WORKING TITLE: THE IMPACT OF CLIMATE CHANGE ON LOCAL SCALE FLOOD RISK FOR INDIVIDUAL DEVELOPMENTS: SCOPING STUDY REPORT.

1. Introduction

A scoping study was carried out in accordance with the proposal to establish the parameters for a full systematic review into the question – "What is the impact of climate and extreme events on local-scale flood risk for individual developments?" This scoping report details the objectives, methods used and databases sampled during the scoping phase. The results of the scoping study are also reported and critically evaluated to provide improved methodology for the proposed full review.

Attached to this scoping report is a draft protocol for the proposed full review and the database of references resulting from the scoping study in the form of an endnote database.

2. Objectives

The aim of this scoping study is to establish the potential for a full systematic review on the question:

> "What is the impact of climate and extreme events on local-scale flood risk for individual developments?"

This aim will be achieved through four specific objectives:

1. Scoping scientific literature and recent public reports in the specific subject area
2. Report on the quality of a sample of available evidence.
3. Report on the extent of evidence and gaps in the evidence.
4. To prepare a draft protocol for a full systematic review on the above question.

3. Scoping Method

The clear objectives led to a method involving systematic sampling of potentially relevant reference databases. This evidence was analysed in outline terms to establish the relevance to the question and to possible secondary questions thus giving an appreciation of the extent and gaps in knowledge. This was followed by detailed analysis of a subsample of the collected data for quality determination. Finally the success of the sampling strategy was evaluated in terms of identifying known evidence and this resulted in a modified search strategy for the systematic review. Further details of the methods are explained below.

3.1 Question Formulation

The review question was supplied by the Natural Environment Research Council (NERC) as part of a wider review into the impact of climate change on the construction industry within the context of research into living with climate change. The review team identified several issues within construction upon which such a review may provide valuable insight as follows:

1. Is the scale of the increased flood risk due to climate change the same in potential development sites as in regions as a whole?

2. How can the national and regional forecasts of increasing flood risk be scaled down to the appropriate scale for development planning?
3. Will increased flood risk increase the cost of future developments or damage the profitability of construction companies?
4. Are the increased levels of flood risk due to climate change changing the way in which developments are planned?
5. What proportion of development sites will become unviable due to future increased flood risk?
6. What sort of forecasts do construction professionals need to design developments robust to future flooding?

However at this stage these questions will not be used as search questions but for scoring and qualifying the usefulness of the resulting evidence and evidence gaps.

3.2 Search Strategy

An inclusive search strategy was employed to sample a wide range of sources from multiple disciplines. As highly sensitive approach but with some high specificity was regarded as appropriate in this multidisciplinary subject area. The databases searched and terms used are described below.

3.2.1 Databases and websites

Databases of academic and industry sources were scoped during this study, generic search websites were also used. As this review concerns impacts on the construction industry there may be a large contribution from grey literature sources [1]. The websites of specialised organisations which may contain relevant information were also accessed. During the scoping study a maximum of 20 references was extracted from each database up to a combined maximum of 200. More specialised databases were sampled first and duplication was avoided.

Databases:
- ISI web of knowledge
- Directory of Open Access Journals
- Sciencedirect
- Infotrac
- EBSCO host research databases
- ICE virtual library
- Geobase
- Knovel Interactive
- Construction Information Service (done)
- Ethos

Search Engines:
- Google scholar
- Scirus
- Google

Websites of Specialised organisations:
- Construction Industry Research and Information Association
- Building Research Establishment

[1] For example scientific and technical reports, government documents, reports from trade organisations, guidance documents etc

- Commission for Architecture and the Built Environment
- National House
- Royal Institution of Chartered Surveyors
- Royal Institute of British Architects
- Royal Town Planning Institute
- National Flood Forum
- Environment Agency
- Centre for Ecology and Hydrology
- British Hydrological Society
- Scotland and Northern Ireland Forum For Environmental Research
- Tyndall Centre for climate change research
- UK Climate Impacts Programme
- Flood risk management research consortium

Further sources had been identified at the proposal stage but the target of 200 references was reached before all sites had been scoped.

3.2.2 Search Terms

Search terms were selected based on the primary question which was analysed on the basis of subject, outcome and intervention terms. Given the multidisciplinary nature of the topic it was thought necessary to use highly specific and discipline relevant terms to reduce search volumes to a manageable level. Search terms are listed in Table 1 and include those terms identified by the team and some discipline specific terms which were identified by subject experts consulted by the team.

> Question: What is the impact of climate and extreme events on local-scale flood risk for individual developments?
>
> Subject or the unit of study is individual developments or local scale spatial units.
>
> Intervention or the action is climate change or extreme weather events
>
> Outcome or measurable result is the flood risk or hazard
>
> Comparator or control is not specified.

