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Multi-objective *optimisation* of flood risk mitigation measures, including *real options*

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Practitioner workshop on asset management

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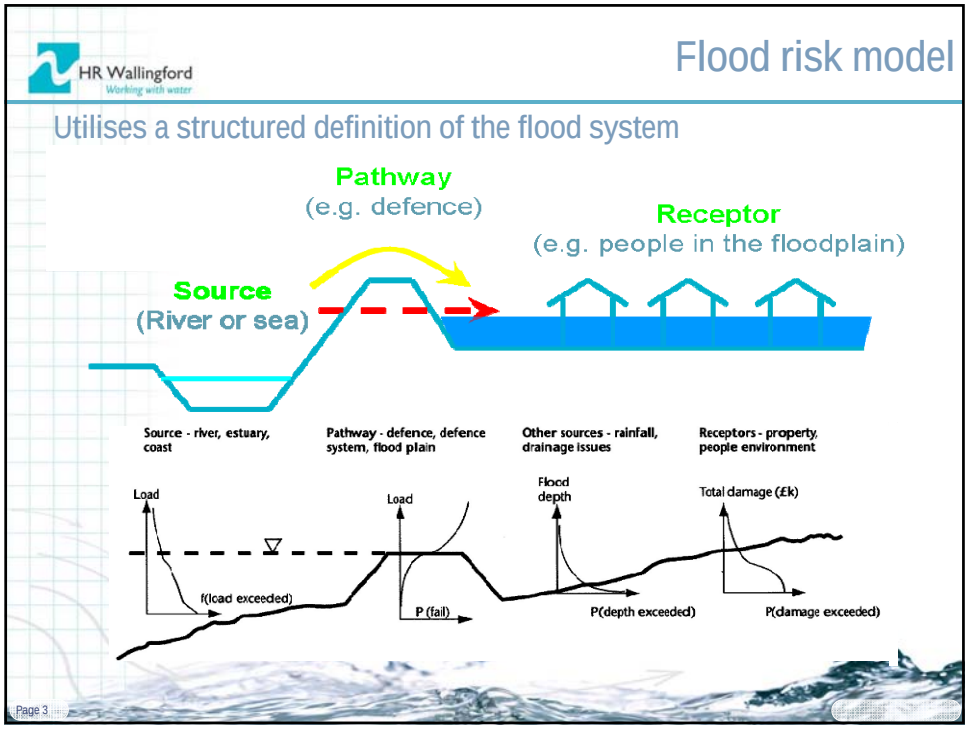
Presentation overview

