

# Assessing the risk

## The bedrock of good decision making

Paul Sayers  
Head of Flood Management  
HR Wallingford

Managing flood risk, reliability and vulnerability  
4<sup>th</sup> International Symposium on Flood Defence, Toronto, 2008



Environment Agency

*Operational and research programmes*



European Union ([www.floodsite.net](http://www.floodsite.net))

*Applied research from across Europe*



Research Councils

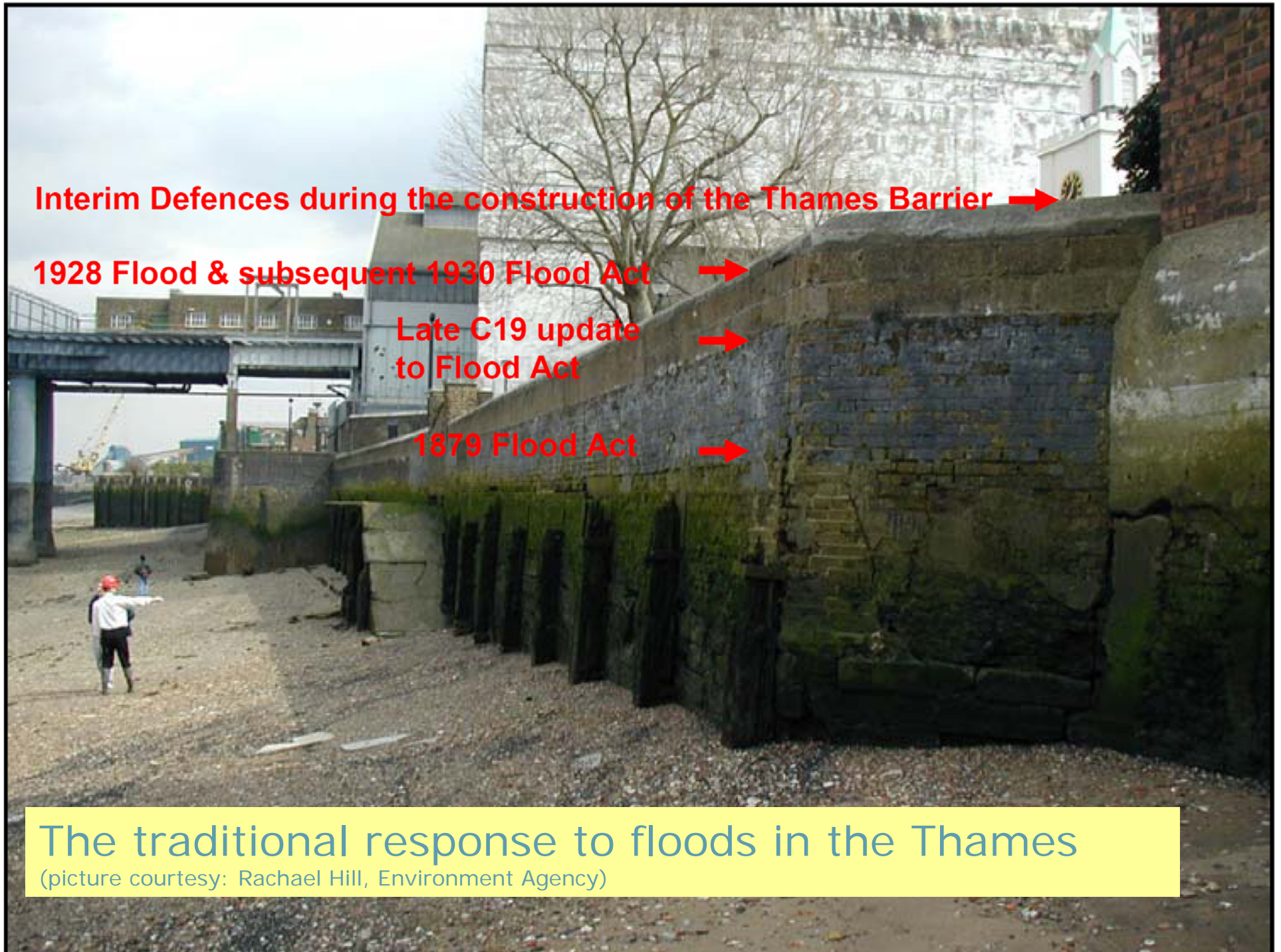
*Underpinning research and concepts*

# Outline of presentation

Demands of present day flood managers  
Hierarchical planning  
Hierarchical analysis  
Conclusions







## The traditional response to floods in the Thames

(picture courtesy: Rachael Hill, Environment Agency)



# Demands of the flood risk manager

## Basic aim of flood risk managers

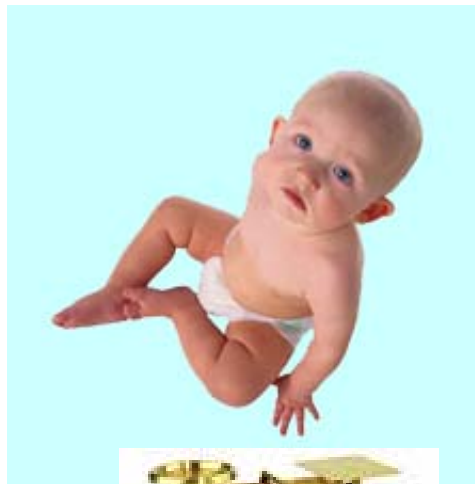
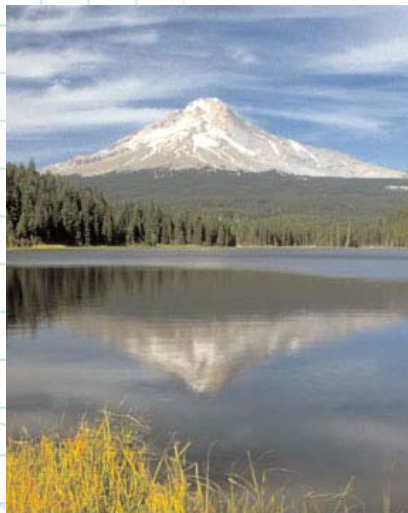
- To target limited resources to achieve maximum benefit.

.....Easy?

Not really...

as the “benefits” are numerous

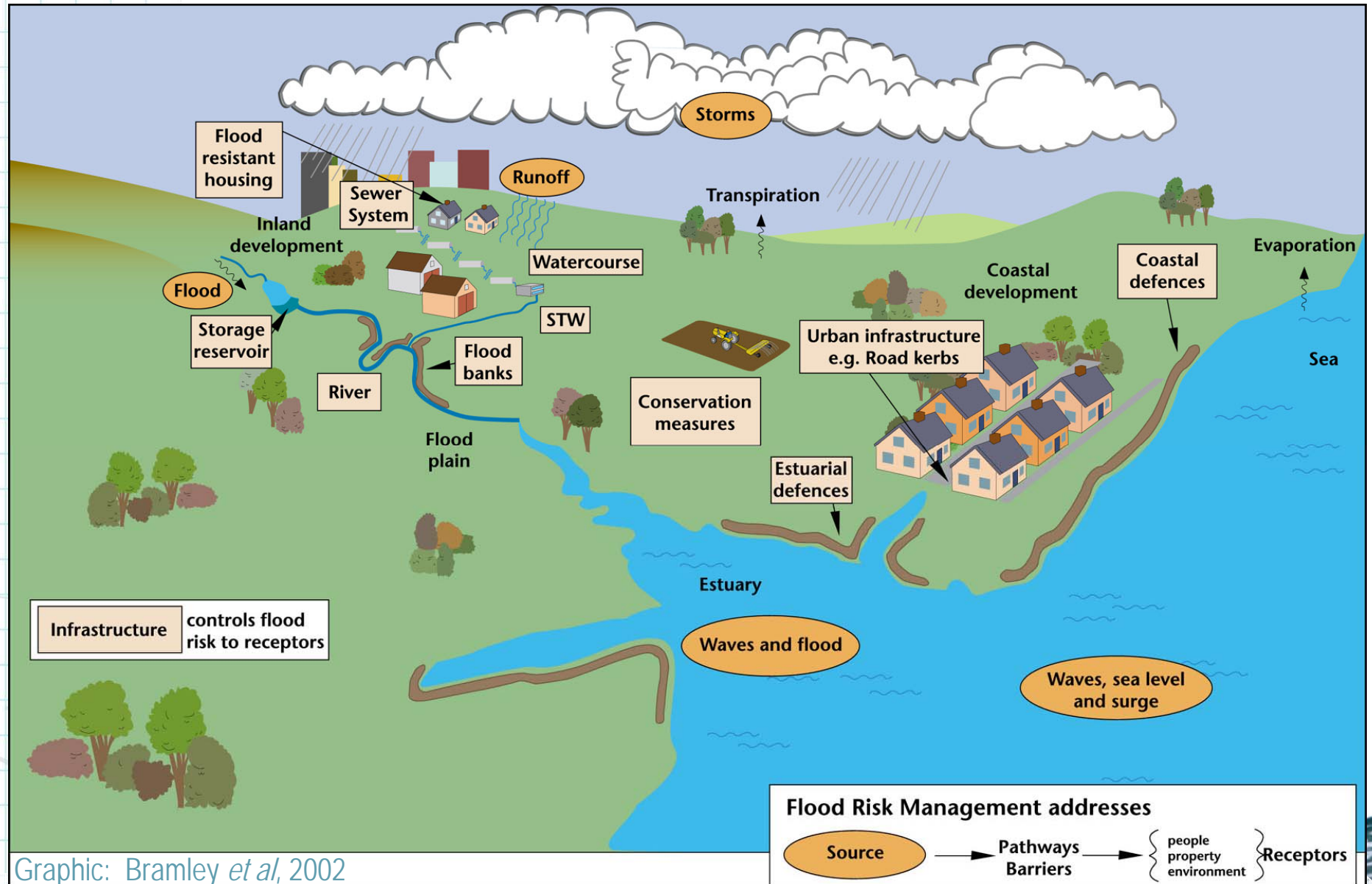
## Multi-functional interventions achieving multi-objectives chosen based on multi-criteria





Not really...