From analysis of these terms it became clear that the word flood was common to the majority of the outcome terms. For high sensitivity it was felt appropriate to adopt flood* as the principal search term for the outcome. Sources that do not deal with flooding were deemed to be irrelevant for the review and the term flood is a relatively unambiguous term and therefore should not result in too many false positives. The subject and intervention terms were seen as more heteregenous and so were trialled more extensively in different combinations. Trialling of search terms was carried out on the Web of Knowledge and Google.

3.2.3 Scoping databases

The search terms were used differently in different databases, partly because of the available searching options and partly due to the number of hits achieved. Broader databases required more specific searching than the narrower subject focussed ones.

Website search facilities were usually rudimentary and some browsing by broad topic was often required.

Table 1: Table of search terms

Subject terms	Intervention terms	Outcome terms
Initial terms identified by review team		
Property level	Environmental Change	Flood risk
Housing development	Climate change	Flood hazard
Development site	Extreme weather	Flooding
Building development	Weather events	Flood vulnerability
Construction site	Increasing risk	Danger of flooding
Construction project	Future risk	Liable to flood
Local scale	Global warming	Flood uncertainty
Building site	Flood events	Possibility of flooding
Building plot	Changing risk	Forecast flooding
Site level	Growth in	Flood exposure
Individual development	Greenhouse effect	
Development scale	Climate threat	
Property development		
Urban development		
Additional terms from subject experts		
High resolution	Extreme rainfall	Flood depth
Fine grain	Climate change scenario	Flood velocity
Small grid	UKCIP	Surface water flooding
Small scale	Increased frequency	Groundwater flooding
Flood risk assessment (FRA)	sustainability	Suds capacity
PPS25	Rapid response	Flood potential
Redevelopment	Storm surge	Flow velocity
Masterplan		Risks to people
Masterplanning		Social vulnerability
Regeneration		Property vulnerability
Brownfield		Property risk
Greenfield		Drainage capacity
Strategic flood risk assessment (SFRA)		Drainage exceedance

3.2.4 Inclusion criteria

Titles were filtered for relevance to at least two out of subject intervention and outcome. Titles where the subject matter lay obviously outside the scope of the study were also rejected at title stage. Abstracts or full text, where available, were then further filtered for relevance to all three subject, outcome and intervention terms. The number of hits and relevant hits were recorded for each source. The first 200 hits from the Web of Knowledge were double checked by two researchers.

3.3 Analysis of extent of evidence and gaps in evidence
The studies were categorised by type of publication and broad subject area to gauge coverage.

3.4 Quality Sampling
Fifteen highly relevant documents were analysed in more detail, ensuring that at least one study relevant to each secondary question is included.

3.5 Critical Appraisal of Strategy
Reference lists of three publications were examined for further search terms and relevant sources not previously captured. Potential for extraction of the results of empirical data was also assessed.

4. Results
The results of the scoping study are summarised here. More details are includedin appendices to the report

4.1 Testing of search terms
Search terms tested in the web of science returned large numbers of results, particularly generic ones such as development or construction because of the ambiguous interpretation of such terms. Therefore highly specific building and mapping terms were selected for the subject terms.

Intervention terms were also selected to be specific as the importance of climate change within the review question is paramount and will help to restrict the hydrological publications down to those which have a predictive element.

Outcome terms were taken to be more general as almost all the outcome terms included one of two words flood or inundation. Details of the searches tried and numbers of hits are shown at appendix 1

The final selection of search for the scoping study was:

Subject terms: "development site", "construction project", "local scale", "site level", "development scale", "high resolution", "urban development", "fine grain", "small scale"

Outcome terms: flood*, inundat*

Intervention terms: "climat* chang*", "environment* chang*", "global warm*", "growth in", "greenhouse effect", "increas* frequency"

4.2 Consistency of relevance test
The results of the comparison of the selection of publications from a web of knowledge search by two different researchers showed an 82% agreement on the categorisation of publications as relevant or irrelevant. The resulting kappa statistic was 0.5 which is just within the acceptable level. The inclusion criteria were therefore further refined for the draft protocol.

4.3 Extent and gaps in evidence

Records of the searches undertaken, the number of results and the number of relevant sources extracted are included at Appendix 2 for databases and at Appendix 3 for the website trawl. The searches resulted in 238 sources. These sources have been categorised by journal, conference, book, report, website, thesis and other. Journals have been further subdivided by main subject area and reports subdivided by type. Table 2 shows the breakdown of sources by category and the number in each category considered in greater detail in this report.

On the whole there was a good balance of sources with perhaps a bias towards hydrology and earth science journals over built environment journals. This may be caused by the lack of indexing of built environment sources in the databases searched. This feature will be discussed further in section 4.5. There was also a heavy concentration of government reports included in the reports section. This is a reflection of the fact that flood risk is high on the government agenda and that it is recognised that future development must take account of the risk. Advice regarding the process of assessing risk, designing for it and planning to avoid it is emerging from many government and trade bodies. However, reports of fundamental research into local level flood risk which must underpin the policy agenda would appear to be less accessible from this scoping study. Sources are unanimous in the opinion that more research is needed to achieve desired climate change adaptation. Sources demand further research into the translation of climate models into impact scenarios, the impacts of uncertainty, the methods of downscaling to local impact and the cost/benefit of adaptation strategies. A holistic, multidisciplinary approach to risk management is advocated by all sources.