- Introduction to the risk model
- Simplified risk model for use in optimisation
- Cost model
- Real Options
- Optimisation framework
- Case study results
- Conclusions/summary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Flood risk model
Utilises a structured definition of the flood system
Pathway
(e.g. defence)
Receptor
(e.g. people in the floodplain)
Source
(River or sea)
Source - river, estuary, coast
Pathway - defence, defence system, flood plain
Other sources - rainfall, drainage issues
Receptors - property, people environment
Load
f(load exceeded)
Load
P (fail)
Flood depth
P(depth exceeded)
Total damage (£k)
P(damage exceeded)
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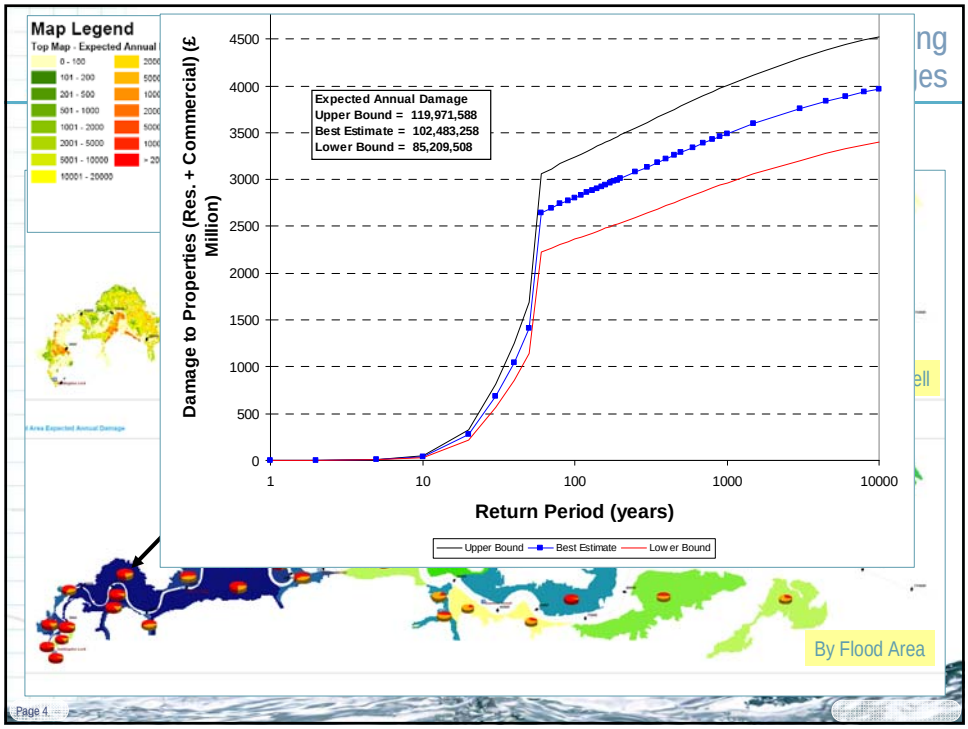
Map Legend
Top Map - Expected Annual
0 - 100
101 - 200
201 - 500
501 - 1000
1001 - 2000
2001 - 5000
5001 - 10000
10001 - 20000
Damage to Properties (Res. + Commercial) (£ Million)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Expected Annual Damage
Upper Bound = 119,971,588
Best Estimate = 102,483,258
Lower Bound = 85,209,508
1
10
100
1000
10000
Return Period (years)
Upper Bound
Best Estimate
Low er Bound
By Flood Area
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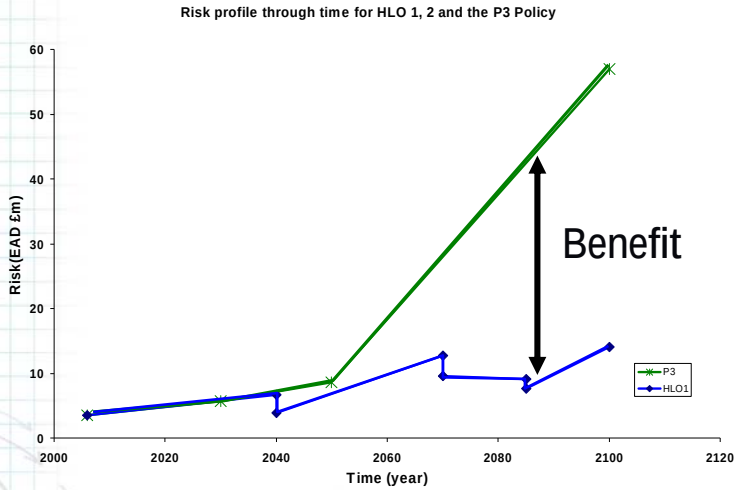
Investigating intervention strategies



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Simplified risk model for optimisation

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Simplified risk model

Model appro… simulation

Interventions evaluated using simplified RASP

Interventions evaluated using Full RASP	Strategy	EAD £36,400	EAD £148,300	EAD £142,600	EAD £148,900	EAD £60,700	EAD £70,700	EAD £26,000	EAD £3,900	EAD £2,000	EAD £73,100
		1	2	3	4	5	6	7	8	9	10
EAD £33,700	1	0	0	0	0	0	0	0	0	0	0
EAD £145,800	2	0	0	0	0	0	0	0	0	0	0
EAD £141,300	3	0	0	0	0	0	0	0	0	0	0
EAD £149,000	4	0	0	0	0	0	0	0	0	0	0
EAD £60,400	5	0	0	0	0	0	0	0	0	0	0
EAD £70,700	6	0	0	0	0	0	0	0	0	0	0
EAD £26,500	7	0	0	0	0	0	0	0	0	0	0
EAD £4,700	8	0	0	0	0	0	0	0	0	0	0
EAD £1,200	9	0	0	0	0	0	0	0	0	0	0
EAD £72,200	10	0	0	0	0	0	0	0	0	0	0
EAD £125,900	11	0	0	0	0	0	0	0	0	0	0
EAD £1,900	12	0	0	0	0	0	0	0	0	0	0
EAD £43,300	13	0	0	0	0	0	0	0	0	0	0
EAD £70,800	14	0	0	0	0	0	1	0	0	0	0
EAD £60,100	15	0	0	0	0	1	0	0	0	0	0