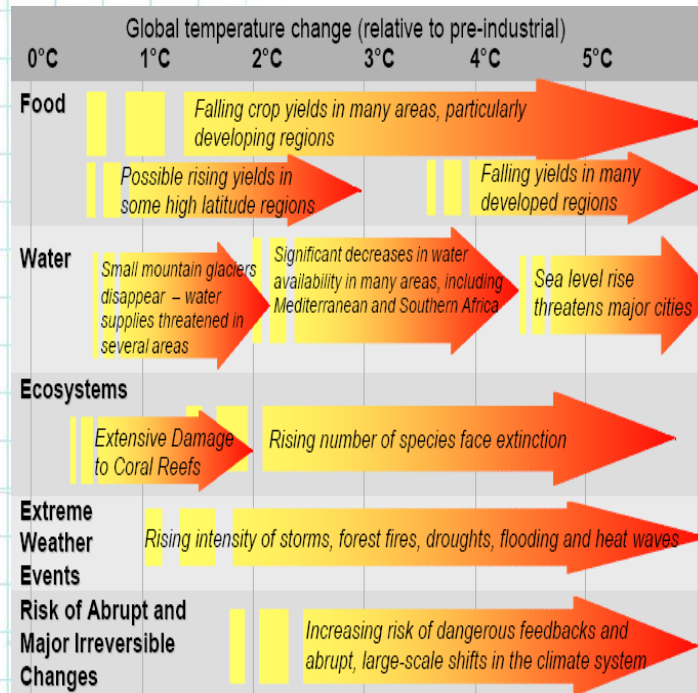
as flood systems exhibit spatial complexity



Graphic: Bramley *et al*, 2002

# Not really... as flood systems exhibit temporal complexity

*"If history taught us one thing, it is that it teaches us less and less. Indeed, a paradox."* (Duin & Stavleu, 2005)



(Source: Stern, 2006)





Not really...

and the management responses are numerous

## Portfolios of responses

Policy to local action

Structural to non-structural

Preparedness to recovery

**Accept**



**Insurance**



**Land use management**

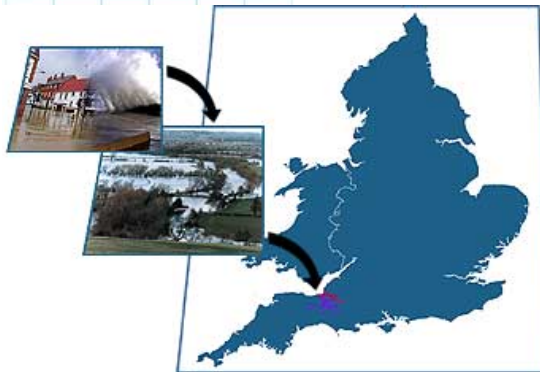


**Litigation**



**Development regulation**

# Assessing the risk – Hierarchical planning



## National Level

National policy and long-term expenditure planning and monitoring

## Regional / River Basin Level

Regional flood risk assessments required by PPS25 for Regional Spatial Strategies

## Catchment / Coastal Cell Level

Catchment Flood Management Plans, Shoreline Management Plans and Coastal Defence Strategies

## Community Level

SFRA required by PPS25 and risk assessments for delivery plans (inc Asset Management Plans and Flood Warning Plans)

## Site / System Level

FRAs required by PPS25, risk assessment for delivery plans (inc. Capital schemes and projects, asset system medium term management plans)

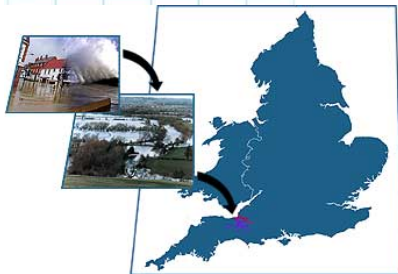
Feedback from more detailed analysis

Decisions at lower level constrained by high level policies and choices

(Source: Report for the Environment Agency - HR Wallingford, 2002)



# And supporting tiered risk analysis tools (so-called RASP framework)



| Level        | Decisions to inform  | Data sources   | Methodologies   |
|--------------|--|--|---|
| High         | National assessment of economic risk, risk to life or environmental risk<br><br>Prioritisation of expenditure<br><br>Regional planning<br><br>Flood warning planning | Defence type<br><br>Condition grades<br><br>Standard of Protection<br><br>Indicative flood plain maps<br><br>Socio-economic data<br><br>Land use mapping   | Generic probabilities of defence failure based on condition assessment and crest freeboard<br><br>Assumed dependency between defence sections<br><br>Empirical methods to determine likely flood extent |
| Intermediate | <i>Above plus:</i><br><br>Flood defence strategy planning<br><br>Regulation of development<br><br>Maintenance management<br><br>Planning of flood warning            | <i>Above plus:</i><br><br>Defence crest level and other dimensions where available<br><br>Joint probability load distributions<br><br>Flood plain topography<br><br>Detailed socio-economic data | Probabilities of defence failure from reliability analysis<br><br>Systems reliability analysis using joint loading conditions<br><br>Modelling of limited number of inundation scenarios                |
| Detailed     | <i>Above plus:</i><br><br>Scheme appraisal and optimisation  | <i>Above plus:</i><br><br>All parameters required describing defence strength<br><br>Synthetic time series of loading conditions   | Simulation-based reliability analysis of system<br><br>Simulation modelling of inundation   |



All RASP tiers.....

## Utilise a structured definition of the flood system

**Pathway**

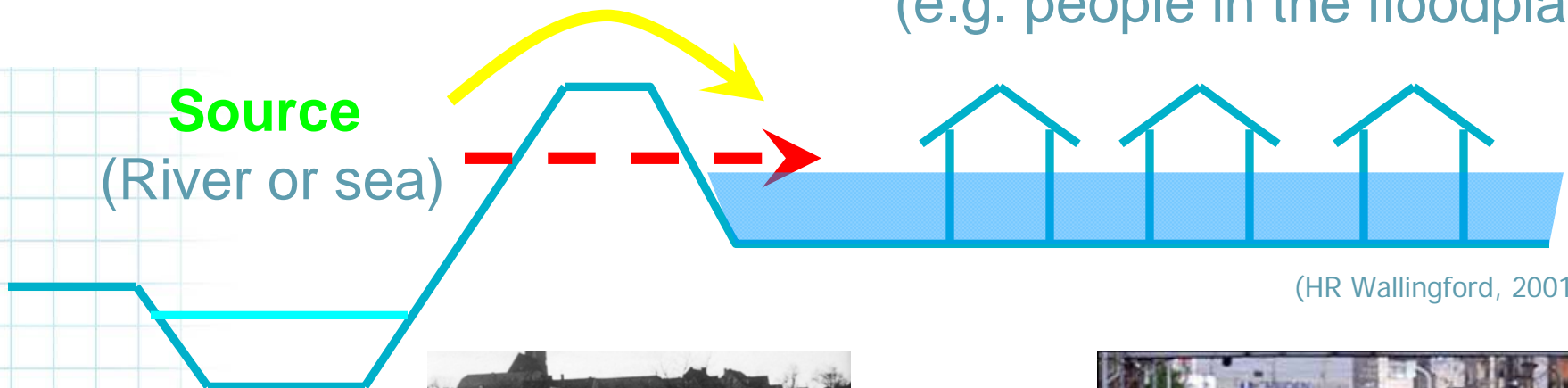
(e.g. beach, defence and floodplain)

**Receptor**

(e.g. people in the floodplain)

**Source**

(River or sea)



(HR Wallingford, 2001)



(courtesy: US Corp)



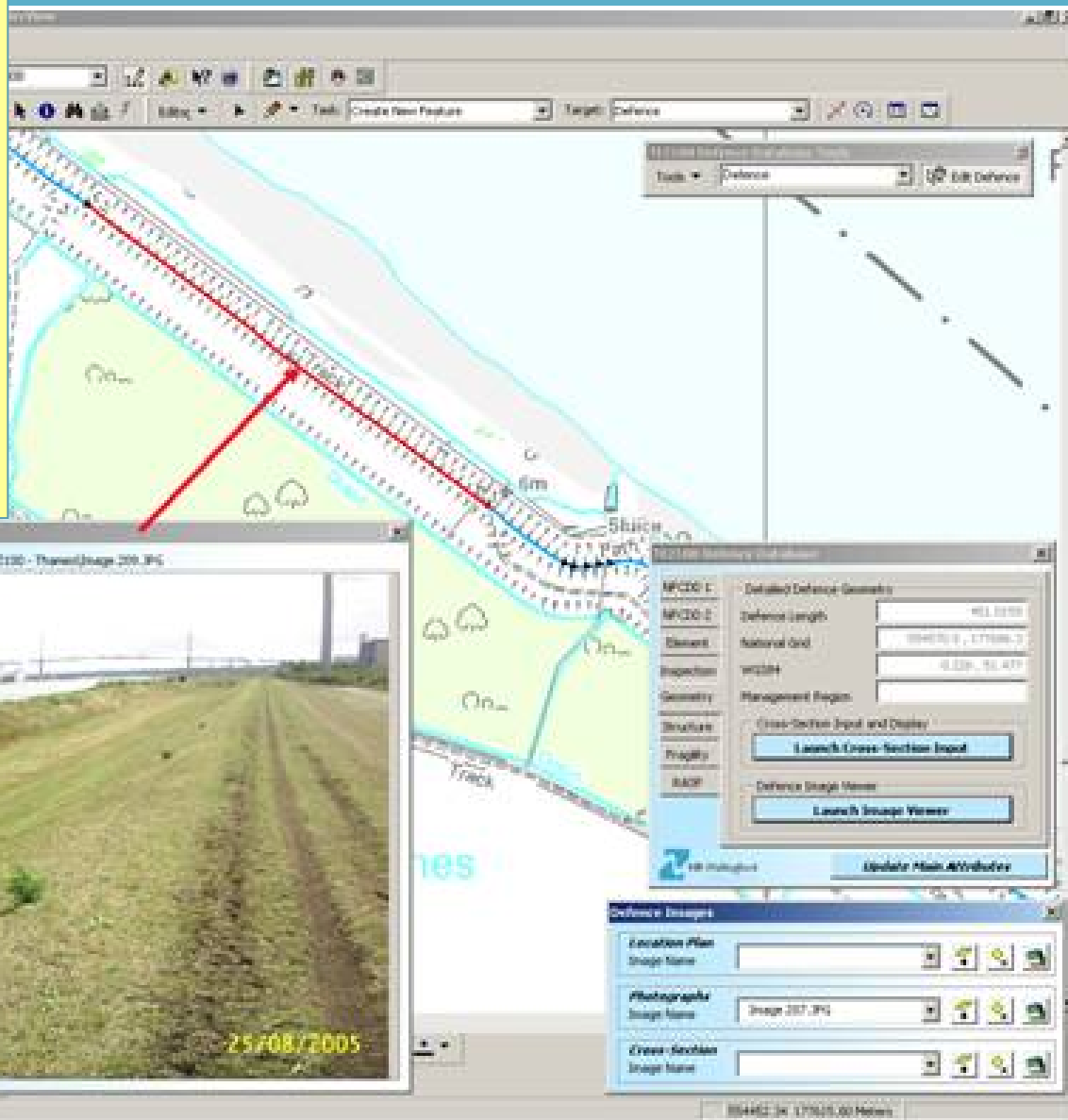
...and...

