

# delivering benefits through evidence



## Cost estimation for temporary and demountable defences – summary of evidence

Report –SC080039/R10

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We operate at the place where environmental change has its greatest impact on people's lives. We reduce the risks to people and properties from flooding; make sure there is enough water for people and wildlife; protect and improve air, land and water quality and apply the environmental standards within which industry can operate.

Acting to reduce climate change and helping people and wildlife adapt to its consequences are at the heart of all that we do.

We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

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The work of the Environment Agency's Evidence Directorate is a key ingredient in the partnership between research, guidance and operations that enables the Environment Agency to protect and restore our environment.

This report was produced by the Scientific and Evidence Services team within Evidence. The team focuses on four main areas of activity:

- **Setting the agenda**, by providing the evidence for decisions;
- **Maintaining scientific credibility**, by ensuring that our programmes and projects are fit for purpose and executed according to international standards;
- **Carrying out research**, either by contracting it out to research organisations and consultancies or by doing it ourselves;
- **Delivering information, advice, tools and techniques**, by making appropriate products available.

Miranda Kavanagh  
**Director of Evidence**

# Executive summary

This detailed summary of evidence provides indicative costs and guidance for demountable and temporary defences. Although these types of defences are quite different, the approach to cost estimation is similar and has therefore been grouped together.

Demountable and temporary barriers		
Key cost components	Key cost components for temporary and demountable barriers will include: <ul style="list-style-type: none"> <li>• initial procurement and capital costs</li> <li>• operation and maintenance costs</li> <li>• event costs</li> </ul>	
Key asset types	<ul style="list-style-type: none"> <li>• Temporary systems (removal flood barriers wholly installed during a flood)</li> <li>• Demountable barriers (structural defences that require some form of permanent foundation and requires operation or part installation during a flood)</li> </ul>	
Data reviewed in specific guidance	Key reports include: <ul style="list-style-type: none"> <li>• Environment Agency temporary and demountable flood protection guidance</li> <li>• RPA report to the Environment Agency (risk and performance evaluation)</li> <li>• Report by R. Stokes and P. May on the Severn Valley case studies</li> </ul>	
Other relevant data	Local or proxy records such as data from Environment Agency SAMPs and local authority information	
Relative cost importance	Enabling costs	Generally low costs but will include initial appraisal, design, operational planning, management and agreements.
	Capital costs	Barrier purchase costs and installation can be high. Costs will be more significant for demountable barriers due to the design and installation of foundation or pre-installed guides/sockets. Costs certainly higher than comparable permanent measures.
	Maintenance costs	Maintenance costs are relatively low but storage, testing/training/preparation for floods and part replacement may be significant.
	Other cost considerations	Event and training installation costs can be significant and are often underestimated.
Cost estimation methodology	Initial concept/national appraisal	Approximate capital costs unit rates for different barrier types available.

	Strategic, regional, or conceptual design	Detailed costs from manufacturers/suppliers. Methodology to estimate event costs based on standard procedures.
	Preliminary feasibility/design	No specific cost information provided. Guidance on data availability and procedures provided.
Design life information	Variable design life and little examples available to date. Advice from manufacturers is likely to provide the most appropriate design life.	
Quality of data	<p>A range of data sources and case studies have been collated and are provided that are suitable for initial option appraisals or strategic studies.</p> <p>Methodologies and examples are provided to assist appraisers with cost estimation for event costs and checklists for all items that need to be considered for operation, maintenance and event cost aspects.</p> <p>More detailed analysis would require estimates from manufacturers to provide sufficient detail.</p>	
Additional guidance	<p>Checklist of factors likely to influence capital and maintenance costs, and key factors to consider for detailed costs estimation</p> <p>List of R&amp;D and general design guidance</p> <p>Case studies for recent schemes .</p>	

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# 1 Flood mitigation measure – temporary and demountable barriers

Temporary and demountable flood mitigation measures provide an alternative solution for locations where permanent defences would be uneconomic or are environmentally unacceptable mainly due to excessive wall height blocking riverside views. While they can provide protection in places that have previously been considered and rejected, this additional flexibility comes at an increased cost. This reflects operational issues that are the trade-off for preserving environmental amenity.

Temporary and demountable barriers may be significantly cheaper than permanent solutions and in some circumstances may be the only viable option. During the July 2007 floods temporary barriers were used to protect the Walham electricity substation, further preventing disruption in electricity supply to south Wales, and avoided the evacuation of 300,000 people from Gloucester and Cheltenham.

Temporary and demountable flood mitigation measures are combined in this evidence summary because of the similarities between the approach applied to them for the costing and determination of whole life costs. However, there are distinctions between the two approaches that should be acknowledged before intervention measures are considered. Although both involve many of the same issues in terms of feasibility and cost estimation, temporary barriers may be an order of magnitude cheaper and may only provide a short term or quick fix for a particular location before more permanent options can be implemented.

Temporary solutions are essentially pro-active non-structural low-cost mitigation measures to replace the use of sandbags during flood events. A temporary system is defined in the *Temporary and Demountable Flood Protection Guide* (Environment Agency 2011, p. 14) as:

‘A temporary flood protection system is formed by removable flood protection products that are wholly installed during a flood event and removed completely when levels have receded, its connection with the underlying surface. and the end connections’.

