good understanding of data Data on coastal processes and beach/cliff morphology are available (via Future Coast for example) and being updated continuously via separate research. Coast protection data in NFCDD.	Good understanding of data . Data on receptors in the coastal "risk" prone areas are available and being updated continuously (via national censuses) Receptor data in Address Point datasets	Good understanding of economic loss data Reasonable understanding of public safety data Growing understanding of environmental harm and opportunity data Need to improve awareness of data emerging from on-going coastal process R&D.

Roles and Responsibilities The SMP2 guidelines recognise legal and contractual issues and responsibilities but do not give detailed advice on these issues.	Roles and responsibilities of Coastal stakeholders, research groups, EA and Defra are evolving to meet needs for SMPs but need to assess whether effectiveness can be improved.	Roles and responsibilities of EA Defra, and coastal local authorities are evolving to meet needs for SMPs but need to assess whether effectiveness can be improved and how this fits in with ICZM.	Roles and responsibilities of government agencies (eg OS), research groups, EA and Defra are evolving to meet needs for SMPs but need to assess whether effectiveness can be improved.	Roles and responsibilities of research groups, EA and Defra are evolving to meet needs for SMPs but need to assess whether effectiveness can be improved. Latest discussions on who is to take responsibility for national and regional datasets are currently taking place.
Processes and Procedures The SMP2 process works within current organisational processes and procedures, and identifies the need for procedures to deal with results (ie the SMPs as they are developed)	Procedures for data provision to SMP teams (and Coastal Groups) needs to be strengthened Procedures required to ensure that data processed by SMP teams and the resulting SMPs are fed back into the broader FCM data management framework.	Procedures for data provision to SMP teams reasonably strong. Procedures required to ensure that data processed by SMP teams and the resulting SMPs are fed back into the broader FCM data management framework	Procedures for data provision to SMP teams needs to be strengthened Procedures required to ensure that data processed by SMP teams and the resulting SMPs are fed back into the broader FCM data management framework Procedure needed for improving access to relevant third party data	Procedures for data provision to SMP teams needs to be strengthened Procedures required to ensure that data processed by SMP teams and the resulting SMPs are fed back into the broader FCM data management framework Procedures needed to improve access to data and information held by stakeholders
Enabling Technologies SMP2 guidelines work within current technologies but SMPs	Technology being used subject to continuous improvement but driven by broader needs than just	Technology being used subject to continuous improvement (eg techniques for shoreline	Technology (including that inherent in models being used is subject to continuous improvement	Technology being used subject to continuous improvement but driven by broader needs than just

may identify and provide a stimulus for the implementation new technologies where appropriate	SMPs	monitoring set out in Eurosion Shoreline Management Guide 2004).	but driven by broader needs than just SMPs	SMPs
Audit The SMP process assumes that procedures are in place for	Individual data providers have in-house audit processes	Individual data providers have in-house audit processes	Individual data providers have in-house audit processes	Individual data providers have in-house audit processes
monitoring processes for data use and exchange – special procedures will be	Data quality needs to be assured (difficult to verify by user)	Data quality needs to be assured (difficult to verify by user)	Data quality needs to be assured (difficult to verify by user)	Data quality needs to be assured (difficult to verify by user)
required to monitor the results and effectiveness of each SMP as it is produced	Meta data standard needs to be decided on and meta data should then be attached to all data	Meta data standard needs to be decided on and meta data should then be attached to all data	Meta data standard needs to be decided on and meta data should then be attached to all data	Meta data standard needs to be decided on and meta data should then be attached to all data