## Share data between levels

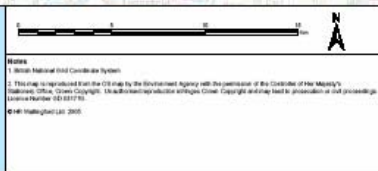
*"Collect once use many times"*

Data is used and returned to a common set of databases

e.g. National Flood and Coastal Defence Database (Environment Agency)





## Accepting and recording varying levels



**Map Legend**

**Crest level data source**

- TE2100 v2 - Analyzed LIDAR Data 105
- TE2100 v2 - GPS Based Survey 101 105
- TE2100 v2 - Hydrology Survey 101 105
- TE2100 v2 - Estimated Crest Level
- TE2100 v2 - Adjusted to Grand Level
- TE2100 v3 - HWRF Revised NFCD
- TE2100 v1 - Avg. Dat\_105
- TE2100 v1 - Dares/DaresData
- TE2100 v1 - Daily/Therm\_StationData/level
- TE2100 v1 - Station Data/level
- TE2100 v1 - Thermo\_NFCD\_20052100
- TE2100 v1a - HGL 1025 10105
- TE2100 v1a - HGL Adjusted 60 1025
- TE2100 v1a - HGL Adjusted 20 1005
- TE2100 v1a - HWRF Adjusted 20 1005

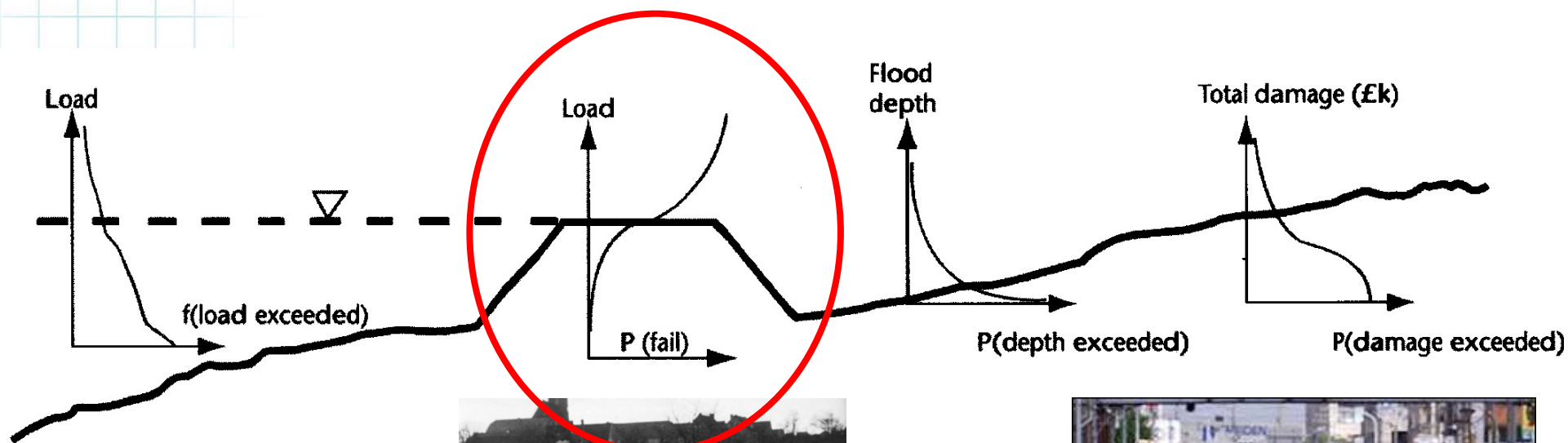
|  |  |
|--|--|
|  Environment Agency                             |  HR Wallingford |
| <b>Title:</b> Model v3 - Crest level source<br><b>Scenario Description:</b> N/A<br><b>Climate Scenario:</b> N/A<br><b>Epooh:</b> N/A |  |
| <b>Date:</b> 27 June 2006  | <b>Revision Number:</b> 00   |
| <b>Job Number:</b> DTR3778   | <b>Drawing Number:</b>   |





# Hierarchical analysis

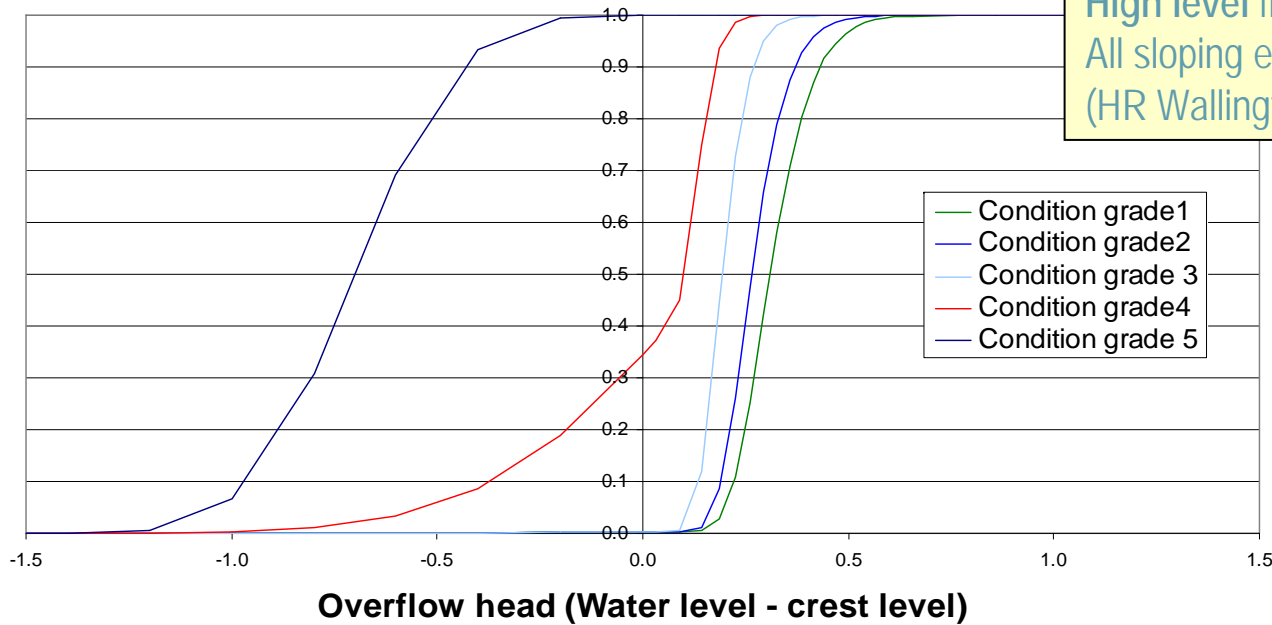
Supports progressive improvement in detail



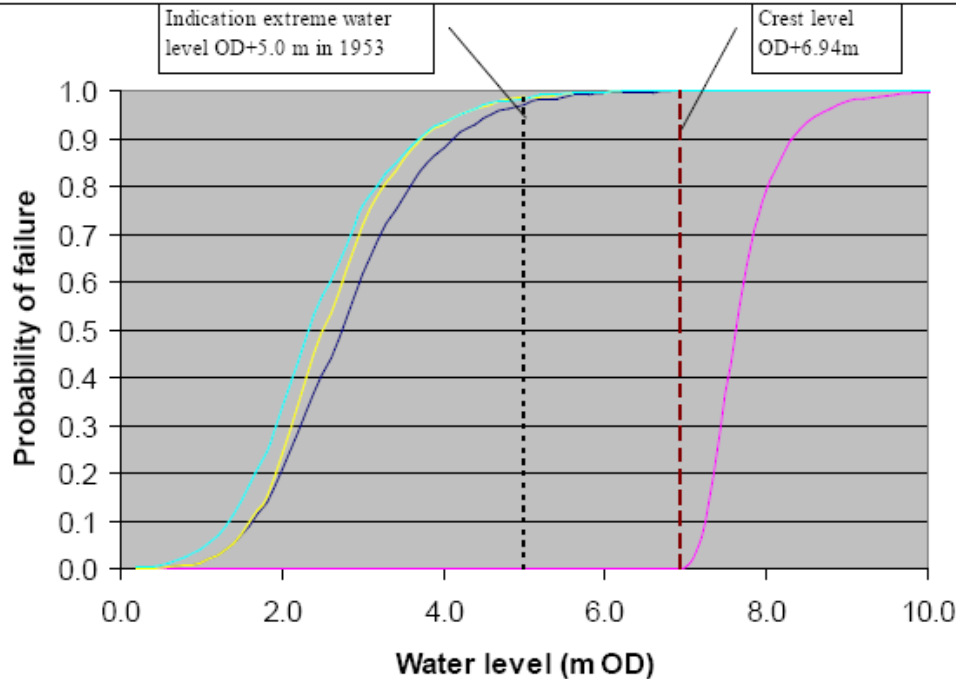


HR Wallingford

P (breaching/overflow)



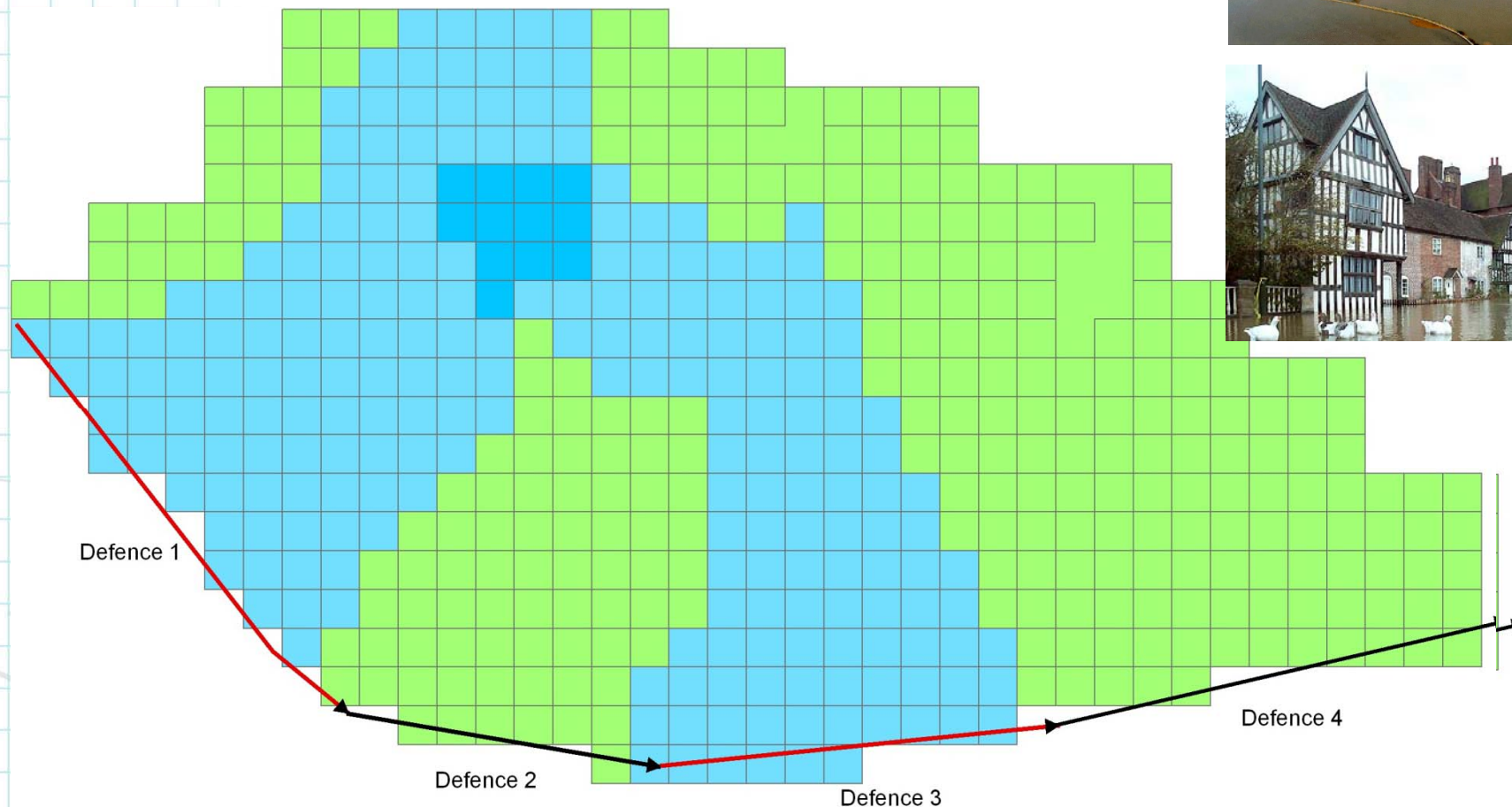
High level fragility curve  
All sloping embankments  
(HR Wallingford, 2004)