Table 2: Categorisation of identified sources

Category	Sub category	Number found	Number reviewed
Journal articles	**All journals**	**86**	**6**
	Hydrology/Earth systems	39	3
	Built Environment	22	2
	Water resources	9	0
	Other	16	1
Conference papers		**18**	**1**
Reports	**All reports**	**88**	**8**
	Central government	30	2
	Local Government	7	1
	Industry/trade body	23	2
	Research body	20	2
	Specific fra/cmp/sfra	6	1
	Other	2	0
Websites/pages		**18**	**0**
Theses		**13**	**0**
Book/book sections		**13**	**0**
Other		**2**	**0**
Total		***238***	***15***

4.4 Quality of evidence

Fifteen sources were examined in more detail, this was greater than the ten anticipated by the proposal because of the wide variety of sources discovered. Their abstracts or summaries are included below and their relevance to the research questions and key content features are indicated in Table 3.

4.4.1 Life handbook. Long-term initiatives for flood-risk environments (BRE 2009).

> "Advises on how to identify flood risk and suitable development options set out in PPS25. Describes the types of flooding and illustrates where they may occur within the river catchment. Identifies how climate change may affect a site. Describes how other sustainable design measures may be integrated into development proposals. Contains illustrated examples and case studies."

4.4.2 Development and Flood Risk in the Broads. Supplementary Planning Guidance (Broads Authority 2000)

> "This guidance initially sets out existing Government guidance and relevant planning policies. It goes on to explain the nature of flood risk in the Broads and the development needs which arise. Different approaches to reducing the risk of flooding in new development areas are then discussed and the Broads Authority's approach to these issues is explained. The Appendix contains information on advisory minimum floor levels for development in different parts of the Broads, based on Environment Agency information."

4.4.3 *Living with water: visions of a flooded future.(Building futures 2007)*

> "Building Futures has been in existence since 2000. It is the RIBA's think tank, charged with looking forward 15 to 20 years to prepare the profession and those we work with for the opportunities ahead and the challenges that we will all face. We work closely with other agencies, particularly CABE, and have jointly published studies on the future of the professions, housing, schools and libraries. We are currently engaged in a programme which includes exploring happiness and well-being in future built environments, universities and university cities, urban futures and the pressure of population growth and migration, and flooding. This publication brings together a cross section of ideas about the increasing number and severity of floods we will face in the UK, and particularly the Thames Gateway, and how we might respond."

4.4.4 *Initial review of the implementation of Planning Policy Statement 25: Development and Flood Risk.* (CLG 2009)

> "Planning Policy Statement 25 *Development and Flood Risk* (PPS25) was published in December 2006 to ensure that flood risk is taken into account at all stages in the planning process. Managing flood risk through the planning system is a key part of the Government's *Making Space for Water* strategy for flood and coastal erosion risk management in England, announced in March 2005, and the new *Future Water strategy* published in February 2008."
>
> "Communities and Local Government (CLG) has therefore carried out an initial review of the implementation of PPS25. This initial review has comprised the following elements:
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> • the annual High Level Target 5 (HLT5) *Development and Flood Risk* report produced by the Environment Agency on the impact of the Agency's technical

advice to planning authorities on flood risk for the period April 2007 – March 2008;

• research jointly managed by the Department for Environment, Food and Rural Affairs (Defra) and CLG on the preparation of strategic flood risk assessments (SFRAs) by local planning authorities and results from a survey of local flood risk management conducted late last year by the Local Government Association and Defra;

• assessment by CLG and the regional government offices of the application of the Flooding Direction; and

• assessment of the implementation of PPS25 policies in emerging local development frameworks (LDFs) based on information provided to CLG by the government offices."

4.4.5 *Conwy Flood Risk Assessment.* Conwy Local Development Plan(Conwy council 2009)

"This background paper outlines the evidence considered by the Conwy County Borough Council during the preparation of the Local Development Plan (LDP) and the actions proposed by Council to ensure that the risk to new developments from flooding is minimised. The paper should be read in association with Local Development Plan Background Paper 21 - 'Site Deliverability Assessment' which records in detail the individual assessments undertaken of all the sites considered for allocation in the LDP."

4.4.6 *River Severn Catchment Flood Management Plan. (Environment Agency 2009)*

"The River Severn CFMP is one of 77 CFMP's for England and Wales. Through the CFMP's, we have assessed inland flood risk across all of England and Wales for the first time. The CFMP considers all types of inland flooding, from rivers, ground water, surface water and tidal flooding, but not flooding directly from the sea (coastal flooding), which is covered by Shoreline Management Plans (SMPs). Our coverage of surface and ground water is however limited due to a lack of available information.

