Bottom seal formed by flexibility and weight of aggregate fill

Suitable aggregate

Frame

Geotextile or similar fabric

Water-filled geosynthetic tube

Reinforced waterproof fabric structure

Tension straps or frames

Long sleeve to provide stability and reduce seepage

Skirt weighted with sand bags or similar

Stability and sealing relies on the weight and bedding surface

Typically steel, plastic or precast reinforced concrete

Stability and sealing relies on the weight and bedding surface

DEFRA/ENVIRONMENT AGENCY
FLOOD AND COASTAL DEFENCE R&D PROGRAMME

TEMPORARY AND DEMOUNTABLE FLOOD PROTECTION

Interim Guidance on Use

R&D Publication 130
Temporary and Demountable Flood Protection
Interim Guidance on Use

Fola Ogunyoye and Michel van Heereveld

R&D Publication 130

Research Contractor:
Posford Haskoning Ltd
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Statement of use
This publication contains guidance to assist technically competent persons with the selection and appropriate use of temporary and demountable flood protection to prevent floodwater from reaching protected properties. The information in this document is intended for use by Flood Defence Operating Authorities, emergency services, property owners, local communities and their advisers. It is intended to update this interim guidance in 2004 in the light of experience and comments on its use.

It is the responsibility of those using this document in connection with the protection of any specific property to ascertain the legal status of the flood protection system in the location concerned. Environment Agency staff should consult the relevant AMS (Agency Management System) guidance on temporary and demountable flood protection.

Keywords
Flood protection, temporary flood protection, demountable flood protection, flood barrier, failure, operation, flood risk management, flood emergency, flood defence

Research contractor
This document was produced under R&D Project WSA-062 by:
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Executive Summary

Background

The traditional view of flood protection taken by the public and many flood defence professionals is of permanent engineered structures such as flood walls, flood embankments and large gated barriers. While temporary and demountable flood protection systems have been around for many years in forms such as sand bags and flood gates, the Environment Agency now recognises the need for a clearer framework within which to use the increasing variety of these systems that is now available. The flexibility offered by these systems can enable flood protection to be provided in locations that are not, or cannot be, protected by permanent flood defences.

As with all flood protection, the consequences of failure can be significant. The Agency recommends that anyone considering the use of these systems who is not experienced in flood protection should take appropriate advice. The Agency is also promoting, along with other interest groups in the UK, a testing and quality control procedure to secure the appropriate performance of these systems in service.

Objective and scope

This guidance results from a research study into available systems. Its objectives were to:

- categorise and review available temporary and demountable flood protection systems;
- develop a systematic method for choosing appropriate defences for various scenarios and using them in a safe manner.

Due to the limited performance information for available systems and the urgent need for guidance, this document is being published as interim guidance. The Agency is working closely with the recently formed Flood Protection Association (FPA) to develop performance assessment and product certification protocols. The Agency plans to review this guidance during 2004.

Temporary and demountable flood protection systems

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

A temporary flood protection system is a removable flood protection system that is wholly installed during a flood event and removed completely when levels have receded.

In contrast to a permanent system, a temporary or demountable system is only functional when the barrier is closed before the water rises to the lowest safe permanent protection level. A demountable flood protection system therefore includes temporary and permanent elements, foundations, seals and joints within the structure, connections between the structure and its formation and subsoil, the end connections and fixing details. Temporary and demountable flood protection systems also include the operational procedures required to close the system such as mobilisation, installation and closure.
Executive summary (continued)

When to use temporary and demountable flood protection systems

The decision on whether or not to use a temporary or demountable flood protection system is made following a risk-based assessment. The decision process recognises that the use of a temporary or demountable protection system, as opposed to a permanent one, introduces an additional risk of operational failure. To remove this risk, a permanent system should be used if it is technically and economically feasible, as well as environmentally and locally acceptable, to provide protection to the required level. Where this is not feasible, a risk management process has been developed that involves minimising the moveable parts of the protection system and maximising the reliability of all operational processes (from flood forecasting and warning through to deployment and post-event clean-up).

How to choose appropriate systems

Available temporary and demountable systems were reviewed and categorised according to their form and behaviour into six temporary and three demountable generic groups. This guide describes a systematic process for eliminating those systems that cannot be safely deployed in the available time with the available resources and those that cannot perform effectively under the required loading in the required location and local conditions. This process follows a logical progression from principal systems to generic systems, then onto specific systems. Appendix A provides more detailed information on specific products and contact details for further enquiries. The fact sheets in Appendix A3 have been developed from available information on known proprietary systems.

Ensuring the safe use of temporary and demountable flood protection systems

The key to achieving the safe use of temporary and demountable systems is to ensure maximum reliability of all the processes involved in the selection, planning and installation or closure of the system, as well as the integrity of the protection system once it is fully in place.
Acknowledgements

Significant contributions to the guide were provided by:

Roy Stokes  Environment Agency, Midland Region
Pam Bowker/Ian Cruickshank  HR Wallingford
Mervyn Bramley  Environment Agency, Bristol.

The performance assessment and testing procedures were developed jointly with HR Wallingford Ltd.

The assistance of the manufacturers and suppliers of flood protection products with the development of the fact sheets is greatly appreciated. In particular, we wish to thank:

Antiflood, Berkshire
Bauer Inner City Ltd, Manchester
Blobel Umwelttechnik GmbH, Germany
Creative Building Products, USA
Dam-It Flood Protection, West Bromwich
Dutchdam BV, The Netherlands
El Kosta (UK) Ltd, Somerset
Euro Consultancy and Marketing Corporation, Surrey
Flood Control America, USA
Flood Control Ltd, Cornwall
Flooding Agency A/S, Denmark
Geodesign AB, Sweden
Greenbanks, Scotland
Hesco Bastion Ltd, Leeds
Hydroscience Ltd, Hants
Intovalve Ltd, Birmingham
MBW (UK) Ltd, Bolton
Megasecur Inc Environmental Security, Canada
MRP Systems Ltd, Marple, Cheshire
Pallet Barrier, Devon
Portadam, Warwickshire
Profile Technologies Ltd, Herefordshire
Quick Damm GmbH, Germany
Richardson Flood Control Products, USA
Riverside Water Technologies Ltd, Swansea
Van Den Noort Innovations BV, The Netherlands
Glossary

**Barrier closing level**

The flood level at which the installation or closure of moveable parts of a temporary or demountable flood protection system commences.

**Barrier opening level**

The flood level at which the opening or dismantling of the moveable parts of a temporary or demountable flood protection system commences following a period of closure.

**Closure**

The process of installing or shutting the moveable parts of a temporary or demountable flood protection system following mobilisation of the resources required to begin the process.

**Demountable flood protection system**

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 guides or sockets within a pre-constructed foundation. It is made up of demountable sections and permanent sections that act together to form a demountable flood protection system when fully installed.

**Demountable section**

A section of a demountable flood protection system that can be removed or opened when water levels are not in a flood condition.

**Deployment**

The process of mobilisation of all required resources and the installation or closure of the moveable parts of a temporary or demountable flood protection system. This process is triggered when the water level reaches a pre-determined flood warning trigger (action) level.

**Failure**

Exceedence of a defined performance threshold or performance indicator.

**Flood defence system**

A formal flood protection system that is managed or controlled by an Operating Authority with responsibility for flood defence under the relevant Land Drainage and Water Resources Acts.

**Flood protection system**

A system for reducing the risks of flooding to people and property. It includes all parts that make up the system such as barriers, joints, foundations, end connections, interaction with the subsoil, and all operational activities required to close the systems (where applicable).
Glossary (continued)

Flood protocol
Agreed procedures outlining all actions to be taken from the receipt of a flood warning through deployment and post-event clean-up operations. It includes mobilisation and closure operation protocols.

Flood warning trigger (action) level
The flood level at which the process of mobilisation or closure begins. It is normally measured upstream of the deployment area.

Local flood protection
Flood protection for an individual property or group of properties that is not part of a formal flood defence system.

Lowest permanent protection level
The lowest point within the permanent protection offered to a flood cell or area.

Lowest safe permanent protection level
The water level above which safe access to the permanent protection cannot be guaranteed. This level is lower than the lowest permanent protection level due to wave run-up and local requirements for safe working.

Mobilisation
The process of communicating the warning trigger (action) level to the deployment team and the transportation of all resources required to begin erection or closure operations.

Performance
The creation or achievement of something that can be valued against some stated initial aim or objective.

Performance evaluation
The process of assessing past or future performance of a defence, policy or project against defined performance indicators.

Permanent flood protection system
A flood protection system that, once constructed, remains fully in place and requires no additional operational activity to provide protection from flooding up to its design flood level or range of levels.

Temporary flood protection system
A removable flood protection system that is wholly installed during a flood event and removed completely when water levels have receded.
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1. Introduction

1.1 Background

Over two million residential and commercial properties occupied by about five million people are estimated to lie within areas at risk from flooding or erosion within the UK (Department of Environment, Food and Rural Affairs, 2001). During past extreme flood events, sand bags were largely relied on to prevent or reduce flood damage to assets at risk. Some 2.5 million sand bags were deployed during the floods of Autumn 2000 (Environment Agency, 2001).

The use of non-permanent forms of barrier for flood protection can provide much needed flexibility and increased opportunities for effective management of a wide range of flood events. This realisation has led to an increase in the availability and development of new temporary and demountable systems – each with its innovative features, particular standard and quality.

As with any engineering system requiring successful operation and design, there is a need for guidance to support developers and potential users in their appropriate development and use. This document reviews and categorises existing systems, and provides guidance on when to use them, how to choose appropriate systems and how to ensure their safe use.

1.2 Purpose and scope

Flooding can occur naturally following a period of precipitation or high tides, as well as less predictive circumstances such as bursts, malfunctions or blockages. This guide deals primarily with reducing the risk of natural flooding by preventing floodwater from reaching protected property using barriers that require full or part erection, or closure during a flood emergency. It is one of a suite of guidance documents aimed at reducing flood risks by blocking the pathway of the floodwater. Guidance on the temporary or permanent sealing of pathways for floodwater within and around properties is given in documents published by the Construction Industry Research and Information Association (CIRIA) and the Department of Transport, Local Government and the Regions (DTLR) (CIRIA, 2001; DTLR, 2002).

The guide is intended to be read by:

- technically competent persons belonging to organisations with responsibilities for the planning and design of flood defences as well as managing flood emergencies. Such organisations and people include flood defence operating authorities, the emergency services, property developers, local communities, planners and designers.
- developers, manufacturers and other organisations involved with the development or improvement of temporary and demountable flood protection systems.

Section 2 provides basic definitions and descriptions of permanent, temporary and demountable flood protection systems.

Section 3 presents an analysis of the risk of failure of permanent, temporary and demountable flood protection systems and provides guidance on deciding when to consider their use.

Section 4 presents the categorisation of available temporary and demountable flood protection systems and a brief review of each of the categories.

Section 5 provides a systematic approach to the selection of appropriate temporary and demountable flood protection systems for different scenarios.

Section 6 provides guidance on ensuring the safe planning and use of temporary and demountable flood protection systems (focusing mainly on operational processes).

Section 7 describes an approach to the performance testing of temporary and demountable flood protection systems to ensure their fitness for the purpose for which they are intended.
As the guide focuses mainly on generic products and their characteristics, brief descriptions of known proprietary systems within the generic groups and relevant contact details are given in Appendices A1 and A2. Where further information was available, fact sheets are provided in Appendix A3.

1.3 Legal context of Temporary Flood Protection

The Environment Agency has legal powers to build and maintain flood defences in relation to any watercourses designated ‘Main river’ (usually larger watercourses) and estuaries that are likely to have significant impact if they flood. It also has powers to enter onto other people’s land to carry out these powers. Local Authorities and Internal Drainage Boards have similar powers in relation to other watercourses. These powers are contained principally in the Water Resources Act 1991, the Land Drainage Act 1991 and the Environment Act 1995.

The rights of others, e.g. private individuals, property owners or community groups, to install temporary or demountable flood protection to protect land and property from flooding is governed by common law. The requirements of planning law and human rights law must also be taken into consideration. Before making any decision in relation to the use of a temporary or demountable flood protection system, the person or body taking the action should ensure that they will have the legal right to erect the protection at the chosen location.
2. **Flood Protection Systems**

2.1 **The flood protection system**

Following a period of rainfall, water finds its way through natural or artificially created pathways to underground aquifers and watercourses, which transport it to the sea. Flood management techniques are used to reduce the risk of flooding during this process. The main techniques for reducing the risk of flooding to an area are:

- flood storage – hold back some water and let it out at a controlled rate;
- channel improvements/control structures – increase conveyance to achieve high flows;
- diversion channel – divert water around the area;
- flood walls/banks – build flood defences to prevent water getting into protected area.

This guide deals with the reduction of flood risk by preventing the water from getting into the protected area.

A flood protection system is made up of the components and operational systems that prevent the entry of water onto protected areas and includes:

- the barrier superstructure;
- the foundation or bedding structure;
- the seepage cut-off (if applicable);
- the seals, joints and interactions within the structure and with the adjacent structures and subsoil.

Where operational activities are required to close part of a barrier, this forms part of the flood protection system.

The details of a flood protection system and the critical factors affecting its performance vary according to the type of protection system. The different types of flood protection systems are discussed below.

2.2 **Distinction between flood defences and local flood protection**

A flood protection system is termed a flood defence or a local protection system depending on the body responsible for its management.

This guide applies the term ‘flood defence’ to any flood protection system that is owned and/or maintained by a statutory Flood Defence Operating Authority. As such, flood defences form the formal flood protection infrastructure.

Where a flood protection system is not under the direct management of a Flood Defence Operating Authority, it is termed ‘local flood protection’.

2.3 **Types of flood protection systems**

There are three main types of flood protection systems:

- permanent
- temporary
- demountable.

While temporary and demountable systems are considered separately within this guide in order to highlight their individual characteristics, the more likely scenario is that of a
composite flood protection system made up of sections of permanent protection combined with temporary or demountable sections, or both.

2.3.1 **Permanent flood protection systems**

A permanent flood protection system is one that requires no operational activity to provide protection from flooding. It is technically the most reliable protection system, as it is always in place to offer flood protection up to its design standard. The most common examples of permanent flood protection systems are:

- flood banks (earth embankments which are the principal form of flood defence used by Operating Authorities);
- flood walls (generally concrete or steel retaining walls).

A flood wall consists of a barrier above ground level, a foundation supporting the barrier, a cut-off barrier below ground level extending to an impermeable layer if present, and joints and end details. A flood bank has a similar structure to the flood wall, but in most cases without a cut-off barrier. The width of a flood bank at its base is normally enough to prevent significant seepage and uplift pressure except in very porous soils. A soak dyke, which is often provided close to the landward toe of an embankment, helps to collect any seepage close to the surface. Figure 2.1 shows the typical elements of a permanent flood protection system.

![Figure 2.1 Typical elements of a permanent flood protection system](image)

2.3.2 **Demountable flood protection systems**

In addition to or as an alternative to permanent flood protection systems, defences may have to be used which:

- remain open or have the ability to be left open during normal conditions;
- require part-installation or operation during high water levels to form a barrier.
Reasons why these types of protection systems are needed include:

- dual use of function such as the need for access through a flood protection system;
- unacceptable environmental impact of a permanent flood protection system;
- management of flood risk above the permanent standard of protection.

A demontable 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.

In contrast to a permanent system, a demontable system is only functional when the barrier is in a closed position before the water rises to the lowest safe permanent protection level. A demontable flood protection system therefore includes:

- the temporary and permanent elements;
- the foundations, seals and joints within the structure;
- the connections between the structure and the surface or bedding layer;
- the end connections;
- fixing details.

A demontable flood protection system also includes the operational procedures required to close the system such as mobilisation, installation and closure.

The performance of a fully erected or closed demontable system depends on the performance of its barrier, interaction with its formation and subsoil, as well as its joint and end details. To ensure system integrity, these must be carefully considered as part of the design.

Typical elements of a demontable protection system are shown in Figure 2.2

**Figure 2.2 Typical elements of a demontable flood protection system**
2.3.3 Temporary flood protection systems

Where permanent or demountable flood protection systems are unable to provide the full protection required for an area, systems that require full installation prior to the onset of flooding and complete removal after the event may be required.

Reasons for needing these types of defences include:

- insufficient economic justification for a permanent or demountable system;
- management of flood risk above the permanent standard of protection;
- stopgap during the development and construction of a permanent or demountable system;
- dual use of function such as the need for access through a flood protection system;
- unacceptable environmental impact of permanent protection.

A temporary flood protection system is a removable flood protection system that is wholly installed during a flood event and removed completely when levels have receded.

As with demountable systems, a temporary system is only functional when the barrier is fully erected before the water rises to the lowest safe permanent protection level. The temporary flood protection system therefore includes:

- the barrier which includes the temporary elements;
- the seals and joints within the structure;
- the interaction between the structure and the surface or bedding layer;
- the end connections;
- fixing details.

A temporary flood protection system also includes the operational procedures required to install the system such as mobilisation, installation and closure.

While the foundations for permanent and demountable systems are designed as part of the installation of the permanent parts, by their nature temporary systems are placed on whatever surface or existing foundation is available. The bedding surface therefore needs to be along a prepared and designated alignment. The need to ensure the suitability of the location, terrain or underlying soil is therefore a requirement for temporary systems. As a result, the ability of temporary systems to prevent groundwater seepage and uplift pressures normally depends on the existing subsoil or structure on which they are erected.

The performance of a fully erected temporary system depends on its barrier, its interaction with its subsoil, and its end joints and details. The type of terrain, formation layer and subsoil suitable for use with a particular form of temporary barrier and the seepage characteristics of the subsoil are critical to the ability of temporary barriers to provide flood protection.

Typical elements of a temporary protection system are shown in Figure 2.3.
Figure 2.3 Typical elements of a temporary flood protection system

- Line of barrier
- Conventional sand bag temporary barrier
- Permanent river bank

Impermeable layer
3. Considerations for Use of Temporary and Demountable Flood Protection Systems

3.1 Factors affecting failure of protection

The aim of a flood protection system is to provide an area with a pre-defined standard of protection from flooding. The flood risk to an area depends on the potential damage within the area (the consequence) and its frequency of flooding (the probability of occurrence).

A flood protection system is deemed to have failed when it is no longer able to meet its pre-defined performance objective or indicator. The three possible failure modes are described below.

3.1.1 Failure of permanent flood protection systems

For permanent protection systems, failure can happen in two ways.

The first mode of failure is the inability of the structure to restrict overtopping or seepage through or under it to a pre-determined performance level under specified conditions. For example, a flood protection system may be designed to limit overtopping and seepage to a maximum of 1 litre/second during a flood event with a 1% annual probability of occurrence. A failure is deemed to have occurred if a flood event with less than a 1% annual probability of occurrence results in overtopping and/or seepage higher than 1 litre/second. This type of failure is termed **serviceability limit state failure**.

The second mode of failure is the structural failure of the system due to breaching, piping, foundation failure, collapse, overturning, rolling or sliding. The flood protection system fails when, as a result of any of these occurrences, the system is unable to meet its performance objective. The failure of a component of a protection system does not necessarily imply the failure of the system, even though it could progressively lead to a system failure. This type of failure is termed **ultimate limit state failure**.

A simplified failure tree for a permanent flood protection system is as shown in Figure 3.1.

*Figure 3.1 Failure tree for a permanent flood protection system*
3.1.2 *Failure of temporary and demountable flood protection systems*

In addition to the two types of failure described above, a third type of failure can occur with temporary and demountable flood protection systems. This is the failure to close or secure protection before inundation and is termed *operational failure*.

Figure 3.2 shows a simplified failure tree for a composite flood protection system made up of permanent and demountable or temporary sections.

For the purposes of this guide, the flood protection is deemed to have failed if any of these three types of failure occur.

*Figure 3.2 Failure tree for a typical temporary or demountable flood protection system*

![Failure Tree Diagram]

3.1.3 *Relative risk of failure by the three failure modes*

An extensive risk analysis of composite flood defences carried out as part of the Kampen Flood Defences scheme in Netherlands (Directorate-General of Public Works and Water Management, 1997) showed that the risk of occurrence for each of the three failure modes described above was as follows:

- Risk of failure by overtopping or excessive seepage through a closed defence: **89%**
- Risk of failure due to insufficient strength or stability: **1%**
- Risk of failure due to non-closure of defence: **10%**

While this breakdown is for a particular scheme and variations are expected for different scenarios, it indicates the relative risks of failure of defence systems with temporary or demountable parts.

Factors that significantly affect the relative risk of failure include:

- the sufficiency of lead-in time;
- reliability of flood forecasting and warning systems;
- durability;
- maintenance of the system components;
- training of deployment teams.
Figures 3.1 and 3.2 suggest that a permanent protection system is potentially safer than one with temporary and demountable parts (there are no additional operational failure concerns). Therefore, temporary and demountable systems should not automatically be used as alternatives to conventional permanent systems without adequate consideration of their expected performance, operational issues and adequacy for the proposed scenario. It should be noted that a temporary or demountable protection system is only functional once the closure or installation of the barrier is achieved.

The performance objective for a temporary or demountable flood protection system is to make it as safe as a corresponding permanent system of the same standard. This guide seeks to minimise the additional risks posed by the operational activities associated with the deployment of temporary and demountable systems, while seeking to improve its performance once closure is achieved.

The three failure modes are considered further below.

### 3.2 Failure due to overtopping or excessive seepage through a closed flood protection system

Overtopping of a barrier occurs when the adjacent water level rises above the lowest point along its crest. This is either caused by inaccurate forecasting of water levels or by a flood event greater than the standard of the defences.

The forecasting of flood levels used for the design of any protection system relies on the statistical analysis of rainfall, flows and expected catchment response. Inherent within these are uncertainties in the data, hydrology, hydraulic assessment, climatic effects and future trends. These uncertainties act together to form an error bandwidth around the design level.

An estimate of these errors is normally allowed for as part of the freeboard for the defence level. This is illustrated in Figure 3.3.

**Figure 3.3 Uncertainties in design flood levels**

Seepage occurs when water percolates through the barrier, joint, seals or subsoil. Factors that can influence seepage include:
• the permeability of the barrier;
• the design or condition of the seals, joints and end details;
• the connection between the barrier and its foundation;
• seepage within the subsoil that depends on the subsoil structure and characteristics.

Overtopping or seepage lead to the failure of a flood protection system if the amount of water that passes through to the protected area exceeds the performance criteria for the protection system. This is normally based on the consequence of flooding and acceptable values.

The factors affecting excessive seepage and overtopping of temporary and demountable systems are similar to those for permanent systems. These issues need to be properly considered as part of the design and choice of the barriers.

3.3 Failure due to insufficient strength or stability

Structural failure of a closed protection system can occur in any of the following forms:

• sliding or rolling
• overturning
• bearing capacity failure
• collapse
• internal erosion or piping.

Adequate structural design of demountable systems should ensure that most of these failures do not occur. Some types of failures, such as rolling or collapse, are not always easy to analyse; such systems require laboratory or field testing to ensure their integrity. Innovation in this field has also led to the use of materials whose performance characteristics are less well established. These systems also require appropriate testing to determine their structural capabilities. Testing of flood protection systems is discussed in Section 7.

Excessive seepage through a defence or its subsoil can cause internal erosion and lead to a scenario where the seepage pressure of the water percolating through becomes greater than the effective weight of the toe on the dry side of the barrier. The result is the generation of a flow condition within the soil, movement and a risk of foundation failure. This phenomenon is known as ‘piping’.

Piping and bearing capacity failure can be avoided by adequate design for demountable systems and the appropriate choice of subsoil, terrain, foundation and bedding surface conditions for temporary systems. Standard stability analysis methods can be used to consider resistance to sliding or overturning for a range of loading and foundation conditions.

In the case of temporary systems, it is not always possible to investigate or designate their location before use. This makes it difficult for individual structural analysis to be performed because soil or bedding information is not available. In these cases, testing may be necessary to confirm the system’s suitability for a number of standard soil types.

The risk of structural failure can be minimised by adequate design and testing. The risk of structural failure for temporary and demountable systems is comparable with that for similar permanent structures. It should be undertaken to the same standards to ensure they are no less safe.
Failure of one or more components of a protection system can occur. If this makes the whole system unable to fulfil its performance objective, then the system is deemed to have failed.

### 3.4 Failure due to non-closure of a flood protection system

#### 3.4.1 General principles

Failure due to non-closure of a barrier occurs only with temporary or demountable systems. It is caused by the failure of one or more of the operational activities required to close or erect the barrier. The successful closure of the barrier before the floodwater level reaches the lowest point at which a significant path for floodwater can occur is therefore critical in ensuring that these systems are as safe as permanent ones in reducing flood risk.

The operational stages necessary to ensure the successful deployment of a temporary or demountable barrier during the life of a flood hydrograph are shown in Figure 3.4.

**Figure 3.4 Operational processes during a flood event**

In Figure 3.4, the operational stages from flood warning through to demobilisation and clean-up have been outlined separately to draw attention to the processes within each stage. The actual process required for the operation of a system depends on the type of system and the organisation or people responsible for its deployment. The times indicated in Figure 3.4 are explained below.