Demountable barriers are structural defences as they require some form of permanent foundation, and are thus more permanent solutions for communities at risk. A demountable system is defined in the *Temporary and Demountable Flood Protection Guide* (Environment Agency 2011, p. 15) as:

‘A demountable flood protection system is a moveable flood protection system that is fully pre-installed and requires operation during a flood event, or a system that requires part-installation into pre-installed guides or sockets within a pre-constructed foundation.’

Demountable barriers include in situ defences that are stored at the point of deployment either in the ground and lifted into an upright position when needed or are passive automatic systems that rise under water pressure.

## 1.1 High level cost estimates

A number of standard cost parameters are required for demountable barriers. These include the following aspects:

- initial procurement and capital costs
- operation, storage and maintenance costs
- event costs

To undertake a very broad level analysis the appraiser needs to consider the length of defence required, and to apply the above cost elements. Consideration should also be given to the asset life and the factors that will affect the costs provided.

### 1.1.1 Capital costs

Capital costs will relate to the type of barrier, the length of barrier and the barrier height. It is important to note different barrier costs used and discussed in the section below reflect different specifications, especially in terms of barrier height.

RPA undertook a study in 2006 for the Environment Agency (Environment Agency, 2006) to review the economic benefits, risks and performance of 3 operational sites on the River Severn where temporary defences had been used and for two further then proposed locations. Based on these 5 Severn sites the average capital cost for barrier purchase was £570 per m (2006 costs).

The table below provides details of each of the systems used and the range of costs associated with each. These examples provide an indicative range of the initial capital costs for three types of temporary barriers used in the UK. At present, no case studies for demountable barriers have been provided to illustrate indicative costs for these barrier types.

**Table 1.1 Costs of temporary defences used on the River Severn (2006 costs)**

	<b>Shrewsbury to Coleham</b>	<b>Ironbridge</b>	<b>Worcester</b>	<b>Bewdley</b>	<b>Shrewsbury to Coton</b>
Barrier type	Mobile dam	Geodesign	Geodesign	Geodesign	Baur K
Total length	100 m	550 m	350 m	205 m	200 m
Barrier cost	£50,000	£264,000	£168,000	£105,500	£60,000
Pump costs	£40,000	£40,000	£10,000	£10,000	£6,000
Total costs	£90,000	£304,000	£178,000	£115,500	£66,000
Cost per m	£900	£553	£509	£563	£330

### 1.1.2 Operation and maintenance costs

Operation and maintenance (O&M) costs may be large due to the costs associated with storage, replacement of parts and annual inspections. It is difficult to define typical costs for each of these measures due to the variations between systems and alternative arrangements for storage of temporary barriers.

Although there are similarities between operation and maintenance costs for temporary and demountable barriers, such as the requirement for inspection, training, event costs

and management/liaison costs, it must also be noted that temporary and demountable barriers will require differing operation and maintenance costs in some circumstances. This is particularly the case where pre-installed demountable barriers are used that do not require off-site storage and replacement of parts, but may have a higher inspection and maintenance cost requirement.

Where storage is not readily available or designed in to a wider scheme, storage may need to be bought or leased. For example, storage costs for the 3 pilot schemes on the River Severn were estimated to be £10,000 per year. However these are now stored at a central depot which is not used solely for the barriers but as part of a larger Environment Agency storage depot, the cost of which are therefore covered elsewhere by the Environment Agency.

Total estimated annual maintenance costs (including storage, inspection, training, and management/liaison) based on the five sites studied as part of the RPA (Environment Agency, 2006) assessment represented between £4,500 to £60,000. This represents approximately 4% - 20% of the total capital costs, with an average of 11%.

### 1.1.3 Event costs

The assessment of operational requirements and the ongoing, long term costs associated with these need to be carefully considered and accounted for as experience from previous projects suggests that these costs are grossly under-estimated (Defra, 2007).

Event costs based on the three operational River Severn sites (two systems were used in the 2004 trials, a water filled Mobile Dam at Shrewsbury and the Geodesign Barrier system at Ironbridge and Worcester) were estimated following the deployment of these systems in February 2004. Event costs were estimated to be an average of £42 per m length of temporary barrier (as shown in the table below (Stokes & May, 2004)).

**Table 1.2 Indicative event costs for three sites on the River Severn (2004 costs)**

Site	Shrewsbury to Coleham	Ironbridge	Worcester
Total length (m)	100	550	350
Plant operating costs	£2,000	£6,000	£5,000
Labour costs	£1,000	£10,000	£4,000
Materials cost	£2,000	£7,500	£2,000
Total cost	£5,000	£23,000	£11,000
Cost per metre	£50	£43	£33

It is recommended that these values are used as an indicative assessment of the potential event costs per event in the absence of any more detailed additional information. These costs are relevant for temporary defences in the region of 100m - 500m long on the River Severn with long duration flood events (48 hours). Event costs for shorter duration flood events may be significantly less.

Total event costs (including transport, erection of barriers, inspection, pumping, site security and demobilisation) based on the 5 sites studied as part of the RPA (Environment Agency, 2006) assessment represented between £9,000 to £30,000. This represents approximately 6–14% of the total capital costs, with an average of 9%.