The role of CFMP's is to establish flood risk management policies which will deliver sustainable flood risk management for the long term. This is essential if we are to make the right investment decisions for the future and to help prepare ourselves effectively for the impact of climate change. We will use CFMP's to help us target our limited resources where the risks are greatest."

4.4.7 Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication. (Hagemeier-Klose and Wagner 2009)

"Flood risk communication with the general public and the population at risk is getting increasingly important for flood risk management, especially as a precautionary measure. This is also underlined by the EU Flood Directive. The flood related authorities therefore have to develop adjusted information tools which meet the demands of different user groups. This article presents the formative evaluation of flood hazard maps and web mapping services according to the specific requirements and needs of the general public using the dynamic-transactional approach as a theoretical framework. The evaluation was done by a mixture of different methods; an analysis of existing tools, a creative workshop with experts and laymen and an online survey. The currently existing flood hazard maps or web mapping services or web GIS still lack a good

balance between simplicity and complexity with adequate readability and usability for the public. Well designed and associative maps (e.g. using blue colours for water depths) which can be compared with past local flood events and which can create empathy in viewers, can help to raise awareness, to heighten the activity and knowledge level or can lead to further information seeking.

Concerning web mapping services, a linkage between general flood information like flood extents of different scenarios and corresponding water depths and real time information like gauge levels is an important demand by users. Gauge levels of these scenarios are easier to understand than the scientifically correct return periods or annualities. The recently developed Bavarian web mapping service tries to integrate these requirements."

4.4.8 Quantified scenarios analysis of drivers and impacts of changing flood risk in England and Wales: (Hall 2003)

"Flood risk to the economy, society and the environment reflects the cumulative effects of environmental and socio-economic change over decades. Long-term scenarios are therefore required in order to develop robust and sustainable flood risk management policies. Quantified national-scale flood risk analysis and expert appraisal of the mechanisms causing change in flood risk have been used to assess flood risk in England and Wales over the period 2030–2100. The assessment involved the use of socio-economic and climate change scenarios. The analysis predicts increasing flood risk unless current flood management policies, practices and investment levels are changed—up to 20-fold increase in economic risk by the 2080s in the scenario with highest economic growth. The increase is attributable to a combination of climate change (in particular increasing precipitation and relative sea level rise in parts of the UK) and increasing socio-economic vulnerability, particularly in terms of household/industrial contents and infrastructure vulnerability. The policy implications of these findings are discussed."

4.4.9 Towards probabilistic projections of climate change. (Hewitt *et al.* 2009)

"As evidence of climate change increases, so too are the effects of weather events and climate variability on civil engineering projects becoming increasingly recognised and understood. The changes indicated by the UKCIP02 scenarios, for example, suggest a number of threats and opportunities for the built environment. The Ensembles project will develop an ensemble climate prediction system for use across a range of timescales (from seasonal to decadal and longer) and spatial scales (from global to regional and local). The outputs from this European Commission funded project will allow further development, within a probabilistic framework, of tailored scenarios for urban areas developed as part of the UKCIP/EPSRC Building Knowledge for a Changing Climate programme. Examples of these projections for London Heathrow are presented; they illustrate the uncertainties in projected changes in extremes for urban and other sites. Modelling work that indicates the importance of representing urban areas within climate simulations is also presented."

4.4.10 *Assessing coastal flood risk at specific sites and regional scales: Regional assessment of coastal flood risk (Milligan 2005)*

"The research project '*Assessing coastal flood risk at specific sites and regional scales'* has undertaken an integrated assessment of erosion and flood risk for the case study area of sub-cell 3b on the Norfolk coast. This project has worked closely with Tyndall Project T2.45 '*Towards an integrated coastal sediment dynamics and shoreline response simulator*' and has used consistent scenarios of climate change (sea-level rise, wave height and direction), management strategies (from total to no coastal protection) and socio-economic scenarios using the DTI framework. To date, this is a unique study.

The major flood-prone area within sub-cell 3b is the Norfolk Broads between Eccles and Winterton. The flood risk analysis carried out further develops the RASP intermediate level approach, which produces a snapshot of flood risk, considering temporal changes in loading conditions and floodplain development. The results show that future flood risk is sensitive to a number of different parameters, including climate change, primarily the rate of sea level rise; the future socio-economic development; and the management of the coast. The management decisions made in the future on this coast determine the amount of cliff protection in place, which in turn controls the amount of sediment supplied to down-drift beaches and hence influences the magnitude of the protective beach in front of flood defence dikes. Flood inundation modelling then analyses the impact of this resultant beach volume on flood risk. The aim of this approach is to emphasise the importance of coastal management in determining future flood risk in the light of climate change"

4.4.11 Planning space for water (Potter 2008)

"Following the dramatic flood events of recent decades, local authority planners and the Environment Agency have come under widespread criticism. The flooding has exposed the cumulative impact of land drainage, urbanisation and river regulation, significantly reducing the natural water storage capacity of catchments. The political rhetoric is growing regarding restoring rivers' natural floodplains as a sustainable solution to flood risk management; nevertheless, converting the rhetoric into reality at the large spatial scales required is said to represent a serious challenge. This paper considers the complexity of the social barriers that challenge the spatial planning system and planning practitioners in implementing the necessary land use change focussing on the unhelpful gaps between research policy and practice. It is alleged that research may fail to inform policy and/or guide practice adequately. In addition, researchers' policy options often contain idealised reasoning that makes implementing policy far from trivial."