A temporary system or demountable section of a flood protection system should be fully in place to form a closed barrier before time $T_2$. $T_2$ is the time when the lowest safe level of the riverbank or permanent part of the protection is reached. This is the floodwater level that can be permitted within the river or floodplain without the risk of floodwater passing the line of the barrier. Due to the effect of wave run-up and safety considerations, this level is lower than the lowest permanent level.

$T_1$ is the time at which the actual closure of the barrier commences. It is determined by working back from $T_5$ by allowing adequate time for closure. At $T_1$, all resources required to commence closure of the barrier are on-site ready to begin closure. The closure period depends on the type of operation required to close the barrier and the extent of the temporary or demountable parts. It can vary from a few minutes for automatic operation of a barrier or gate to over 24 hours for the erection of long lengths of barriers requiring the use of heavy plant and materials.
T₀ is the trigger level at which the call-out procedure is instigated and mobilisation of all resources begins. The maximum value of T₀ is determined by working back from T₁ by allowing adequate time for mobilisation. The actual trigger (action) level is then decided. This is based on the need to provide adequate time for mobilisation and to minimise the risk of carrying out abortive emergency operations. An unacceptable level of abortive warnings and operations is counter-productive. The mobilisation period depends on the call-out procedure of the organisation or people responsible for the operation of the defences and the transportation and access requirements to get all necessary resources to the site. The mobilisation period can range from zero for automated sites to over 12 hours for isolated sites where the demountable sections or temporary barrier units are not stored near the proposed deployment area.

The length of time T₂ – T₀ is the period required between the water reaching a pre-determined trigger or action level and achieving full closure. This is the most important factor in determining whether an area at risk from flooding can be protected with a temporary or demountable protection system, and which types of systems are suitable. A temporary or demountable system that requires significant mobilisation and closure time may be suitable for areas at the downstream end of a large river catchment. However, a demountable system that is operated automatically by water level sensors may be the only viable non-permanent option for the protection of an area at the upstream end of a catchment where river levels rise quickly following a storm.

After reaching its peak, the flood level starts to fall with time until it reaches a level at time T₃ corresponding to the barrier opening level. This level is usually the same as the lowest (safe) permanent protection level (the level at time T₂). Unless a second peak in level is forecast, barrier opening or dismantling normally begins at T₃.

Failure of closure of a flood protection system will occur when the river level is higher than the lowest permanent part of the river bank or system and the temporary barrier or demountable section of the defence is not fully in position. Using the principles laid out in Figure 3.4, Figure 3.5 shows a simplified failure tree for non-closure of a flood protection system. The three types of failure shown in Figure 3.5 are considered in Sections 3.4.2–3.4.4.

*Figure 3.5 Failure tree for non-closure of a flood protection system*
3.4.2 Failure of the flood warning system

Once the design flood hydrograph (see Figure 3.4) or another reliable indication of threshold flood level has been determined, a flood warning system is required to trigger the mobilisation phase of the closure operation. Flood warning can be based on rainfall forecasts, flow measurements or water level measurements. These systems can be read manually, recorded electronically or monitored and simulated in real-time. The actual warning process can be automated, a manual call-out or a combination of both. For a local community, this might be activated by a more general warning from the Agency, for example through Floodline.

Failure of a flood warning system occurs either due to the failure of a technical part of the system such as instrument malfunction, or human failure to interpret and act to initiate mobilisation following a flood warning.

To ensure reliability, the size and skills of the operating body must be sufficient to manage the flood warning system. The mechanics of forecasting and monitoring also need to be reliable, with a ready back-up system. A forecasting and monitoring system that relies solely on weather forecasts or rainfall/run-off read-outs will have a low reliability, while one that is based on real-time monitoring of the upstream catchment will have a high reliability.

A reliable flood warning system is a pre-requisite for the successful use of a temporary or demountable flood protection system.

3.4.3 Failure of mobilisation

The aim of mobilisation is to ensure that all personnel, material and plant required to commence erection or closure of a temporary or demountable protection system are on-site before the closure protocol begins.

There is no mobilisation phase for fully automated demountable systems. For all other non-permanent systems requiring some form of human operational intervention, this is a necessary phase for successful closure.

The time available for mobilisation depends on the steepness of the flood hydrograph (the rate at which local river levels rise after a storm).

Mobilisation will fail if the call-out system fails or if the required resources such as people, equipment and material do not reach the barrier before the time set to begin closure or installation.

The mobilisation period can be reduced by the following actions:

- automation of part of the call-out and mobilisation processes;
- on-site or local storage of temporary barriers or demountable sections and any other materials required for the composite protection system;
- regular training and emergency exercises;
- improved access to the locations where the barrier sections are stored and deployed;
- improved communication systems.
3.4.4 Failure of closure operation

Once the flood warning and mobilisation phases have been successfully carried out (before the closing level is exceeded), the actual closure or erection of the temporary barrier or demountable section of the system can begin. The resourcing of this phase depends on the time available for closure. This is normally constrained by the steepness of the relevant flood hydrograph. The period for carrying out the closure processes can be reduced by the following actions:

- increased resources such as people and plant;
- an increase in the level and extent of the permanent parts of the composite protection system;
- regular training and emergency exercises;
- regular maintenance and testing of the defence elements.

The closure operation can fail due to either human error or technical malfunction.

Failure due to human error can include performing an operation wrongly, carrying out a series of processes in the wrong order and the lack of necessary tools or keys. These errors can be easily prevented or rectified with proper supervision and a good written and practised closure plan.

Failure due to technical malfunction may occur both through external circumstances or malfunction of one of the elements within the temporary or demountable protection system. Within automated or semi-automated demountable systems, failure often occurs within the mechanical system (for example, failure of a drive or the electrical supply to part of the system). For manually operated or erected systems, failure is more likely to be due to an omission or a material or plant-related problem.

Some typical sources of failure during mobilisation and closure are given in Table 3.1.

Table 3.1 Typical sources of failure during mobilisation and closure

<table>
<thead>
<tr>
<th>Temporary or demountable systems requiring part erection or manual closure</th>
<th>Demountable systems with fully-automatic or semi-automatic operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport or crane malfunction</td>
<td>Jamming of moving parts</td>
</tr>
<tr>
<td>Material damage or lost</td>
<td>Barrier temporarily away for maintenance or repair</td>
</tr>
<tr>
<td>Materials mixed-up</td>
<td>Failure of locomotion</td>
</tr>
<tr>
<td>Damage to permanent elements</td>
<td>Power supply failure</td>
</tr>
<tr>
<td>Blocked access or jamming of covers or locks to permanent elements</td>
<td>Lack of maintenance</td>
</tr>
<tr>
<td>Insufficient time allowed for operations</td>
<td>Accident due to automatic closure of gap during its use for other purposes</td>
</tr>
<tr>
<td>Insufficient access or space for required plant</td>
<td>Debris or obstruction jammed within defence</td>
</tr>
<tr>
<td>Resources not available</td>
<td></td>
</tr>
</tbody>
</table>

Resources not available
3.5 Summary of risk analyses

Risk analysis has shown that, when dealing with temporary and demountable systems, it requires extra effort to establish the same level of safety as with permanent protection systems. As a result, permanent protection systems set the benchmark for safety.

The main difference for temporary and demountable systems is the added series of operational activities that need to be carried out successfully to ensure safe closure of the system. More extensive failure analysis of temporary and demountable flood protection systems is given in two reports from the Dutch Technical Advisory Committee on Water Retaining Structures (TAW) (Technical Advisory Committee on Water Retaining Structures 1997 and 2000).

Aspects such as warning systems, operational procedures, training and regular emergency exercises play a vital role. Provided thorough consideration is given to these matters, temporary and demountable flood protection systems can be safe alternatives in situations where permanent systems cannot be used.

3.6 When to use temporary and demountable flood protection systems

If it is not feasible to construct permanent protection to the required level, the initial issues governing the possible use of a temporary or demountable system are:

- the availability of adequate forecasting and warning systems;
- the ability to complete all operational activities in time.

The high-level decision-making process necessary to determine the suitability of temporary and demountable systems for a given scenario is outlined below. A simple flow chart to illustrate the process of deciding whether to use a temporary and demountable system is shown in Figure 3.6.
The decision whether to use a permanent, temporary or demountable system should follow a review of factors such as:

- feasibility
- local acceptability
- safety
- operational and legal constraints
- available resources.

The decision process is a risk management process that starts with the identification of the additional risks due to operational requirements for temporary and demountable systems.

The first step in the process is to seek to eliminate the risk. If a permanent flood protection system can be constructed that is technically, economically and environmentally feasible, then this is the preferred option.

There are a number of situations where a permanent system cannot be built to the required standard. This may be due to issues such as the need for dual purpose (for example, flood
protection and access), economics or aesthetic reasons. Where this is the case, options for
temporary and demountable systems can be considered.

Once it has been decided that a temporary or demountable protection system is a potential
option, the next step is to carry out a high-level feasibility study and the likely acceptability of
such a system in the locality. This phase includes considering the access to the site during an
emergency. The concept of using a temporary or demountable system must be acceptable to
the local population. A feeling of safety is an important factor in obtaining public acceptance.
Public acceptance can be increased by early involvement in the scheme.

If temporary and demountable systems are in principle acceptable locally, the next step is to
review the reliability of existing flood forecasting and warning systems, and their use to
trigger closure. These can be considered using reliability indicators. The use of reliability
indicators involves assessing and rating possible actions. For flood level monitoring, these
could be periodically read gauge boards with forecasting based on rainfall forecasts at the
lower end of the scale and electronically recorded river levels with real-time forecasting at the
higher end of the scale. The required reliability level will depend on the acceptable flood risk.

If the existing forecasting and warning system is deemed sufficiently reliable, the next step is
to allocate responsibility for all phases of the system life cycle. Responsibility for the design,
construction, future operation and maintenance phases must be clearly stated.

The capability of the organisation to provide and manage resources in an emergency should
also be considered at a high level.

Whichever organisation is deemed responsible, it is important to consider their legal position.
For example, the legal issues faced by a Flood Defence Operating Authority under their
operational powers may differ from those for a developer or landowner. The main issue is the
possibility of worsening the risk of flooding to other properties.

Before deciding on the use of a temporary and demountable protection system, the
organisation or person responsible for its management must ensure that they are legally
allowed to erect or use such a system. Third party concerns such as ownership issues, rights of
access, effect of barriers on third party flood risk, conflict with other parties or local bye-laws
should be considered and any requirement for planning or other consent checked with the
local planning authority. This is particularly necessary for demountable systems as they
include permanent parts.

The use of a temporary or demountable protection system should be considered further if:

- it is not possible to construct permanent protection to the required level;
- a reliable flood forecasting and warning system exists;
- local and legal issues are favourable;
- there is a reliable organisation with sufficient resources to manage the system.

Sections 4 and 5 describe the categorisation of available temporary and demountable systems,
and the process of choosing appropriate systems for various conditions and requirements.
4. **Generic Categorisation and Description of Existing Systems**

4.1 **Approach to categorisation**

This section deals with the classification of existing temporary and demountable flood protection systems into generic categories. The categorisation system was developed on the basis of existing products and those currently in development. It was, however, designed to accommodate likely new systems. Every endeavour was made during the generic categorisation to ensure consistency across both types of systems.

The most important factor in the development of the generic categories was the behaviour of the systems during operation and under hydraulic loading. If any aspect of a group of systems made their behaviour or form significantly different from others, they were separated into a generic group. While it could be argued that more or less categories would have been appropriate, a balance was made between having enough generic groups to minimise large behavioural ranges within each category and having a manageable number of groups.

Every temporary or demountable flood protection system has unique functional, operational and structural characteristics which limit how, where and when it can be effectively deployed. The characteristics important for the satisfactory performance of temporary and demountable flood protection systems are discussed in Section 4.2. As these characteristics are similar for systems within the same generic grouping, a review of each group was undertaken to highlight some of their key characteristics. The results of this review are given in Sections 4.3 and 4.4 for temporary and demountable systems, respectively.

4.2 **Characteristics of temporary and demountable systems**

The characteristics of a temporary or demountable flood protection system determine its ability to be used within a particular scenario. Functional, operational, structural and seepage characteristics are discussed in Sections 4.2.1–4.2.3.

4.2.1 **Functional characteristics**

These are the physical characteristics of a protection system such as dimension, shape and form. In particular, the following attributes need to be considered:

*Height of the protection system*

The deployed height of the system above its bedding surface determines the maximum head of floodwater that can be retained before overtopping occurs. This height also limits the location where the system can be deployed – especially where physical height restrictions exist. The height of the system is sometimes higher than the design head of water to be retained or the protection capability. The protection capability is deduced from structural analyses and performance testing.

The ability to increase the height of a flood defence system during service conditions is also important. A protection system with the capability to be increased in height after installation is useful when the flood event is higher than predicted. This is important for sites where there is a lack of confidence in the ability to forecast flood levels. Where the system height can be increased during service, it is important to confirm the structural adequacy of the barrier and the bearing capacity of the underlying soil for the total stacked loading.
**Width of the protection system**

The deployed width of the protection system is important in deciding whether it can be used within the site’s space constraints. This can be a key characteristic when protection is required on top of an embankment or a wall with a set crest width, or in areas where there is limited width for closing or erecting the barrier.

**Adaptability to terrain and bedding conditions**

The barrier acts with its bedding surface and foundation to form the protection system. The ability of the barrier to adapt to various terrain and bedding conditions therefore needs to be considered. The rigidity of barriers affects their ability to adapt to types of terrain such as undulating or sloping, and soft or hard surfaces. This adaptability affects the system’s seepage and stability characteristics.

**Adaptability to change in alignment**

The ability of a barrier to adapt to the required vertical or horizontal change in alignment at its location of use can be critical to its suitability – especially where sharp bends or steps are involved. Adaptability is normally achieved either through the flexibility of the system due to its form, or the provision of fixings or procedures that allow some form of alignment change.

**Joints and end fixings**

The form of a barrier and its accessories/fitting affect both its ability to achieve an effective connection with its end conditions and the integrity of the joints between separate connected units. Good connections are essential to ensure effective performance of the whole of the temporary or demountable system. Connections and joints are unique to a particular system and are not generally assessable at a generic level.

### 4.2.2 Operational characteristics

These are the operational requirements that are necessary to store, transport, deploy and remove a flood protection system. These operational issues are critical to ensuring the system is available for use and is erected before the relevant flood levels are reached. Relevant operational characteristics include the following.

**Time required for deployment**

The time required for the deployment of a flood protection barrier is one of the most important attributes that governs its suitability for a particular scenario. The total time required for deployment is the time from when mobilisation begins to the time when the protection system is fully in place.

The mobilisation process depends on:

- the procedures followed by the organisation or people responsible for the deployment;
- the location of the system;
- the remoteness of the site;
- transportation requirements;
- the amount of site preparation required.

The second stage of the deployment process is the erection or closure of the temporary or demountable barrier. The time required for closure depends on the type of product, the resources available, the length of the required protection and the complexity of the operation.
**Resources required for installation**
The number of people and the amount of plant required for the installation of a system and the requirement for other materials affect the ability of an organisation to install a temporary or demountable system effectively. The minimum resource requirement is governed by the weight, size and installation requirement of the system. The type of plant that can be used in an area may be limited by site constraints, which in turn affect the type of protection systems suitable for the area.

**Storage and transportation requirements**
The ideal situation is for all sections required for the installation of a temporary or demountable flood protection system to be stored near their proposed deployment. Where this is not practical due to space or other constraints, off-site storage should be provided.

The amount and type of storage required depend on the size of the components in their packed state, their form, and the design of individual components. The type of storage depends on the need for protection from external factors such as rain, ultraviolet radiation and vandalism. The review of available systems in Sections 4.3 and 4.4 considers storage and transport requirements for different types of system.

The organisation or people responsible must have access to the vehicles and/or lifting equipment required for loading or transporting barrier components. The deployment site must be accessible by these vehicles during an emergency.

**Site preparation and clean-up requirements**
The site preparation required for a temporary or demountable system can be significant. It depends on the particular system and is usually carried out to remove any blockage from the line of protection and to prepare the bedding surface. Actual requirements normally depend on:

- the form and design of the barrier;
- the bedding surface;
- other functions for which the line of protection is used.

Clean-up requirements after demobilisation or opening of the system can also be significant and again depend on the system. They usually involve:

- the physical removal of dirt and debris from the barrier components and the deployment area;
- removal and disposal of materials such as aggregates and water used as part of the protection;
- return of the bedding surface to its usual state.

**Ease of deployment**
Temporary and demountable flood protection systems are almost always deployed in cold, wet and windy conditions. Deployment can be made easier by:

- using modular systems whose sections can only be connected the correct way;
- providing training and operational manuals;
- minimising operational activities.
Although the ease of installation or closure of barriers is influenced by the design of individual barriers, some appreciation of the ease of deployment on a generic scale was made during the review.

4.2.3 Structural and seepage characteristics

These characteristics affect the structural stability or seepage through or around temporary and demountable flood protection systems. They also affect the system’s ability to resist the loads to which it might be subjected in service. Some relevant characteristics include the following.

Likely structural failure methods
The resistance of a temporary or demountable system to typical failure methods such as sliding, rolling, excessive seepage, piping, bearing capacity failure, overturning and collapse provides an indication of its likely mode of failure under extreme loading. The form and design of structures can also provide some clues. A review of the likely methods of failure can improve the design and management of systems. Stability calculations and testing are required to obtain data on the expected performance of individual systems.

In addition to structural stability under design loading conditions, other considerations are:

- wind resistance – usually critical before the floodwater arrives;
- the bearing pressure of the barrier on the bedding surface (this affects foundation or bedding requirements).

Excessive seepage and piping
Seepage through a system can occur:

- through the barrier;
- at the joints between the barrier and the bedding or adjoining structures;
- through the subsoil.

Seepage characteristics are important as they can exceed acceptable limits or lead to structural failure of the system due to the development of internal erosion, piping and foundation failure.

Seepage through the barriers can be assessed by considering the design and form of the material. The seepage at the barrier’s interface with its bedding surface, adjoining structures or through the subsoil depends on site-related issues such as terrain and subsoil characteristics.

For demountable systems, such issues must be dealt with as part of their foundation design by one or more of the following methods:

- stopping or reducing seepage using joint and edge sealing methods;
- increasing the seepage path horizontally (wide barriers or use of aprons/skirts);
- increasing the seepage path vertically by providing a seepage cut-off.

For temporary systems, the appropriate choice of location and use of systems with adequate designs for sealing and horizontal seepage path extension should reduce the likelihood of excessive seepage and piping.
Resistance to damage

The review considered:

- the resistance of the temporary or demountable barrier to damage of its components by impact, vandalism and tear/puncture;
- how easy it was to repair damage during service conditions;
- the likelihood of component damage leading to a progressive failure of the system.

These attributes are important in mapping the strength of the barriers to the expected loading or potential form of damage for a particular scenario. In general, rigid structures such as steel and aluminium are more resistant to damage and failure progression, but are less easy to repair under service conditions compared with more flexible systems.

4.2.4 Other relevant characteristics

In addition to the functional, operational and structural and seepage characteristics described above, the review covered other characteristics that affect the whole life cost and environmental acceptability of the system. These include:

- initial purchase cost
- maintenance requirements
- aesthetic qualities
- durability
- re-usability
- versatility of use for other functions required by the organisation or people managing its deployment.

Some of these factors are crucial to the economics of buying a system and can have a major influence on the business decision of selecting the system that provides the best value for money.

4.3 Temporary flood protection systems

Six categories of temporary flood protection systems have been identified. These are:

- filled containers – permeable;
- filled containers – impermeable;
- air and water filled tubes;
- flood barriers – free-standing;
- flood barriers – with frame;
- panel barriers.

A brief description of each type of barrier is given below, together with a summary of their advantages and disadvantages. To ensure adequate system performance, all types of barrier need to be deployed on suitable (preferably planned) bedding surfaces and subsoils.
4.3.1 *Filled containers – permeable*

These are cellular barriers filled with aggregates to form a barrier against floodwater. The barrier materials are typically geotextile or geosynthetic fabrics, which can usually be collapsed for storage. Some systems are strengthened and held in place by wire meshes, pins and steel frames. Figure 4.1 shows a typical filled container – permeable.

As the geotextile liners are not impermeable, water tightness is achieved by the mass of material with which they are filled. Some systems are stackable, providing the flexibility to increase the barrier height during service.

This type of barrier functions as gravity dams. They rely on their weight to provide structural stability and their overall permeability to prevent seepage through the structure. They are generally flexible and adapt well to uneven terrain. Sand bags ideally fall within this group.

*Advantages:*

- Height of some systems can be increased during service by stacking.
- Can usually be installed by unskilled labour.
- Small storage space required.
- Adapt to uneven formation/terrain.
- Ideal replacements for sand bags.
- Can use readily available fill material.

*Disadvantages:*

- Clogging of material/effluents within the fabric can make cleaning difficult or impossible.
- Stacked defences require significant width, which may not always be available.
- Some steel supports and pins may buckle or deform beyond reuse under stacking and service loading.
- Need to dispose of large volumes of probably contaminated material after flood event.
- Seepage can be a problem, but this can be minimised by using a suitable choice of geotextiles and fill.
- High bearing pressure on bedding surface when stacked.
4.3.2 Filled container – impermeable

These are barriers made of impermeable materials such as polyester, polyethylene and plastic. The containers themselves are impermeable and are filled with water or aggregates only to provide additional weight. These systems are gravity structures achieving stability through their weight and shape.

The more flexible materials are susceptible to tearing by sharp objects and some ground preparation is therefore necessary before installation. Minor leaks can usually be repaired in service. These systems are generally more rigid than permeable filled containers and do not adapt as well to uneven terrain.

Figure 4.2 shows a typical filled container – impermeable.

Advantages:

- Height of some systems can be increased during service by stacking.
- Does not rely on fill material for water tightness.
- Can be filled with any available material (including water).
- Easily washed and reusable.
- Minor repairs to tears or punctures can be done in service.

Disadvantages:

- Most systems are currently untested in flood conditions.
- Significant seepage may occur under the barriers due to their rigidity.
- Large structure to store and transport.
- Significant mobilisation and demobilisation operations.
- High bearing pressure on bedding surface when stacked.
4.3.3 **Air and water filled tubes**

These flood protection products are typically pre-fabricated geomembrane tubes filled with air or water to form a dam. They utilise air or water – always in abundance during flood events. The water-filled tubes are gravity dams, which use the weight of water to provide stability.

The tubes are normally portable and require pumps for inflation. Some are stackable. This should be performed with caution, as the tubes do not necessarily adhere to each other as well as they do to the bedding surface.

The tubes have a significant width-to-height ratio when fully deployed (a 2 m high tube can occupy a width of about 7 m). They can be quickly deployed and require only manual installation and one or two mobile pumps. Larger tubes may, however, require four or more people for deployment.

To prevent rolling, most systems have some form of anchoring. Internal anchoring methods include using internal baffles, internal tubes and multiple tubes secured to form a stable shape. External anchoring methods include anchor pins and the use of long skirts on which the vertical pressure of the water acts. Air-filled tubes tend to have external anchoring due to their light weight.

Air and water filled tubes are generally suitable for long lengths of protection close to a water source. They are not ideal for filling small gaps. They are susceptible to tears and punctures, which can usually be repaired during service (if on the external tube).

Figure 4.3 shows a typical air and water filled tube.

**Advantages:**

- Low bearing pressure on the bedding surface.
- Very versatile – can be used for many other emergency or operational scenarios.
- Quick and easy to install.
- Small storage space required.
• Installation only requires people and mobile pumps.
• Tears can usually be repaired in service.
• Flexible enough to accommodate minor uneven terrain.
• Easily cleaned and reusable.

Disadvantages:

• High width-to-height ratio is restrictive for larger tubes.
• Major tear affecting internal tubes or air-filled tubes can lead to failure of the whole system.
• Require relatively flat surfaces.
• Risk of water freezing in tubes at low temperatures leading to failure.

Figure 4.3 Air and water filled tube

4.3.4 Flood barrier – free-standing

These barriers are made of free-standing heavy duty sections, which are self-supporting. The barrier material is flexible and impermeable. The stability of these barriers depends on the weight of water acting on a long skirt on the upstream side of the defence resisting the imposed loading on the barrier. The length of the skirt is designed to ensure adequate stability.

Seepage may occur at low water levels. To minimise this, weighting with sand bags or similar material is advised at the upstream end of the skirts.

The materials used for the barriers are susceptible to tear or puncture, but can be repaired during service conditions. They are easily cleaned and reusable. Deployment does not require any equipment, and is quick and easy.

Figure 4.4 shows a typical flood barrier – free-standing.

Advantages:

• Quick and easy to install.
- No equipment or machinery required for installation.
- Small storage space required.
- Easily transportable in cars and small pick-up trucks.
- Low bearing pressure on bedding surface.
- Low mobilisation, demobilisation and clean-up requirements.
- Easily cleaned and reusable.