Detailed fragility curve  
(Dartford Creek embankment)  
(HR Wallingford, 2006)

## All tiers consider “all” loads and defence states

Wide range of loads – 1 year to the 1000-10000 year events  
All defence states – breach/not breach/overtopped

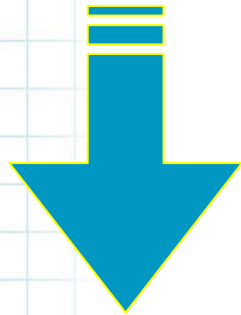




### All inundation scenarios

A new super fast  
inundation model (**HR-  
RFSM**) enables 10000s of  
inundation scenarios to be  
realised

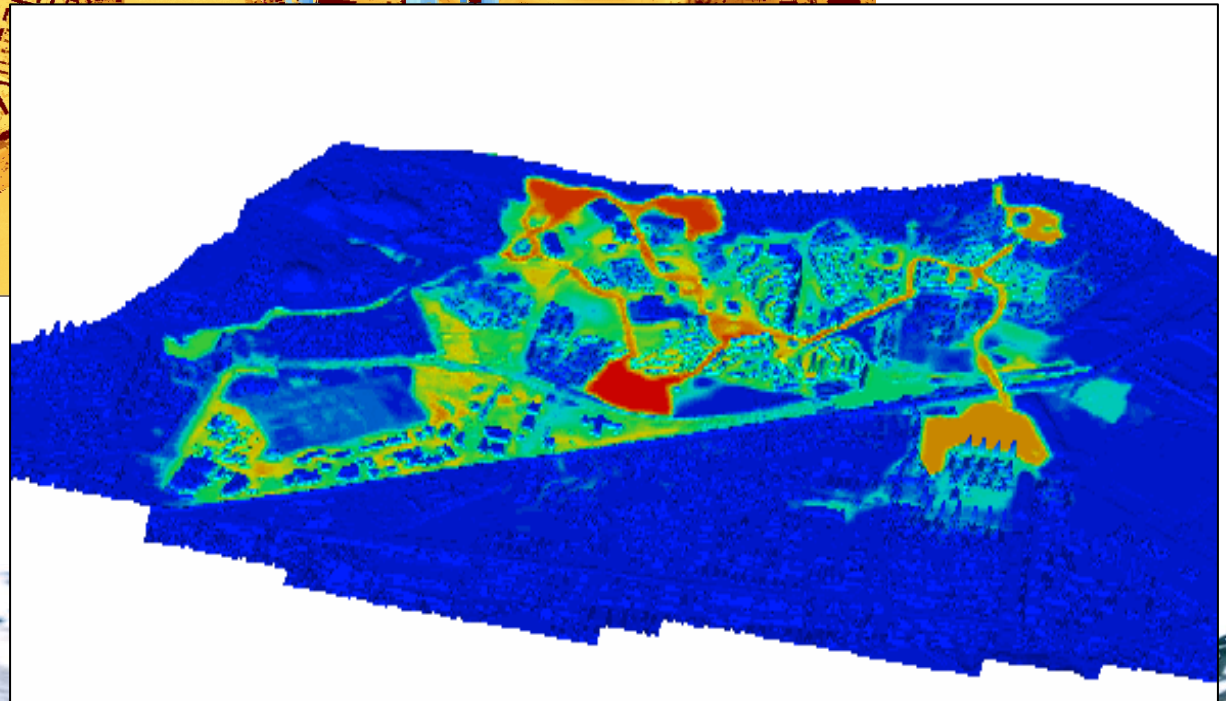
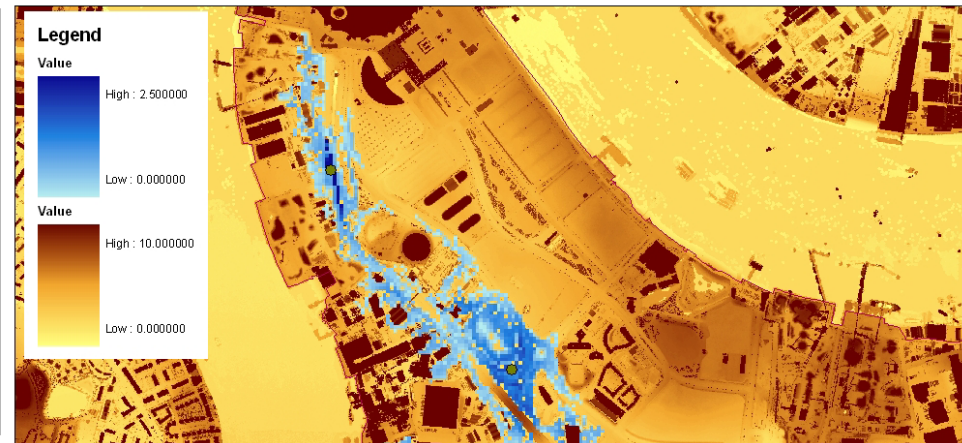
Runtime: <10 secs



### Selected inundation scenarios

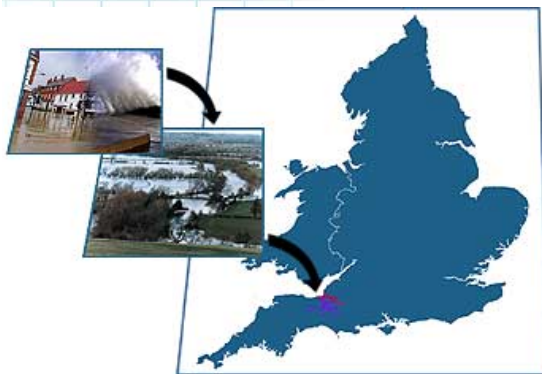
Infoworks-RS2D is used to  
refine results for selected  
**high risk** scenarios

Runtime: app. 6 hour



# Example applications

## National and Regional Applications



**National Level**  
National policy and  
planning and mo

RASP – National models  
Foresight, 2004,  
NaFRA, 2002,2004,2005,2006...

**Regional / River Basin Level**

Regional flood risk assessments required by  
PPS25 for Regional Spatial Strategies

**Catchment / Coastal Cell Level**

Catchment Flood  
Management Plan  
RASP – Regional models  
Thames Estuary Project  
Shoreline  
Strategie

**Community Level**

SFRA required by PPS25 and risk assessments  
for delivery plans (inc Asset Management Plans and  
Flood Warning Plans)

**Site / System Level**

FRAs required by PPS25, risk assessment for deliv  
plans (inc. Capital schemes and projects, asset  
system medium term management plans)

Feedback from more detailed analysis

Decisions at lower level co  
strained by  
high level policies and cho  
ces

HR Wallingford, 2004



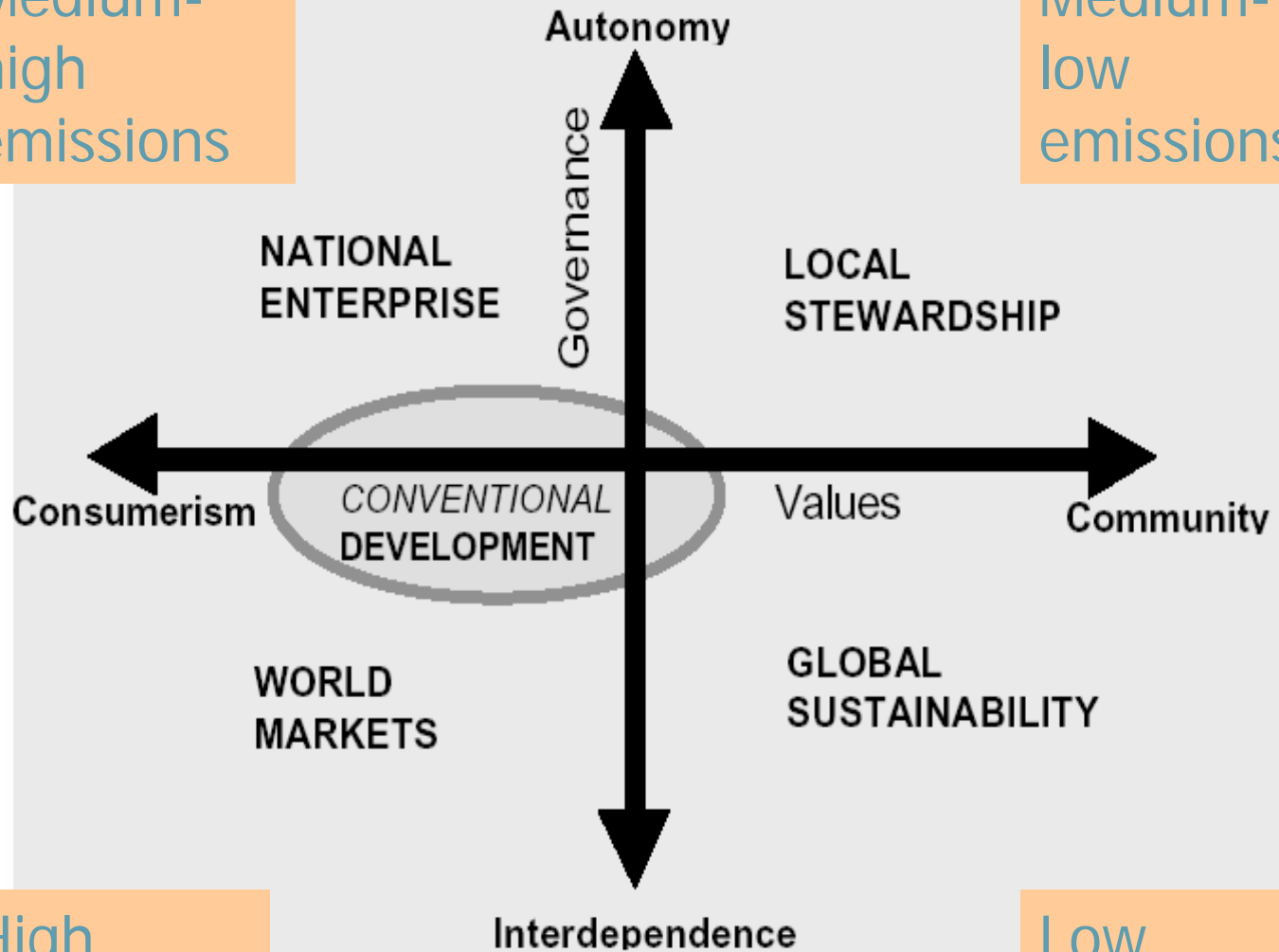
## Example 1 – National Horizon scanning and direction setting (e.g. Foresight UK)