For more detailed assessments it is recommended that specific event costs are assessed from the recommended numbers of staff required to deploy and demobilise the chosen system. Operational costs will reflect a multi-agency cooperative effort, not just an Environment Agency response. This can help to share costs with Local Authorities and Water Companies.

## 1.2 Detailed analysis

### 1.2.1 Procurement and capital costs

As with any scheme there are initial procurement and capital costs that cover the initial stages of the project. In the case of demountable barriers this would cover all aspects from project inception to the point where all components have been procured, delivered, tested and (if relevant) permanent structural aspects installed. At this point suitable training, flood warning and an operations plan agreed with partner organisations would be in place to ensure system installation and success during a flood.

Specific costs that may need to be included within a cost estimate are:

- initial appraisal, design, operational planning, management and agreements
- barrier purchase costs
- structural and drainage infrastructure costs
- associated new or upgraded flood warning and forecasting systems

#### *Management, planning and partnership liaison costs*

Costs associated with initial set up and ongoing management, liaison and publicity will be required, especially due to the large number of organisation and responsibilities associated with flood event management. This may include the need for development of operational action plans and close working among a number of organisations.

Third party labour costs may also need to be determined, including costs associated with Local Authority staff, Water Companies and emergency services. Costs of external providers of 'admin services' would also be eligible.

#### *Appraisal, design and associated costs*

Initial procurement and acquisition costs may be sunk costs at the point of appraisal, however there are additional costs that will be incurred prior to implementation of a demountable barrier scheme which may include the following items:

- planning exercise and traffic diversion plan development
- procedural implications for emergency services, residents and businesses
- site surveys to identify drainage infrastructure that may bypass the defence
- development of operational plans
- determination of storage (and plant) requirements
- planning permissions, land consent, land purchase/lease agreements

- hydraulic analysis and modelling of any adverse local impacts from proposed barriers on opposite bank, upstream or downstream
- ongoing management, liaison and publicity
- on-going consultation with all interested parties

### *Barrier purchase capital costs*

Barrier purchase costs represent an initial high capital cost but may represent a small percentage of the total whole life cost estimate depending on the longer term operation, maintenance and event costs. An internal EA study in 2006 (Environment Agency, 2006) on the performance of temporary flood barrier systems in the Midlands region suggested that the barrier capital costs could represent anything from 10-45% of the total whole life costs. Due to the relatively new and infrequent use of demountable barriers to protect against flooding, the options available and systems used are highly variable and site specific.

It is recommended that for site specific studies that costs for barrier purchase costs are obtained directly from manufacturers of the specific products of interest. Each site will have its own requirements and needs that relate to the length, height and type of defence system. Most manufacturers will be able to provide unit costs per m length and will be able to advise on installation costs of permanent fixtures and fittings, training costs and any bespoke storage that may also be supplied.

Depending on the type of defence, temporary barrier systems could be used for alternative uses. The capital costs could therefore be split between departments. There is of course a raised risk of failure to deploy in this instance and this should be considered in the benefit calculations.

There are a large number and variety of manufacturers. The following links provide existing links to manufacturers' details to help those undertaking a cost estimate for demountable barriers.

- 'The Blue Pages' - an independent directory of flood protection products and services provided as a resource by the National Flood Forum (<http://www.bluepages.org.uk/>)
- Flood Protection Association ([http://www.floodprotectionassoc.co.uk/flood\\_defence.php](http://www.floodprotectionassoc.co.uk/flood_defence.php))
- Independent Flood Defence Products (<http://www.ifdp.co.uk/index.html>)
- EA 2002, Temporary and Demountable Flood Protection Guidance (<http://publications.environment-agency.gov.uk/pdf/SPUB130-e-p.pdf>)
- EA 2010, Temporary and Demountable Flood Protection Guidance (<http://www.environment-agency.gov.uk/research/library/science/43005.aspx?Status=&ProjectId=7733>)
- EA guidance on buying products and a links to Kitemark certified products that protect doorways and airbricks (<http://www.environment-agency.gov.uk/homeandleisure/floods/113219.aspx>)
- Kitemark website providing links to manufacturers of flood protection products <http://www1.kitemark.com/cms/listing/guide/flood-protection-products>

The latest Environment Agency Temporary and Demountable Flood Protection Guidance (Environment Agency, 2009) has collated capital cost estimates for a number of temporary flood protection types. These are provided below and provide indicative capital costs of purchase and provision of pre-installed elements. These costs are indicative and may or may not include training costs. These values are appropriate for an initial assessment of barrier costs but should not be relied upon for detailed appraisal studies. More detailed costs should be obtained from manufacturers.