4.4.12 Uncertainty and climate change impact on the flood regime of small UK catchments. (Prudhomme *et al.* 2003)

"A rigorous methodology is described for quantifying some of the uncertainties of climate change impact studies, excluding those due to downscaling techniques, and applied on a set of five catchments in Great Britain. Uncertainties in climate change are calculated from a set of 25,000 climate scenarios randomly generated by a Monte Carlo simulation, using several Global Climate Models, SRES-98 emission scenarios and climate sensitivities. Flow series representative of current and future conditions were simulated using a conceptual hydrological model. Generalised Pareto Distributions were fitted to Peak-Over-Threshold series for each scenario, and future flood scenarios were

compared to current conditions for four typical flood events. Most scenarios show an increase in both the magnitude and the frequency of flood events, generally not greater than the 95% confidence limits. The largest uncertainty can be attributed to the type of GCM used, with the magnitude of changes varying by up to a factor 9 in Northern England and Scotland. It is therefore essential that climate change impact studies consider a range of climate scenarios derived from different GCMs, and that adaptation policies do not rely on results from only very few scenarios."

4.4.13 *Helping to Deliver Climate Change Adaptation through the UK Planning System. (Town and Country Planning Association (TCPA) 2009)*

"The objective of this study is to understand the planning systems of the four UK nations and respective powers and duties available in planning and environmental legislation to enable and deliver on adaptation. Its aim is to produce a report that:

- identifies how the planning systems currently work to deliver spatial patterns of development and land use that are climate change-resilience;
- identifies the range of statutory duties and discretionary powers in legislation which enable adaptation action by the relevant planning authorities;
- identifies the role of stakeholders and communities in the planning systems, presents nation-specific observations on current experience of adaptation in
- practice and implementation at the policy and development levels; and
- reaches conclusions that would help to inform future policy developments.

The overall conclusions of the study are that its findings reinforce the powerful statutory basis of the UK planning systems. At its best, the system is capable of integrating and giving spatial expression to a range of policy priorities within the sustainable development paradigm. Policy-makers and practitioners recognise that delivering adaptation needs to be embedded within the development plan-led approach of the planning systems. From national policy guidance to regional, subregional and local development plans, measures to adapt the built environment and various land use development activities need to be implemented in an integrated manner. But for now, the complexities of implementing adaptation across stakeholders from different sectors, parallel strategies and plans, and organisational structures and hierarchies in the context of significant planning reforms have surpassed the capability and capacity of planners and planning departments. The study also indicates the lower tiers of the planning system hierarchy are underperforming - particularly when measured against the ambition of some national planning policy. Therefore, it is imperative that policy-makers take note of the findings of this report as well as the final report from the RCEP, and seek to ensure that the institutional capacity of the UK planning systems will be fit-for-purpose as part of the wider coordinated effort to tackle the challenges of climate change."

4.4.14 Land use, water management and future flood risk. *Land Use Policy (Wheater and Evans 2009)*

"Human activities have profoundly changed the land on which we live. In particular, land use and land management change affect the hydrology that determines flood hazard, water resources (for human and environmental needs)

and the transport and dilution of pollutants. It is increasingly recognised that the management of land and water are inextricably linked (e.g. Defra, 2004). "Historical context, state of the science and current management issues" section of this paper addresses the science underlying those linkages, for both rural and urban areas. In "Historical context, state of the science and current management issues" section we discuss future drivers for change and their management implications. Detailed analyses are available for flood risk, from the Foresight Future Flooding project (Evans et al., 2004a,b) and other recent studies, and so we use flooding as an exemplar, with a more limited treatment of water resource and water quality aspects. Finally in "Science needs and developments" section we discuss science needs and likely progress. This paper does not address the important topic of water demand except for some reference to the Environment Agency's Water Resources Strategy for England and Wales (Environment Agency, 2009)."

4.4.15 Climate change and fluvial flood risk in the UK: more of the same? (Wilby *et al.* 2008)

"The potential impact of climate change on fluvial flooding is receiving considerable scientific and political interest thanks to evidence from climate model projections and a widely held belief that flood risk may be increasing at European levels. This review compares published work on historical trends in UK rainfall and river flow records with high-resolution regional climate change projections, and attempts to reconcile apparent differences between the two. Attention is focused on the techniques used for climate change detection and attribution, as well as the potential confounding effects of land-use change. International and domestic efforts to build adaptive capacity rest on improved quantification of uncertainty in flood risk at very local, catchment and regional scales. This will involve further research to better integrate climate and land-management interactions, to understand changes in the dependence between different flood generating mechanisms, and to improve the characterization and communication of uncertainty at all stages of analysis. Resources are also needed to ensure that latest, but still uncertain, science is presented in an appropriate form to underpin policy development and is translated into sensible guidance for practitioners."