Medium-  
high  
emissions

Medium-  
low  
emissions

Foresight Future  
Flooding Project,  
2004

Looked forward to  
2050 and 2100



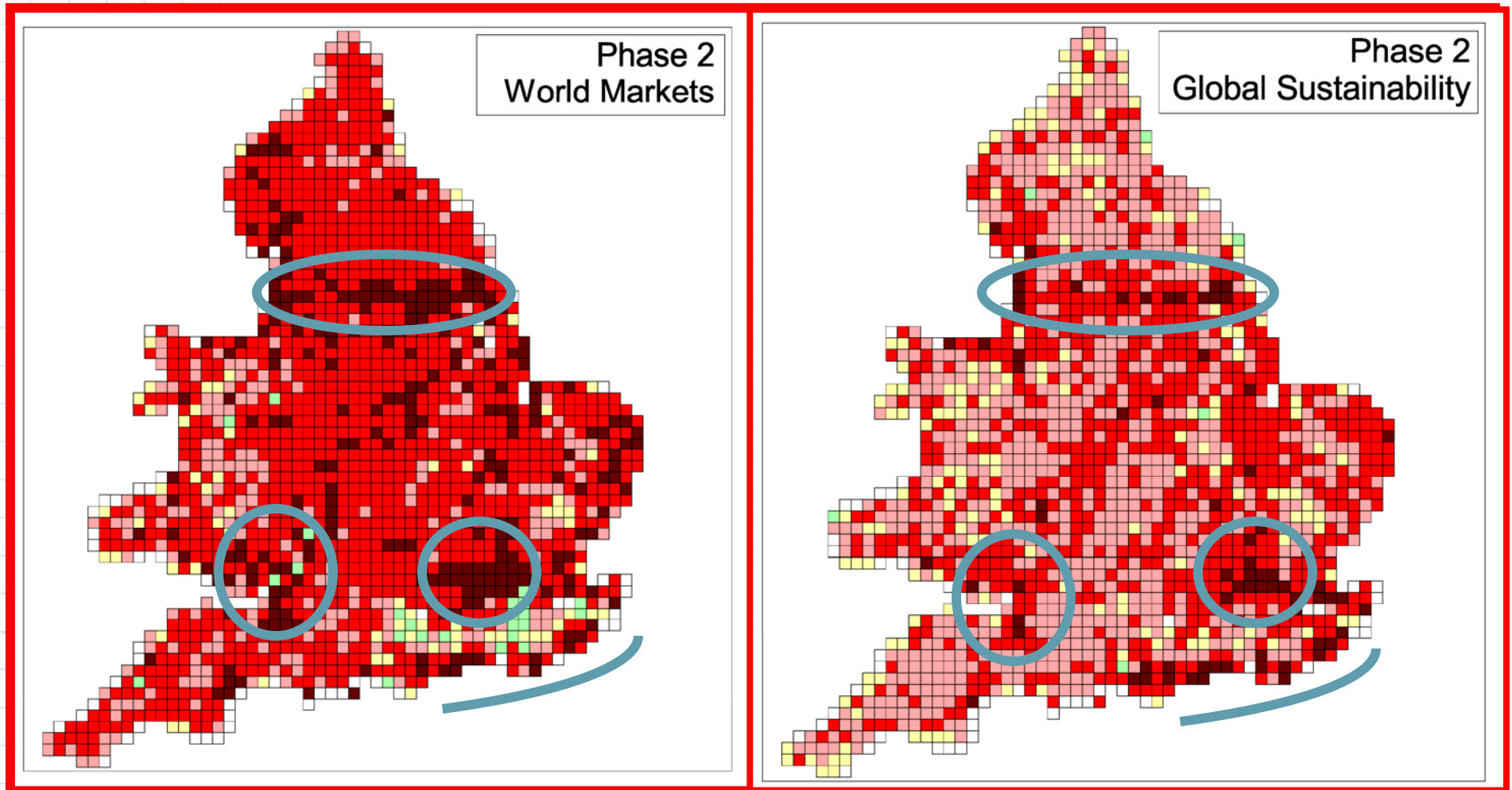
High  
emissions

Low  
emissions



## Example 1 – National horizon scanning and direction setting

### How might the **expected annual damages** change?



EAD £21 Billion (\$40 Billion Dollars)

EAD £2 Billion (\$4 Billion Dollars)

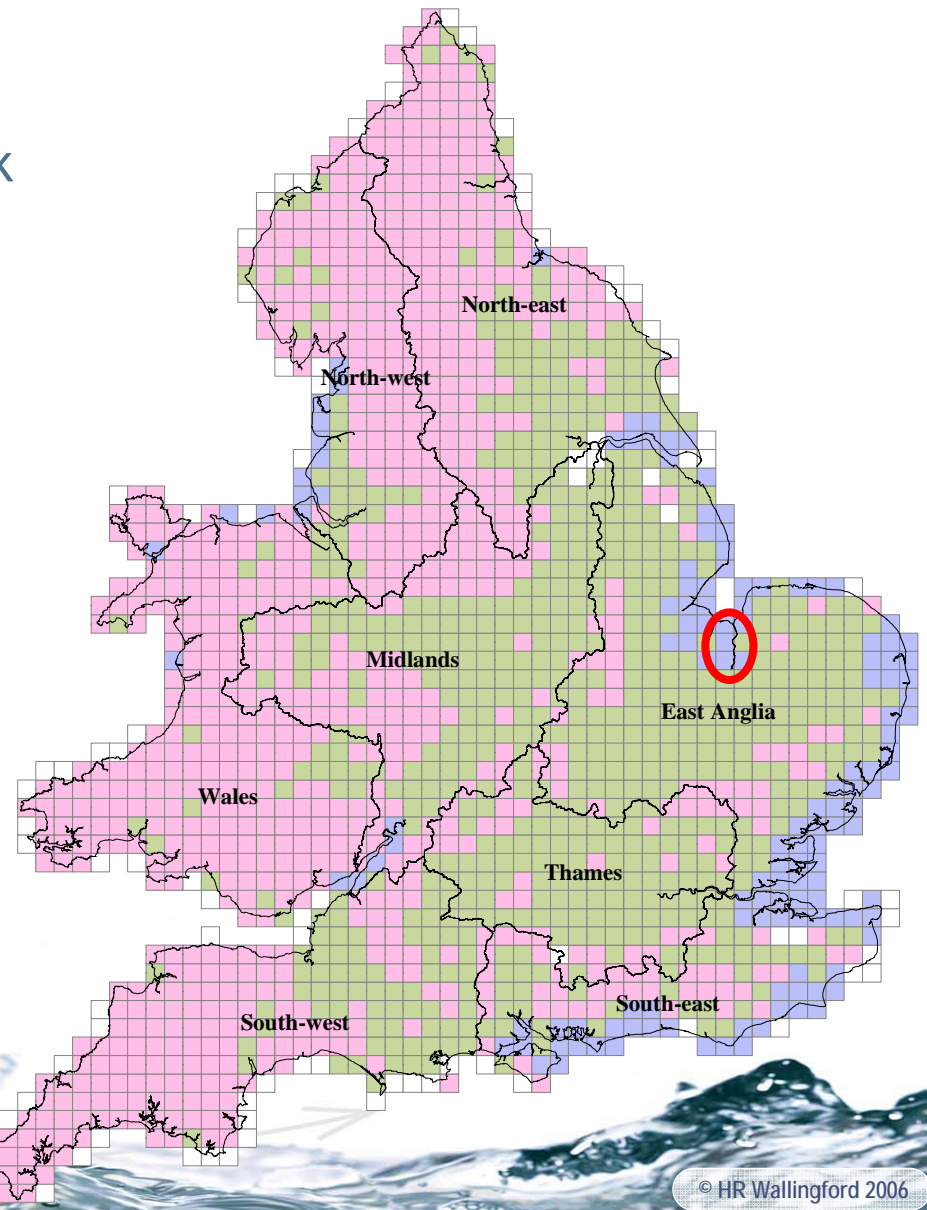
# Monitoring present day national flood risk

## Simple questions...

- How well are we managing flood risk year on year?
- Has it gone up or down ?
- Which areas have seen the most change – is this expected?
- At a national scale are our schemes and policies working?

## Providing answers

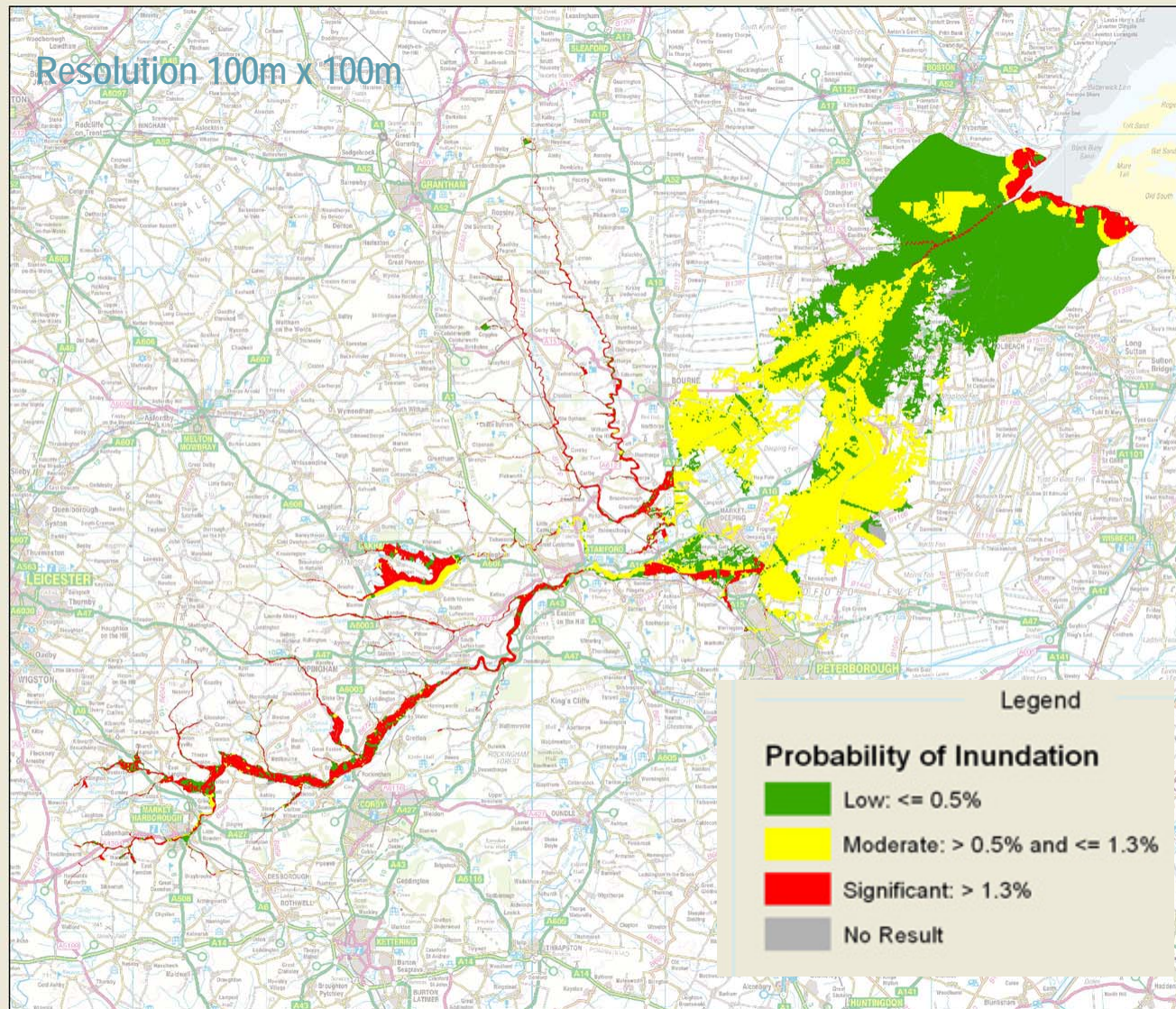
- National Flood Risk Assessment (NaFRA based on RASP)
- Undertaken annually since 2002 (Defra and Environment Agency)