Disadvantages:

- Susceptible to leakage at low water levels.
- Skirt may twist or flap under heavy winds and current.
- Susceptible to vandalism and accidental tear or puncture.

Figure 4.4 Flood barrier – free-standing

4.3.5 Flood barrier – with frame

These consist of metal frames with non-rigid impermeable membranes spanning between them. Some products have other semi-rigid materials that also span between the metal frames and which are covered by an impermeable membrane. The impermeable membrane normally extends upstream to form a long skirt for increased stability and sealing.

The frames have a tendency to exert high bearing pressures on the bedding surface and thus may not be suitable for areas with direct application onto soft soils.

Figure 4.5 shows a typical flood barrier – with frame.

Advantages:

- Adapt well to various terrain conditions (except hard surfaces).
- Some systems can be increased in height during service.
- Easily cleaned and reusable.
- Minor repairs to membrane can be made under service conditions.

**Disadvantages:**

- Membrane is susceptible to heavy winds (especially before flood peak).
- High bearing pressure on soil.
- Susceptible to leakage at low water levels.
- Heavy transportation and storage requirement.
- Susceptible to vandalism, accidental tear and puncture damage.

**Figure 4.5 Flood barrier – with frame**

Sand bags or similar weighting for fabric wind resistance.

**4.3.6 Panel barrier**

These are pre-fabricated concrete, steel or other rigid panel elements connected together to form a continuous barrier. They are gravity structures, depending on their weight for stability.

They are very resistant to impact and vandalism, but require heavy lifting equipment, transportation and a large storage area. They transmit high bearing pressures onto the bedding surface and may not be suitable for direct erection on soft soils. Seepage under the barriers is often significant due to their rigidity. They are generally not suitable for alignments that need to contain corners.

Figure 4.6 shows a typical panel barrier.

**Advantages:**

- Some systems can be increased in height during service by stacking.
- High resistance to impact and vandalism.
- Durable and reusable.
Disadvantages:

- Requirement for heavy lorries and lifting equipment.
- Likelihood of high seepage under barrier.
- Failure cannot be easily rectified during a flood event.
- Systems cannot easily accommodate corners.
- High bearing pressures on bedding surface.

Figure 4.6 Panel barrier

Typically steel or precast reinforced concrete

Stability and sealing relies on the weight and bedding surface

4.4 Demountable flood protection systems

Three categories of demountable flood protection systems have been identified. These are:

- flood barriers – flexible
- flood barriers – rigid
- panel barriers.

A brief description of each type of barrier is given below, together with a summary of their advantages and disadvantages. All these barriers rely on the design of their permanent foundation to ensure adequate bearing capacity and to prevent excessive seepage or piping through the subsoil.

4.4.1 Flood barriers – flexible

These barriers are made of heavy duty flexible impermeable materials. The barrier is normally removable, with the sockets or grooves being the only permanent parts. They are similar to the ‘temporary flood barrier – free-standing’ type described in Section 4.3.4, except for their shorter skirts (their stability relies on connection to their foundation).
The materials used for the barriers are susceptible to tear or puncture, but can be repaired during service conditions. They are easily cleaned and reusable. Deployment is quick and easy. Currently available systems come in set heights, which cannot be increased in service conditions.

Figures 4.7a and 4.7b show a typical flood barrier – flexible under normal and flood conditions.

**Advantages:**

- Quick and easy to install (no equipment or machinery required).
- Small storage space required.
- Easily transportable in cars and small pick-up trucks.
- Low mobilisation and demobilisation requirements.
- Easily cleaned and reusable.

**Disadvantages:**

- Susceptible to vandalism and accidental tear or puncture.
- Currently available systems come in fixed heights.

*Figure 4.7a Flood barrier – flexible under normal conditions*
4.4.2 Flood barriers – rigid

These barriers are made of rigid materials such as steel or fibreglass. The barriers are normally fully pre-installed and only require operation during an emergency. Operation can be either manual or automatic. They are normally hidden away in an underground compartment or attached to an adjacent structure or permanent protection. Most flood gates fit this class of protection system.

Manual operation normally involves opening the protective cover and pulling the barrier up into place, or just closing the barrier. This process can be semi-automated. Automatic operation can be controlled by sensors and actuators, or by direct hydraulic link to the watercourse.

This group of barriers is subject to significant ongoing development as their acceptance will depend on confidence in their reliability to operate without a significant risk of failure. Most existing proprietary systems of this type are manual or semi-automated.

Figures 4.8a and 4.8b show a typical flood barrier – rigid under normal and flood conditions.

Advantages:

- No installation or construction required during event.
- Easy and quick operation.
- No off-site storage or transportation is required.
- Stable and high resistance to impact.

Disadvantages:

- Defence height cannot be increased during service.
Possibility of failure of mechanical part or electricity supply.
- Cover or structure can get jammed with debris.
- Risk of conflict of dual use with automatic operation.

Figure 4.8a Flood barrier – rigid under normal conditions

Figure 4.8b Flood barrier – rigid under flood conditions

4.4.3 Panel barriers

These are rigid panels placed horizontally between stanchions supported by permanent foundations. The panels and stanchion guides are usually lined with seals to ensure water tightness.
This is the only feasible system for temporarily increasing the flood protection of a narrow wall. However, the foundation of such a wall needs to be able to withstand the new imposed loading.

Sealing between the panels and onto the stanchions is normally of high quality, with on-sealing pressures maximised within most product designs.

Depending on the time available for installation, these systems can normally be erected with only a few people. For barrier heights over 1.2 m, lifting equipment is required for safe installation.

Figures 4.9a and 4.9b show a typical demountable panel barrier under normal and flood conditions.

**Advantages:**

- Generally robust and well engineered.
- Good resistance to loading and impact.
- Very durable.
- Can be increased in height by adding panels up to the height of the frame.
- Very low seepage through and under the structure.

**Disadvantages:**

- Large storage area required.
- Heavy transportation and lifting requirements.
- Long installation and mobilisation period.
- Permanent parts susceptible to damage and vandalism.

**Figure 4.9a Demountable panel barrier under normal conditions**
Figure 4.9b Demountable panel barrier under flood conditions

- Demountable barrier
- Truss
- Foundation
- Fixed sections of structure
5. **Selecting an Appropriate System**

5.1 **Approach**

This section provides guidance on how to select the most appropriate system(s) for a particular flood protection scenario. This selection process (Figure 5.1), which is a follow-up to the initial decision process outlined in Figure 3.1, assumes that the use of temporary and demountable defences is the chosen option.

A risk-based approach to the selection of an appropriate system is used, which systematically removes systems that cannot be safely deployed within the available time by the available resources. Once closure is achieved, the ability to protect the area at risk effectively is then considered by ensuring the appropriate protection levels and integrity of the protection system. Other relevant economic, environmental and/or whole life management issues are then brought to bear in making the final decision.

Due to an increasing number of available systems and a large range of potential situations where protection systems are required, the selection process involves the elimination of unsuitable systems. This elimination process is simplified by a gradual progression from principal types of defences to generic types, and then onto specific systems.

Through each stage, there is a constant review of the ability of the available systems or groups of systems to provide the required protection effectively at the required location, with the required resources and within the time available. All these requirements need to be satisfied for a system(s) to be suitable.

The selection process illustrated in Figure 5.1 has four distinct stages. The first stage is as described in Section 3.6 and is added for completeness only. The remaining three stages are described in Sections 5.2 to 5.4, respectively.
Figure 5.1 Selection process chart

**Stage 1 Decision on use**

- Consider feasibility of permanent protection system
- Consider legal and local acceptability issues
- Consider reliability of flood forecasting and warning system

**Stage 2 Selection of principal options**

- Determine catchment hydraulic characteristics
- Determine available lead-in time for mobilisation and closure of barrier

**Stage 3 Selection of appropriate generic groups**

- Consider functional requirements
- Consider operational requirements
- Consider structural requirements
- Map all requirements to generic product characteristics and level of organisational resources

**Stage 4 Selection of appropriate system (s)**

- Review available systems within selected generic groups
- Consider cost, durability, environmental impact, appearance, versatility and performance data

Selected system (s)
5.2 Selection of principal options

Stage 2 of the selection process involves a review of the hydraulic characteristics of the catchment such as the shape, magnitude and timing of level hydrographs. This information can be obtained from:

- hydrological studies;
- calibrated hydraulic model runs;
- historical catchment knowledge and records.

The reliability of this information is important because the results of subsequent processes depend on its accuracy. After reviewing the catchment hydraulics for a range of flooding probabilities, the next step involves determining the lead-in time between the flood warning trigger or action level and the lowest safe permanent level. These levels are as described in Section 3.4 and Figure 3.4.

The lead-in time is made up of mobilisation and closure – two separate processes that lead onto each other. The mobilisation period includes the call-out and transportation of all required personnel, plant and materials to the site. Its duration depends on the call-out system and the remoteness of site from resources (including storage of the temporary barrier or demountable section and any required materials). Transportation and access can also affect the mobilisation period.

Closure is the process of sealing the gap in the flood protection or erecting the temporary system. This can involve:

- site preparation;
- erection of a temporary barrier or demountable section;
- manual closure of a pre-installed barrier;
- automatic closure based on the receipt of electronic signals;
- direct closure though hydraulic connection of a moveable barrier to the watercourse.

The closure period depends on the type of protection system, the length of the moveable sections or barrier, and the resources available for its closure.

The time available for mobilisation and closure can be determined from the hydrograph (see for example, Figure 3.4). This is governed by:

- the steepness of the hydrograph;
- the character of the trigger mechanism or action procedure in relation to the location of the defence;
- the difference in level between the flood warning trigger or action level and the lowest safe permanent level.

A decision on the principal type of temporary or demountable flood protection can be made from the available lead-in time using the chart given in Figure 5.2.
Where automatic operation is chosen, it is necessary to manage potential conflicts from dual use in order to avoid failures or accidents.

The lower the option in the chart (Figure 5.2), the more organisational resources and management are required. The ability of the organisation or community concerned to manage the required emergency operational activities should therefore be considered at a high level. The organisational capability will depend on available personnel and plant in an emergency. Another key to capability are the organisational systems, including:

- available emergency systems;
- call-out and standby systems;
- extent of training and emergency drills;
- availability of good supervision.

If the organisational capabilities are considered inadequate, either a higher option can be selected from the chart (Figure 5.2) or non-permanent parts of the protection system reduced. This can be done either horizontally by increasing the length of the permanent part or vertically by increasing the lowest permanent level. This process should be continued until an option that can be effectively managed by the organisation is selected.

This stage should eliminate systems that cannot be safely and effectively closed within the available lead-in time.
5.3 Selection of appropriate generic groups

The generic categorisation is described in Section 4, which includes a discussion of some of the issues outlined above in Section 4.2. Stage 3 of the selection process aims to eliminate all inappropriate generic types by the mapping functional attributes, structural attributes and operational requirements of the generic groups of systems to the protection requirements and organisational resources.

Functional considerations generally relate to dimensions, location and water tightness. They include:

- required protection height versus available height range;
- ability to increase the height of protection during service conditions;
- available width versus required width for protection system (including space for installation or closure operations);
- available ground and terrain conditions versus suitable terrain conditions for temporary barrier;
- suitability of the protection system for the required horizontal and vertical alignment;
- subsoil (in particular seepage characteristics).

Structural considerations involve estimating the design loading on the system and assessing the system’s ability to resist this loading and to maintain structural stability. The characteristics to be considered include:

- resistance to failure by sliding, overturning, foundation bearing capacity failure, excessive seepage and piping;
- the ability to repair damage during service;
- the likelihood of progression of damage to whole defence failure.

Operational considerations involve mapping the time and organisational resources available to that required for the erection or closure of the moveable part of the protection system. This ensures that an organisation does not choose a system that it may not be able to install completely within the lead-in time available. Operational considerations include:

- available period for mobilisation and closure versus period required for operation of the protection system with the resources available;
- required resources (labour, plant, materials) for different system types;
- required storage, transportation and lifting facilities;
- requirement for site preparation and clean-up;
- ease of installation.

Once these issues have been considered, a reduced list of appropriate generic groups should be available from which specific systems can be selected.

To assist readers with the selection process, tables showing the characteristics of the generic groups of temporary and demountable protection systems are provided (Tables 5.1 to 5.6).
This stage should eliminate all generic groups of systems that are not suitable for the expected loading, available resources and site conditions.

5.4 Selection of appropriate system(s)

Stage 4 involves considering specific individual characteristics of products found in the generic system(s) selected by stage 3.

Even within the generic groups, there is a wide range of characteristics. Therefore, the information in Tables 5.1 to 5.6 show ranges of applicability in some cases instead of specific characteristics.

Actual dimensions and other information should be reviewed at this stage by considering the individual characteristics of available products in the chosen generic groups. Information on currently available proprietary systems within each category and contact details for their suppliers are given in Appendix A. This is not an exhaustive list as new products and changes to existing ones are continuously being made. Updated information on these systems is available on the Agency’s Floodline website (http://www.environment-agency.gov.uk/flood).

Other characteristics that are individual to products but critical to their suitability for particular sites (for example, their adaptability to the end conditions available at the site, alignment and terrain characteristics) should also be considered.

This stage of the review will further reduce the systems to those which:

- are technically, economically, environmentally and legally suitable;
- can be erected or closed within the available time by the available resources;
- once closed perform the required function effectively without failure.

The final decision follows consideration of other issues that affect the whole life cost and potential impact of use. These include:

- cost (including initial capital, maintenance, storage and deployment costs);
- durability, reusability and life expectancy;
- environmental characteristics such as appearance and potential for pollution;
- versatility of use – especially for multi-operational organisations;
- performance information from test results and use in flood conditions;
- ease of use of system;
- availability of installation guide, training and after sales support service.
<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum head of water above permanent protection level</th>
<th>Yes/No</th>
<th>Range</th>
<th>Wall extensions</th>
<th>Soil</th>
<th>Concrete/tarmac</th>
<th>Sloping surface</th>
<th>2.5 m wide bank</th>
<th>4.0 m wide bank</th>
<th>Product adaptability to bends/corners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filled container – impermeable</td>
<td>1.5 m</td>
<td>Yes</td>
<td>0.375 – 1.5 m</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes (some systems)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Filled container – permeable</td>
<td>2.0 m</td>
<td>Yes</td>
<td>0.3 – 2.0 m</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (some systems)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Air and water filled tube</td>
<td>1.75 m</td>
<td>Yes (some systems)</td>
<td>0.3 – 3.0 m</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes (some systems &lt;0.75 m in height)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flood barrier – free-standing</td>
<td>2.0 m</td>
<td>No</td>
<td>0.38 – 2.0 m</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Flood barrier – with frame</td>
<td>2.5 m</td>
<td>Yes (some systems)</td>
<td>1.8 – 2.5 m</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Panel barrier</td>
<td>1.5 m</td>
<td>Yes</td>
<td>0.5 – 1.5 m</td>
<td>No</td>
<td>Yes (not very soft soils)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (some systems)</td>
</tr>
</tbody>
</table>

Table 5.1 Functional characteristics of temporary flood protection systems
Table 5.2 Operational characteristics of temporary flood protection systems

<table>
<thead>
<tr>
<th>Type</th>
<th>Time required for installation of 100 m long and 1 m high barrier</th>
<th>Minimum resources required for installation</th>
<th>Storage and transportation requirements</th>
<th>Requirement for site preparation</th>
<th>Level of skill required for installation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Labour</td>
<td>Plant</td>
<td>Materials</td>
<td>Storage area needed</td>
</tr>
<tr>
<td>Filled container – impermeable</td>
<td>2 – 6 hours¹</td>
<td>2 – 6 people</td>
<td>Pump or aggregate filler</td>
<td>Aggregate or water</td>
<td>Small to large (depending on system)</td>
</tr>
<tr>
<td>Filled container – permeable</td>
<td>2 – 6 hours¹</td>
<td>2 – 6 people</td>
<td>Aggregate filler</td>
<td>Aggregate</td>
<td>Small</td>
</tr>
<tr>
<td>Air and water filled tube</td>
<td>2 – 3 hours¹</td>
<td>2 – 5 people</td>
<td>Pump</td>
<td>Water</td>
<td>Small</td>
</tr>
<tr>
<td>Flood barrier – free-standing</td>
<td>2 – 3 hours¹</td>
<td>2 people</td>
<td>None</td>
<td>None</td>
<td>Small</td>
</tr>
<tr>
<td>Flood barrier – with frame</td>
<td>&gt;6 hours¹</td>
<td>2 – 3 people</td>
<td>None</td>
<td>None</td>
<td>Medium to large</td>
</tr>
<tr>
<td>Panel barrier</td>
<td>&gt;6 hours¹</td>
<td>3 – 6 people</td>
<td>Heavy lifting equipment</td>
<td>None</td>
<td>Large</td>
</tr>
</tbody>
</table>

¹  Time allowed does not include site preparation and will vary depending on available resources and site conditions.
²  4WD = four-wheeled drive vehicle
<table>
<thead>
<tr>
<th>Type</th>
<th>Sliding</th>
<th>Excessive seepage</th>
<th>Bearing capacity failure</th>
<th>Overturning and collapse</th>
<th>Seepage at high head of water</th>
<th>Seepage at low head of water</th>
<th>Barrier resistance to damage</th>
<th>Damage repair during service</th>
<th>Likelihood of progressive system failure</th>
<th>Resistance to wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filled container – impermeable</td>
<td>Yes</td>
<td>Yes (under barrier)</td>
<td>No</td>
<td>Yes</td>
<td>Low – Med</td>
<td>Low – High</td>
<td>Low</td>
<td>Low – Med</td>
<td>Yes</td>
<td>Med – High</td>
</tr>
<tr>
<td>Filled container – permeable</td>
<td>Yes</td>
<td>Yes (through barrier)</td>
<td>No</td>
<td>Yes</td>
<td>Low – Med</td>
<td>Med – High</td>
<td>Low</td>
<td>Med – High</td>
<td>No</td>
<td>Med</td>
</tr>
<tr>
<td>Air and water filled tube</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low – Med</td>
<td>Yes</td>
<td>Med (Low for air filled)</td>
</tr>
<tr>
<td>Flood barrier – free-standing</td>
<td>Yes</td>
<td>Yes (under barrier)</td>
<td>No</td>
<td>Yes</td>
<td>Low</td>
<td>Low – Med</td>
<td>Med – High</td>
<td>Low – Med</td>
<td>Yes</td>
<td>Med – High</td>
</tr>
<tr>
<td>Flood barrier – with frame</td>
<td>Yes</td>
<td>Yes (under barrier)</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
<td>Low – Med</td>
<td>Low – Med</td>
<td>Low – Med</td>
<td>Yes</td>
<td>Low – Med</td>
</tr>
<tr>
<td>Panel barrier</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Med – High</td>
<td>Low – Med</td>
<td>High</td>
<td>High</td>
<td>No</td>
<td>Low</td>
</tr>
</tbody>
</table>

1. Seepage assessment relates to a typical subsoil such as silty clay. The actual seepage will be affected by the subsoil and bedding condition.
Table 5.4 Functional characteristics of demountable flood protection systems

<table>
<thead>
<tr>
<th>Type</th>
<th>Protection capability</th>
<th>Increase protection height during service?</th>
<th>Product height</th>
<th>Adaptable to terrain and bedding conditions</th>
<th>Product adaptable to bends/corners</th>
<th>End fixing provision for connection to bank/walls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum head of water above permanent protection level</td>
<td>Yes/No</td>
<td>Range</td>
<td>Wall extensions</td>
<td>Soil</td>
<td>Concrete/tarmac</td>
</tr>
<tr>
<td>Panel barriers</td>
<td>5.0 m</td>
<td>Yes</td>
<td>0.15 – 5.0 m</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Flood barrier – flexible</td>
<td>1.0 m</td>
<td>No</td>
<td>1.0 m</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flood barrier – rigid</td>
<td>2.5 m</td>
<td>No</td>
<td>Variable to 3.0 m</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
**Table 5.5 Operational characteristics of demountable flood protection systems**

<table>
<thead>
<tr>
<th>Type</th>
<th>Time required to deploy 100 m long and 1 m high barrier</th>
<th>Minimum resources required for installation</th>
<th>Storage and transportation requirements</th>
<th>Requirement for site preparation</th>
<th>Fixings susceptible to damage (silt, rubbish and vandalism)</th>
<th>Level of skill required for deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel barriers</td>
<td>2 – 5 hours(^1)</td>
<td>2 – 3 people</td>
<td>Yes (lifting equipment)</td>
<td>None</td>
<td>Large, No, Yes</td>
<td>Low/Med/High</td>
</tr>
<tr>
<td>Flood barrier – flexible</td>
<td>2 – 3 hours(^1)</td>
<td>2 people</td>
<td>None</td>
<td>Small</td>
<td>Yes, No</td>
<td>Med</td>
</tr>
<tr>
<td>Flood barrier – rigid</td>
<td>2 – 4 hours manual(^1); a few minutes automatic</td>
<td>2 or more manual, none automatic</td>
<td>None</td>
<td>None (fully pre-installed)</td>
<td>No, No, Yes</td>
<td>Low – Med</td>
</tr>
</tbody>
</table>

---

\(^1\) Time allowed does not include site preparation and will vary depending on available resources and site conditions.

\(^2\) 4WD = four-wheeled drive vehicle
### Table 5.6 Structural characteristics of demountable flood protection systems

<table>
<thead>
<tr>
<th>Type</th>
<th>Likely failure methods (extreme conditions)</th>
<th>Bearing pressure on bedding structure</th>
<th>Seepage at high head of water¹</th>
<th>Seepage at low head of water¹</th>
<th>Barrier resistance to damage</th>
<th>Damage repair during service</th>
<th>Likelihood of progressive system failure</th>
<th>Resistance to wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sliding or rolling</td>
<td>No</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
<tr>
<td>Excessive seepage</td>
<td>No</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
<tr>
<td>Bearing capacity</td>
<td>No</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
<tr>
<td>failure</td>
<td>No</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
<tr>
<td>Overturning</td>
<td>Yes³</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
<tr>
<td>and collapse</td>
<td>No</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
<tr>
<td>Mechanical failure</td>
<td>No</td>
<td>Low/High</td>
<td>Low</td>
<td>Low</td>
<td>Low/High</td>
<td>No</td>
<td>Low/High</td>
<td>Low/High</td>
</tr>
</tbody>
</table>

¹ Seepage assessment relates to a typical subsoil such as silty clay. The actual seepage will be affected by the subsoil and bedding condition.
² Good foundation design should prevent this.
6. Guidance on Use

To ensure safe use of temporary and demountable flood protection systems, effective management of the three main potential modes of failure (overtopping, structural and operational) is required. These modes of failure are discussed in Section 3.1. This section concentrates on organisational and operational aspects, which require continuous management once the system has been bought and any permanent parts installed. The information given in this section aims to provide basic guidance to maximise reliability. However, it can be extended as necessary to suit specific needs.

6.1 Organisation

Responsibility for the design, installation, operation and maintenance of the system should be clear. The organisation or community responsible for the operation and maintenance of the system must be able to implement adequate procedures and provide sufficient resources to ensure the safe mobilisation and operation of the protection system. Some key organisational requirements are outlined below.

6.1.1 Availability of appropriate resources

The knowledge and experience of the available personnel are crucial to the reliability of the protection system. The level of skill required depends on the type of system and its operational requirements.

In addition to the people carrying out operational processes, appropriately skilled personnel should be available to provide adequate supervision. Highly skilled supervisors are better able to develop safe creative solutions when things do not happen as planned. Someone should be available (preferably the supervisor) who can make emergency financial decisions without having to refer to others.

The right type of equipment and material for every stage of the mobilisation and operational phases must be available. The use of the wrong type of tool or equipment should be avoided as this can lead to unsafe installations or injury to personnel.

6.1.2 Training

Appropriate Skills need to be refreshed as necessary with adequate training. Two forms of training are required:

- training in the basic skills required for the operations;
- regular emergency exercises (drills).

These forms of training will help to:

- increase familiarisation and thus improve the reliability of those concerned;
- verify the adequacy and condition of the flood barriers and emergency procedures.

Emergency drills should ideally be carried out at least once a year before the flood season.
6.1.3 Flood protocol

The reliability of a flood barrier increases when the mobilisation and closure operation procedures are laid down in a flood protocol. This ensures everyone is aware of what individual actions need to be carried out, by whom and when. More importantly, it ensures that the anticipated time for mobilisation and closure activities can be achieved.

The procedures for all operational processes from the receipt of the flood warning to post-event clean-up should be outlined clearly in the flood protocol. This should state:

- the trigger levels or codes;
- their interpretation and communication;
- the actions required by all team members during the mobilisation installation/closure, period of closed protection, demobilisation and clean-up phases.

The protocol should be reviewed regularly following significant changes to key personnel, catchment or flood protection structure, or any operation that may affect the emergency procedures.

For greater reliability, the protocol should provide for back-up and troubleshooting at all stages of the operation. Every process should also have a confirmation loop to ensure early detection of errors or mistakes. It should also be recognised that a defence is only as good as its weakest point.