**Table 1.3 Indicative costs associated with different temporary and demountable systems**

Type of flood protection system	Cost (£)	Comment
Air filled tube	£318/m	Training costs included
Water filled tube	£290/m	Cost based on one product
Permeable container	£40–110/m*	
Impermeable container	£150–1000/m*	
Flexible freestanding barrier	£188–350/m*	
Rigid freestanding barrier	£145–470/m*	
Flexible frame barrier	N/A	Quoted on a site by site basis
Rigid frame barrier	£200–520/m	Training costs included
Flexible freestanding barrier (part pre-installed)	£600/m	
Rigid freestanding barrier (part pre-installed)	£470–10,000/m	Training costs included
Frame barrier (part pre-installed)	£400–800/m*	
Manual sectional barrier (fully preinstalled)	£600–1,900/m*	
Automatic sectional barrier (fully preinstalled)	£2,100/m*	
Flood gates (fully preinstalled) - 5 x 1m (manual)	£5,500	Training costs included
Flood gates (fully preinstalled) - 5 x 1m (automatic)	£17,000	Training costs included
Flood gates (fully preinstalled) - 8 x 1m	£21,000	Training costs included
Flood gates (fully preinstalled) - 12 x 1m	£50,000	Training costs included

Notes: \* Based on a range of products, some of which may include training costs.

Factors that may influence the costs of obtaining and installing barriers are provided below.

**Table 1.4 Key factors/considerations influencing the capital costs of temporary and demountable barriers**

Factors influencing capital costs	Impact on cost estimation
Type of system	Cost dependant on choice of supplier Costs of associated equipment and replacement

	parts
Temporary or demountable barrier	Permanent, pre-installed demountable barriers will require higher installation and design costs
Length and height of system	More likely to affect choice of system, but will also impact on total costs
Inclusion of training costs	If included initial costs can be omitted
Kitemarked product or warranty	Non Kitemarked products may be cheaper as design and accreditation costs may be lower. However these may not meet EA specifications.
Likelihood of damage	Additional cost of purchase of spare parts and so on

### *Structural and drainage infrastructure costs*

Some systems will require the provision of fittings to ensure an effective connection with end units or the pre-installation of foundations and permanent parts with which to connect the demountable barrier to the pre-constructed foundation.

Works to the drainage network may also be required to reduce leakage and bypassing through outfall pipes that cut across the subsoil and flooding from sewers. Provision of flap valves or the ability to temporarily block drainage pipes may be required. This may also include the provision of sumps to capture residual seepage and removal via pumps during an event.

**Table 1.5 Key factors influencing the structural costs of demountable barriers**

<b>Factors influencing structural costs</b>	<b>Impact on cost estimation</b>
Type of system	Pre or part installed foundations will increase costs significantly
Temporary barriers	Zero or very small fitting/installation costs
Presence of outfalls and sewers	Costs to limit bypassing and pumping may be required (together with additional studies if necessary)

### *Associated new or upgraded flood warning and forecasting systems*

The provision of demountable or temporary barriers requires a reliable flood forecasting and warning system to trigger closure either automatically or by operatives. A key question when deciding whether to use a demountable or temporary barrier is whether there is a reliable flood forecasting system in place, and if not, can existing systems be upgraded or provided prior to the implementation of the barriers.

The costs of providing this will depend on the site in question and availability of flood warning. Costs should be determined if necessary and particularly if a new system is required. Whether the costs for this should be offset against other benefits to the wider community should be reviewed by the appraising organisation.

**Table 1.6 Key factors associated with warning costs of temporary and demountable barriers**



<b>Factors influencing warning costs</b>	<b>Impact on cost estimation</b>
No current warning system	New forecasting and warning required
Current warning system not sufficiently reliable	Upgrades to forecasting and warning scheme required
Automated barriers	Require activation via direct link to watercourse or via signals from water level sensors
Fully automatic self-closing (rising) barriers that act hydraulically	These systems remove the need for warning system, but may require telemetry to confirm closure
Cost of provision of warning has wider benefits	Costs of provision/upgrade may not need to be considered as part of appraisal

### **1.2.2 Ongoing operation and maintenance costs**

Demountable barriers require ongoing maintenance and inspection to minimise risks and ensure successful intermittent barrier placement and operation during a flood, but also to provide long term performance of the system and to extend asset component life. In the case of demountable barriers, the operation and maintenance costs represent those from the procurement phase above through to the end of the appraisal period.

Maintenance activities are less likely to comprise a major contribution to total life costs due to the cheap replacement part costs and inspection/maintenance costs. Despite this, annual costs for these items will add up over a life of a scheme and the appreciation and understanding of these aspects are essential for a whole life cost estimate.

Specific activities associated with the operation and maintenance aspect of the works may include the following:

- storage costs for barrier parts (annual costs)
- inspection and maintenance of components to ensure reliability of the system
- component replacement costs

#### ***Storage***

Storage may be provided as a one off cost by supplier (bespoke mobile storage systems or containers) or utilise existing depots, in which case costs may be minimal in some circumstances. However, some sites may require sites to be bought or require an annual rental cost and the added cost of rates for premises. Furthermore, larger schemes may require multiple storage locations to ensure lead times are minimised.

Storage costs are not required for in-situ or some tilting demountable defences as these are stored flat in the ground and lifted into an upright position when required.

It is recommended that if storage is not available at the site, and local rental of storage is required, then quotes or estimated rentals are obtained for the purposes of detailed cost estimation. Factors that affect storage costs are summarised below.