# Monitoring present day national flood risk

## Example 2



**Legend**

**Probability of Inundation**

- Low:  $\leq 0.5\%$
- Moderate:  $> 0.5\%$  and  $\leq 1.3\%$
- Significant:  $> 1.3\%$
- No Result

**Scale**



**Project:** NaFRA 2006  
**Title:** Probability of Inundation

**Sub-Title:** Catchment 3100

**Date:** 14/08/2006

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© HR Wallingford Ltd. 2006



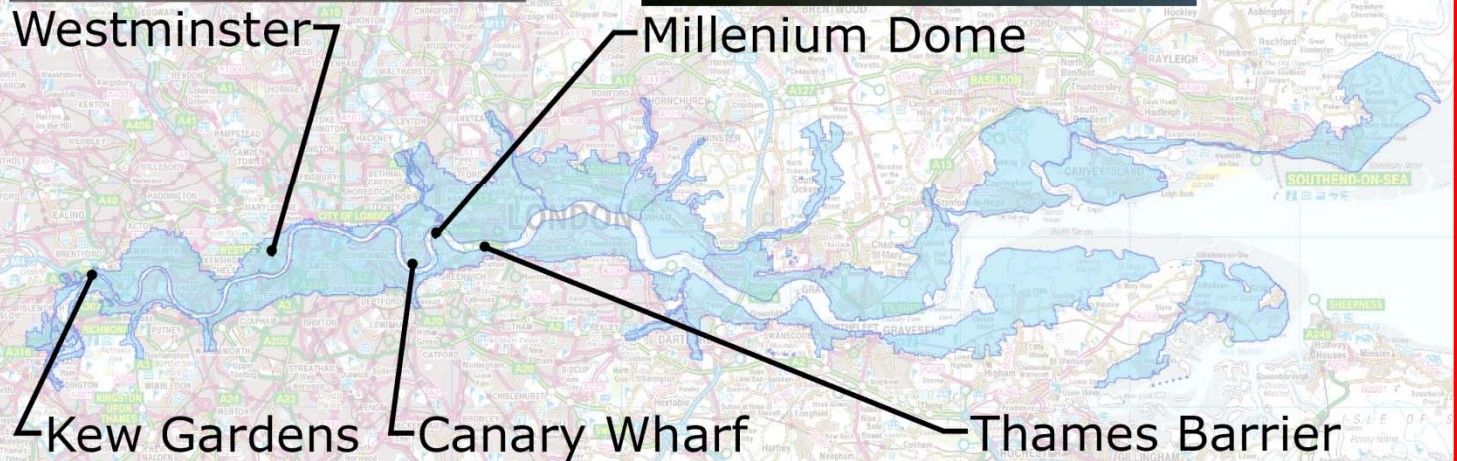
## Regional assessment in the Thames Estuary



Westminster



Millenium Dome



Kew Gardens

Canary Wharf

Thames Barrier





# The existing defence system includes dykes, barriers, pumps and gates

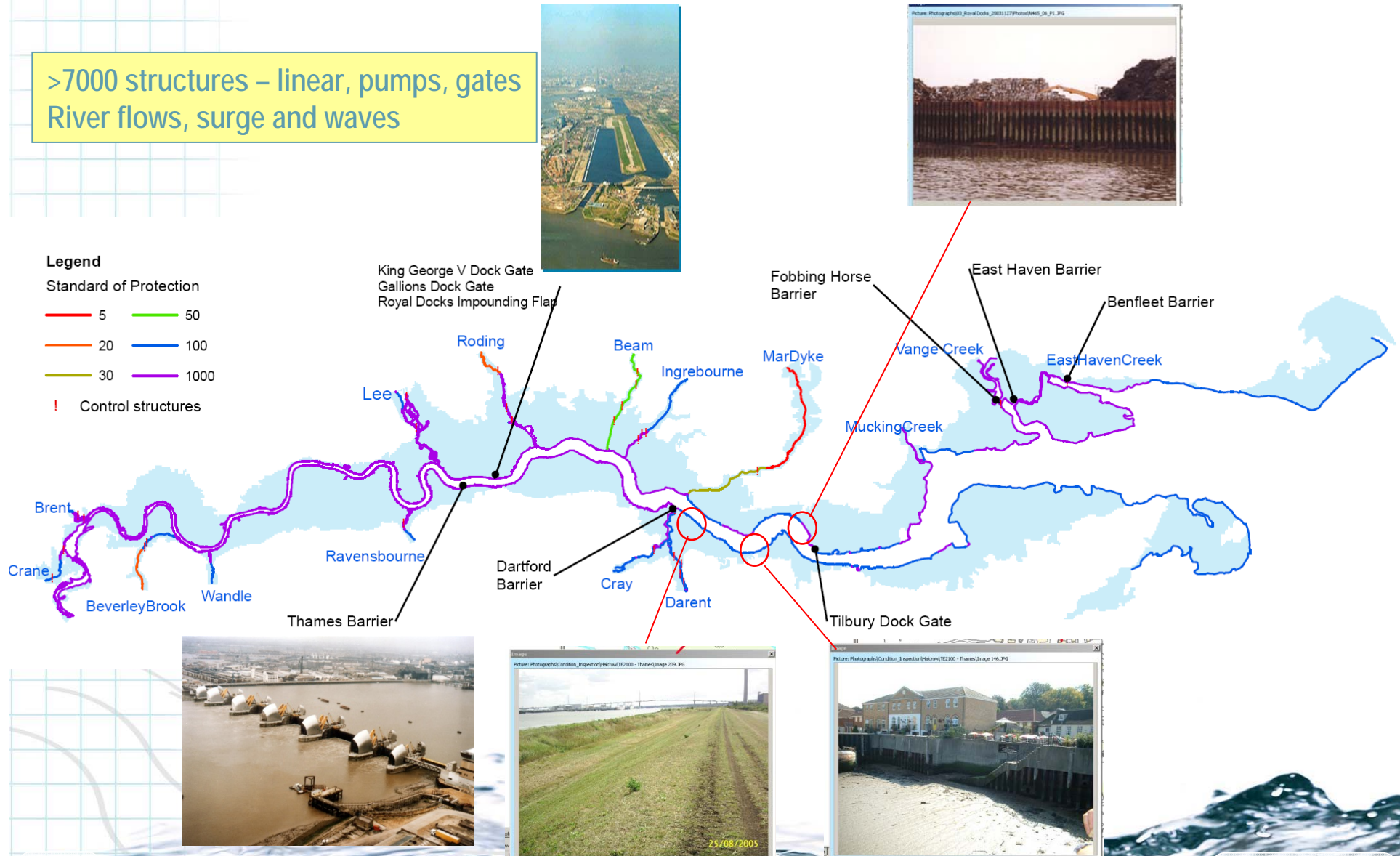
>7000 structures – linear, pumps, gates  
River flows, surge and waves



## Legend

Standard of Protection

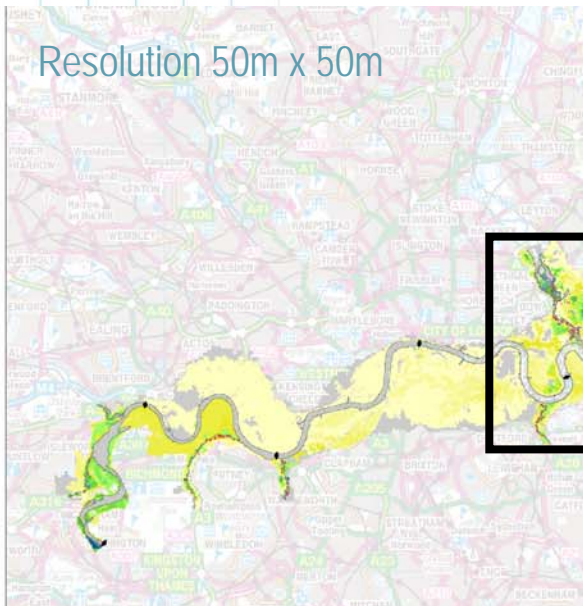
- 5
- 20
- 30
- 50
- 100
- 1000
- ! Control structures





HR Wallingford  
Working with water

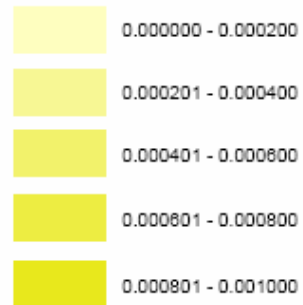
Resolution 50m x 50m



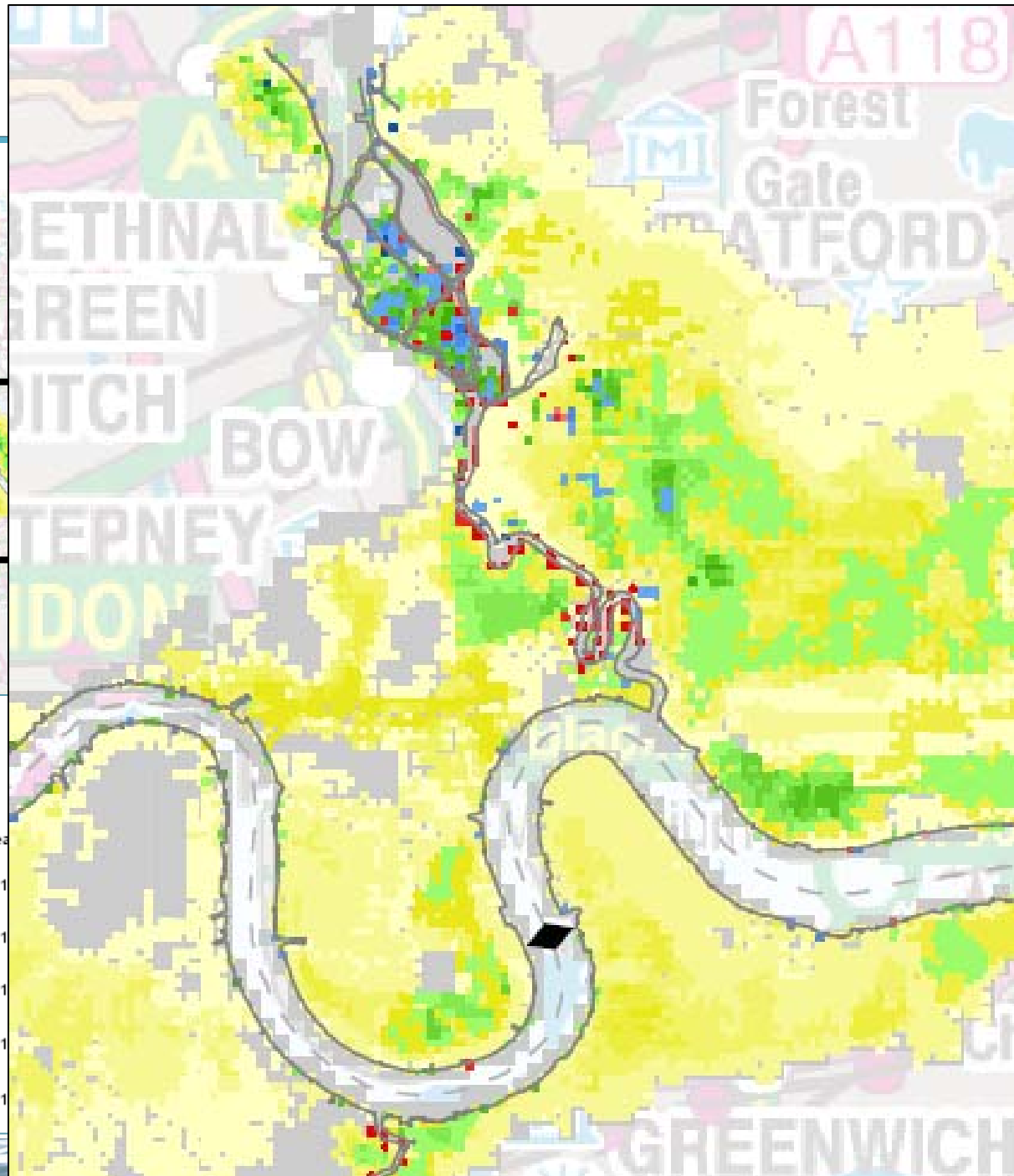
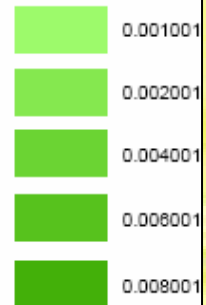
## Map Legend