Typical elements in a flood protocol are:

- contact list of all personnel, back-up personnel and relevant third parties;
- call-out procedure;
- trigger water levels and required action;
- plant and material location (including back-ups);
- mobilisation protocol;
- closure operation protocol;
- clean-up procedure.

Mobilisation and closure operation protocols are discussed in more detail in Sections 6.3.4 and 6.4.5, respectively.

6.2 Storage and maintenance

6.2.1 Storage

For those systems that require installation as part of the emergency operations, the temporary or demountable parts require adequate storage when not in use. The following guidance relates to the storage of moveable components.

- If possible, the storage area should be next to the required deployment area. In all cases, it needs to be as near as practicable to the area or group of locations for which it is intended. The storage area should be accessible at all times.
• The type of storage provided should offer adequate protection from the environment for the type of system concerned.

• Sections should be laid and stacked in accordance with the manufacturer’s instructions and should not be allowed to retain standing water. They should be laid in such a way as to facilitate adequate access for inspection and maintenance, and easy removal in an emergency.

• Storage facilities should be well lit to allow for fast and safe deployment.

• If possible, dedicated storage should be provided for the temporary or demountable parts of the system to avoid both damage through other activities and loss of components.

6.2.2 Maintenance

Adequate maintenance of all moveable and permanent parts is essential to ensure the reliability of the flood protection system in service. These parts should be cleaned thoroughly and inspected after each use. All tears or damages should be repaired or parts replaced before the parts are stored for future use. All moving parts should be greased as necessary. Regular inspection and maintenance should also be carried out at intervals defined by the manufacturer. A quick visual inspection should be carried out before use, with adequate provision made for spares.

Regular testing should be carried out as recommended by the manufacturer. Initial performance assessment and testing are discussed in Section 7.

If possible, a logbook containing the maintenance and inspection records should be kept with the defences. This will provide information on the state of the defences. Attention should be drawn to elements that have been removed for repairs or that are awaiting repairs to ensure they are not used in an emergency.

6.3 Mobilisation

The mobilisation phase begins with the receipt of the flood warning and continues until all personnel, material and plant required for to commence installation or closure of the defence are on site.

6.3.1 Call-out

Call-out procedures should be well documented and practised. A reliable call-out system depends on dedicated, 24-hour availability of all personnel. To ensure this, a stand-by rota is required. All personnel on standby should be contactable and available at all times. Back-up lists should be available for unavoidable absences.

The call-out system should be managed from a central point to:

• ensure a single point of information management;
• identify and resolve mobilisation problems.

This management point can be passed to a dedicated site person or supervisor for the latter stages of the mobilisation. The key to a successful call-out exercise is good communication and feedback.
6.3.2 **Access**

Successful mobilisation requires accurate information about access. Reliable access during a flood scenario for all personnel and plant should be planned, available in the protocol and known by all members of the emergency team. Back-up information for key points of access should also be available in case of emergency blockages.

Reliability of access is critical where considerable transportation of defence elements and materials is required. The capacity of the access points should be checked beforehand for all vehicles (loaded weights) required to install the flood protection system.

Shared use of space can occur where the alignment of the temporary or demountable protection system is also used for other purposes such as parking, access, mooring or as part of a domestic or industrial building. Regular inspection of these sites is required to ensure their availability during flood events. In addition, 24-hour contact information should be available for all other interested parties.

Responsibilities for obtaining access to all closed areas requiring keys or opening mechanisms should be clear. Such keys should always be held by more than one person to ensure back-up. There should be a check system for keys; lack of keys is a common delaying factor during mobilisation.

6.3.3 **Equipment and materials**

All equipment and materials required for the erection or closure of the system should be identified and recorded in the flood protocol. It is essential that the right tools and equipment are available along with trained people to use them in an emergency.

The location of materials should be recorded and checked regularly to ensure their continued availability. Contact details for obtaining material or equipment should be set out in the flood protocol.

Back-up equipment and materials should always be available, as they are not normally dedicated for the sole use of the flood protection system.

6.3.4 **Mobilisation protocol**

The mobilisation protocol is that part of the flood protocol that deals specifically with mobilisation issues and verification of the state of readiness of the organisation. The protocol should outline:

- all the processes involved in the mobilisation;
- the responsibilities of all personnel;
- check procedures.

It is vital that continuous water level monitoring takes place during mobilisation to ensure that real-time information is available and to assist with decision-making. The mobilisation protocol should be clear on the link between mobilisation and closure operation. Based on the ongoing monitoring and the progress of mobilisation, decisions will need to be made before the closure period begins. The ability to make the decision to abort or commence closure will depend on the quality of the real-time forecasting information available. There should be clear responsibility for making such decisions and for their communication as appropriate. There
should also be clear responsibility for checking the list of required resources to ensure their availability on site.

6.4 **Closure operation**

The closure operation phase commences once the mobilisation phase is complete and a decision has been made to begin the erection or closure of the flood protection system.

6.4.1 **Site preparation**

In all situations, it is important to ensure that the area where the flood barrier is to be erected is clear. This is particularly important where the sealing of the barrier depends on its interface with the soil. Large holes or protrusions can reduce water tightness.

Drainage pipes or systems that cut across the subsoil into the protected area should be blocked temporarily, as this is a common seepage route. Sharp objects should be removed from the bedding surface of flexible barriers to reduce the risk of a tear or puncture.

Where sites share spatial uses, the need to tow or lift large objects away from the deployment area may arise. Access to suitable moving equipment should therefore be available.

All fittings, covers to underground housings, sockets and defence sections should be checked and made ready for use. A check should be made along the length of the protection to ensure there are no blockages, debris or access issues.

Site preparation sometimes occurs or begins during the mobilisation phase once some personnel are on site (especially for small sites). What is important is that it is carried out before the system is erected or the barrier is closed.

6.4.2 **Supervision and quality control**

A system of quality control is required within the closure operation protocol to ensure that adequate checks and supervision are carried out at all stages of the operational phase. Every part of the protection system should be checked by a competent person for correct fixing and adequate time allowed for dealing with errors or omissions.

Supervision should involve a review of the remaining time before the lowest safe permanent level (as defined in Section 3.4.1) is reached to ensure that the removable barrier or sections are installed, or the system is fully closed and checked in time. Any overrun in the preceding stages should be managed by using more resources (if practical) to achieve timely closure. A temporary or demountable protection system is not functional unless it is closed before the water level reaches the lowest safe permanent level.

6.4.3 **Health and safety**

The safe method of carrying out all operational processes should be recorded clearly and all personnel given appropriate training.

Flood emergencies often occur in the middle of the night in dark, wet, cold and slippery conditions. The use of personnel who are already tired after a normal day’s work for long lengths of emergency operations increases the risk of accidents. To avoid this, the emergency procedures should provide for proper staff management and shift work for the installation of systems requiring over six hours of erection.
Adequate safety work gear should also be available to reduce the risk of accidents.

6.4.4 *Defence surveillance*

Once erected, the protection system must be kept under continuous surveillance until flood levels have receded below the opening level (Figure 3.4). This is particularly important for flexible protection systems, which are more susceptible to damage by vandalism or accidental impact. Responsibility for this surveillance and the actions to be taken if damage occurs should be made clear and written into the flood protocol.

Damage to flexible systems can normally be repaired by covering the damaged area with repair material. Rigid materials usually require other sections or containers to be placed behind the damaged section to reinforce the structure.

Whatever material the protection system is made of, the recommended damage repair method should always be recorded in the flood protocol, and adequate repair materials and equipment made available on site.

6.4.5 *Operations protocol*

All aspects of the operational processes should be laid down within the closure operation protocol. This is part of the flood protocol and should include all requirements for:

- site preparation
- erection
- closure
- surveillance
- damage repair
- supervision.

Each process should be detailed clearly and responsibilities stated. The protocol should make clear:

- how the closure operation phase is begun or triggered;
- the checking procedure following closure or erection;
- surveillance and monitoring activities;
- the actions that lead towards beginning the removal of the temporary barrier or demountable sections at the end of the flood event.

6.5 *Demobilisation and performance evaluation*

6.5.1 *Demobilisation*

The demobilisation phase begins once the water level has receded below the opening level and the flood event is confirmed as over. The procedure for demobilisation, clean-up and storage of demountable or temporary sections of the protection system should be outlined in the flood protocol.
To avoid damage, the system should be dismantled, lifted and transported according to laid down procedures and manufacturers’ guidelines.

Once all removable parts have been dismantled or the barrier opened, they should be properly cleaned, checked for damage and counted. Any recommended post-event oiling or coating should also be carried out.

All permanent and moveable parts should be inspected and all damage recorded. Damaged parts should then be separated and repaired or replaced as soon as possible after the event. Lifting, transportation and storage should be carried out in accordance with laid down procedures.

Some systems use materials such as aggregates or water as part of the protection system. These should be removed from the systems completely before cleaning. Disposal of aggregates should be carried out in accordance with current guidelines and legal requirements. Aggregates that have been in contact with floodwater may be contaminated. They should be examined and disposed by a method appropriate to their post-event condition.

Once all temporary or demountable parts have been removed from the line of protection, the area should be cleaned up and returned to its pre-event state. This may involve:

- removal of debris;
- levelling of the ground surface;
- opening of access points;
- securing all permanent parts of the system to discourage public access or tampering.

### 6.5.2 Performance evaluation

As soon as practical after demobilisation, all relevant information about the loading on the barrier and its response should be collated. Such information may include:

- the predicted and actual flood level hydrograph;
- timing of the flood warning trigger or action level;
- seepage and damage records;
- the performance of the protection system under loading;
- the effectiveness of the call-out system;
- the time taken for all phases of mobilisation and operation;
- the ease of erection, closure or damage repair;
- resource deployment;
- the adequacy of storage, access and communications;
- demobilisation issues.

These and other relevant issues should be reviewed with the emergency team in a debriefing session. The aim of this session is to compare the predicted performance of the protection system and all operational procedures with the actual performance, and to identify improvements or, at the minimum, validate the performance of the existing protection system and flood protocol.
As temporary or demountable systems are seldom erected or closed, it is important to carry out emergency drills. During such exercises, the information highlighted above should be reviewed and the flood protocol amended as necessary.
7. **Performance Assessment and Testing**

Like all engineering systems, temporary and demountable flood protection systems should be designed properly and constructed in accordance with a well-defined specification.

During development, techniques such as desk-based assessments, laboratory tests and field testing can be used to assess how the system will perform and to identify ranges of application (for site-specific or more general applications).

In a separate move, the industry is seeking to develop a standard specification for accreditation testing of temporary protection systems to help users recognise products that have achieved a minimum standard. It is not intended that testing will address all design issues (such as establishing safety factors for that product), but will serve to benchmark individual products.

The flow chart shown in Figure 7.1 represents how temporary and demountable flood protection systems may be developed. The rationale and processes for product development and product accreditation are described in Sections 7.1 and 7.2, respectively.

*Figure 7.1 Product development chart*

* It may be possible for a system designer to achieve accreditation without undertaking design development using desk studies, laboratory testing and field testing. However, for temporary and demountable protection products, it is unlikely that system designers will be able to demonstrate the product’s performance without undertaking this work.
7.1 Product development

7.1.1 Objectives for design development

The primary objective of performance assessment and testing for a temporary or demountable flood protection system is to determine whether the system can perform its stated function in its stated deployment environment for a specified length of time.

Testing helps to confirm or define the characteristics and limitations of a system, making it possible to map protection types to different flood risk scenarios.

To establish confidence in the test results, testing needs to be performed or supervised by competent independent specialists.

The two main issues that need to be addressed during performance tests are:

- protection system stability and seepage characteristics;
- construction issues.

Performance testing of stability and functionality characteristics is carried out to determine the water retention characteristics of the system and its safety factor against structural stability failure under service conditions. Testing requirements may include some or all of the following:

- rate of seepage (through and under the barrier, including joints);
- safety factors against overturning, sliding, rolling and bearing capacity failure under design loading of hydrostatic water pressure (plus appropriate allowance for waves, currents and floating objects);
- resistance to damage by impact, tear or puncture, and vandalism;
- progressive deterioration of the system or damage to it;
- ability to repair or strengthen the system during service conditions;
- behaviour of the system under loading in excess of its design (particularly on overtopping) and identification of the likely failure mode.

Performance testing of construction characteristics is carried out to confirm the operational and local site conditions required for deployment. Testing requirements may include some or all of the following:

- assessment of manpower, plant, materials and time required for the installation and removal of a set length and height of system (for example, 100 m long and 1 m high);
- assessment of the additional requirements for higher systems up to the maximum height;
- assessment of the suitability for various bedding and terrain conditions such as flat, sloping and undulating terrain, rock, soil, hard, smooth and rugged surfaces;
- the ease and versatility of construction along straight lines, bends, corners, joints and end connections;
- simplicity of construction;
- required storage and transportation;
required site preparation and operational space.

7.1.2 Approach to performance evaluation

Temporary and demountable flood defences are available in various forms, and are designed for a wide range of loading, location, terrain and foundation conditions. The approach used for their performance evaluation needs to be sufficiently flexible to recognise their proposed loading and exposure conditions.

The testing methodology should be based on a phased process, with the contents of each phase determined by:

- available information on the design;
- previous testing and use;
- the form of the defence;
- the stated conditions of use.

The performance testing process generally consists of three phases. The desk study review (phase 1) is vital for the developer to understand how the system actually works and to ensure it has adequate safety factors. Laboratory and field testing (phases 2 and 3) are necessary to prove that the system works in practice. The number of phases and the extent of testing depend on the type of defence and available information.

Testing requirements for defences within the same generic class are expected to be similar.

7.1.3 Performance testing phases

Phase 1: Desk study review (to understand and justify how the product works)
This phase involves an examination of the stability calculations for critical design loading and exposure conditions. The method of construction and data from previous tests, the product’s development and use are also reviewed.

The system is categorised using the generic categorisation described in Section 4.

The output from this phase is a review of the system and the specification for the next phase(s) of testing. This review indicates the types of tests to be carried out as well as appropriate ranges and combinations of hydrostatic, wave, current and wind loading.

Phase 2: Laboratory testing (to test and understand the product performance in a controlled environment)
Laboratory tests are carried out as identified in phase 1 to test the ability of the system to withstand the critical loading scenarios and foundation conditions for which its use is recommended. Where the terrain, soil or foundation conditions can not be modelled easily in the laboratory, then additional field testing may be required if these conditions are considered critical and if the laboratory experiments cannot be modified to establish behaviour under the required operating conditions.

Laboratory testing is expected to be more appropriate for predicting the response of defences to a range of combinations of hydrostatic, wave and current and wind conditions. This is because these can be simulated accurately in a controlled manner for a specified range of loading conditions.
While it may be appropriate to measure seepage through and under the barrier in still water conditions, the behaviour of the defences in terms of stability will require application of the critical loading.

If the conditions permit, information about construction issues such as the ease of construction, demobilisation, time and resources required can be tested in the laboratory. However, the practicalities of the construction process may limit this to field testing.

**Phase 3: Field testing (to check the complete system, including installation issues, in real situations)**

This type of testing is carried out at a site suitable for the demonstration and measurement of aspects of the performance of defence systems that cannot be measured reliably in phase 2. This phase is particularly relevant for testing the behaviour of defences in different terrain and foundation conditions, as well as construction issues.

The ability to carry out this phase depends on locating suitable sites.

### 7.2 Product accreditation

HR Wallingford is currently (May 2002) drawing up a performance assessment protocol for stability and functionality testing of temporary protection systems in a project led by the Department of Trade and Industry (DTI). Satisfactory assessment of performance is expected to secure certification of the protection system for use in designated conditions. This will help users select their preferred system and, in the longer term, will help to develop incentive and other financial support schemes.

The recently formed Flood Protection Association (FPA) – a trade association for manufacturers of flood protection systems within and away from protected properties – is represented on the DTI-led project. The FPA’s prime objective is to promote best practice within the industry.

The testing regime is still being assessed, but will include as many of the attributes identified in Section 7.1 as possible within the limits of practicality and cost-effectiveness. These limits may mean that the accreditation process will cover laboratory testing only. However, the testing process will record on the test certificate whether:

- the developer (or designer) has undertaken design calculations;
- an installation guide has been produced that contains information on standard subject areas (similar to the way in which COSHH statements for products address specified subject areas).

It is envisaged that a system will either pass or fail the tests. If a product fails, then it may be necessary to review the designated conditions and/or undertake further development work as described in Section 7.1.

To reduce cost, product accreditation may be undertaken by the developer at the end of the design development process.


References


Institution of Civil Engineers (ICE), 2001. Learning to live with rivers. ICE, London.


Technical Advisory Committee on Water Retaining Structures (TAW), 2000. From probability of exceedance to probability of inundation. TAW, Delft.
## Appendix A1: Summary table for proprietary temporary flood protection systems

<table>
<thead>
<tr>
<th>Filled container - impermeable</th>
<th>Name of product</th>
<th>Manufacturer/supplier</th>
<th>Contact information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dura-Bull Barricade*</td>
<td>Creative Building Products</td>
<td><a href="http://www.soacorp.com/cbp">www.soacorp.com/cbp</a> (+1) 260 459 0456 (+1) 260 459 0920 fax</td>
<td>Tough hollow plastic containers up to 1.35 m high and 0.8 m wide. Filled with water or aggregates. Can be stacked to form higher defences, which will occupy a wider area. Non-slip bottom surface, fabricated from recycled UV-protected polyethylene.</td>
</tr>
<tr>
<td></td>
<td>MRP Systems Modular Shielding*</td>
<td>MRP Systems Ltd</td>
<td><a href="mailto:Jsims@ukmrp.com">Jsims@ukmrp.com</a> <a href="http://www.ukmrp.com">www.ukmrp.com</a> 0161 427 8910</td>
<td>Hollow polyethylene boxes 1.0 m x 0.75 m x 0.5 m (minimum dimensions). Filled with water or aggregate depending on requirements. Can be stacked to form higher defences, which require lateral stabilisation by constructing T-shaped walls.</td>
</tr>
<tr>
<td></td>
<td>Quick Damm Flood Safety System*</td>
<td>Quick Damm GmbH</td>
<td><a href="mailto:info@quick-damm.de">info@quick-damm.de</a> <a href="http://www.quick-damm.de">www.quick-damm.de</a> (+49) 641 96870 (+49) 641 9687137 fax</td>
<td>Steel tube frame enclosed within a PVC-covered polyester textile and filled with water or aggregate. It has been used in numerous flood prevention situations. Variable heights from 0.5 m to 2.0 m. Easily transportable roll-down container available.</td>
</tr>
<tr>
<td>Filled container - permeable</td>
<td>Continuous Berm*</td>
<td>MBW (UK) Ltd.</td>
<td><a href="mailto:mbwuk@btinternet.com">mbwuk@btinternet.com</a> <a href="http://www.mbw.com">www.mbw.com</a> 01204 387784</td>
<td>Geosynthetic fabric encapsulated continuous berm of sand rock or soil produced by the continuous berm machine. Can be installed to a height of 0.3 m. Extensively used in the USA for construction site run-off water quality control.</td>
</tr>
<tr>
<td></td>
<td>Hesco Concertainer Bastion* (manufacturer)</td>
<td>Hesco Bastion Ltd</td>
<td><a href="http://www.Hesco-group.com">www.Hesco-group.com</a> <a href="mailto:Hescob@AOL.com">Hescob@AOL.com</a> 0113 2486633</td>
<td>Aggregate-filled geotextile concertained panels connected by joining pins. Fully collapsible. Bezinal-coated wire mesh panels joined by coil hinges lined with geotextile. Height of units from 0.6 m to 2.0 m. Stackable.</td>
</tr>
<tr>
<td></td>
<td>Hesco Concertainer Bastion* (supplier – only in Hereford and Worcestershire)</td>
<td>Profile Technologies Ltd</td>
<td><a href="mailto:Info@Profiletechnologies.co.uk">Info@Profiletechnologies.co.uk</a> <a href="http://www.profiletechnologies.co.uk">www.profiletechnologies.co.uk</a> 01544 230023</td>
<td>As above</td>
</tr>
<tr>
<td></td>
<td>Quick Damm Flood Safety System*</td>
<td>Quick Damm GmbH</td>
<td><a href="http://www.quick-damm.de">www.quick-damm.de</a> <a href="mailto:info@quick-damm.de">info@quick-damm.de</a> (+49) 641 96870 (+49) 641 9687137 fax</td>
<td>Steel tube frame enclosed within a geotextile fleece and filled with aggregate. It has been used in numerous flood prevention situations. Variable heights from 0.5 m to 2.0 m. Easily transportable roll-down container available.</td>
</tr>
</tbody>
</table>
## Flood barrier – free-standing

| **Rapidam*** | Hydrosience Ltd  
The Barn, Back Lane Southwark, Fareham Hants PO17 6EG | sales@hydrosience.co.uk  
www.hydrosience.co.uk  
02392 214579 | Heavy duty PVC-coated linen fabric materials with a triangular shape and extended skirt for stability and sealing. Sections are joined together to form a barrier. The installed system is 1.0 m high. A 2.0 m high system is under development. |
| **Water-Gate*** | MegaSecur Inc.  
145 Jutras Boulevard East Suite 3 Victoriaville Quebec, Canada G6P 4L8 | info@megasecur.com  
www.megasecur.com  
(+1) 819 751 0222  
(+1) 819 751 5550 fax | Wedge-shaped, sectional heavy duty material with skirt. Available from 0.38 m to 2.0 m high and ranging from 7.5 m to 75 m in length. Different sized barriers can be connected. |

## Flood barrier – with frame

| **Pallet Barrier***  
(manufacturer) | Geodesign AB  
Teknikringen 1  
S-583 30 Linkoping Sweden | kullberg@geodesign.se  
www.geodesign.se  
(+46) 13 21 19 55  
(+46) 705 515 4555  
(mobile) | Standard euro pallets fitted into galvanized steel supports and covered by waterproof polypropylene membranes. Available to a height of 1.8 m. Tubular sandbags hold down the leading edge and clips secure the membrane over the pallets. |
| **Pallet Barrier***  
(UK supplier) | Pallet Barrier  
5 Fore Street  
Topsham  
Exeter, Devon EX3 0HF | Britt.Warg@palletbarrier.com  
01392 876100  
07890 983239 (mobile) | As above |
| **Portadam*** | Portadam  
107 Bawnmore Road  
Rugby  
Warwickshire CV22 6JJ | Portadam@btinternet.com  
www.portadam.co.uk  
01788 815011 | Welded rectangular steel ‘A’ frames covered by impervious fabric membrane with a leading edge for hydrostatic sealing. Longest Portadam used to date was 250 m. Available to a height of 2.5 m. Only available for hire. |