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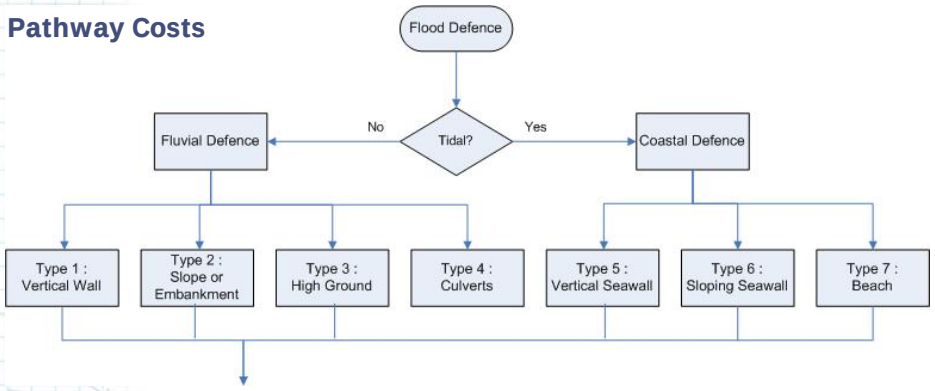
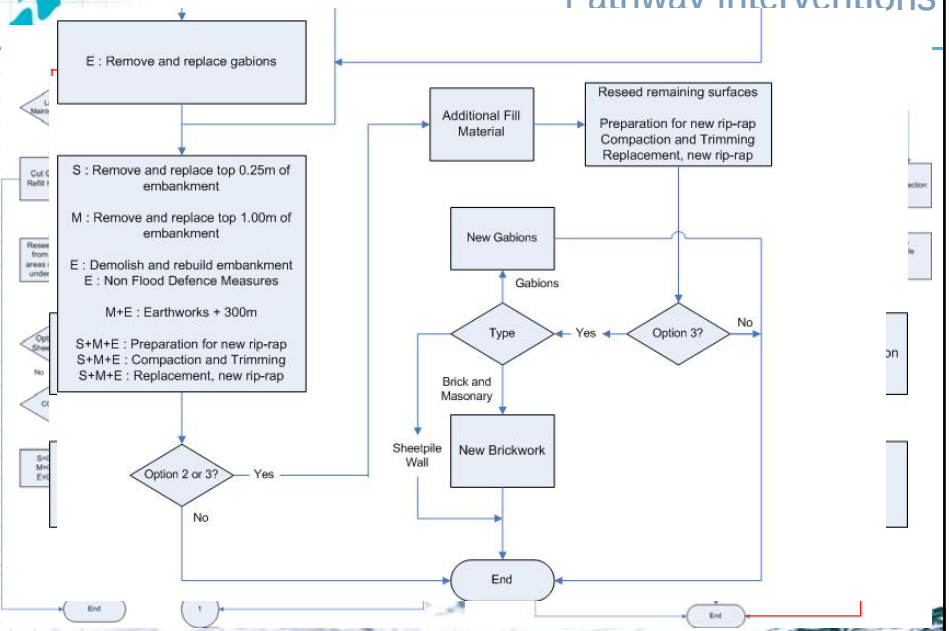
Cost Model

Cost Model

Pathway Costs



Pathway Interventions



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Real Options

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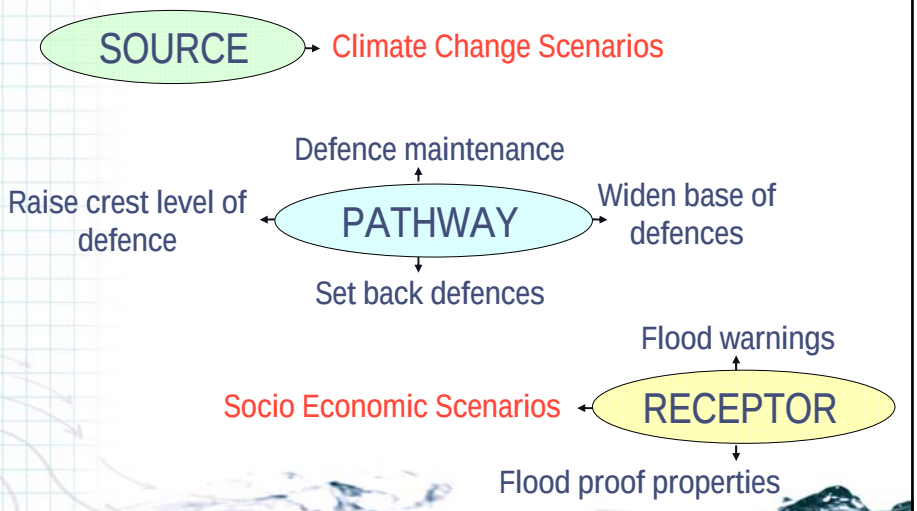
Intervention measures and future scenarios