Table 3: Content and relevance of sources, summary table

	Qn1 regional scale	Qn2 down scaling	Qn3 increase cost	Qn4 development planning	Qn5 proportion unviable	Qn6 Information needs	Case studies	Detailed maps	Empirical data	statistics
(BRE 2009)			☑	☑		☑	☑	☑	☑	
(Broads Authority 2000)	☑			☑	☑	☑			☑	
(Building futures 2007)	☑		☑	☑	☑	☑				
(CLG 2009)	☑			☑	☑	☑			☑	☑
(Conwy council 2009)	☑			☑		☑	☑	☑		
(Environment Agency 2009)	☑							☑		☑
(Hagemeier-Klose and Wagner 2009)		☑				☑				
(Hall 2003)	☑	☑								
(Hewitt *et al.* 2009)		☑				☑				
(Milligan 2005)	☑	☑		☑				☑	☑	☑
(Potter 2008)				☑		☑				
(Prudhomme *et al.* 2003)		☑		☑		☑	☑		☑	
(Town and Country Planning Association (TCPA) 2009)		☑	☑	☑		☑				
(Wheater and Evans 2009)	☑			☑		☑				
(Wilby et al. 2008)		☑	☑	☑		☑				

4.5 Appraisal of search strategy

This multidisciplinary topic proved problematic to scope as was anticipated by the proposal. Different subjects not use different terminology but also can interpret the same terminology differently. Local scale for some modellers may imply whole regions or catchments rather than property level. The reference lists of four publications were searched by title for potentially relevant sources which had not been identified in the scoping study. The results of that analysis are shown in Table 4 and include the additional search terms taken from the titles of the potentially relevant studies.

Table 4: Analysis of reference lists

	Wilby (2008)	**BRE (2009)**	**Wheater (2009)**	**TCPA (2009)**
Number of references	125	14	73	53
Cited in web of science	4	n/a	n/a	n/a
Cited in google scholar	6	n/a	n/a	n/a
References in scoping database	5	7	5	3
Potentially relevant	6	1	0	3
Additional terms	Adaptat*	Changing climate		Changing climate
	Uncertain*			Climate adaptation
	Downscal*			
	Increas* runoff			
	Changing climate			

The large number of publications in these reference lists not relevant is because of the dual needs to include small scale or downscale models and climate change. Additional publications by key authors who were included in the scoping were not found. In the built environment arena the majority of sources came from website trawling and consisted of many reports. In the analysis of suitable publications it was noted that certain key journals were not listed in the databases scoped. Some new terms were identified.

5. Implications for Draft Protocol

The implications of these findings for the draft protocol are that the range of search terms should be increased slightly to include the newly identified terms. Author searches on key authors or centres could be used and some buldings publications need to be searched on an individual basis.

6. List of References

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APPENDIX 1: SEARCH TERM ANALYSIS
Analysis of search terms in the Web of Knowledge

	Search string	**Number of hits**	**Comment**
1	Flood*	69,668	
2	Flood* and inundate*	73,918	Unmanageable
3	Flood* risk*	1,057	
4	Flood* hazard*	496	
5	“Flood* risk*” OR “flood* hazard*”	1469	
6	“Flood* risk*” OR “flood* hazard*” OR “flood* probab*”	1513	
7	“flood* risk* OR “flood* hazard* OR “flood* probab*” or “flood* vulnerab*” OR “danger of flood*” OR “liab* to flood*” OR “flood* uncertain*” OR “possibility of flood*” OR “flood* forecast*” OR “forecast* flood*” OR “flood exposure”	2421	
8	Climat* chang*	58,968	Unmanageable
9	“flood* risk* OR “flood* hazard* OR “flood* probab*” or “flood* vulnerab*” OR “danger of flood*” OR “liab* to flood*” OR “flood* uncertain*” OR “possibility of flood*” OR “flood* forecast*” OR “forecast* flood*” OR “flood exposure” **AND** “climat* chang*”	259	Rather low
10	Flood* OR inundat* AND “climat* chang*”	2651	Better. **Choose flood* or inundat*** as outcome terms
11	Property	>100,000	
12	development	>100,000	
13	building	>100,000	
14	construction	>100,000	as expected buildings terms too ambiguous
15	“property level”	60	
16	“Individual development”	971	
17	“Construction site”	990	
18	“Development scale”	308	
19	“Housing development”	505	
20	“Development site”	121	
21	“Building development”	96	
22	“Construction project”	1373	
23	“Local scale”	4432	
24	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development	14,206	Combine all property terms