## Panel barrier

| **Beaver Barrier** | ARTTEC  
Innovation Trade GMBH  
Franz-Abt-Str 10  
D-65193 Wiesbaden Germany | Info@arttec.com  
www.arttec.com  
(+49) 06 11 9 92760  
(+49) 06 11 3 9635 fax | A steel ‘A’ framed pallet with sheet membrane sheet to cover the frame offering 1.5 m protection. Tested by the Wiesbaden Institute of Technology and Frankfurt Fire Department. Constructed a 10 m dam in 15 minutes. |
| **Concrete Block Diversions Structures** | Gallatin Conservation District  
3710 Fallon #B  
Brozeman, MT 59718 USA | www.nacdnet.org  
(+1) 406 444 5484  
(+1) 406 522 4011 | 2000 lb (907 kg) concrete blocks set directly into the water course. Concrete blocks are 1.8 m long and 0.6 m high. Can install flash boards on top of the blocks. |
| **Prestressed Concrete Panel Flood Defence** | ACP (Concrete Ltd)  
Prestressed Concrete Panel Division  
Solway Industrial Estate  
Maryport  
Cumbria CA15 8NF | www.acp-concrete.co.uk  
01900 810841  
07710 600426 | Prestressed concrete panelling constructed to form temporary flood barriers. |
| **Richardson Flood Control Panel Barriers*** | Richardson Flood Control Products  
105 Gardenia Court  
Upland, CA 91786 USA | Res07wgd@verizon.net  
(+1) 909 982 8479 | Sheet metal and precast concrete panel frames from 2.4 m to 6.0 m long. Units connected by flexible interconnecting gaskets to accommodate corners. Large panels require tractors and cranes. Lightweight designs are available. |
### Air/water filled tube

| **Aquadam* (Water Structures®) (manufacturer)** | **Water Structures Unlimited**  
Box 206  
Carlotta, California 95528  
USA | **INFO@Cofferdam.net**  
www.waterstructures.com  
(+1) 800 682 9283 | **Pressurised water-filled tubes. Geotextile-fabricated outer tube and extruded plastic inner tubes. One main tube and double 'inner' tube. Available up to a height of 3.0 m. Reusable. Used in various flooding events in the USA. Can be filled from either end and have extension collar couplings.** |
|---|---|---|---|
| **Aquadam* (supplier)** | **Riverside Water Technologies Ltd**  
Morfa Road  
Swansea SA1 1TD | **Help@riverside-water.co.uk**  
www.riverside-water.co.uk  
01792 655968 | **As above** |
| **AquaTube* (manufacturer)** | **Hydro-Solutions Inc.**  
9597 Jones Road  
Houston  
Texas, USA | **Barrier1@afo.net**  
www.aquabarrier.com  
(+1) 800 245 0199 | **Water-filled dam made of vinyl-coated polyester with internal restraint diaphragms or baffles. Available up to a height of 2.44 m. Varying lengths can be joined by end-to-end butting or overlapping. Maximum protected level must not exceed 75% of barrier height. Single or double diaphragm versions available.** |
| **AquaTube* (supplier)** | **Greenbanks**  
19 Langside Drive  
Kilbarchan  
Johnstone PA10 2EL | **mcmillan@greenbanks.nl**  
www.greenbanks.com  
01505 704214 | **As above** |
| **Beaver Inflatable Tube (Hochwasserschutzsystem)** | **Bieri Blachen AG**  
Rothmatte 2 CH-6022  
Grosswangen  
Switzerland | **Info@bieri.ch**  
041 984 2121 | **Water-filled dam. It took 1 day for five people to assemble a 500 m x 0.85 m Beaver inflatable tube protection system.** |
| **FloodMaster barrier* (manufacturer)** | **FloodMaster Barriers Inc.**  
74 Brookdale Avenue  
Toronto  
Canada M5M 1P3 | **Info@floodmaster.ca**  
(+1) 416 488 4189  
(+1) 416 488 5889 fax | **Water-filled flood barrier made of flexible geotube composites stacked on top of each other and harnessed independently to each other. The elliptical barriers conform to the terrain by friction and gravity. They can be repaired on-site and come in a range of sizes or can be customised.** |
| **FloodMaster barrier* (supplier)** | **ECMC**  
c/o Braeside Cottage  
Crimp Hill  
Englefield Green  
Surrey SL4 2HL | **Hgervais@floodmaster.ca**  
01784 431186  
07977 444440 (mobile) | **As above** |
| **Mobile Dam*** | **Flooding Agency A/S**  
Steinnersvej 17  
Ringsted  
Denmark | **Flooding@fraflood.com**  
www.fraflood.com  
(+45) 5767 4811 | **Water-filled dam incorporating two pressurised water-filled Twin Flex™ tubes made of polyfibre coated with PVC. A third tube may be placed on top. Each coupling has valves for air and water filling, stored on large rolls.** |
| **NOAQ Flood Fighting System** | **NOAQ Nordisk Aquateknik AB**  
PO Box 343  
S-824 27 Hudiksvall  
Sweden | **www.noaq.se**  
(+46) 650 181 10 | **Interconnecting air-filled tube with skirt on water side. Weight/pressure of the water keeps the tube secure. One section is equivalent to 1,400 sandbags.** |
| **SuperiorDam LLC** | SuperiorDam LLC  
14535 Highway 36  
Carlotta CA 95528  
USA | superior@Humboldt1.com  
daniel@Humboldt1.com  
tcarter@Humboldt1.com  
www.superiordam.com | Pressure-secured water-filled system with two conjoined PVC tubes covered with a spillway skirt. This skirt extends away from the structure to protect the adjacent surface from overflow erosion. The pressure-secured technology reduces the uplift pressure. |
| --- | --- | --- | --- |
| **Waterwall** | Waterwall/H2O Product Solutions,  
P.O. Box 1734,  
Station Main, Brantford,  
Ontario N3T 5V7, Canada | h2owall@waterwall.com  
www.waterwall.com  
(+1) 519 751 3599  
(+1) 519 751 1737 fax | A flexible tank manufactured from strong PVC-coated fibres which can be filled with water. Length 5 m, width 1.5 m, height 1 m with a volume of 3,000 litres. |
| **Sand bags** | Various manufacturers | | Hessian or polypropylene sacks filled with sand. Typically 0.325 m x 0.75 m (unfilled) and about 0.225 m wide x 0.5 m long x 0.1 m high (filled). Traditionally stacked to form temporary flood walls. Generally not reusable and require a lot of resources and time to fill and stack into defences. |

* Flood protection system for which a fact sheet is provided in Appendix A3.
Appendix A2: Summary table for proprietary demountable flood defences

<table>
<thead>
<tr>
<th>Panel barriers</th>
<th>Manufacturer/supplier</th>
<th>Contact information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antiflood Barrier System</strong></td>
<td>Antiflood</td>
<td><a href="mailto:info@Antiflood.com">info@Antiflood.com</a>  <a href="http://www.antiflood.com">www.antiflood.com</a> 0118 934 5299</td>
<td>Galvanized lightweight (rigid polyethylene) panels with braces which are fitted into pre-installed receptacles. Available to a maximum depth of 0.7 m.</td>
</tr>
<tr>
<td><strong>Aqua Stop 200AL and Aqua Stop 200GL</strong></td>
<td>AQUA-STOP Hochwasserschutz GmbH</td>
<td><a href="mailto:info@aquastop.de">info@aquastop.de</a>  <a href="http://www.aquastop.net">www.aquastop.net</a></td>
<td>Self-supporting removable dams and supports. Glass protection barrier used for flood protection. Supported by 1.1 m x 3.0 m galvanized iron tubing. 200GL is 42 mm thick glass/sheet pile barrier with cover strip system and adjustment structure that can only be anchored in concrete.</td>
</tr>
<tr>
<td><strong>Bauer-IBS flood protection system</strong></td>
<td>IBS – Zentrale Gemeindewald 4 D-86672 Thierhaupten Germany</td>
<td><a href="mailto:IBS@technik.de">IBS@technik.de</a>  <a href="http://www.hochwasserschutz.de">www.hochwasserschutz.de</a> (+49) 827 181760</td>
<td>Lightweight aluminium profiles supported by posts. The supporting posts are fixed into anchor beams, which are set into a concrete foundation. The ground seals are compressive, allowing for slight undulations in the foundation surface. Maximum defence height is 5.0 m. Bracket supports and permanent end posts have security covers when not in use.</td>
</tr>
<tr>
<td><strong>Bauer-IBS flood protection system (UK supplier)</strong></td>
<td>Bauer Inner City Ltd</td>
<td>Demflood  @bauerfoundations.co.uk <a href="http://www.demflood.co.uk">www.demflood.co.uk</a> 0161 777 4400</td>
<td>As above</td>
</tr>
<tr>
<td><strong>BL/HAP-SB</strong></td>
<td>Blobel Umwelttechnik GmbH</td>
<td><a href="mailto:vertrieb@blobel.de">vertrieb@blobel.de</a>  <a href="http://www.blobel.de">www.blobel.de</a> (+49) 8205 96070</td>
<td>Reinforced aluminium body sections mounted in 'U' shaped galvanized steel supports with compressible polyurethane-based seals. Pressure screws ensure a tight seal both horizontally and vertically. Suitable for blocking gaps in defences.</td>
</tr>
<tr>
<td><strong>Coplasticx stoplogs</strong></td>
<td>Simon-Hartley</td>
<td><a href="http://www.simonhartley.com">www.simonhartley.com</a> 01782 202300 01782 260534 fax</td>
<td>Drop-in synthetic, steel or stainless steel stoplogs and stanchion systems. Can form barrier up to 2.0 m high. Standard sizes 1.0 m to 2.0 m square. Stoplog sizes either 0.3 m or 0.4 m. Typically used for blocking gaps in defences.</td>
</tr>
<tr>
<td><strong>DPS 2000</strong></td>
<td>G.O.H.mbH and Zetzch &amp; Sohn GMBH</td>
<td><a href="mailto:GOH@Handwerkonline.de">GOH@Handwerkonline.de</a>  <a href="http://www.handwerkonline.de/GOH/Indexe.html">www.handwerkonline.de/GOH/Indexe.html</a> (+49) 2236 962583</td>
<td>Toothed aluminium profiles between galvanized steel supports, rubber-edged with ties to keep profiles in place. Freestanding to 1.6 m. Has been used in The Netherlands. Height of 4.0 m and more possible. Permanent base connection is needed.</td>
</tr>
</tbody>
</table>
Flood Guard and Flood Dam K are part of a suite of flood dam systems. Heavy duty modular aluminium panels installed in galvanized steel stanchions. EPDM (ethylene-propylene diene monomer) seals provide sealing between panels and stanchions. Heights up to 3.0 m (Flood Guard) and 5.0 m (Flood Dam K) are available.

As above

Mild steel or aluminium stanchions with aluminium, plastic, steel or wooden panels. Locating studs are concealed under lockable caps on bedding surface.

Stackable barrier board system. Other defences sold alongside this product include flood gates and flood boards.

1. Gate closes automatically when flooding occurs. 2. Based on barrier system with a special rubber sealant. 3. Full pneumatic system operated electronically. 4. Rectangular fill with rubber sealant inserted in a 'U' shaped uptake complete with stretching device.

Collapsible aluminium flood barrier fencing stored out of view under panels in the location when not in use. Available in heights up to 1.5 m. Higher versions are proposed. Once installed, deployment requires manual lifting of cover only. Easy erection.
<table>
<thead>
<tr>
<th><strong>Ferndon Flood Gate</strong></th>
<th>Ferndon Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bishops Hull</td>
</tr>
<tr>
<td></td>
<td>Taunton</td>
</tr>
<tr>
<td></td>
<td>Somerset</td>
</tr>
<tr>
<td></td>
<td>TA1 5EA</td>
</tr>
<tr>
<td><strong><a href="mailto:Info@elkosta.co.uk">Info@elkosta.co.uk</a></strong></td>
<td><a href="http://www.elkosta.co.uk">www.elkosta.co.uk</a></td>
</tr>
<tr>
<td><strong>01823 271911</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Horizontal sliding, horizontal hinged and vertical lifting/lowering gates.</strong></td>
<td><strong>Horizontal sliding gates have side seals and lower into a sealing strip. Hinged gates closing into a 'V' water pressure helps seal the gate. Lifting/lowering gates are electromechanical or electrohydraulically operated. All gates are purpose-designed and built to specific requirements.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Floodgate - watertight and flood gates</strong></th>
<th>Trans-Global Engineering Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Beck Group</td>
</tr>
<tr>
<td></td>
<td>Camlock Works</td>
</tr>
<tr>
<td></td>
<td>Bridlington Road</td>
</tr>
<tr>
<td></td>
<td>Hunmanby North Yorkshire</td>
</tr>
<tr>
<td></td>
<td>YO14 0LR</td>
</tr>
<tr>
<td><strong><a href="mailto:info@beckgroup.co.uk">info@beckgroup.co.uk</a></strong></td>
<td><strong><a href="mailto:trans@beckgroup.co.uk">trans@beckgroup.co.uk</a></strong></td>
</tr>
<tr>
<td><strong><a href="http://www.beckgroup.co.uk">www.beckgroup.co.uk</a></strong></td>
<td><strong>01723 892122</strong></td>
</tr>
<tr>
<td><strong>01723 891554 fax</strong></td>
<td><strong>Watertight gates that can block off walkways and similar gaps or accesses. Manually operated by a single person using a ratchet mechanism. Made to specification.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hydraulic Barrier</strong></th>
<th>Flood Control Limited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Torrington House</td>
</tr>
<tr>
<td></td>
<td>Gunnislake Cornwall</td>
</tr>
<tr>
<td></td>
<td>PL18 9HL</td>
</tr>
<tr>
<td><strong><a href="mailto:sales@floodcontrol.co.uk">sales@floodcontrol.co.uk</a></strong></td>
<td><strong><a href="http://www.floodcontrol.co.uk">www.floodcontrol.co.uk</a></strong></td>
</tr>
<tr>
<td><strong>01822 832385</strong></td>
<td><strong>01822 833401 fax</strong></td>
</tr>
<tr>
<td><strong>Automatic 'flip-up' barrier which is fully recessed into the floor and does not restrict vehicular access. Height can be tailored to requirement. Maximum length 12 m. Can be run off 24 volt supply.</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Presray flood gates</strong></th>
<th>Presray Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>159 Charles Colman Boulevard Pawling NY 12564-1193 USA</td>
</tr>
<tr>
<td><strong><a href="mailto:info@presray.com">info@presray.com</a></strong></td>
<td><strong><a href="http://www.presray.com">www.presray.com</a></strong></td>
</tr>
<tr>
<td><strong>(+1) 845 855 1220</strong></td>
<td><strong>(+1) 845 855 1139 fax</strong></td>
</tr>
<tr>
<td><strong>Model FB55 (bottom-hinged 'flip-up' flood gate with inflatable gaskets and BF44 hinged gate) provides flood protection to over 2.4 m. Bottom hinged 'flip-up' flood gate. Systems consist of either lift-out or hinged barriers with pneumatic seal inflatable gaskets or compression gaskets on both sides and bottom.</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Dam-It flood gates (UK Presray licensee)</strong></th>
<th>Dam-It (Flood Protection) Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit 3A Brandon Way</td>
</tr>
<tr>
<td></td>
<td>West Bromwich West Midlands</td>
</tr>
<tr>
<td></td>
<td>B70 8JB</td>
</tr>
<tr>
<td><strong><a href="mailto:mwhite@talk21.com">mwhite@talk21.com</a></strong></td>
<td><strong>0121 525 3338</strong></td>
</tr>
<tr>
<td><strong>Pressray model FB55 - as above</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Self Closing Wall (manufacturer)</strong></th>
<th>Van Den Noort Innovations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zilverschaan 47</td>
</tr>
<tr>
<td></td>
<td>8265 HE Kampen</td>
</tr>
<tr>
<td></td>
<td>The Netherlands</td>
</tr>
<tr>
<td><strong><a href="mailto:info@noort-innovations.nl">info@noort-innovations.nl</a></strong></td>
<td><strong><a href="http://www.noort-innovations.nl">www.noort-innovations.nl</a></strong></td>
</tr>
<tr>
<td><strong>(+31) 38 4204948</strong></td>
<td><strong>(+31) 38 4204949 fax</strong></td>
</tr>
<tr>
<td><strong>Fibreglass floating wall lifted into place automatically by the hydrostatic pressure of the flood waters. The floating wall is located in a steel basin, which is hydraulically connected to the flood water. Once installed, operation is automatic. When not in use, the wall is not visible (underground).</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Self Closing Wall (supplier)</strong></th>
<th>Fydro BV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Postbus 96</td>
</tr>
<tr>
<td></td>
<td>NL-6710 BB Ede</td>
</tr>
<tr>
<td></td>
<td>The Netherlands</td>
</tr>
<tr>
<td><strong><a href="http://www.fydro.com/english/meen.htm">www.fydro.com/english/meen.htm</a></strong></td>
<td><strong><a href="mailto:info@fydro.com">info@fydro.com</a></strong></td>
</tr>
<tr>
<td><strong>(+31) 31 8648320</strong></td>
<td><strong>As above</strong></td>
</tr>
<tr>
<td><strong>Walz &amp; Krenzer Flood barriers and hatches</strong></td>
<td>Walz &amp; Krenzer, Inc</td>
</tr>
<tr>
<td></td>
<td>USA</td>
</tr>
<tr>
<td><strong><a href="http://www.wk-mapeco.com">www.wk-mapeco.com</a> <a href="mailto:sales@wk-mapeco.com">sales@wk-mapeco.com</a></strong></td>
<td><strong>(+1) 203 267 5712</strong></td>
</tr>
<tr>
<td><strong>(+1) 203 267 5716 fax</strong></td>
<td><strong>Flood barriers and hatches. Manual or automatic. Compression, lip seal or inflatable gaskets. Steel, aluminium and stainless steel. Aluminium panels with lightweight mild steel frames.</strong></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Flood barrier – flexible</th>
</tr>
</thead>
</table>
| Rapidam (bolt-down version) | Hydroscience Ltd  
The Barn  
Back Lane  
Southwark  
Fareham  
Hants  
PO17 6EG | sales@hydroscience.co.uk  
www.hydroscience.co.uk  
02392 214 579 | Heavy duty PVC-coated linen fabric materials with a triangular shape and extended skirt for stability and sealing. Sections are joined together to form a barrier. The installed system is 1.0 m high. A 2.0 m high system is under development. Barrier is secured in place by eyebolts screwed into prepared threaded sleeves. |
1  Product name and manufacturer details

Antiflood barrier system

Antiflood
Pondwood Farm, Pondwood Lane, White Waltham, Berkshire SL6 3SS
Tel: 0118 934 5299
E-mail: info@antiflood.com
http://www.antiflood.com
Mick Holdaway and Nigel Streeter

2  Diagram and general description

2.1 General description
The Antiflood barrier system consists of a series of flood barrier panels which, when erected, can provide protection from floodwater to a depth of 0.7 m. The modular panels are made from 4 mm rigid polythene (high molecular weight). The panels lock into a receptacle mounted in concrete. Brace panels can be added to provide further rigidity. Corner panels and corner receptacles are also available to allow a full enclosure to be erected. The panels are sturdy and lightweight (to allow ease of assembly and handling).

3  Available sizes/dimensions

3.1 Length per unit
1.2 m per panel

3.2 Maximum number of coupled units
Unlimited

3.3 Product height range
0.7 m (new model under development will cover heights up to 1.0 m)

3.4 Flexibility with regard to angles in horizontal plane
Purpose-built corner panels and receptacles allow 90° corners.

3.5 Number of vertical joints/sealings (per unit/unit width)
One

3.6 Number of horizontal joints/sealings (per unit/unit width)
One

3.7 Width of structure at base
0.73 m (including additional diagonal brace)
4 Structural aspects

4.1 Likely modes of failure
Antiflood claims that the system should not fail, but overtopping could occur with extreme water levels.

4.2 Maximum design head of water
0.7 m

4.3 Behaviour subject to seepage
Seepage depends on ground conditions but, if assembled correctly, the system itself does not leak. Pumping may be required to keep the landward side of the barrier dry as a result of ground seepage and rainfall.

4.4 Behaviour subject to breach (breach growth)
No details were submitted. No system has yet failed, so Antiflood cannot confirm how the barrier would react after damage.

4.5 Increase protection height during service
Antiflood states that the system height can be raised during service, but the company has not submitted details on how this could be achieved.

4.6 Resistance to damage/repair during service conditions
The system is rigid and thus expected to withstand debris and water pressure. Antiflood has not submitted information about repair during service conditions.

5 Operational aspects

5.1 Time required for installation (100 m long × 1 m high)
One person can erect the stated barrier in 5 hours. This excludes the time taken to prepare the receptacles.

5.2 Method of installation (including site preparation)
Manual. Panels and parts are lightweight.

5.3 Likelihood of incorrect installation
Antiflood states that the system is “idiot proof” and that the only possible fault is distortion of the seals (this would allow minimal seepage only).

5.4 Storage and transportation requirements (including mobilisation)
The system can be stored outdoors – no covering is required. One panel requires 1.2 m x 0.77 m x 0.5 m for storage. Transporting the system is easy and requires a light van or lorry. Its size depends on the number of panels required for protection.

5.5 Adaptability to terrain conditions
The system is suitable for all terrain conditions, but requires the receptacle to be installed in a concrete foundation.

5.6 Provision of fixings/susceptibility to damage or vandalism
The receptacles are the only fixings left in situ. These are recessed to ground height and can be covered to ensure no blockage can occur.

5.7 Possible locations of use
Antiflood states that the system can be used in all flood locations. However, the design makes it more applicable to reasonably short lengths of shallow flooding or enclosures around properties.

6 Financial aspects

6.1 Maintenance/re-use/durability
The Antiflood barrier system is extremely durable, being made from rigid polythene which will not deteriorate with time. The system can be reused and is easy to clean after use. Periodic replacement of the seals is required, but the system will not fail if a seal needs replacing.
Fact sheet for Antiflood barrier system
Generic group: panel barrier

6.2 Installation costs (100 m long x 1 m high – excluding resources)
£13,153 plus VAT for all components

6.3 Installation resource requirements
Once the receptacle has been fitted, only one person is needed.

6.4 Additional installation and removal costs (training/supervision)
None. There are no training or deployment costs.

7 Other

7.1 Aesthetic aspects
The system is designed mainly for domestic use and, as such, the panels are neat and well-finished. The receptacle is recessed and therefore not very visible once installed. Different colours are available.

7.2 Test information
Test calculations are available. Antiflood has not submitted any field test results.

7.3 Performance under service conditions
No information on performance was submitted.

7.4 Environmental aspects
There is no known environmental impact from the system.

7.5 Additional comments
The barrier system is just one of Antiflood’s many products. The company also offers a comprehensive series of pipe blockers, airbrick covers, and pumps.
Fact sheet for AquaTube
Generic group: air and water filled tube

1 Product name and manufacturer details

AquaTube®

Hydro-Solutions Inc. (manufacturer)
9597 Jones Road, Houston, Texas, USA
Tel: (+1) 800 245 0199
E-mail: barrier1@afo.net
http://www.aquabarrier.com
Darren Miller

Greenbanks (UK supplier)
19 Langside Drive, Kilbarchan, Johnstone PA10 2EL
Tel: 01505 704214
E-mail: mcmilian@greenbanks.nl
http://www.greenbanks.com
Robert McMillan

2 Diagram and general description

2.1 General description
AquaTube® (Aqua-Barrier® in the USA) is constructed from industrial grade vinyl-coated polyester with one or two perforated, inner restraint diaphragms or baffles running the length of each unit. The tube is filled with water to form a temporary barrier against flooding. The system is sufficiently flexible to conform to various terrains and stream bed materials. The AquaTube® is available in six different heights (from 0.91 m to 2.44 m) and unit lengths up to 60 m. Connections between the separate units are made without special tools using a simple overlapping technique.

3 Available sizes/dimensions

3.1 Length per unit
For ease of handling, 30 m is typical. The maximum length made by the current manufacturing plant is 60 m.

3.2 Maximum number of coupled units
No technical limit

3.3 Product height range
0.91–2.44 m
3.4 **Flexibility with regard to angles in horizontal plane**
   Curves and arcs are limited due to the inflation of the barrier. Corners and other changes of direction can be constructed by overlapping ends of barriers at appropriate angles.

3.5 **Number of vertical joints/sealings (per unit/unit width)**
   None

3.6 **Number of horizontal joints/sealings (per unit/unit width)**
   None

3.7 **Width of structure at base**
   Up to 6.1 m depending on the height of structure

4 **Structural aspects**

4.1 **Likely modes of failure**
   Rolling, sliding and overtopping are the likely forms of failure when the design capacity of the AquaTube® is exceeded.

4.2 **Maximum design head of water**
   1.83 m

4.3 **Behaviour subject to seepage**
   Seepage is low if the system is installed correctly and depends on the seal with the ground.

4.4 **Behaviour subject to breach (breach growth)**
   The system should not worsen progressively after a tear or puncture. If a breach occurs, however, it is likely to affect the operation of the whole barrier.

4.5 **Increase protection height during service**
   No

4.6 **Resistance to damage/repair during service conditions**
   The system can be protected by a geotextile layer to minimise vandalism and damage from the stream bed. The system can be repaired during service.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
   2 hours with a typical installation team (see Section 6.4 below)

5.2 **Method of installation (including site preparation)**
   Installation is manual and requires the use of pumps and some plant (these have to be transported to the site). There are, however, minimum site-specific requirements which must be evaluated before applications can be undertaken. These include slope and grade parameters, water depth, water velocity, anticipated water flows and related hydrology. The bed area where the barrier is to be deployed should be prepared to remove any sharp debris and/or fill any large hollows.

5.3 **Likelihood of incorrect installation**
   Appropriate safety factors and installation/safety documents are included with the design certification. A free design programme is available.

5.4 **Storage and transportation requirements (including mobilisation)**
   The system can be stored and transported on pallets (it folds down into a flat pack). It should be stored in a dry, frost-free environment.

5.5 **Adaptability to terrain conditions**
   Greenbanks states that the AquaTube® will adapt to most terrain conditions. Large hollows or large sharp objects should be removed from the site before deployment. Where the bed surface slopes transversely to the line of the AquaTube®, the slope parameters are checked by the design programme.
Fact sheet for AquaTube
Generic group: air and water filled tube

5.6 Provision of fixings/susceptibility to damage or vandalism
The system is temporary and so requires no fixings. AquaTubes® are susceptible to vandalism and for extra protection, the system can be covered by a suitable geotextile layer.

5.7 Possible locations of use
The system can be used at bank tops and reservoir banks (wave environments are subject to design checks), as a second line of protection, and as an enclosure around properties. Only smaller sizes can be used on embankments due to their width. The system is not recommended for small gaps and openings.

6 Financial aspects

6.1 Maintenance/reuse/durability
Protect from sharp objects on laying surfaces. Clean and check system after use and before redeployment. The supplier claims the system is totally reusable and should not deteriorate with time if stored and used correctly.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
£160 per metre (£16,000 for a 100 m barrier)

6.3 Installation resource requirements
A typical installation team consists of four people. A large pump is required. Lifting plant is optional, but desirable for larger installations.