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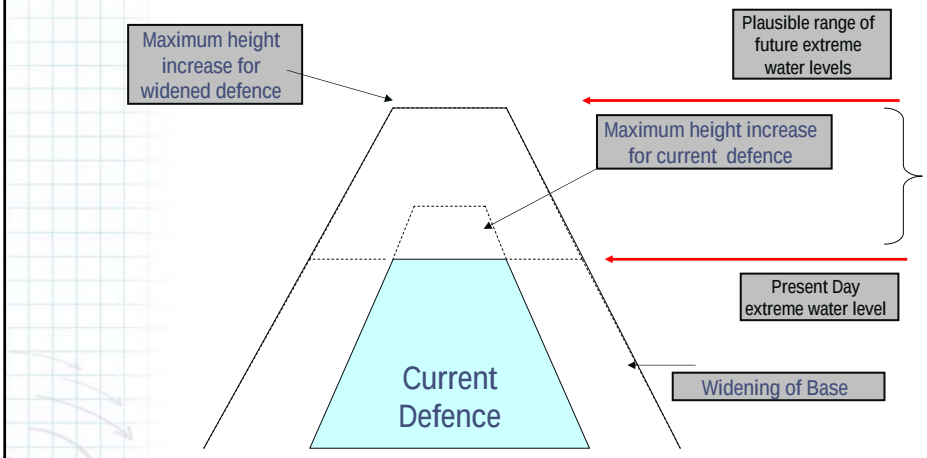
Flood Defence Real Options



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Optimisation framework

(given large range of possible future interventions and real options)