### Probability of Inundation

( $\leq 0.001$  - 1 in 1,000 years)



( $\leq 0.01$  - 1 in 100 years)



100m

0m  
100m  
metres

78/v3/PO4





HR Wallingford  
Wallingford

## Providing "rich" evidence

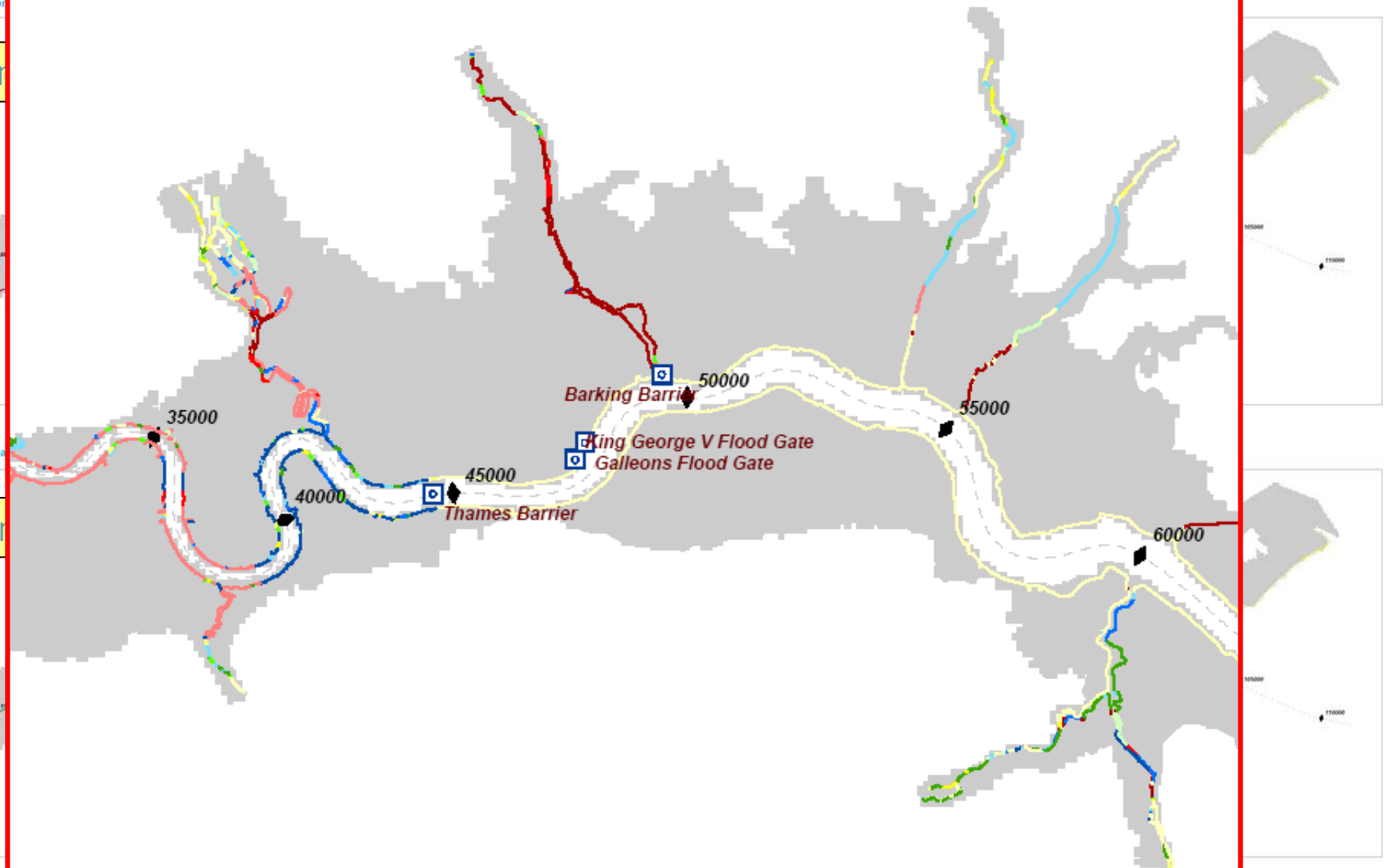
ences

Contribution

Defence Annual Probability of Over

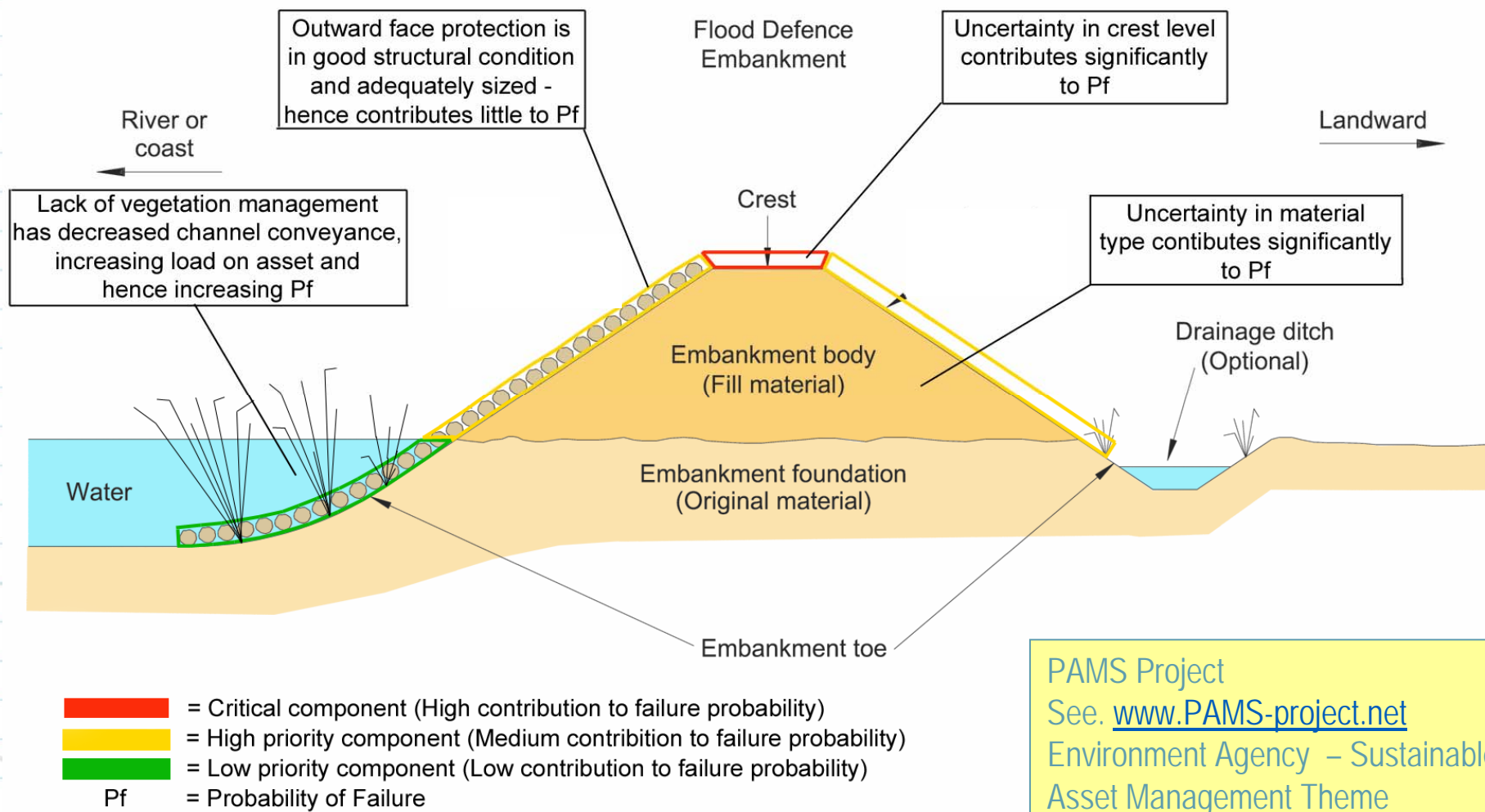
Defence Annual Probability of Bre

Contribution



Source: Gouldby and Sayers, 2006

# Providing "rich" evidence ...attributing importance to specific dyke components



## “Rationale doubt as to what choice to make”

(Colin Green)