6.4 Additional installation and removal costs (training/supervision)
The product includes training and delivery costs. Basic training and supervision in the UK are available by arrangement with Greenbanks.

7 Other

7.1 Aesthetic aspects
The system is large compared with other systems due to the nature of its design. However, the temporary nature of its deployment should reduce any effect on the area. The system is available in colours to suit its location or use.

7.2 Test information
The system has been tested extensively in field tests. A computer model called AquaCOMP has been developed to calculate the stability and applicability of an AquaTube® for a particular project. This software uses a numerical technique commonly used in engineering and is free.

7.3 Performance under service conditions
The AquaTube® has been shown to perform well under a variety of service conditions.

7.4 Environmental aspects
The system has no known physical, chemical or permanent effects on the environment. No reinstatement is required after use.

7.5 Additional comments
The system is larger than most, but has proved effective for a range of uses.
Fact sheet for Aquadam
Generic group: air and water filled tube

1 Product name and manufacturer details

Aquadam (Water Structures®)

Water Structures Unlimited®
PO Box 206, Carliotta, California 95528, USA
Tel: (+1) 800 682 9283
E-mail: INFO@Cofferdam.net
http://www.waterstructures.com
David Doolaege

Aquadam™

Riverside Water Technologies Ltd
Riverside Centre, Pipe House Wharf, Morfa Road, Swansea SA1 1TD
Tel: 01792 655968
E-mail: help@riverside-water.co.uk
http://www.riverside-water.co.uk
Ian Rees

2 Diagram and general description

2.1 General description

Aquadam™ (Water Structures® in the USA) combines three tubes and a supply of water. Two extruded polyethylene ‘inner’ tubes inside a single, woven geotextile, outer ‘master’ tube are pumped simultaneously full of water. The mass and internal friction between the master tube and the inner tubes gives a solid non-rolling ‘wall’, which adjusts automatically to the bottom terrain as the Aquadam™ is deployed. The Aquadam™ combines weight and counter-friction to create an effective water-filled dam.

3 Available sizes/dimensions

3.1 Length per unit
Available in three lengths: 15 m, 30 m and 60 m

3.2 Maximum number of coupled units
Unlimited

3.3 Product height range
0.3–3.0 m inflated height

3.4 Flexibility with regard to angles in horizontal plane
Can be installed in curves and arcs.
3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
None

3.7 Width of structure at base
The installed width at the base for a 0.3 m Aquadam™ is 0.55 m.
The installed width at the base for a 3.0 m Aquadam™ is 6.5 m.

4 Structural aspects

4.1 Likely modes of failure
The nature of its construction means that overtopping, rolling and sliding are possible modes of failure for an Aquadam™.

4.2 Maximum design head of water
This depends on the size of the Aquadam™. The maximum design head of water varies from 1.75m (58%) for the 3.0 m high system to 0.225 m (75%) for the 0.3 m high system.

4.3 Behaviour subject to seepage
Seepage depends wholly on the seal achieved with the ground. The seepage associated with the Aquadam™ is relatively low due to the size and mass of the structure. Some pumping may be required to keep the landward side dry.

4.4 Behaviour subject to breach (breach growth)
The behaviour subject to breach depends on the size of the breach relative to that of the Aquadam™. A small breach can be repaired or controlled by temporary super-inflation; a major breach is likely to affect the barrier’s operation.

4.5 Increase protection height during service
Small increases can be obtained by super-inflating the Aquadam™ temporarily. Stacking one tube above another is not recommended.

4.6 Resistance to damage/repair during service conditions
An Aquadam™ leaks if punctured or torn. Depending on the size of the tear, an Aquadam™ can be maintained as a barrier either by continuous pumping or by using waterproof tape. An Aquadam™ is susceptible to vandalism as it is constructed from fabric and polyethylene.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
3 hours

5.2 Method of installation (including site preparation)
The deployment surface should be free from large boulders or large obstacles, which may damage the Aquadam™ or prevent an effective seal with the underlaying ground. Installation is manual and requires two people and two portable pumps (or one larger pump with a split outlet) for a 0.9 m high Aquadam™.

5.3 Likelihood of incorrect installation
The tubes must be filled simultaneously.

5.4 Storage and transportation requirements (including mobilisation)
A 0.9 m high, 30 m long Aquadam™ can be stored in a roll 3 m wide and 0.5 m in diameter. A trailer or a 4x4 pick-up truck is all that is needed to transport the Aquadam™ to the deployment site. The Aquadam™ can be handled manually onto the site. A 0.9 m high, 30 m long Aquadam™ weighs 113 kg.

5.5 Adaptability to terrain conditions
The Aquadam™ can adapt to most terrain conditions. It cannot be deployed on either an existing wall or on a sloped surface.
5.6 **Provision of fixings/susceptibility to damage or vandalism**
Aquadam™ is a temporary system and fixings are not therefore required.

5.7 **Possible locations of use**
Aquadam™ is long and continuous in design and, as such, is more suited to larger areas of protection. It is ideal for bank tops, as a second line of protection and as an enclosure around properties. Its use on embankments is limited to smaller sizes due to their width. The Aquadam™ is not recommended for gaps or openings less than 6m long. The Aquadam™ is also suitable for redirecting water flow.

6 **Financial aspects**

6.1 **Maintenance/reuse/durability**
The Aquadam™ is easy to clean by washing with water before removal. It should be dried before storage to increase its service life. Small tears can be repaired; if repair is not practical, the inner tubes can be replaced. The Aquadam™ is totally reusable and is treated to protect it against UV light.

6.2 **Installation costs (100 m long x 1 m high – excluding resources)**
£7,872 (all components necessary to withstand a maximum head of 700 mm)

6.3 **Installation resource requirements**
One 4x4 vehicle (or similar) to transport the Aquadam™ to the site, a team of two people (minimum) and two pumps

6.4 **Additional installation and removal costs (training/supervision)**
Training can be provided on the deployment of the system, but this is not included in the product cost. There are no additional installation or removal costs. Site clearance after use is not excessive.

7 **Other**

7.1 **Aesthetic aspects**
An Aquadam™ is a large structure and very visible. However, its deployment is neat and the infill material (water) can be obtained on site. No evidence is left after the system’s removal.

7.2 **Test information**
Aquadam™ and Water Structures® meet both US Environmental Protection Agency (USEPA) standards and the requirements of the US Clean Water Act. They have little or no adverse effect on the aquatic ecosystem. Aquadam™ and Water Structures® have been used successfully in the USA since 1990 by a number of organisations and authorities. They are approved by the US Army Corps of Engineers, the Canadian Federal Department of Fisheries and Oceans, the British Columbia Ministry of the Environment and the Ontario Ministry of Natural Resources

7.3 **Performance under service conditions**
Good

7.4 **Environmental aspects**
An Aquadam™ is not designed for permanent deployment. It can be removed totally with no subsequent environmental impact. It does not pollute and no aggregate infill has to be removed from the deployment site.

7.5 **Additional comments**
It has been successfully used for over 10 years. The tubes can be filled from either end.
Fact sheet for BAUER-IBS flood protection system
Generic group: panel barrier

1  Product name and manufacturer details

BAUER-IBS flood protection system

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Volker Weingartner

2  Diagram and general description

2.1 General description
The BAUER-IBS demountable flood protection system is a well-engineered system consisting of lightweight, extruded aluminium profiles (including supporting posts and dam beams). These can be erected quickly in the event of a flood warning and subsequently dismantled and placed in storage when not in use. When in service the supporting posts are fixed into anchor plates, which are cast into a suitably constructed permanent ground beam. The system has a compressible base/ground seal, which negates the need for a ground rail.

3  Available sizes/dimensions

3.1 Length per unit
Variable depending on protection requirement, but typically (but not limited to) 1.0–3.5 m

3.2 Maximum number of coupled units
Unlimited

3.3 Product height range
Variable to a maximum height of 5.0 m

3.4 Flexibility with regard to angles in horizontal plane
Corner posts with individual angles can be specially designed for individual projects allowing the system to incorporate corners and arcs.
3.5 Number of vertical joints/sealings (per unit/unit width)
   None
3.6 Number of horizontal joints/sealings (per unit/unit width)
   Depends on installed height. Each dam beam is 150 mm high.
3.7 Width of structure at base
   Variable depending on the back support detail. Width of supporting posts is 300 mm. With back support, larger support beams up to 1.3 m are available depending on the installed height. Back supports are generally only necessary for system heights above 1.6 m.

4 Structural aspects

4.1 Likely modes of failure
   No failure of the BAUER-IBS system has ever been reported although the system has been used for many years in Germany and continental Europe. Overtopping could occur with a flood level greater than the specified design level.

4.2 Maximum design head of water
   Currently 5.0 m

4.3 Behaviour subject to seepage
   The BAUER-IBS system protects against water ingress above the formation level as soon as it is erected and ensures protection against water ingress above ground level. Furthermore, the system height can be increased during service without seepage occurring. BAUER-IBS recommends a full geotechnical assessment of ground conditions. If significant lateral seepage through the soil is likely, this should be cut off using a sheet-piled wall or similar on which the ground beams and demountables should be fitted.

4.4 Behaviour subject to breach (breach growth)
   The seals on the dam beams are deliberately kept to a small volume to ensure that a small amount of damage or leakage does not compromise the system’s integrity.

4.5 Increase protection height during service
   It is possible to carry out a partial erection of the system (using a minimum of 4-5 beams) and increase its height during service. The pressing tool, which locks the upper dam beam in place, can be released and further dam beams added. This is because the hydrostatic pressure in and around the lower hollow beam profile compresses the seals and locks the system firmly in place without compromising its integrity.

4.6 Resistance to damage/repair during service conditions
   The extruded aluminium beams are tough and difficult to damage. The system is designed to withstand impacts of up to 20 kN/m². The seals are intentionally kept small to minimise the risk of damage. Repairs can be carried out during service conditions, but due to the size of the seals, a small amount of damage can be repaired after the flood event without fear of system failure in service.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
   BAUER-IBS has not stated an erection time for these dimensions. The company’s video shows a barrier 65 m long and over 2.5 m high being erected in 3.5 hours.

5.2 Method of installation (including site preparation)
   Barrier heights of less than 1.5 m can be installed manually. Lifting equipment is necessary above this height. Construction of the foundations and ground beams is required first. Transport of the system to the site requires forklift trucks and light duty vehicles (LDVs).

5.3 Likelihood of incorrect installation
   The limited number of symmetrical components in the system design means that the probability of incorrect installation is low. In addition, any of the dam beams can accommodate a ground seal.
5.4 Storage and transportation requirements (including mobilisation)
The system is stored on pallets designed to accommodate the supporting posts and dam beams for ease of storage and recovery when required for use. Separators prevent contact between the components on the pallets. This obviates unnecessary compression on the seals and avoids contact corrosion. Storage should be under cover in a shed or warehouse. Depending on the size of the scheme, trailer units, flatbeds and light duty vehicles (LDVs) are required for transport. Forklifts or other lifting equipment are required for loading and unloading.

5.5 Adaptable to terrain conditions
BAUER-IBS states that the system is suitable for most ground types providing that the ground is suitable for the construction of a permanent foundation and that plant can reach the site in times of deployment. The system can accommodate changes in level and direction.

5.6 Provision of fixings/susceptibility to damage or vandalism
Minimal. Seals are intentionally designed to be small to minimise the risk of damage. Protective covers and cover strips are available for use with the permanent end posts when not in use. For the anchor plates, countersunk locking bolts remain in place when the posts are removed.

5.7 Possible locations of use
The BAUER-IBS system is suitable for all locations with the exception of openings such as pipes and airbricks.

6 Financial aspects

6.1 Maintenance/reuse/durability
The extruded aluminium profiles are not expected to deteriorate with time provided they are maintained and stored properly when not in use. The system is easy to clean using steam washers and high pressure, water jetting without the use of detergents. The system is totally reusable. The components are stored in specially designed pallets, which together with special separators, prevent contact between components. This also provides sufficient air circulation, thus facilitating quick drying and contributing to the expected life span.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
There is no universal cost as each scheme needs to be assessed on its merits. For the dimensions quoted, a typical cost is around £750–£850/m² of demountables (supporting posts and dam beams). This cost excludes ground beam construction.
The total cost for the barrier components would be in the region of £75,000 to £85,000.

6.3 Installation resource requirements
Transport to the site and lifting equipment for handling and storing pallets are required. The number of people depends on the size of scheme and the lead-in time available for erection.

6.4 Additional installation and removal costs (training/supervision)
There are no additional costs as the price of the system includes training and deployment costs. Assistance/supervision with the first and possibly second erection is available.

7 Other

7.1 Aesthetic aspects
The system is not unsightly as the components are symmetrical with a neat and tidy appearance.

7.2 Test information
BAUER-IBS has its own test bed facility where the behaviour of the materials in continuous use can be monitored and tested. Ice tests and crash tests have also been undertaken.
7.3 Performance under service conditions
The BAUER-IBS system has been in use in Germany and continental Europe for at least 10 years on rivers which experience annual flooding such as the Rhine and the Mosel. During this time, no ‘in-service’ breaches or failures have been experienced. A video is available which shows the system performing well during a flood.

7.4 Environmental aspects
The components of the system are essentially inert, being aluminium-extruded profiles made from at least 75% recycled aluminium. As the system is demountable, the visible barrier is only a temporary feature; any visual impact is therefore minimal. The system is quite pleasant in appearance when erected.

7.5 Additional comments
The BAUER-IBS system is well designed and engineered. It is a fully patented system.
Fact sheet for BL/HAP-SB floodwater barrier
Generic group: panel barrier

1  Product name and manufacturer details

BL/HAP-SB floodwater barrier

Blobel Umwelttechnik GmbH
Friedberger Strasse 4, D-86453 Dasing, Germany
Tel: (+49) 82 05 96070
E-mail: vertrieb@blobel.de or info@blobel.de
http://www.blobel.de
Rudolf Regensburger

2  Diagram and general description

2.1  General description
The floodwater barrier consists of two or more hollow, reinforced aluminium body sections with lower edge protection. A compressible, highly adaptable special seal is applied on the lower most section. The other barrier sections are provided with an easily compressed polyurethane-based seal. The floodwater barrier sections are rigidly installed and universally mounted in two ‘U’ or double ‘U’ shaped mounting devices (depending on preference within the continuous flood barrier). The barrier sections are pressed firmly against the seal of the mount and floor from both the side and the top using pressure screws or Tommy screws. This ensures a reliable seal. The aluminium barrier sections have a polished bare metal finish. Steel components are galvanised. Paintor powder coatings are available on request.

3  Available sizes/dimensions

3.1  Length per unit
Unit section lengths are designed for individual projects. Recommended unit section length for a 100 m long and 1 m high system is 2.5 m.

3.2  Maximum number of coupled units
No limit. Depends on design.

3.3  Product height range
As the system is a stacked barrier system, the height can be variable. Height depends on the individual project.

3.4  Flexibility with regard to angles in horizontal plane
No information was submitted about curves, arcs and corners. As the system is based on straight profiles the system can only account for changes in direction through the construction of angled mounting sections.

3.5  Number of vertical joints/sealings (per unit/unit width)
Four (based on a system 100 m long and 1 m high)

3.6  Number of horizontal joints/sealings (per unit/unit width)
None (based on a system 100 m long and 1 m high)
3.7 **Width of structure at base**

0.3 m (installation plate)

4 **Structural aspects**

4.1 **Likely modes of failure**
No information has been provided about possible failures. As the system is based on a panel barrier approach, its fixings and design mean it should not slide, roll or overturn. The system could possibly experience some seepage. The height of the stanchions can be increased in height during service and should be such as to prevent overtopping. The risk of bearing capacity failure depends on the foundation design.

4.2 **Maximum design head of water**
Depends on individual project requirements.

4.3 **Behaviour subject to seepage**
Differences in terrain and circumstances make it difficult to give a precise statement about seepage. Reports from existing systems and tests suggest:

- Seepage over 2 hours = 0.11 litres/m
- Seepage over 2 to 24 hours = 0.51 litres/m
- Seepage over 1 to 14 days = 0.51 litre/m

Blobel guarantees that seepage will remain below the guidelines of the LGA-Baumusterprüfung (the trade supervision department of Bavaria) and that maximum seepage will not exceed 1 litre/m/day.

4.4 **Behaviour subject to breach (breach growth)**
Although no test information is available, breach is not expected to grow with this system.

4.5 **Increase protection height during service**
Not possible with the standard system. The system needs to be designed specifically to accommodate this.

4.6 **Resistance to damage/repair during service conditions**
Due to the materials used, the system is very durable. No information was submitted about repair during service conditions.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
Erection of a 330 m barrier in difficult conditions to a height of 1 m can be achieved in 4 hours by a team of six people using two forklifts.

5.2 **Method of installation (including site preparation)**
Manual. Lifting equipment is required to transport some plant to the deployment site.

5.3 **Likelihood of incorrect installation**
The design of every column and double column in a continuous flood barrier is the same, making them interchangeable. If possible, every unit section is the same length. These factors reduce the possibility of incorrect installation.

5.4 **Storage and transportation requirements (including mobilisation)**
Storage areas need to be accessible by forklifts and lorries. For easy deployment, Blobel recommends that the equipment is stored in lattice boxes and on pallets. Forklifts, small trucks and lorries are best for transporting the system. The site should be assessed with regard to transportation and access. Access requirements are usually established with the client and controlled by staff in charge of the deployment.

5.5 **Adaptability to terrain conditions**
The system is suitable for hard and flat surfaces such as walls or concrete.

5.6 ** Provision of fixings/susceptibility to damage or vandalism**
Seals can be damaged or removed if not stored in a safe place. Pressure screws or Tommy screws can be removed.
5.7 **Possible locations of use**  
Blobel states that the system can be used at all locations with the exception of those that may be subject to extreme wave action. The Blobel system is capable of handling ‘normal waves’ along rivers or banks. It is ideal for blocking gaps in defences.

6 **Financial aspects**

6.1 **Maintenance/reuse/durability**  
The Blobel system is designed for reuse and is easy to clean with water. The company recommends that the system is maintained twice a year, but maintenance depends on how often the system is in operation. Proper storage, lubrication of all moving parts and checks on the function of pressure levers, thread connections, mounting brackets and seals are all essential.

6.2 **Installation costs (100 m long x 1 m high – excluding resources)**  
Material cost for all components = DM114,000 (excluding tax but including delivery to the border and packaging)  
Fitting costs = DM10,000

6.3 **Installation resource requirements**  
Blobel recommends a minimum of two people for all types of installations. For the stated size (100 m x 1 m), the system can be deployed by two people with one forklift or truck.

6.4 **Additional installation and removal costs (training/supervision)**  
The product costs do not include training or deployment costs.

7 **Other**

7.1 **Aesthetic aspects**  
Ten years of experience has allowed Blobel to learn how to minimise the impact of its systems.

7.2 **Test information**  
No test information is currently available in English. However, extensive tests have been carried out.

7.3 **Performance under service conditions**  
The system performs well under service conditions with a small amount of seepage.

7.4 **Environmental aspects**  
No environmental impact study has been conducted on the Blobel system. The system is sturdy and well-finished.

7.5 **Additional comments**  
This is just one of Blobel’s flood protection systems, most of which are based on this core system. Blobel also offers flood gates, door barriers and drain covers.
1  Product name and manufacturer details

Continuous Berm

MBW (UK) Ltd
Unit 6, Bradley Fold Trading Estate, Radcliffe Moor Road, Bolton BL2 6RT
Tel: 01204 387784
E-mail: mbwuk@btinternet.com
http://www.mbw.com
Greig Sandiford

2  Diagram and general description

2.1 General description
The Continuous Berm is constructed using a designated machine that extrudes a fabric-encapsulated 0.3 m x 0.3 m continuous berm of sand, rock or native soil. By choosing an appropriate geosynthetic fabric, the berm can be designed to filter or contain run-off flows. It is rated as 95% effective in removing sediment. The berms can also be cut into sections and stacked as a replacement for sandbags.

3  Available sizes/dimensions

3.1 Length per unit
Continuous. The length is determined by the length of geosynthetic fabric on the roll.

3.2 Maximum number of coupled units
No limit

3.3 Product height range
Up to 0.3 m. The system is specifically for the containment and filtering of run-off.

3.4 Flexibility with regard to angles in horizontal plane
The continuous berm machine can be used for arcs and curves. Corners can also be created.

3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
One seal along the top edge, which is stapled.

3.7 Width of structure at base
0.3 m
4 Structural aspects

4.1 Likely modes of failure
MBW has not specified modes of failure. However, the construction of the berm and its low height make overtopping, rolling and seepage the most likely modes.

4.2 Maximum design head of water
300 mm. This is higher if the berms are stacked.

4.3 Behaviour subject to seepage
The amount of seepage depends on the infill and geosynthetic used for the berm. It can therefore be used to dam and direct run-off flows. Seepage does not affect the stability of the structures.

4.4 Behaviour subject to breach (breach growth)
The berm is continuous and should not breach. Breach growth is unlikely.

4.5 Increase protection height during service
Protection height can be increased during service conditions by stacking.

4.6 Resistance to damage/repair during service conditions
The geosynthetic fabric is robust, but damage could occur. Repair is not possible in service conditions; however, replacement lengths of berm can be placed at the site of the damage.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
Two or three people can install a berm 0.3 m high over a 100 m length in 20 minutes.

5.2 Method of installation (including site preparation)
The continuous berm machine is towed behind a small tractor or a 4x4 vehicle. Some manual assistance is required.

5.3 Likelihood of incorrect installation
MBW has not given any information about the likelihood of incorrect installation. However, the process is simple and requires little manual deployment.

5.4 Storage and transportation requirements (including mobilisation)
The continuous berm machine is small enough to be transported to the site on a trailer or by a flatback truck. The machine does not need any special storage. The geosynthetic fabric should be stored under cover.

5.5 Adaptability to terrain conditions
MBW states that the continuous berm machine is adaptable to all flat terrain conditions. However, the type of surface dictates how much seepage will occur as this is linked to the berm’s seal with the ground surface.

5.6 Provision of fixings/susceptibility to damage or vandalism
The berm is temporary and thus requires no fixings. The berm is susceptible to vandalism, but sections can be replaced after damage.

5.7 Possible locations of use
MBW claims that the continuous berm is suitable for all locations with the exception of small specific openings.

6 Financial aspects

6.1 Maintenance/reuse/durability
No maintenance is required. The geosynthetic fabric is not reusable; the berm’s deterioration depends on the geosynthetic fabric used in its construction.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
The berm costs approximately $5 per metre. Therefore, a length of 100 m is likely to cost $500 (but this is only to a height of 0.3 m).
6.3 **Installation resource requirements**

A team of two or three people, a vehicle to tow the berm-making machine and aggregate to fill the berm.

6.4 **Additional installation and removal costs (training/supervision)**

Replacement geosynthetic fabric. There are no additional training or installation costs.

7 **Other**

7.1 **Aesthetic aspects**

Unlike sand bags, the berms are continuous and tidy. The low height of the berms makes them less noticeable.

7.2 **Test information**

Good results have been obtained in extensive tests with the continuous berm machine in Colorado, Tennessee and California. These tests also identified alternative uses such as sediment traps, check structures and inlet filters.

7.3 **Performance under service conditions**

The berm performs well under a range of service conditions, but only to a low head of water.

7.4 **Environmental aspects**

The berms are removable and the fill material can be incorporated into the surrounding soil.

7.5 **Additional comments**

The system is not designed to control floodwaters, but may be useful for directing run-off waters away from low-lying areas where localised flooding may occur.
Fact sheet for Dura-Bull Barricade
Generic group: filled container – impermeable

1 Product name and manufacturer details

Dura-Bull Barricade

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Fax: (+1) 260 459 0920
http://www.soacorp.com/cbp
Mr J C Brown (sales)

2 Diagram and general description

2.1 General description
The Dura-Bull Barricade system consists of hollow plastic units that can be filled with water or sand. The units are constructed from recycled polyethylene and are UV-protected. They have two 100 mm fill holes in the top and two 25 mm drain holes underneath. The unit has a non-slip bottom surface. The Dura-Bull Barricade was originally designed as a protection or security barrier and, as such, Creative Building Products has no test data on the system’s performance in terms of flood protection.

3 Available sizes/dimensions

3.1 Length per unit
1.2 m, 1.8 m, 2.4 m and 3.0 m

3.2 Maximum number of coupled units
As necessary

3.3 Product height range
Barricades are 0.6 – 1.35 m in height. Stacking of units is possible.

3.4 Flexibility with regard to angles in horizontal plane
Limited flexibility. Corners are possible, but not arcs.

3.5 Number of vertical joints/sealings (per unit/unit width)
Two

3.6 Number of horizontal joints/sealings (per unit/unit width)
None

3.7 Width of structure at base
0.8 m. This is wider if stacking occurs.
4 Structural aspects

4.1 Likely modes of failure
Overtopping and seepage are possible modes of failure for the Dura-Bull Barricade system.

4.2 Maximum design head of water
1.2 m

4.3 Behaviour subject to seepage
Seepage occurs through the Dura-Bull Barricade system. In some cases, pumping is necessary to keep the landward side dry.