Evolutionary Algorithms

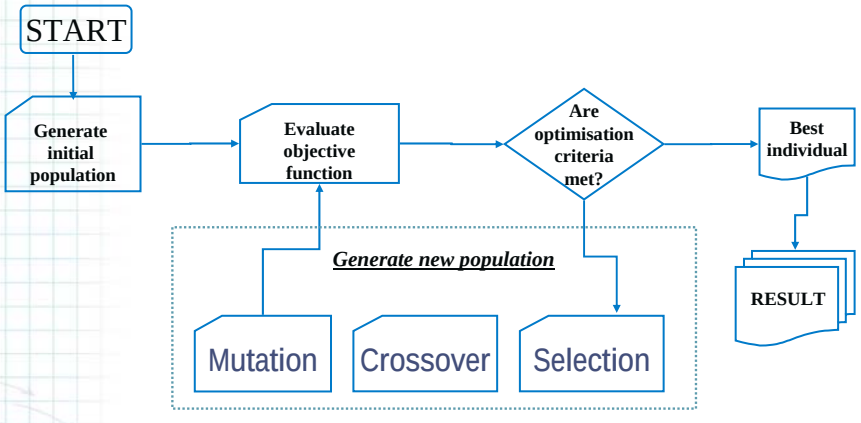
-Powerful Search Process

-Based on Darwin's Theory of Natural Selection

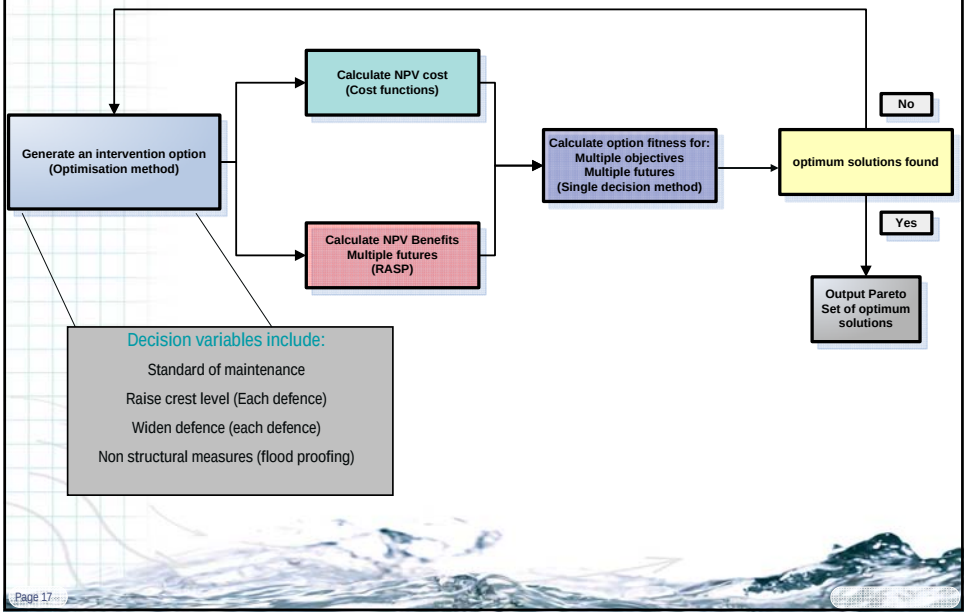
-Methods include:

- Genetic Algorithms
- Shuffled Complex Evolution
- Ant Colony Optimisation
- Multi-Objective Genetic Algorithm

Genetic Algorithm



Overview of GA with RASP



Multi-objective optimisation

- Multi objective optimisation methods seek solutions that are “optimum” with respect to all objectives.
- Invariably a set of optimal solutions is discovered (known as a *Pareto set*)

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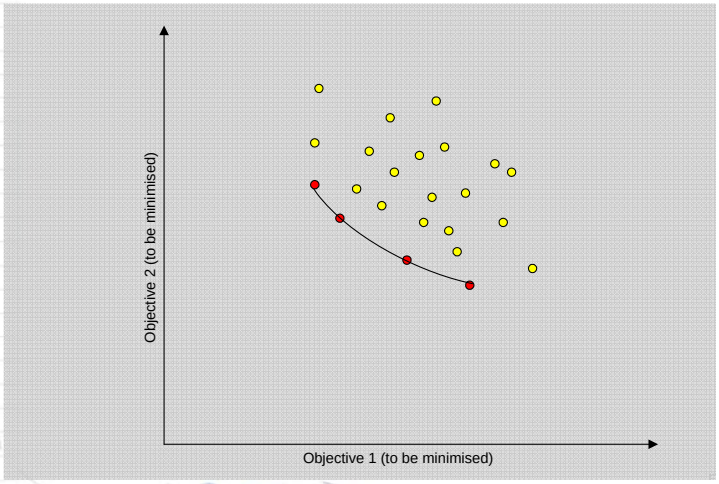
The Pareto Front



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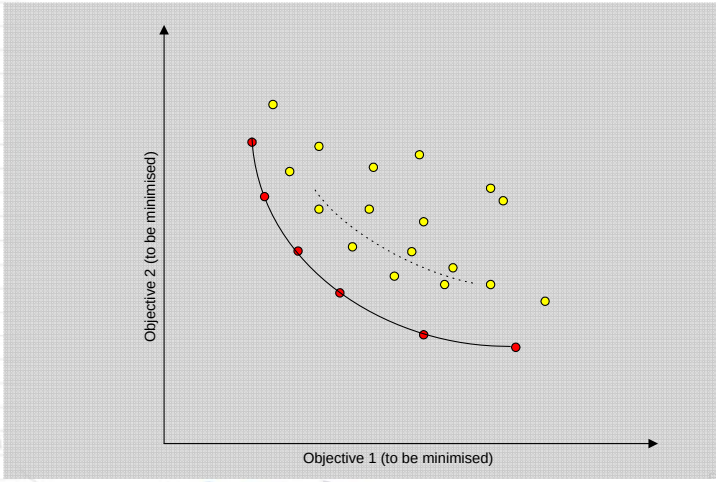
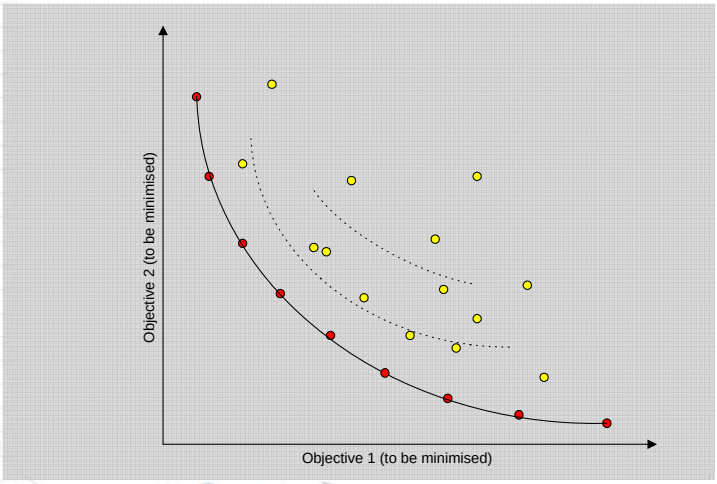
The Pareto Front