	scale" or "urban development")		
25	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale")	>100,000	Inclusion of mapping terms causes inclusion of huge irrelevant literature
26	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale") AND Topic=(flood*)	1886	But combining with flood removes a lot
27	Topic=("Flood Risk assessment" OR "FRA" OR "PPS25")	8175	Includes a lot of medical
28	Topic=("Flood Risk assessment" OR "FRA" OR "PPS25") AND Topic=(flood*)	101	Removing FRA only loses 2
29	Topic=("Flood Risk assessment" OR "PPS25" OR "FRA" OR "Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale") AND Topic=(flood*)	1981	Not much gained over 26
30	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale") AND Topic=(flood* OR inundat*) AND Publication Name=("climat* chang*")	132	
31	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level"	437	

	or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale") AND Topic=(flood* OR inundat*) AND Topic=("climat* chang*"OR "environment* chang*" oR "extreme weather" OR "weather events" OR "increasing risk" OR "future risk" OR "global warming" OR "changing risk" OR "flood events" OR "changing RISK" or "growth in" OR "greenhouse effect" or "climate threat" or "extreme rainfall" or UKCIP or "increased frequency" or "storm surge")		
	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale") AND Topic=(flood* OR inundat*) AND Topic=("climat* chang*"OR "environment* chang*" oR "extreme weather" OR "weather events" OR "increasing risk" OR "future risk" OR "global warming" OR "changing risk" OR "changing RISK" or "growth in" OR "greenhouse effect" or "climate threat" or "extreme rainfall" or UKCIP or "increased frequency" or "storm surge")	361	Removing flood event because not really intervention
	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or "small scale") AND Topic=(flood* OR inundat*) AND Topic=("climat* chang*"OR "environment* chang*" OR "increasing risk" OR "future risk" OR "global warming" OR "changing risk" OR "changing RISK" or "growth in" OR "greenhouse effect" or "climate threat" or UKCIP or "increased frequency")	316	Removing all non changing terms
	Topic=("Property level" OR "housing development" OR "development site" OR "building development" OR "construction site" OR "construction project" or "local scale" or "building site" or "building plot" or "site level" or "individual development" or "development scale" or "urban development" or "high resolution" or "fine grain" or "small grid" or	316	Streamline intervention terms

	"small scale") AND Topic=(flood* OR inundat*) AND Topic=("climat* chang*" OR "environment* chang*" OR "global warm*" or "growth in" OR "greenhouse effect" or "increas* frequency")		
	Topic=("development site" or "construction project" OR "local scale" or "site level" or "development scale" or "high resolution" OR "urban development" or "fine grain" or "small scale") AND Topic=(flood* OR inundat*) AND Topic=("climat* chang*" OR "environment* chang*" OR "global warm*" or "growth in" OR "greenhouse effect" or "increas* frequency")	316	Streamlining subject terms 30 references relevant after title filter

Analysis of search terms in Google

	Search string	Number of hits	Comment
1	Flood	**51,400,000**	Unmanageable
2	Flood OR inundate OR inundation	**266,000,000**	Unmanageable
3	Flood risk	**944,000**	Unmanageable
4	Flood hazard	**1,280,000**	Unmanageable
5	“Flood risk” OR “flood hazard”	**2,120,000**	Unmanageable
6	“Flood risk” OR “flood hazard” OR “flood probability”	**2,090,000**	Goes down because google cannot have 3 alternatives
7	“flood risk OR “flood hazard OR “flood probability” or “flood vulnerability” OR “danger of flood” OR “liable to flood” OR “flood* uncertain*” OR “possibility of flood*” OR “flood* forecast*” OR “forecast* flood*” OR “flood exposure”	na	
8	Climate change	**63,200,000**	Unmanageable
9	“flood* risk* OR “flood* hazard* OR “flood* probab*” or “flood* vulnerab*” OR “danger of flood*” OR “liab* to flood*” OR “flood* uncertain*” OR “possibility of flood*” OR “flood* forecast*” OR “forecast* flood*” OR “flood exposure” **AND** “climat* chang*”	na	
10	Flood OR inundate OR inundation AND “climate change”	**6,530,000**	Better. **Choose flood or inundate or inundation** as outcome terms
11	Property	**530,000,000**	
12	development	**669,000,000**	
13	building	**469,000,000**	
14	construction	**349,000,000**	Too ambiguous
15	“property level”	**113,000**	
16	“Individual development”	**819,000**	
17	“Construction site”	**4,470,000**	
18	“Development scale”	**131,000**	
19	“Housing development”	**3,640,000**	
20	“Development site”	**1,960,000**	
21	“Building development”	**574,000**	
22	“Construction project”	**3,570,000**	
23	“Local scale”	**445,000**	
24	flood "construction site" OR "housing development" OR "property level" "climate change"	**361,000**	
25	flood-risk "construction site" OR "housing development" OR "property level" "climate change"	**57,500**	Search terms used