4.4 Behaviour subject to breach (breach growth)
Creative Building Products has no data on the system’s potential for flood conditions. Due to its construction, a breach is not expected to deteriorate into a complete system failure.

4.5 Increase protection height during service
It is possible to stack the Dura-Bull Barricade during service conditions.

4.6 Resistance to damage/repair during service conditions
The barricades are tough and difficult to damage. They can be repaired during service conditions and are not readily susceptible to vandalism.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
Approximately 40 minutes

5.2 Method of installation (including site preparation)
Manual. The barricades should be installed before loading with the preferred material.

5.3 Likelihood of incorrect installation
Low. Simple to install.

5.4 Storage and transportation requirements (including mobilisation)
Storage is needed for the barricades. Creative Building Products has not specified any storage requirements. A lorry/truck is needed to transport the barricades to the deployment site. If not available on-site, the aggregate also requires transportation.

5.5 Adaptability to terrain conditions
The system is suitable for use on relatively flat surfaces.

5.6 Provision of fixings/susceptibility to damage or vandalism
The system is temporary and therefore no fixings are required.

5.7 Possible locations of use
These include: second line protection; an enclosure around a property; access locations; and bank tops on a fluvial watercourse.

6 Financial aspects

6.1 Maintenance/reuse/durability
The Dura-Bull Barricade is low maintenance, requiring only simple cleaning. The barricade is totally reusable. Creative Building Products quotes a 10-year service life.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
Approximately $13,000

6.3 Installation resource requirements
The above installation requires a minimum of four people and a pump (if water-filled). Vehicles are needed to transport the barricades to the site.
6.4 Additional installation and removal costs (training/supervision)
The product includes operational instruction. If not using water from the site, the provision of aggregate may be an additional cost.

7 Other

7.1 Aesthetic aspects
Construction is neat. Uses local materials and the aggregate is contained within blocks.

7.2 Test information
The Dura-Bull Barricade was designed originally as a protection or security barrier, and Creative Building Products has no data on the system's capabilities in flood conditions.

7.3 Performance under service conditions
No data

7.4 Environmental aspects
Good. The system uses local materials and sand (if employed), which is contained within the blocks. Construction is neat. The blocks can also be produced in safety yellow and olive drab. The system is made from recycled plastic.

7.5 Additional comments
Due to the rigidity of the structure, end jointing details and seepage control at the connections of units and the underlying surface are potential issues.
1 **Product name and manufacturer details**

**Dutchdam**

Dutchdam BV
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E-mail: Rijlaarsdam@run-mate.com
http://www.dutchdam.com or www.standbydam.com
Corné Rijlaarsdam

2 **Diagram and general description**

2.1 **General description**

Dutchdam is a folding aluminium flood protection system, which is stored at its location by folding it down into its own case. There are two different models. The first is a wall or quay version that can protect up to the height of 1.0 m. The second is a ground version contained within its own concrete housing and foundation, and which can be installed independently in the subsoil to a height of 1.5 m.

3 **Available sizes/dimensions**

3.1 **Length per unit**

6.0 m per casing unit and 3.0 m per flood barrier element

3.2 **Maximum number of coupled units**

No limit or as needed

3.3 **Product height range**

0.6 m, 0.8 m, 1.0 m, 1.25 m and 1.5 m. Higher versions are planned.

3.4 **Flexibility with regard to angles in horizontal plane**

Dutchdam is currently designing sections, which will accommodate corners and curves.

3.5 **Number of vertical joints/sealings (per unit/unit width)**

One per 3.0 m length

3.6 **Number of horizontal joints/sealings (per unit/unit width)**

Two per 3.0 m length
3.7 Width of structure at base
0.3–0.8m

4 Structural aspects

4.1 Likely modes of failure
As the barrier cannot be increased in height during service conditions, overtopping is the most likely mode of failure.

4.2 Maximum design head of water
Currently 1.0 m and 1.5 m for the wall/quay and ground versions, respectively.

4.3 Behaviour subject to seepage
Dutchdam states that the system will remain watertight and pumping on the landward side of the barrier should not be necessary.

4.4 Behaviour subject to breach (breach growth)
Dutchdam states that the system will not worsen progressively if damaged, as the construction is durable and stable due to its design.

4.5 Increase protection height during service
No. Protection heights are standard.

4.6 Resistance to damage/repair during service conditions
The system is not susceptible to vandalism, as the whole system is self-contained and stored underground. The strong materials used in its construction limit the potential for damage. If damage does occur, Dutchdam states that repairs during service conditions can be undertaken.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
A team of two people can set up the Dutchdam in approximately 3–4 hours.

5.2 Method of installation (including site preparation)
Once the Dutchdam is fully installed, the barrier is erected manually and does not require additional materials. Mechanical aids are available. There is no site preparation apart from the initial construction of the installation.

5.3 Likelihood of incorrect installation
Incorrect deployment is not possible due to its simple design. Construction is monitored and checked throughout.

5.4 Storage and transportation requirements (including mobilisation)
None. Once the barrier is in place, there are no transport, mobilisation or storage requirements.

5.5 Adaptability to terrain conditions
Dutchdam states that the system is suitable for all surfaces. The type of Dutchdam used depends on the location of the site.

5.6 Provision of fixings/susceptibility to damage or vandalism
As the system is stored completely in situ, there are no fixings to consider. The system is protected from tampering and vandalism by being contained within its own housing.

5.7 Possible locations of use
Dutchdam is suitable for use in all locations, including banks with some wave action (Dutchdam has calculated that the top 0.4 m section can cope with 10 times the hydrostatic pressure). It can also be used as an enclosure around properties and for access locations.
6 Financial aspects

6.1 Maintenance/reuse/durability
Regular physical inspection is required. The Dutchdam system is durable and easy to clean. It has a service life of up to 50 years or more and can be used as often as necessary. The system should be inspected for damage after the flood has subsided.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
For the wall/quay version, the cost of the housing plus the actual flood barrier (including trusses) is €800/m – therefore the cost is €80,000 for 100 m.

6.3 Installation resource requirements
Following initial installation, erection is manual. The only additional requirement is a hand tool for unlocking the cover of the barrier housing.

6.4 Additional installation and removal costs (training/supervision)
None. Its simplicity means that training is not required.

7 Other

7.1 Aesthetic aspects
The barrier is modern in design and is stored totally in its own housing. It therefore has little or no impact on the surrounding area. The design can be adapted to suit aesthetic requirements.

7.2 Test information
Extensive testing is currently being carried out and a full test report should be available by the end of 2002. Development tests and calculations have been carried out. Calculations for inertia forces and water pressure have been made.

7.3 Performance under service conditions
Tests are planned during 2002.

7.4 Environmental aspects
Minimal environmental impact, with no pollution or cosmetic damage to the environment.

7.5 Additional comments
Dutchdam has demonstration units. The Dutchdam is patented in The Netherlands (NL1017109) and international patents have been applied for.
Fact sheet for Ferndon flood gates
Generic group: flood barrier – rigid

1  Product name and manufacturer details

Ferndon flood gate

Elkosta (UK) Ltd
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http: www.elkosta.co.uk
Rodney Coate

2  Diagram and general description

2.1  General description

Ferndon Projects specialises in perimeter security and constructs various types of flood gates. The company produces three main types of flood gate – the horizontal sliding gate, the horizontal hinged gate and the vertical lifting/lowering gate. All gates are purpose-designed and built to suit specific requirements and installation restrictions. A full design, manufacture and installation service is available. The sliding gates can be used to close off access locations and can be powered or manual. When the gate is closed, it engages into a receiving post with side seals and is lowered into a sealing strip to give a watertight seal. The horizontally hinged gate works in the same way as conventional canal or river lock gates. The gates open towards the water and close to form a “V” – the pressure of the water helps seal the gates. Lifting/lowering gates are stored in recesses either overhead (lowering) or underground (lifting). All drive mechanisms are either electromechanical or electrohydraulic. All drive components are installed away from possible water contamination.

3  Available sizes/dimensions

3.1  Length per unit
Variable depending on client/project requirements

3.2  Maximum number of coupled units
One

3.3  Product height range
Variable depending on client/project requirements

3.4  Flexibility with regard to angles in horizontal plane
Single gates are produced so curves and arcs are not necessary.

3.5  Number of vertical joints/sealings (per unit/unit width)
One in the hinged gate
None for the other designs
Fact sheet for Ferndon flood gates
Generic group: flood barrier – rigid

3.6 Number of horizontal joints/sealings (per unit/unit width)
None

3.7 Width of structure at base
Variable depending on client/project requirements

4 Structural aspects

4.1 Likely modes of failure
Overtopping and seepage are likely failure modes for these systems.

4.2 Maximum design head of water
Variable depending on client/project requirements

4.3 Behaviour subject to seepage
Pumping is not required to keep the landward side dry, although some seepage does occur. The gates themselves are watertight.

4.4 Behaviour subject to breach (breach growth)
The manufacturer had no information on breach, but this product is not expected to be susceptible to breach growth.

4.5 Increase protection height during service
Yes. No details were submitted.

4.6 Resistance to damage/repair during service conditions
The gates are reasonably substantial and are therefore expected to withstand impact. However, this point has not been tested.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
Deployment takes a matter of minutes.

5.2 Method of installation (including site preparation)
Manually or power operated depending on client requirements.

5.3 Likelihood of incorrect installation
Once installed, the gates operate automatically.

5.4 Storage and transportation requirements (including mobilisation)
Gates are stored within housings either to the side, above or below the openings.

5.5 Adaptability to terrain conditions
The gates require hard surfaces for installation and housings to be enclosed within walls.

5.6 Provision of fixings/susceptibility to damage or vandalism
EiKosta states that it has not been supplying the product long enough to comment. Due to access to the parts, vandalism could be an issue but the metallic construction should limit the potential damage.

5.7 Possible locations of use
Access locations are the ideal locations for these products. They are not suitable for long lengths of protection.

6 Financial aspects

6.1 Maintenance/reuse/durability
Six monthly checks

6.2 Installation costs (100 m long x 1 m high – excluding resources)
No data was submitted.

6.3 Installation resource requirements
No data was submitted.
6.4 Additional installation and removal costs (training/supervision)
Costs include training. No additional costs associated with its operation.

7 Other

7.1 Aesthetic aspects
The gates are sturdy and have a polished or ‘warning’ finish.

7.2 Test information
No data was submitted

7.3 Performance under service conditions
No data was submitted

7.4 Environmental aspects
No data was submitted.

7.5 Additional comments
Fact sheet for Flood Guard and Flood Dam K
Generic group: panel barrier

1  Product name and manufacturer details

Flood Guard and Flood Dam K

Flood Control Limited
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Tel: 01822 832385
E-mail: John.scoot@floodcontrol.co.uk or sales@floodcontrol.co.uk
http://www.floodcontrol.co.uk
John Scoot

Flood Guard and Flood Dam K (high water dyke system ESH/K)

RS Stepanek OHG (supplier)
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E-mail: vertrieb@RS-Stepanek.de
http://www.rs-stepanek.de

2  Diagram and general description

2.1  General description
Flood Control Limited produces a range of panel barriers of varying sizes. The two most relevant to this study are Flood Guard (left hand photograph) and Flood Dam K (middle and right-hand photographs). Flood Guard and Flood Dam K are modular panel barriers fabricated from construction-grade aluminium, which is installed into galvanised steel stanchions. They are heavy duty systems capable of withstanding adverse flood conditions. They can be configured to provide totally stand-alone barriers of any length and to heights of 3 m for Flood Guard and over 5 m for Flood Dam K. The barriers can be incorporated into concrete protection structures or used to increase the height of existing protection. Ethylene-propylene diene monomer (EPDM) rubber seals are used to create a watertight seal between the panels and stanchions. A locking device at the top of the panels provides added pressure, which enhances sealing.

3  Available sizes/dimensions

3.1  Length per unit
Length of units is variable, but for practical purposes is limited to 6.5 m per unit.
3.2 Maximum number of coupled units
   No limit
3.3 Product height range
   Variable depending on protection requirements. Maximum available heights are 3.0 m for Flood Guard and 5.0 m for Flood Dam K. The height of individual panels is 200 mm for Flood Guard and 300 mm for Flood Dam K.
3.4 Flexibility with regard to angles in horizontal plane
   All curves, arcs and corners are configurable.
3.5 Number of vertical joints/sealings (per unit/unit width)
   None
3.6 Number of horizontal joints/sealings (per unit/unit width)
   Depends on height of barrier.
3.7 Width of structure at base
   Flood Guard: barrier 57 mm and channel 120 mm
   Flood Dam K: barrier 100 mm and channel 160 mm

4 Structural aspects

4.1 Likely modes of failure
   Overtopping in extreme conditions or foundation failure could lead to system failure.
4.2 Maximum design head of water
   3.0 m for Flood Guard and 5.0 m for Flood Dam K.
4.3 Behaviour subject to seepage
   Flood Guard and Flood Dam K are watertight above formation level and require no pumping on the landward side of the barrier.
4.4 Behaviour subject to breach (breach growth)
   The systems do not worsen progressively and can be repaired during service conditions.
4.5 Increase protection height during service
   The barrier heights can be raised during service in increments of 600 mm using a locking point/flange mechanism.
   The extra pressure from the locking mechanism is not available during this process but this is compensated for by the weight of floodwater already within the lower parts of the system.
4.6 Resistance to damage/repair during service conditions
   The system is robust and can be repaired during service conditions.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
   For Flood Dam K, installation takes one person two hours and four people 30 minutes. Installation of Flood Guard is slightly quicker, as each panel section is only 300 mm high.
5.2 Method of installation (including site preparation)
   Manual – although mounting brackets (ground plates) have to be constructed before service.
5.3 Likelihood of incorrect installation
   All sections are modular and interchangeable, thus reducing the possibility of incorrect installation.
5.4 Storage and transportation requirements (including mobilisation)
   Wall-hung storage racks are supplied. Their modular design makes the systems easy to transport. Vans or lorries are required depending on the size of the barrier to be deployed.
5.5 Adaptability to terrain conditions
   The systems require hard, flat surfaces to ensure a watertight seal is maintained.
5.6 Provision of fixings/susceptibility to damage or vandalism
The systems should be stored somewhere secure, but all the components are of construction-grade material and very durable. Demountable fixings are covered to prevent damage.

5.7 Possible locations of use
The systems are suitable for all locations, but they are too large to apply to domestic properties.

6 Financial aspects

6.1 Maintenance/reuse/durability
The systems are totally reusable and the main parts require no ongoing maintenance. Damaged seals may need to be replaced periodically. The choice of materials means that there is no appreciable deterioration over 10–15 years. The systems are easy to clean with high pressure or normal water hoses.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
No cost has been supplied as the system is costed per project.

6.3 Installation resource requirements
Minimum requirement of one person

6.4 Additional installation and removal costs (training/supervision)
There are no additional costs, although the system does not include the cost of training.

7 Other

7.1 Aesthetic aspects
All components except the ground plates are totally removable with minimum visual impact. The materials have a high quality finish.

7.2 Test information
No test results were submitted

7.3 Performance under service conditions
Used by Conwy County Council Structures Group to dam a culvert. Other reference sites are available on request.

7.4 Environmental aspects
The system has no known environmental impact.

7.5 Additional comments
Watertight gates can be incorporated within some systems enabling access once deployed until the critical flood level is reached. Flood Guard and Flood Dam K are two of the many systems available from Flood Control Limited and RS Stepanek. Other designs include property protection for domestic and commercial buildings, and gates and shutters for specific openings that do not require the level of engineering found in Flood Dam and Flood Dam K.
Fact sheet for the FloodMaster™ barrier
Generic group: air and water filled tube

1 Product name and manufacturer details

FloodMaster™ barrier

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Euro Consultancy and Marketing Corporation (ECMC) (UK supplier)
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Tel: 01784 431186
Tel: 07977 444440 (mobile)
E-mail: hgervais@floodmaster.ca
http://www.floodmaster.ca
Humphrey Gervais

2 Diagram and general description

2.1 General description
The FloodMaster™ barrier offers an environmentally friendly and economically viable alternative to sandbags. The system consists of a number of elliptically shaped barriers, which are stacked and staggered forming a pyramid-type construction. A proprietary thermoplastic composite material, which is 100% recyclable, is used to make the barriers. Once filled with floodwater or water from conventional sources, the structure creates an impermeable wall of up to 2.70 m. The system provides greater ground friction protection from lateral floodwater pressure than sandbags. Each 15 m section weighs more than 140 tonnes when it is stacked, staggered, harnessed and anchored to adjoining barriers.

3 Available sizes/dimensions

3.1 Length per unit
Currently available in 15 m lengths

3.2 Maximum number of coupled units
No limit. Units are coupled together by means of a sleeve into which the barrier tubes are inserted prior to filling.
Fact sheet for the FloodMaster™ barrier
Generic group: air and water filled tube

3.3 **Product height range**
Heights of 1.07 m, 2.09 m and 2.7 m are possible for the one, two and three layer systems, respectively. These provide protection against a maximum of 0.61 m, 1.22 m and 1.65 m, respectively.

3.4 **Flexibility with regard to angles in horizontal plane**
Due to the independent harnessing of the units to each other, various geometric configurations can be built in addition to standard linear and 90° corners.

3.5 **Number of vertical joints/sealings (per unit/unit width)**
For the single layer system, the only sealing is with the bedding surface. For two-layer system, there is a joint between the first and second layer. For the three-layer system, there are two joints (between each layer).

3.6 **Number of horizontal joints/sealings (per unit/unit width)**
None

3.7 **Width of structure at base**
FloodMaster™ barriers are always deployed by placing three staggered and parallel units side-by-side. The width of the unit varies from 1.52 m to 3.43 m, making the width of the placed barriers 4.56–10.29 m.

4 **Structural aspects**

4.1 **Likely modes of failure**
Failure of the structure may occur if the magnitude of the flood is very much greater than anticipated and is likely to be by sliding. The weight of each water-filled barrier and that of adjoining units creates the mass and stability required to resist lateral floodwater pressures up to 1.65 m.

4.2 **Maximum design head of water**
1.65 m

4.3 **Behaviour subject to seepage**
The proprietary thermoplastic composite material used to construct the FloodMaster™ barrier is impermeable. The manufacturer claims that the structure is waterproof and that seepage is not an issue. ‘Boil’ (the erosion of ground caused by floodwater currents underneath the structure) is also not a factor due to the width and weight of the structure. However, care and attention has to be given to the soil type. FloodMaster do not recommend using its barrier system at a location where a sand bag barrier would not be installed.

4.4 **Behaviour subject to breach (breach growth)**
The FloodMaster™ barrier has been designed to withstand severe impact and damage from floating debris. In the unlikely event of a breach due to a puncture of an outer bag, the structure would retain its integrity because (in a full-size structure) there are two additional FloodMaster™ bags in the base layer and an additional bag in the second layer. Since each bag is self-contained and harnessed individually, breach growth is highly unlikely.

4.5 **Increase protection height during service**
When floodwaters reach higher levels than expected, additional units can be quickly attached in situ up to the maximum structure height of three levels (2.70 m).

4.6 **Resistance to damage/repair during service conditions**
FloodMaster™ barriers are made of an inherently flexible material, which is resistant to impact, abrasion, puncture, tear and tensile stress. The patented thermoplastic composite material used in its manufacture can be heat-welded on-site using a portable thermoplastic heat-welder. The resultant repair is homogeneous with the original material.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
Assuming no extraordinary ground preparation is needed, a 1.07 m high system can be installed by eight people in 30 hours. This includes laying the groundsheet, putting the straps and empty barriers in place, filling bags, strapping and anchoring.
5.2 Method of installation (including site preparation)
The terrain needs to be reasonably flat, so a mechanical digger may be required. The first step is to lay a
groundsheet, position the straps and anchor devices, and lay the barriers on the ground according to the planned
configuration. Each barrier is then filled with water in a stacked and staggered configuration. Once filled, the barrier
units are harnessed and anchored to the ground. Once the floodwaters have receded, retrieval of the barriers and
clean-up of the site are simple, economical and efficient. In some cases, the barriers can be cleaned and stored for
further use.

5.3 Likelihood of incorrect installation
A team of eight people with about 4 hours of on-site training can readily assemble the structure. Use of the correct
welding procedure requires a longer training period. Components are few (groundsheet, bag, strap and anchor) and
of a simple design.

5.4 Storage and transportation requirements (including mobilisation)
Units ship flat in appropriate cylinder containers for easy handling. These containers come in a variety of sizes
depending on the quantity ordered and their size. FloodMaster recommends that the barrier units are stored under
cover. Units can be transported using transit vans or lorries (depending on the unit size and length of protection).

5.5 Adaptability to terrain conditions
The terrain needs to be reasonably flat although the inherent flexibility of the unit allows it to conform to the contour of
the terrain (also making it difficult to dislodge). Sleeving allows adjacent units to ‘hinge’ to accommodate sloping or
undulating terrain.

5.6 Provision of fixings/susceptibility to damage or vandalism
The base layer is anchored with a ground rod 5 mm thick and 1.52 m long. The anchors are turned in via a
turbuckle. The harness material is steel-belted and the proprietary thermoplastic composite material used to
manufacture the FloodMaster™ barrier is resistant to impact, abrasion, puncture and tearing. Nevertheless, a
determined vandal would be able to damage the structure.

5.7 Possible locations of use
FloodMaster™ barriers can be used wherever a sand bag barrier would be deployed. They can be used as a first or
second line of protection and for blocking accesses not less than 15m wide.

6 Financial aspects

6.1 Maintenance/reuse/durability
Once the structure is in place, it is virtually maintenance-free. Once the floodwaters have receded, retrieval and
clean-up are simple, economical and efficient operations. The barriers can be emptied, cut into smaller pieces and
returned for recycling. FloodMaster™ barriers are both disposable and recyclable. In certain circumstances, the
barriers can be emptied, cleaned, repaired, inspected and folded for reuse as a secondary or third line of protection in
subsequent floods. As they contain no plasticisers or additives, the barriers will not lose flexibility due to the loss of
additives over time. They also tend to be resistant to rodents and micro-organisms.

6.2 Installation costs (100 m long x 1 m high– excluding resources)
$99,933 (for the 1.07 m high system)

6.3 Installation resource requirements
The minimum number of people required is eight. They do not need specialised skills. One person needs to be able
to operate the thermal welding apparatus and another to operate the pumping equipment. Both activities require
moderate skill.

6.4 Additional installation and removal costs (training/supervision)
FloodMaster provides clients with training free of charge at its facilities in Toronto, Canada and /or at its secondary
site in Grand Prairie, Texas. Clients pay for their travel, accommodation and meals. Training at the client’s site is
provided in accordance with FloodMaster’s published daily rates.
7 Other

7.1 Aesthetic aspects
Once in place, the sheer size of the FloodMaster™ barrier makes it an impressive and substantial structure. Installation is neat and clean. The product is available in either black or white.

7.2 Test information
FloodMaster™ barriers have been tested under laboratory and simulated flood conditions, as well as at a number of live flood conditions in different parts of the world. These tests met and exceeded all pre-set parameters. FloodMaster has also tested all components to ensure product integrity.

7.3 Performance under service conditions
FloodMaster™ barriers were installed and remained in place for an entire flood season at Ayutthaya City, a UNESCO world heritage site in Thailand. During this time, the barriers successfully withstood five severe floods. The tests encompassed multiple installations and sites within Ayutthaya.

7.4 Environmental aspects
The FloodMaster™ barrier uses water to fight water and is made from a 100% recyclable thermoplastic material. FloodMaster Barriers Inc. is a recognised and registered licensee of Environment Canada’s Environmental Choice Program (ECP) and its ‘EcoLogo’. To obtain the EcoLogo, a product or service must provide significant environmental benefits and meet or exceed any applicable industry specific safety and performance standards.

7.5 Additional comments
The FloodMaster™ barrier can be customised both in the factory and at the deployment site. Depending on the application, topology conditions, gradients and soil type, FloodMaster can also provide custom-ordered lengths and diameters. As well as temporary flood protection, the FloodMaster™ barrier can also be used to contain chemical spills, collect potable water or temporarily redirect water during land reclamation projects.
1  Product name and manufacturer details

Hesco Concertainer Bastion

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E-mail: hescob@aol.com
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Kevin Hardy

Profile Technologies Ltd (supplier in Hereford and Worcestershire areas only)
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E-mail: info@proiletechnologies.co.uk
http://www.proiletechnologies.co.uk
Brian Jackson

2  Diagram and general description

2.1 General description
The Concertainer Bastion consists of a series of welded mesh panels connected vertically with wire coil spirals to form a series of fully collapsible multi-cellular units. These units are lined with a non-woven geotextile. Units are joined quickly and easily with vertical steel pins. The units are then filled with sand or a sand/gravel mix, either manually or using a JCB or a cement wagon. The Bastions are constructed from a Bezina-coated welded mesh. The geotextile is a 200 g/m² robust reusable liner available in grey, sand or green.