The Pareto Front

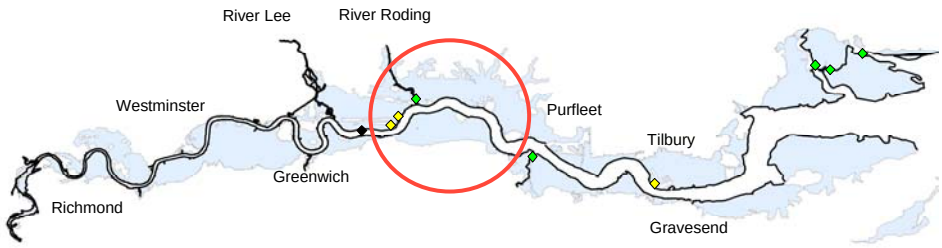


Case Study on the Thames Estuary

Legend

Tidal flood risk area

Tidal flood defences



Flood Defence Examples

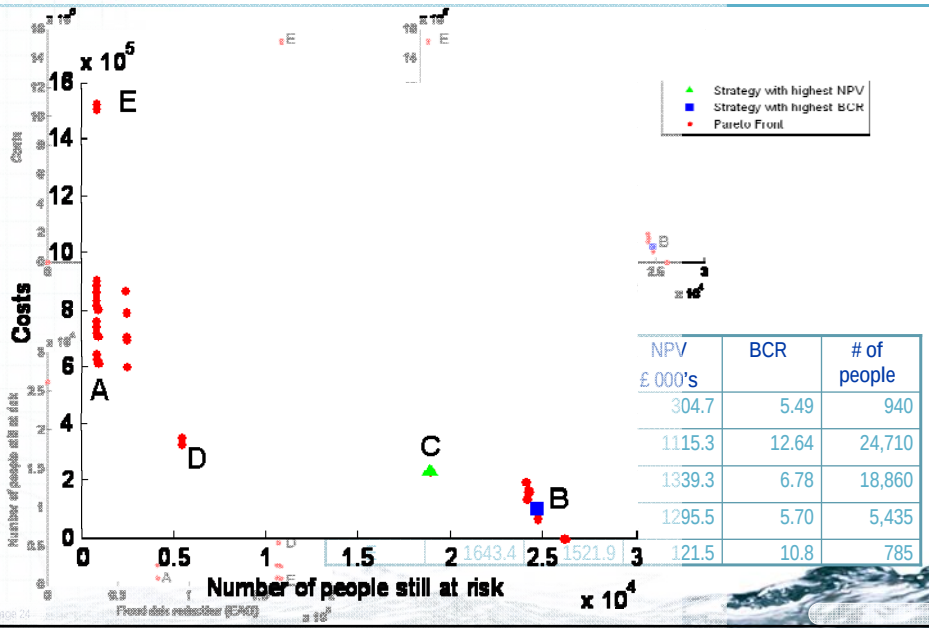
1.

2.

3.

1. Concrete vertical wall
2. Embankment
3. Sheet-pile vertical wall

Pareto front for three objectives



NPV £ 000's	BCR	# of people
304.7	5.49	940
1115.3	12.64	24,710
1339.3	6.78	18,860
1295.5	5.70	5,435
121.5	10.8	785

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Summary/conclusions

- Risk models are useful decision support tools

- These models can be simplified for use in optimisation analysis

- Multi-objective optimisation techniques can provide more information to decision makers

- Need to incorporate a greater range of consequences in risk models, loss of life (hence benefits of flood warning), environmental impacts etc.