**Table 1.7 Key factors influencing storage costs of temporary and demountable barriers**

<b>Factors influencing storage costs</b>	<b>Impact on cost estimation</b>
Storage provided by supplier	Cost may be part of capital cost
Storage built into wider scheme	Cost may be part of capital cost
Storage provided by existing arrangements	Cost may not be applicable
Specific storage and loading areas required	Cost of rental and/or rates to be estimated
Multiple storage locations required for larger schemes	Cost to be multiplied by number of locations

### *Inspection and maintenance*

Inspection and maintenance are required activities that ensure that all parts remain in good working order and ensure reliability of the system and reduce the risk of system failure. The most appropriate option is to schedule these work at regular intervals defined by either the manufacturer or within an operation plan. This work may be carried out as part of event practice/training procedures.

Costs for inspection may be increased for in-situ temporary barriers as they can suffer damage when not used and require regular inspection and testing.

Costs for this work should be defined through discussions with the manufacturer or an assumption regarding the number of number of staff and interval of inspection required (for example, 2 operatives for 3 days per annum per 100m length of defence). In the absence of this information inspection and maintenance costs of 1-5% of purchase costs are applicable.

Factors that affect inspection and maintenance costs are summarised in the table below.

**Table 1.8 Key factors influencing inspection and maintenance costs**

<b>Factors influencing inspection &amp; maintenance costs</b>	<b>Impact on cost estimation</b>
Length of demountable barrier	Larger schemes will require more operatives to check and maintain asset components
Associated plant maintenance	Some products may require additional maintenance requirements (for example, pumps and so on)
Presence of permanent pre-installed fixings	Increased frequency of inspection of pre-installed components (damage to these could prevent installation)
Health and safety considerations	Is there a minimum number of staff required to undertake the inspection/maintenance?

## Component replacement costs

Component replacement may be required to ensure that a system remains reliable. Replacement may be required due to deterioration, damage or loss of parts. In most cases initial capital costs should include initial spare parts to mitigate against addition costs in the short term.

Component replacement costs will be required as specified by the manufacturer or following inspection. Replacement intervals will affect the whole life costs dependant on the design life of component parts. Due to discounting however, these are unlikely to be significant unless complete replacement of barriers is required.

Vulnerable parts such as clips and fixing bolts may need to be replaced relatively frequently depending on frequency of use, but represent relatively low costs per item. Other components are more likely to have a much longer life and may only require replacement once or twice over a 100 year scheme life.

It should be noted that for some water and air-filled tubes and barriers that use membrane materials, these might only be used once as it is difficult to roll back up and re-use once deployment during a flood event has occurred. Once the tubes and membranes become wet, there are also contamination and damage issues to consider. The replacement of these membranes therefore represents a large ongoing capital outlay for schemes that use these materials. Typical costs for replacement rolls<sup>1</sup> are approximately £515 per 50m length of 1.8m wide membrane, and £425 per 100m length of 1.25m wide membrane. Freight costs would be on top of these costs.

Appraisers should consult manufacturers to define product asset life. In the case where the barrier design life is less than the appraisal period, replacement costs will be the cost of the original barrier capital cost. If component part replacement costs are high, appraisers should also consider the costs of replacement parts over the design life. The key considerations that affect component replacement costs are summarised below.

**Table 1.9 Key factors influencing component replacement costs**

<b>Factors influencing component replacement costs</b>	<b>Impact on cost estimation</b>
Length of demountable barrier	Larger schemes will increase costs
Associated plant requirements	Items such as pumps may have a different design life to that of the barrier system
Design life of asset/components	Dependant on type of system used

### 1.2.3 Emergency exercises and event costs

Unless a system is fully automatic, regular emergency training exercises are required to ensure staff familiarisation, public awareness and to confirm the condition of the barriers and operational procedures. This is particularly important when there are large multi-agency operations teams involved, potentially with new contractors or staff unfamiliar with the systems. It is usually recommended that emergency drills are carried out at least once a year, typically before winter high flows.

Event costs during a flood event should also be anticipated depending on the estimated frequency of flooding at a site. Thus, the costs associated with anticipated event costs should be included at the stated interval.

<sup>1</sup> Pers. Comm. Christian Wilcox, Environment Agency.

Specific activities that need to be jointly reviewed and assessed during training exercises and associated with the emergency procedures may include the following:

- transport to site
- erection
- inspection during operation/site security
- pumping
- dismantle, transport, clean up
- health and safety issues for site operatives
- public awareness issues including health and safety
- provision of site welfare facilities
- review of warning arrangements and trigger thresholds

Appraisers should consider whether the costs associated with Environment Agency (and other organisation) staff costs involved with flood event barrier costs are applicable for inclusion within appraisal studies. The Environment Agency employs operation delivery teams that are paid no matter what they are doing during a flood. If they are not putting up temporary and demountable flood defences they would be at the same town or region assisting communities at risk and responding to flood incidents. Therefore where staff costs are already covered by existing funding mechanisms, it may be appropriate to exclude these costs from an appraisal. However, costs of staff wholly employed for these aspects would be eligible.

The inclusion of these costs may therefore double-count these staff costs that would be incurred in any case. As there is no specific guidance on this matter it is suggested that the costs are included in an appraisal, but a sensitivity test is undertaken to exclude labour costs.