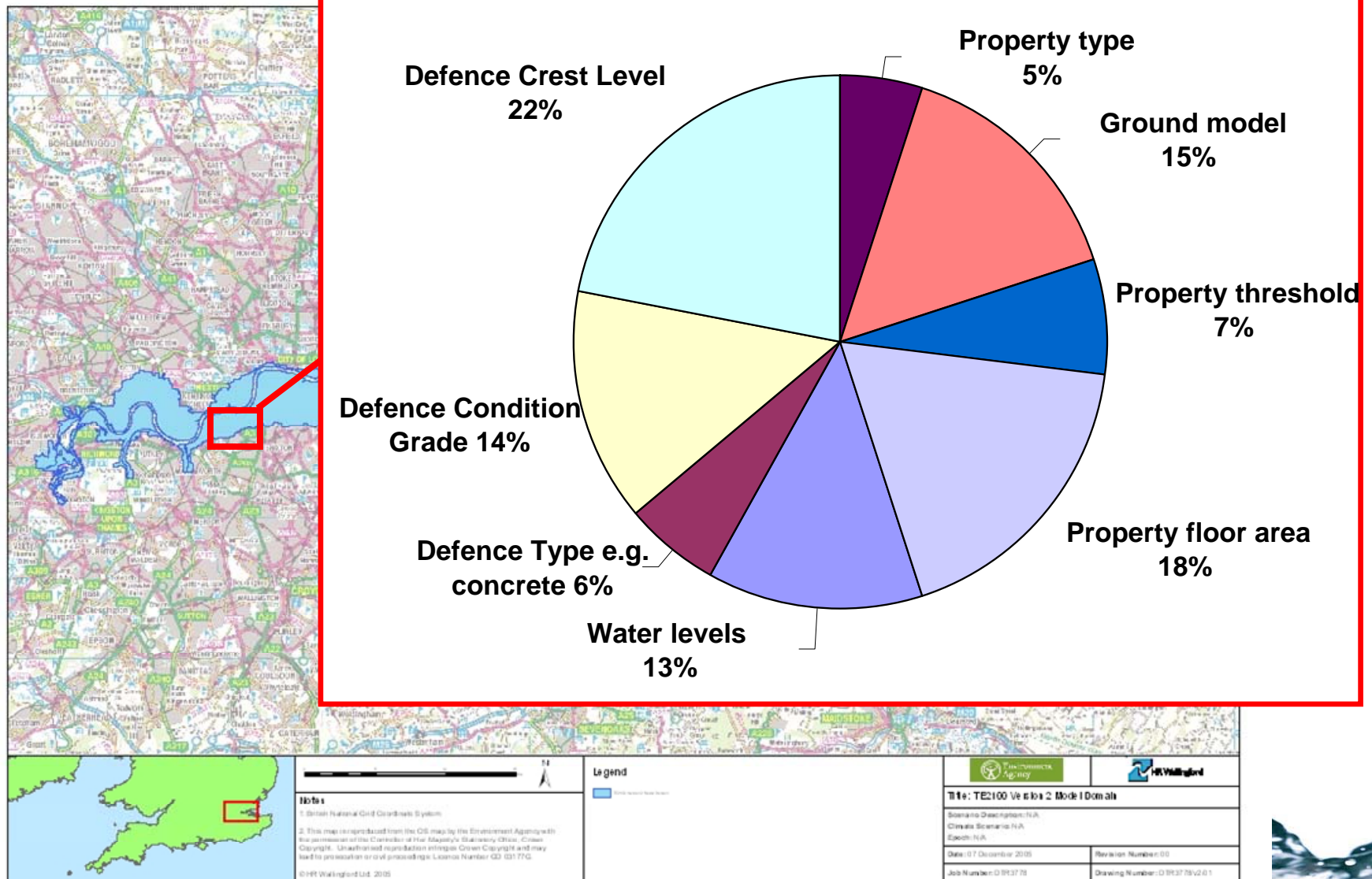
- Should we invest in better models or data?
- Should we invest in maintenance or rebuilding our dykes?
- Should we improve our flood warning and evacuation plans?
- etc





# Dealing with “moderate” uncertainty

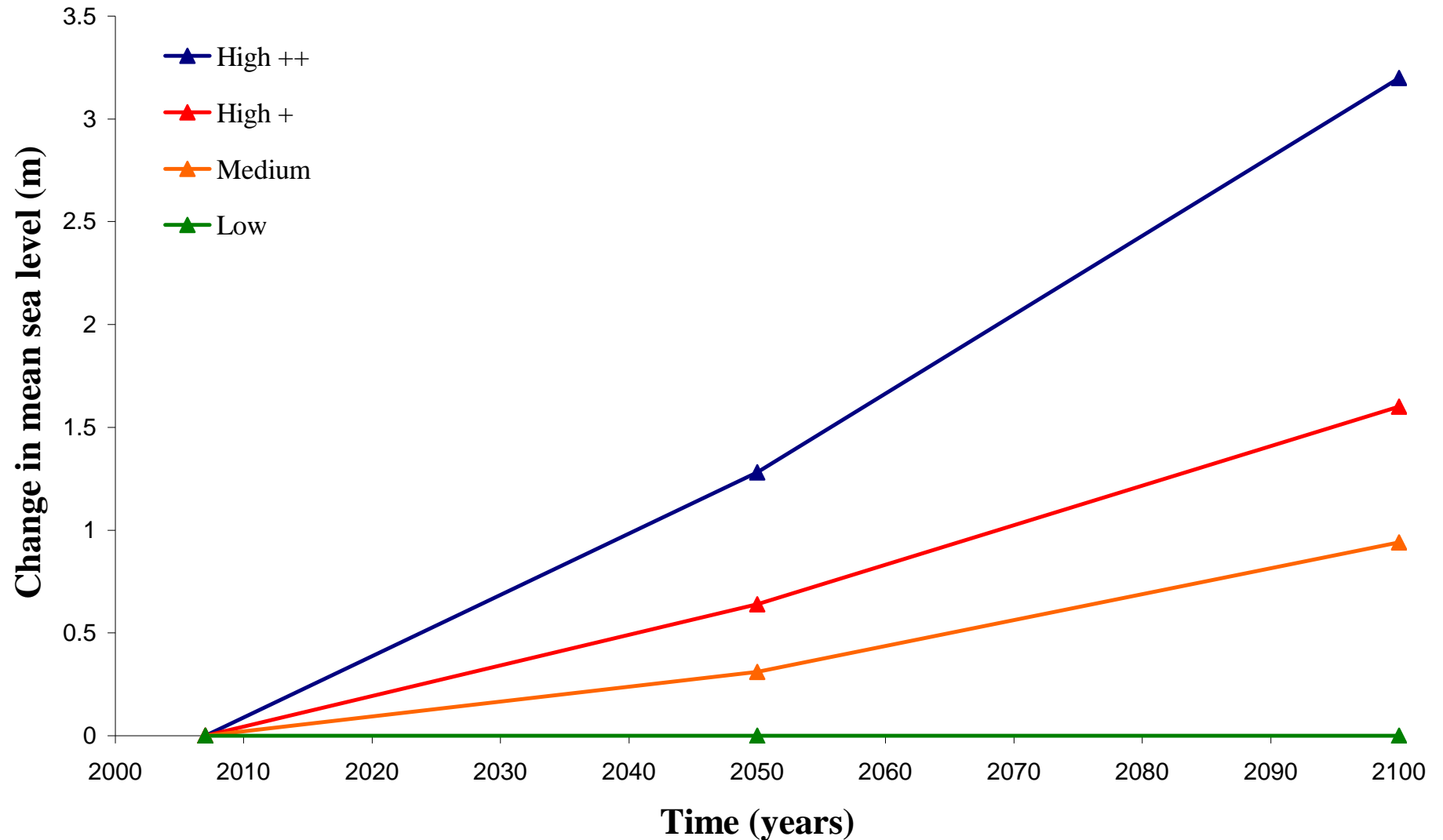
## Better models or better data – what are the priorities?





# Dealing with “gross” uncertainty

## Identifying robust strategies





# Dealing with “gross” uncertainty

## Identifying robust strategies

### Housing growth

- 2012 Olympics
- Thames Gateway
- Many local plans





# Dealing with uncertainty

## Identifying robust strategies

Continuous climate scenario description

e.g. characterised by sea level rise, temperature etc

Selected  
**performance**  
measure  
(BCR, no. of serious  
injuries or deaths etc)

**Robustness** describes how well a given  
strategy **performs** in the context of all  
**futures**

Expressed (uncertain)  
belief in **future** climate  
and socio-economic  
trajectory

Continuous socio-economic scenario description

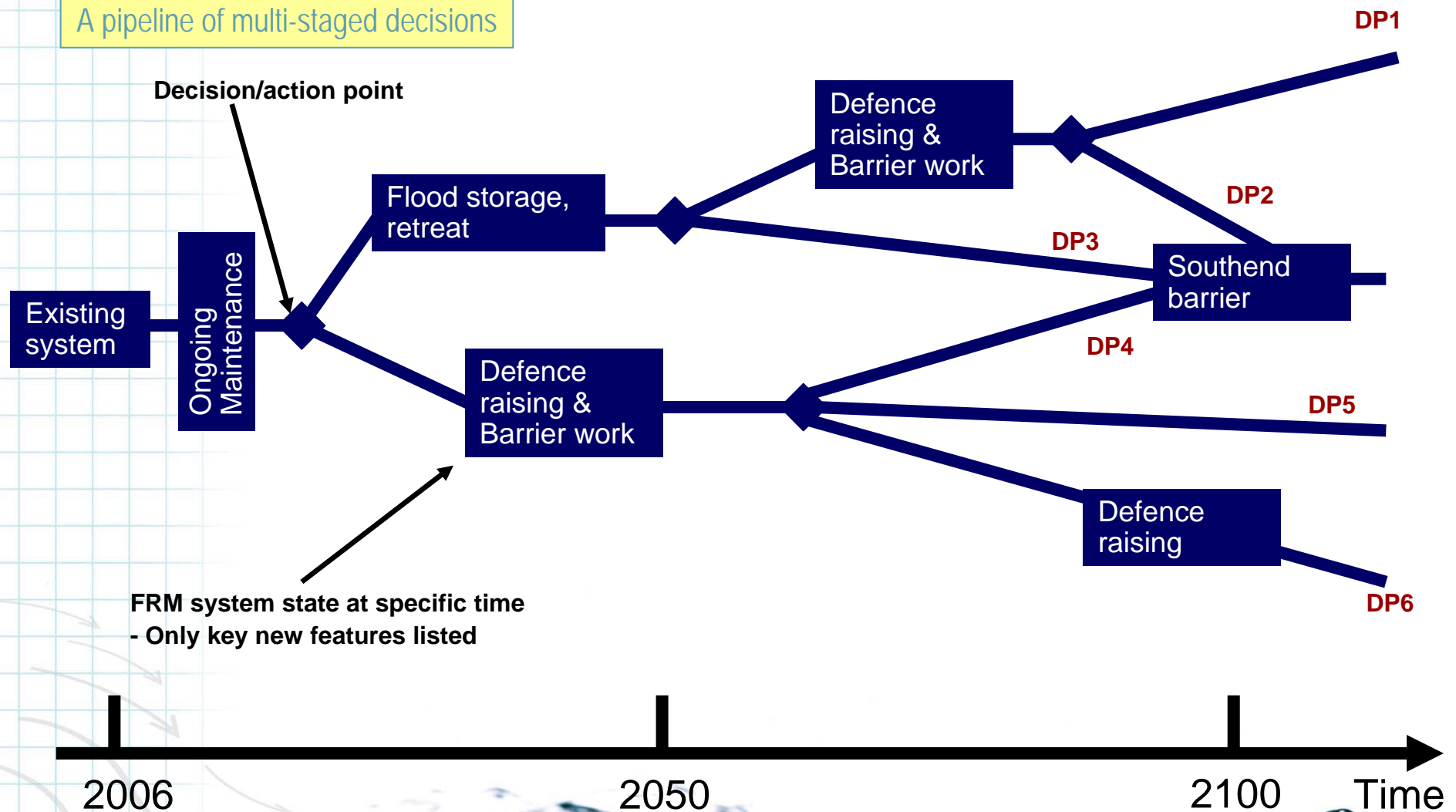
e.g. characterised by housing growth, GDP



## Dealing with uncertainty

## Identifying flexible and adaptable strategies

## A pipeline of multi-staged decisions



**DP = Decision pipelines (time varying portfolios)**

# Some conclusions

- The decision maker will always need to utilise judgement and experience but often **can not** intuitively determine what approach is best
- Hierarchical planning and assessment – from future horizon planning, the national policy, regional and local actions – is becoming a reality (**but there is someway to go!**)
- The principle of “collect once use many times” is becoming a reality (**but there is someway to go!**).
- Structured system analysis (such as the RASP framework) can provide a **“rich picture”** of the flood risk and what drivers it – linking more closely the scientific evidence with the decision needs (**but there is someway to go to support IWRM!**).