APPENDIX 2: DATABASE SCOPING

Database	SEARCH TERMS	NUMBER OF RESULTS	RELEVANT RESULTS
Geobase	**Building site or construction site or local scale or property level or housing development or development site or construction project or building plot or site level or individual development or development scale) and (flood risk or flood hazard or flooding or Flood vulnerability or danger flooding or liable flood or flood uncertainty or possibility flood or forecast flood or flood exposure) and (environmental change or climate change or extreme weather or weather events or increasing risk or future risk or global warming or flood events or changing risk or growth or greenhouse effect or climate threat)).mp. [mp=title, abstract, geobase descriptor, heading word, original title, keyword]**	43	5
CIS	Building site OR construction site OR local scale OR property level OR housing development OR development site OR construction project OR building plot OR site level OR individual development OR development scale) AND (flood* OR inundat*) AND (change OR increase OR growth)	200 accessed	20
ICE virtual library	Building site OR construction site OR local scale OR property level OR housing development OR development site OR construction project OR building plot OR site level OR individual development OR development scale) AND (flood* OR inundat*) AND (change OR increase OR growth)	200 accessed	15
EBSCO	Over 3,000 in full text Limited to title, keyword, abstract	39	3
Science direct	Full text too many Building site OR construction site OR local scale OR property level OR housing development OR development site OR construction project OR building plot OR site level OR individual development OR development scale and TITLE-ABSTR-KEY((flood* OR inundat*) AND (change OR increase OR growth))	587 200 accessed	12
Ethos	Flood	243	13
Knovel	Flood and “climate change”	31	1
Infotrac	Building site OR construction site OR local scale OR property level OR housing development OR development site OR construction project OR building plot OR site	134	9

	level OR individual development OR development scale and TITLE-ABSTR-KEY((flood* OR inundat*) AND (change OR increase OR growth))		
Directory of Open Access Journals	Search engine problems *Title*=flood* OR *Abstract*=flood*	606 Accessed first 200	7
Web of knowledge	Topic=("development site" or "construction project" OR "local scale" or "site level" or "development scale" or "high resolution" OR "urban development" or "fine grain" or "small scale") AND Topic=(flood* OR inundat*) AND Topic=("climat* chang*" OR "environment* chang*" OR "global warm*" or "growth in" OR "greenhouse effect" or "increas* frequency")	316	15
Scirus	title:flood (title:"development site" OR title:"construction project" OR title:"local scale" OR title:"site level" OR title:"development scale" OR title:"high resolution" OR title:"urban development" OR title:"fine grain" OR title:"small scale")	81	7
Google scholar	allintitle: flood local OR property OR housing OR construction OR building OR plot OR site OR development OR change OR increase OR growth	2300 Accessed first 200	17
google	flood-risk "construction site" OR "housing development" OR "property level" "climate change"	**42,200 Accessed first 200**	21
Total database sources			147

APPENDIX 3: WEBSITE TRAWL RECORD

ORGANISATION	WEB ADDRESS	SEARCH TERMS	NUMBER OF RESULTS	RELEVANT RESULTS
CIRIA	http://www.ciria.org	Flood	72	8
Building Research Establishment	http://www.bre.co.uk	flood	9 pages 21 publications	4
Commission for Architecture and the Built Environment	http://www.cabe.org.uk	flood	191 hits 1 publication 41 case studies 20 design review	7
House Builders Federation	http://www.hbf.co.uk	flood	50 hits	2
Royal Institution of Chartered Surveyors	http://www.rics.org	Building site OR construction site OR local scale OR property level OR housing development OR development site OR construction project OR building plot OR site level OR individual development OR development scale) AND (flood* OR inundat*) AND (change OR increase OR growth)	259	5
Royal Institute of British Architects	http://www.architecture.com	Flood and climate	115	4
Royal Town Planning Institute	http://www.rtpi.org.uk	Flood in body text	82	7
National Flood Forum	http://www.floodforum.org.uk	No search facility used menu to browse information		0
Environment Agency	http://www.environment-agency.gov.uk	Flood and climate change	143 planning and research	20 out of 80 accessed

			(accessed) 121 news 20 Business and industry 19 at home and leisure 5 about us 1 media centre	
Centre for Ecology and Hydrology	http://www.ceh.ac.uk	flood	255 Accessed 100 with climate change	8
British Hydrological Society	http://www.hydrology.org.uk	No search facility, browed publications, 2008 symposium		4
Scotland and Northern Ireland Forum for Environmental Research	http://www.sniffer.org.uk	flood	108	8
Tyndall Centre	http://www.tyndall.ac.uk	flood	43	4
UK Climate Impacts Programme	http://www.ukcip.org.uk	Flood and construction Browse publications	19	0 relevant 7
Flood Risk Management Research Consortium	http://www.floodrisk.org.uk	Browsed reports, publications and presentations		3
Total website sources				91