## *Transport*

Costs of loading, transporting and unloading demountable barriers are required as part of event costs to include both plant and labour costs. Transport requirements will depend on the location of storage, type of barrier system proposed and length of scheme. Transport requirements may vary from small trailer/truck vehicles to specialist lifting equipment, or may not be required at all if located sufficiently close to the site.

While transport plant costs may be incorporated within an organisation's existing arrangements, some systems or organisations may require specific transportation hire costs. Labour costs should be determined in association with manufacturers' recommendations and will typically be similar to that required for erection purposes.

**Table 1.10 Key factors influencing transport costs**

<b>Factors influencing transport costs</b>	<b>Impact on cost estimation</b>
Type of system	Fully pre-installed systems do not require storage or transport  Also affects type of vehicle required
Distance from storage to site	Greater the distance, greater the cost

Reliability of transport routes	Delays, traffic jam/road closures can increase time and costs of transport and may need to be included within the risk assessment
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### *Assembly, inspection during operation and dismantle and clean up operations*

Staff resources are required to erect and dismantle the demountable system. Knowledge and experience of the system is required, along with staff with sufficient supervision to oversee the operations and make emergency decisions if necessary. Health and safety is also an issue to ensure safe working conditions during flood events.

The costs for erection are typically determined by assessing the time required to assembly the demountable barriers and the number of operatives required per unit length of barrier. Manufacturers should be consulted to determine these aspects.

In addition, costs for supervisory or site security personnel are required for the length of time that the system will be in place during a flood to ensure systems are working properly and to prevent damage from vandalism or accident. This period of time is likely to be greater than the initial assembly period, but require fewer staff numbers. Costs may include the supply and assembly of security fencing, policing, road closure and signage to reduce the risk to the public and to minimise damage to barriers.

Additional considerations will be the requirement to bring pumps to the site, manning these and running them throughout the flood event and confirming arrangements for refuelling. The cost of pumping will depend on the capacity required and noise constraints.

Costs for dismantling and cleanup operations are typically included as a proportion of the number and of operatives required to erect the barriers, primarily as the temporal requirement to dismantle in a specific time period is reduced.

**Table 1.11 Key factors influencing deployment and removal costs**

<b>Factor influencing deployment and removal costs</b>	<b>Impact on cost estimation</b>
Type and size of barrier system	Affects the number of personnel required to move, assemble and dismantle barriers
Duration of flood event	Affects duration of personnel on site
Number of annual training events	Typically 1–2 a year
Number of flood events	Whole life cost will depend on the anticipated number of events over an appraisal period
Requirement for additional site security	Additional costs
Likelihood of seepage	Additional costs for pumping and trained staff to operate
Pumping capacity	Increased capacity will increase costs
Location of training	Annual training may be undertaken off site where suitable space is available and disruption is reduced. On-site training may increase costs

Factor influencing deployment and removal costs	Impact on cost estimation
	due to disruption to public

### *Example for costing of event costs*

For an assumed 250m long temporary barrier, the following assumptions and costs required to deploy and assemble a temporary barrier might apply:

- A minimum of 6 operatives are required to deploy the barrier over a period of 6 hours. Assume 6 operatives at £26 per hour = £156 per hour. Total cost of deployment over 6 hours = £936.
- Assume that 2 operatives are required for 24 hours during the time that the barrier is in place to check security and to monitor the integrity of the barrier. Total cost = £1,248 per day.
- 3 operatives are required for 12 hours to disassemble and ensure barrier is clean and ready for deployment. Total cost = £936.
- Plant costs are assumed to be £70 per hour each for a flat bed wagon and 2 telehandlers, required for a minimum of 10 hours during deployment and demobilisation. Total cost = £2,100.
- Costs for 2 operatives to bring pumps to site, operate and man for 24 hours. Total cost = £1,248 per day.
- Total cost for deployment prior to flood, inspection for 24 hours and demobilisation after flood = £6,500.

## 1.3 Other cost estimate requirements

In addition to the above cost estimates required, whole life costs will also need to consider the appraisal period, discount rates and optimism bias. The design life and discount rates are used to convert future costs over a scheme life to 'present values' so that they can be compared against the benefits.

### 1.3.1 Appraisal period/design life

The design life is typically defined as the minimum length of time that a scheme is required to perform its intended function. The design life for appraisals is typically taken to be 100 years, although alternative periods can be used. The design life is also an important consideration in whole life costing as component assets of a design may have a shorter service life and not be last as long as the design life. This has implications for cost estimates to ensure that a whole life cost estimate correctly identifies all long term maintenance and asset replacement costs over the intended appraisal period.

Design lives of temporary and demountable barriers are expected to be 25 to 50 years assuming appropriate maintenance and replacement of parts. Advice from manufactures should be sort for the overall appropriate design life and any specific component replacement needs and costs.

## 1.4 Cost estimation methodology

The following shows the key aspects required to generate a whole life cost for a temporary and demountable barrier for capital costs and operation and maintenance costs.

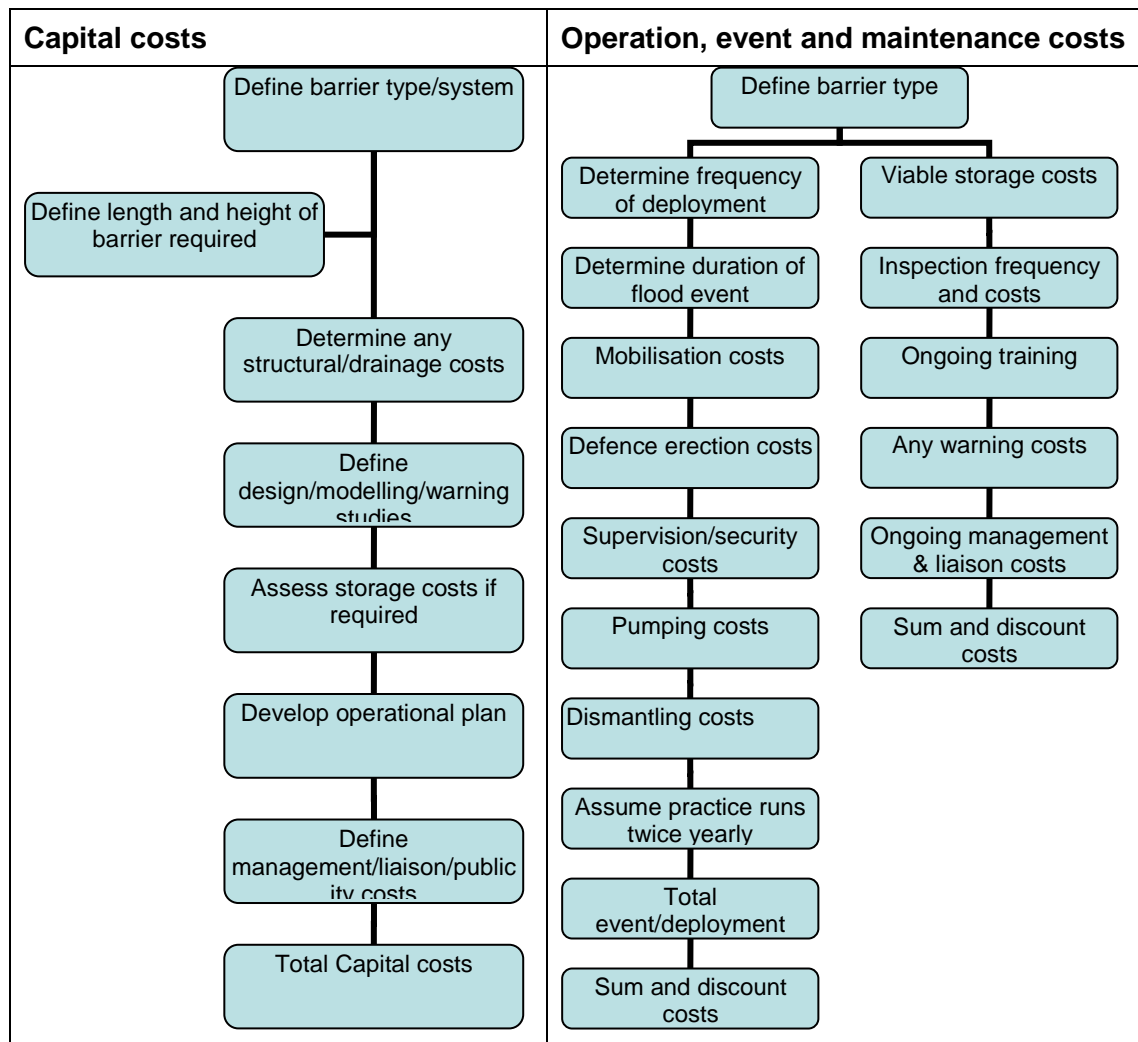


Figure 1.1 Flow diagram for temporary and demountable barrier whole life costs

## 1.5 Case studies

Several case studies are available in the literature. An example<sup>2</sup> of how costs can be derived is shown below and illustrates the very high whole life costs associated with annual and event costs.

<sup>2</sup> RPA (2006), Temporary Flood Barrier Systems Risk and Performance Evaluation. Final Report for the Environment Agency.

**Table 1.12**

<b>Item</b>	<b>Description</b>	<b>One-off costs</b>	<b>Annual or intermittent costs</b>	<b>Whole life cost (assuming events every three years)</b>
Barrier purchase	Assume £400 per m for 300 m length of barrier	£120,000	N/A	£120,000
Design modelling and agreements	Assume £10,000	£10,000	N/A	£5,000
Transport and plant costs	Assume truck and telehandler (×2) hire for 12 hours	N/A	£2,520	See below
Barrier assembly	Assume 16 operatives for 8 hours	N/A	£3,328	See below
Inspection and security/traffic management	Assume 3 operatives for 48 hours	N/A	£3,744	See below
Pumping	Assume 2 operatives for 48 hours	N/A	£2,496	See below
Demobilisation	Assume 8 operatives for 12 hours	N/A	£2,496	See below
Total event costs			£14,584	£113,189
Storage	Assume £5,000	N/A	£5,000	See below
Annual inspection	Two operatives twice yearly	N/A	£780	See below
Membrane replacement	£425 per 100 m per event	N/A	£425 per annum	See below
General management and liaison	Assume £2,000	N/A	£2,000	See below
Training	Assume 30 operatives five hours per year	N/A	£3,900	See below
Total operation and maintenance costs			£12,955	£317,337
Total present value costs				£534,704

Notes: Assumptions: 50 year design life and standard discount rates

### **1.5.1 Upton-upon-Severn**

Some more up to date figures on the costs of deploying temporary flood barriers from the Environment Agency are summarised below. These were supplied by the Environment Agency and relate to estimated costs as part of the 2009 Project



Appraisal Report<sup>3</sup> based on estimated flood event deployment costs that occurred in September 2008.

**Table 1.13 Example breakdown of deployment costs**

Element	Assumption	Total cost
Labour cost – deployment	12 staff @ £27/hour for 9 hours	£2,916
Labour cost – dismantling	12 staff @ £27/hour for 9 hours	£2,916
Labour cost – telehandler staff	2 staff @ £27/hour for 18 hours	£972
Site security	2 staff @ £27/hour for 7 day event duration	£9,072
Total Labour cost		£15,876
Site welfare	1 welfare unit monthly rate @ £1,200 + £200 delivery/collection	£1,600
Telehandler hire	2 @ £300 per monthly hire cost + £200 delivery/collection	£1,400
Transport	One wagon to transport barrier to site @ £1,500 for delivery and collection	£3,000
Membrane cost	Membrane replaced after each flood @ £2,000 for replacement and disposal costs	£2,000
Total event cost		£23,876
Capital costs	Assumed 750m @ £400 per m	£300,000
Storage costs	Assumed annual storage @ £8,000/year	£8,000

Based on the costs above, year one costs would be £300,000. Annual costs covering storage and £3,000 annual maintenance costs would be £11,000. Assuming a 3 yearly event cost of £23,876 and standard discount rates, the total 50 year present value costs would amount to £738,000.

## 1.6 Checklist

Use the checklist to:

- identify the key cost elements required for watercourses
- ensure all relevant whole life costs are incorporated into the cost estimate

### Whole life cost estimate checklist for temporary and demountable barriers

Item	Description	Frequency	Comment
<b>Capital</b>			
Design, modelling, permissions,	All costs associated with design, feasibility, modelling, warning and initial planning and	One-off	May be sunk cost by time

<sup>3</sup> Environment Agency (Dec 2009), Upton upon Severn FAS, Appendix F.

agreements	permissions		of appraisal
Barrier	Capital cost of barrier	One-off or recurring	Depends on design life
Structural infrastructure	Fixings and permanent infrastructure required for defences – a significant cost for demountable barriers	One-off	
Drainage infrastructure	Adaption and alteration activities for pumping and drainage works	One-off	
Operation and maintenance plan	Set up of operation and maintenance plan for all relevant authorities	One-off	
Management, liaison and publicity	Initial setting up of management and ongoing liaison and scheme publicity	Initial and ongoing	
Warning system	Design and implementation of new or improved warning system and telemetry	Initial and periodic review	
<b>Operation and maintenance</b>			
Storage	Costs associated with barrier storage if required	Annual	May not be required
Inspections	Regular inspection of barrier and maintenance costs.	Annual	
Component replacement	Annual or intermittent component replacement or maintenance activities	Intermittent	
<b>Event or training/practice costs (erect, check, maintain and dismantle)</b>			
Transport to site	Cost of loading and transport (labour and plant costs)	Recurring	
Erection	Staff costs associated with deployment of barrier	Recurring	
Inspection, supervision and site security	Staff costs and welfare provision throughout the event	Recurring	
Pumping	Costs associated with pump hire/implementation.	Recurring	
Dismantle, transport, clean-up	Cost of loading and transport (labour and plant costs)  Cost of disposal of consumable parts.	Recurring	

## 1.7 R&D and general design guidance

- Defra and Environment Agency, 2002. *Temporary and Demountable Flood Protection: Interim Guidance on Use*. R&D Publication 130.
- Defra and Environment Agency, 2007. *Sustainable Flood and Coastal Management – Case Studies Report*. R&D Technical Report FD2015/TR2.
- Environment Agency, 2011. *Temporary and Demountable Flood Protection Guide*. Project SC080019
- BSI, 2003. *PAS 1188-2. Flood Protection Products, Specification, Part 2: Temporary and Demountable Products*

## 1.8 References

DEFRA and ENVIRONMENT AGENCY, 2007. *Sustainable Flood and Coastal Erosion Risk Management, Part 2: Case studies report*. R&D Technical report FD2015/TR2. London: Department for Environment, Food and Rural Affairs.

ENVIRONMENT AGENCY, 2009. *Temporary and Demountable Flood Protection Guidance*. Draft report, 13 November 2009.

RPA, 2006. *Temporary Flood Barrier Systems Risk and Performance Evaluation*. Final Report for the Environment Agency.

STOKES, R. and MAY, P., 2004. *The Severn Valley: An Alternative Solution Evaluation of Temporary Flood Barriers during February 2004 Flood*. Solihull: Environment Agency.

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