3  Available sizes/dimensions

3.1 Length per unit
1.2–10.0 m long x 0.6–2.0 m high x 0.3–2.0 m wide

3.2 Maximum number of coupled units
No limit

3.3 Product height range
0.6–2.0 m. Can be stacked ‘pyramid style’ to increase height.

3.4 Flexibility with regard to angles in horizontal plane
Units can be curved or joined at right angles. They are very flexible and strong.

3.5 Number of vertical joints/sealings (per unit/unit width)
None
Fact sheet for Hesco Concertainer Bastion
Generic group: filled container – permeable

3.6 Number of horizontal joints/sealings (per unit/unit width)
   None

3.7 Width of structure at base
   0.3–2.0m depending on single unit size

4 Structural aspects

4.1 Likely modes of failure
   Hesco Bastion states that seepage and overtopping are the likely forms of failure.

4.2 Maximum design head of water
   Tested up to 3.0 m depth (stacked pyramid style).

4.3 Behaviour subject to seepage
   Minimal seepage occurs from onset of floodwater. This is expected to worsen progressively over time as the soil becomes saturated. Pumping should only be required to keep the landward side dry in extreme conditions. Hesco Bastion advises laying a non-permeable membrane over the system to prevent seepage through the system.

4.4 Behaviour subject to breach (breach growth)
   Due to its continuous construction, Hesco Bastion believes that the concertainer should not breach or worsen progressively during service conditions.

4.5 Increase protection height during service
   Additional units can be placed and filled behind and on top of existing units to increase the width and height of the barrier.

4.6 Resistance to damage/repair during service conditions
   Resistant to waves and floating debris. Vandalism has no serious impact on the Concertainer Bastion. The system can be repaired during service conditions.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
   3 hours and 20 minutes with two people and a mechanical filling machine

5.2 Method of installation (including site preparation)
   Construction is manual. Mechanical filling plant can be used to fill the concertainer. This reduces the time for deployment.

5.3 Likelihood of incorrect installation
   The system is simple to construct. Hesco Bastion provides installation guides and offers training. Profile Technologies Ltd (a supplier) also offers the option of labour under contract for deployment.

5.4 Storage and transportation requirements (including mobilisation)
   Lorry access is necessary to move larger units to site or to transport infill soil if not present on-site. The concertainers can be stored on pallets 1.0–1.3 m long x 1.0–1.4 m wide x 1.8 m high. A pallet contains 70–140 m of concertainer units.

5.5 Adaptability to terrain conditions
   The concertainer can be deployed on any surface with the exception of the top of flood walls where its use is limited by the width of the wall.

5.6 Provision of fixings/susceptibility to damage or vandalism
   The Concertainer Bastion is a temporary system and therefore there are no permanent fixings.

5.7 Possible locations of use
   The concertainer can be deployed on banks (fluvial watercourses and reservoirs), and will withstand some wave activity. It can also be deployed as a second line of protection, as an enclosure around property and to close access locations.
6 Financial aspects

6.1 Maintenance/reuse/durability
The units need to be hosed down after use before being stored. The system is totally reusable. Due to their Bezinal coating, the steel components should last up to 30 years; the geotextile should last up to 10 years in temporary use.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
Depends on the size of concertainer used and excluding the cost of infill, cost is typically £3,500.

6.3 Installation resource requirements
A lorry is needed to transport the containers to the site and a lorry of aggregate is required to fill the containers. A team of two to three people is required to deploy the system.

6.4 Additional installation and removal costs (training/supervision)
Cost of infill and transport to site

7 Other

7.1 Aesthetic aspects
Construction is neat. It uses local materials and the aggregate is contained.

7.2 Test information
Successful trials were carried out by the Agency in 1998 on the River Ouse and at its test site at Lea Marston in the West Midlands. In a comparative test, a wall 10 m long x 1 m high x 1 m wide was constructed using sand bags. This took a team of ten men 7 hours to construct using approximately 1,500 sand bags. Using a concertainer, the same wall was constructed by two men in 20 minutes. The concertainer units were lined with a waterproof membrane and seepage was considerably less than the wall constructed from sand bags.

7.3 Performance under service conditions
Video evidence of tests shows that the concertainer performs well under service conditions

7.4 Environmental aspects
Most units are fully reclaimable for reuse. Permanent units can be faced with stone or timber. Their environmental impact is low. All units can be removed and/or reclaimed. The infill can be removed either manually or mechanically.

7.5 Additional comments
A quicker, better alternative to sand bags
Fact sheet for Hydraulic Barrier
Generic group: flood barrier – rigid

1 Product name and manufacturer details

Hydraulic Barrier

Flood Control Limited
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Tel: 01822 832385
E-mail: john.scoot@floodcontrol.co.uk or sales@floodcontrol.co.uk
http://www.floodcontrol.co.uk
John Scoot

2 Diagram and general description

2.1 General description
The Hydraulic Barrier is an automatic ‘flip-up’ flood barrier which, when not in use, is fully recessed into the floor and does not restrict normal vehicular access to openings. The reinforced steel plate is raised by means of hydraulic lifts powered by a 24-volt system. This can close the barrier even if mains electricity is lost. Built-in safety mechanisms stop the progress of the barrier immediately an obstruction occurs. The barrier is available with an audible operating signal and automatic/manual barrier activation options.

3 Available sizes/dimensions

3.1 Length per unit
12.0 m maximum

3.2 Maximum number of coupled units
One

3.3 Product height range
Tailored to client’s requirements

3.4 Flexibility with regard to angles in horizontal plane
The hydraulic barrier closes access locations and is therefore does not applicable to curves or corners.

3.5 Number of vertical joints/sealings (per unit/unit width)
Two – closure against side walls

3.6 Number of horizontal joints/sealings (per unit/unit width)
One – made with the base of the construction

3.7 Width of structure at base
Depends on the client’s requirements for the height of the system (the gate lies flat when not in use).
4 Structural aspects

4.1 Likely modes of failure
The barrier is constructed into a floor recess and therefore cannot fail by rolling, sliding or overturning. As it is constructed to a specified height, overtopping is a possible form of failure if water levels are higher than expected. Failure of the lifting mechanism could cause the whole system to fail.

4.2 Maximum design head of water
Depends on client's specifications for the height of the barrier.

4.3 Behaviour subject to seepage
No details were submitted on seepage.

4.4 Behaviour subject to breach (breach growth)
The system will not worsen progressively.

4.5 Increase protection height during service
No

4.6 Resistance to damage/repair during service conditions
The barriers are constructed of reinforced steel and therefore unlikely to be damaged by debris. No details were submitted about repair in service conditions.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
Once installed, the barrier can be deployed in less than 15 minutes.

5.2 Method of installation (including site preparation)
Automatic or manual

5.3 Likelihood of incorrect installation
Once the barrier has been installed, the likelihood of incorrect installation is negligible.

5.4 Storage and transportation requirements (including mobilisation)
None

5.5 Adaptability to terrain conditions
For use within a man-made environment, on concrete surfaces and on roads.

5.6 Provision of fixings/susceptibility to damage or vandalism
No details were submitted. However, its recession into the floor when not in service should minimise the barrier’s susceptibility to vandalism.

5.7 Possible locations of use
Enclosures, access locations and specific openings. Only available to a maximum length of 12.0 m.

6 Financial aspects

6.1 Maintenance/reuse/durability
The barrier requires regular servicing due to its automatic features. It is totally reusable and durable.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
No details were submitted

6.3 Installation resource requirements
Manual installation requires one person. Alternatively, installation can be fully automatic using liquid detection, thermostatic levels, alarm systems and smoke detection.

6.4 Additional installation and removal costs (training/supervision)
None
7 Other

7.1 Aesthetic aspects
   As the barrier is housed flush to the floor, it is not visible until deployed.

7.2 Test information
   No test information was submitted.

7.3 Performance under service conditions
   The system locks due to an automatically controlled constant hydraulic pressure. The system performs well under service conditions.

7.4 Environmental aspects
   It is hidden from sight until use. The system does not pollute. It is available in a polished steel finish or in red.

7.5 Additional comments
   Flood Control Limited offers many products from flood boards, gates, barriers and pipe blockers. A completed questionnaire was not submitted for this flip-up gate and some judgements in this fact sheet were therefore made from product literature.
Fact sheet for Intovalve Stoplog removable flood barrier
Generic group: panel barrier

1  Product name and manufacturer details

Intovalve ‘Stoplog’ removable flood barrier

Intovalve Limited
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Tel: 0121 711 4911
E-mail: paul.h@intovalve.co.uk
http://www.intovalve.co.uk
Paul Higginson

2  Diagram and general description

2.1  General description

The Intovalve system consists of mild steel or aluminium stanchions with plastic, marine-grade hardwood, aluminium or steel fencing planks. The system has concealed location plates under lockable caps on the roadway. Installed onto these plates are the stanchions, which can handle planks of various materials with an average length of 2,000 mm.

3  Available sizes/dimensions

3.1  Length per unit

All installations are specifically designed for a site; therefore, lengths vary according to project requirements. The average length for planks is 2.0 m.

3.2  Maximum number of coupled units

No limit. Depends on the required protection.

3.3  Product height range

To suit location. No maximum height stated.

3.4  Flexibility with regard to angles in horizontal plane

The system can accommodate curves, arcs and corners through the use of angled, upright stanchions.

3.5  Number of vertical joints/sealings (per unit/unit width)

Two – where the planks join the upright stanchions.

3.6  Number of horizontal joints/sealings (per unit/unit width)

Depends on the size of planking and the required height of the barrier.

3.7  Width of structure at base

This depends on the height of the barrier as the higher the requirement the larger the width at the base of the structure due to angled support bars being installed for added security.
4 Structural aspects

4.1 Likely modes of failure
   Overtopping and seepage are the only perceived forms of failure for this system.

4.2 Maximum design head of water
   Depends on the location and the site-specific requirements.

4.3 Behaviour subject to seepage
   The system is liable to some seepage. However, Intovalve states that this can be adjusted depending on the
designed leakage tolerance of any project or location.

4.4 Behaviour subject to breach (breach growth)
   Breach is not considered a form of failure for this system. If a breach did occur, the system would not worsen
progressively because of the upright steel stanchions.

4.5 Increase protection height during service
   Yes – by placing more logs or panels into the stanchions.

4.6 Resistance to damage/repair during service conditions
   The system is durable and does not deteriorate with time. The seals are replaceable and mechanically fixed. The
system can be repaired during service. The system should not be susceptible to vandalism provided it is stored
securely and the covering caps are installed on the cover plates correctly.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
   Time required for deployment depends on the number of people in the team and the deployment method.

5.2 Method of installation (including site preparation)
   Manual and plant. Site preparation is required in the early stages to install the socketsthat will hold the stanchions in
place.

5.3 Likelihood of incorrect installation
   Intovalve claims that this was unlikely due to the simplicity of the system.

5.4 Storage and transportation requirements (including mobilisation)
   Stoplogs should be stored in a vertical position and the frames stored flat and covered to protect the seal faces from
contamination. The logs and frames have to be transported to the site on lorries or low loader trucks. Lifting
equipment is required to position the stoplogs in the frames.

5.5 Adaptability to terrain conditions
   The system is best suited to flat hard surfaces, although any surface can accommodate the system provided an invert
section has been fitted and the ground includes foundations to support the stanchions.

5.6 Provision of fixings/susceptibility to damage or vandalism
   Intovalve claims that the system is not susceptible to vandalism. Stanchions and stoplogs should be stored at a
secure location.

5.7 Possible locations of use
   Intovalve states that the system is suitable for all likely locations.

6 Financial aspects

6.1 Maintenance/reuse/durability
   Intovalve advises frequent checking of the components, with the frequency determined by the protection
requirements of the system. Lifting beams and slings should be checked annually by an independent authority to the
required safety limits and a new test certificate obtained. Cleaning should be carried out as the barrier is removed.
The system is durable, but correct maintenance will increase the service life of the barrier units.
6.2 **Installation costs (100 m long x 1 m high – excluding resources)**
   The following costs are estimates only:
   - Mild steel galvanised frame and stanchions = £75,000
   - Wood logs = £46,000
   - Aluminium logs = £65,000
   - Stainless steel (SS304) = £78,000

6.3 **Installation resource requirements**
   Due to the heavy nature of some of the components, an installation team is required along with plant and lifting equipment to transport and position the structure.

6.4 **Additional installation and removal costs (training/supervision)**
   The price does not include training or deployment costs.

7 **Other**

7.1 **Aesthetic aspects**
   No information was submitted on aesthetics although the system is neat when fully installed.

7.2 **Test information**
   Intovalve is an established gate manufacturer and can demonstrate use over typical service periods.

7.3 **Performance under service conditions**
   No details were submitted.

7.4 **Environmental aspects**
   - The system does not pollute. Timber treatment may be necessary.

7.5 **Additional comments**
   - None
Fact sheet for the Invisible Flood Control Wall
Generic group: panel barrier

1 Product name and manufacturer details

Invisible Flood Control Wall™ (IFCW)

Flood Control America (FCA)
29 Goodmans Hill Road, Sudbury, MA 01776 USA
Tel: (+1) 978 440 8902
E-mail: fryklund@ultranet.com
http://www.floodcontrolam.com

2 Diagram and general description

2.1 General description
The Invisible Flood Control Wall™ is made up from hollow, aluminium, gasketed planks that stack to form a barrier of the desired level of protection. A bracing system is bolted to a foundation, which is constructed at ground level, to support the barrier. The planks are removed and stored when not in use.

3 Available sizes/dimensions

3.1 Length per unit
Typically 6.0 m long and 0.2 m high

3.2 Maximum number of coupled units
No limit

3.3 Product height range
Installed in 0.2 m increments, currently to a maximum of 5.0 m.

3.4 Flexibility with regard to angles in horizontal plane
Yes – customised upright stanchions can accommodate curves, arcs and corners.

3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
Depends on the height required for protection. Planks stack in 0.2 m increments.

3.7 Width of structure at base
Planks are only 0.1 m wide at the base. The width required for the stanchions is more, but was not specified in the questionnaire. If the height of the barrier exceeds 2.4 m, then a further area is needed as the barrier requires angled supports to be fitted to the wall.
4 Structural aspects

4.1 Likely modes of failure
   FCA states that overtopping is the only form of failure for this system. Bearing capacity failure can occur depending on the foundation design.

4.2 Maximum design head of water
   5.0 m is the current installable height – this can be made higher if adjustments are made to the bracing system.

4.3 Behaviour subject to seepage
   FCA states that the system does not allow seepage.

4.4 Behaviour subject to breach (breach growth)
   The system should not worsen progressively in the case of breaches.

4.5 Increase protection height during service
   Yes – in 0.2 m increments

4.6 Resistance to damage/repair during service conditions
   The system is durable and strong and, as such, is resistant to damage. No information was provided concerning repair during service conditions.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
   FCA states that installation of a 100 m barrier to a height of 1.0 m takes approximately an hour.

5.2 Method of installation (including site preparation)
   Manual. Some lifting equipment may be required for high barriers.

5.3 Likelihood of incorrect installation
   FCA has produced a manual containing all the information necessary for deployment. The system is designed to be easy to install, with interlocking mating surfaces on the planks to assist with fitting and stacking.

5.4 Storage and transportation requirements (including mobilisation)
   The system stacks completely. It is lightweight and can be handled manually, although trucks or small lorries are needed to transport the system to the deployment site. Storage requirements depend on the individual lengths and quantity.

5.5 Adaptability to terrain conditions
   The system adapts to almost any terrain condition; however, the system does require initial construction of foundations.

5.6 Provision of fixings/susceptibility to damage or vandalism
   The system should be stored in a secure location to ensure that the planks and fixings are kept in good condition.

5.7 Possible locations of use
   FCA states that the system is well suited for primary line of protection along rivers, as an enclosure around properties and for access locations.

6 Financial aspects

6.1 Maintenance/reuse/durability
   There are no maintenance requirements other than cleaning, which can be performed using a pressure hose. The barrier is totally reusable and should not deteriorate over time.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
   For all components, the cost is $30,000
Fact sheet for the Invisible Flood Control Wall
Generic group: panel barrier

6.3 Installation resource requirements
Installation requires a minimum of two people for heights up to 2.0 m. Higher protection requires a bigger deployment team or more time.

6.4 Additional installation and removal costs (training/supervision)
The system price excludes training costs. FCA provides an erection and maintenance manual.

7 Other

7.1 Aesthetic aspects
Looks neat once installed and is not aesthetically unpleasant.

7.2 Test information
FCA has carried out testing and it has been analysed and accepted by the US Army Corps of Engineers. FCA has a test wall (height up to 4.2 m), which is being ‘tough tested’ in a northern climate to answer questions about icing of installations and performance. The test wall consists of two IFCW systems erected with two “I” beams as end containers. The inside void is filled with water to recreate the pressures exerted by floodwaters.

7.3 Performance under service conditions
The system has been successfully used in a number of locations including on the Rhine at Cologne in Germany.

7.4 Environmental aspects
No known environmental impact

7.5 Additional comments
The system has ‘off the shelf’ components thus allowing additional elements to be provided at little expense.
Fact sheet for the Mobile Dam
Generic group: air and water filled tube

1 Product name and manufacturer details

Mobile Dam

Flooding Agency A/S
Sleipnersvej 17, 4100 Ringsted, Denmark
Tel: (+45) 5767 4811
E-mail: Flooding@FRAFlood.com
http://www.FRAFlood.com
Henning Gertz (Executive VP Sales and Marketing)

2 Diagram and general description

2.1 General description
The Mobile Dam system consists of Twin Flex™ tubes (two large tubes) made of polyfibre coated with PVC, which are joined lengthways with special coupling units. These couplings are hollow and made of aluminium. Each coupling has air and water valves fitted internally to protect them during transportation. The couplings may be closed between each tube section making it possible to differentiate the water pressure inside each tube. The tubes are attached to the coupling by a tightening clip before the Twin Flex™ tubes are filled with water. The system can be unrolled as it is being filled to reduce the deployment time.

3 Available sizes/dimensions

3.1 Length per unit
Units are available from 50 m to 250 m.

3.2 Maximum number of coupled units
No limit

3.3 Product height range
The 1.15 m diameter tube has a height of 0.9 m.
The 1.25 m diameter tube has a height of 1.00 m.
The 1.50 m diameter tube has a height of 1.25 m.

3.4 Flexibility with regard to angles in horizontal plane
The Mobile Dam is designed for maximum flexibility and will follow curves and arcs. Ninety-five degree corners are under construction but not yet been tested.

3.5 Number of vertical joints/sealings (per unit/unit width)
Two (one at either end)

3.6 Number of horizontal joints/sealings (per unit/unit width)
None
3.7 **Width of structure at base**

For a tube size of diameter 1.25 m, the width at the base is 2.80 m.

4 **Structural aspects**

4.1 **Likely modes of failure**

Overtopping and sliding are possible forms of failure for the Mobile Dam.

4.2 **Maximum design head of water**

The maximum design head of water is 75% of the tube diameter to maintain a safety factor of 2.0. The system itself stays watertight for long periods.

4.3 **Behaviour subject to seepage**

On concrete, no seepage should occur unless there are holes in the concrete. On soft ground there is a small amount of seepage. Less seepage occurs with time due to the heavy weight of the dam which, over a period of hours, lowers itself a few centimetres into the ground. Some pumping may be necessary, not due to seepage through the barrier but to the high pressure of the retained water forcing it under the dam.

4.4 **Behaviour subject to breach (breach growth)**

Small holes and tears may occur in the outer tube, but these will not worsen progressively. Deployment on sharp objects may cause small holes to occur in the inner tube; these are difficult to discover. In these cases, Flooding Agency A/S recommends that the inner tube should be changed for safety reasons. As part of the service agreement, Flooding Agency A/S offers new sections in exchange for the return of used ones. A major breach is likely to affect the operation of the barrier.

4.5 **Increase protection height during service**

The Mobile Dam can be increased in height by a single tube with a smaller diameter. However, this is only recommended to prevent overtopping.

4.6 **Resistance to damage/repair during service conditions**

After a tear or puncture, the system does not worsen progressively. A tear or puncture up to 200 mm can be repaired during service conditions. The system is susceptible to vandalism.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**

After moving the system the initial distance from storage to the deployment area, it takes approximately 45 minutes to roll out the hoses and prepare the generator. The Mobile Dam can be rolled out at a rate of 10 m/minute. For a barrier length of 100 m, installation takes approximately 1–1½ hours.

5.2 **Method of installation (including site preparation)**

Installation is manual, but deployment requires plant and transport. The site should be cleared of sharp objects before deployment.

5.3 **Likelihood of incorrect installation**

The Mobile Dam is designed for simplicity and is easy to handle even under severe weather conditions. When two or more sections are coupled, the valves fitted in the couplings are closed for safety reasons and can only be opened or closed by hand or air pressure. The training provided by Flooding Agency A/S minimises the probability of incorrect installations.

5.4 **Storage and transportation requirements (including mobilisation)**

The required storage volume per unit (100 m) is 4m³ including couplings. For maximum durability, the Mobile Dam is best stored indoors out of direct sunlight and in dry conditions. It can be stored in rolls or layers or directly on hydraulic reels. Due to its low weight (3 kg/m), it can be transported by two 4x4 vehicles and trailers. In areas where access to vehicles is limited, the dam can be carried (a 50 m section weighs approximately 150 kg). Larger sections can be moved by helicopter.
5.5 *Adaptability to terrain conditions*
Flooding Agency A/S states that the Mobile Dam is suitable for all terrain types. Against a wall, a single tube solution is applicable. Due to the Twin Flex™ design, the water pressure in each tube may be varied, making the system suitable for rough and uneven terrain. Its use on slopes is not advisable.

5.6 *Provision of fixings/susceptibility to damage or vandalism*
The Mobile Dam is a temporary system and thus does not require fixings.

5.7 *Possible locations of use*
The Mobile Dam has a long continuous design and, as such, is more suitable to larger areas of protection. It is ideal for bank tops, as a second line of protection and as an enclosure around properties. Its use on embankments is limited by the crest width of the embankment. The Mobile Dam is also suitable for the redirection of water flow.

6 *Financial aspects*

6.1 *Maintenance/reuse/durability*
Materials are treated to give them protection against UV light. A high-pressure hose is recommended for easy cleaning. The Mobile Dam can be reused many times. All hoses, pumps and electrical equipment require standard service maintenance and testing.

6.2 *Installation costs (100 m long x 1 m high – excluding resources)*
The cost of the Mobile Dam is € 20,000 per 100 m (based on the minimum purchase of 3,000 m).

6.3 *Installation resource requirements*
An installation/deployment team consists of five people, two 4x4 vehicles and trailers. All materials required for installation are included in the product package.

6.4 *Additional installation and removal costs (training/supervision)*
Deployment training and a basic introduction to hydraulics are included in the product package.

7 *Other*

7.1 *Aesthetic aspects*
The Mobile Dam is a large but neat construction. Infill (water) is easily obtained at the site and the dam is available in a variety of colours.

7.2 *Test information*
A team of four men with the use of a tractor can deploy 5 km of Mobile Dam in just 5 hours. In comparison, it would take a team of 100,000 people to construct an equivalent barrier using sand bags. The Mobile Dam has not yet been tested in a real flood situation. A field test carried out at the North Sea in April 2000 successfully dammed tidal water up to 800 mm over five tidal cycles. Further successful demonstrations have been carried out in Budapest and Poznan. A technical report has been prepared by Danish Water and Environment (an independent consultancy), which looked at the calculation and assessment of the Mobile Dam’s stability and performance. All tests and demonstrations were carried out with the full co-operation of the appropriate civil protection services.

7.3 *Performance under service conditions*
The Mobile Dam has not yet been tested in a real flood situation.

7.4 *Environmental aspects*
The materials used in the product are environmentally friendly, and the product has no known environmental impact. The dam can also be used to protect the coastline against oil spills. Furthermore, the polluted oil can be pumped into the tubes to await further action. With a few adjustments, the tubes may serve as a floating barrier.

7.5 *Additional comments*
Product can also be hired.
1 Product name and manufacturer details

MRP Systems Modular Shielding

MRP Systems Limited
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Tel: 0161 427 8910
E-mail: jsims@ukmrp.com
http://www.ukmrp.com
John Sims

2 Diagram and general description

2.1 General description
The MRP block system consists of a range of hollow, plastic, moulded interlocking units. Each unit is provided with interlocking features on all four edges. A plugged hole on the top surface provides access to the interior for filling with sand or water; pumps are also available for filling. The blocks are made of black polyethylene, which is UV-stabilised. Wall and floor fixing plates and self-adhesive strips are available for the interlocking surfaces. The system was designed specifically for radiation resistance and, as such, MRP has no data on its performance in flood conditions.

3 Available sizes/dimensions

3.1 Length per unit
Minimum – 0.5 m long x 0.75 m high x 0.5 m wide
Maximum – 1.0 m long x 0.75 m high x 0.5 m wide
Half height and length units are available.

3.2 Maximum number of coupled units
No limit

3.3 Product height range
Blocks are 0.75 m and 0.375 m in height, but they can be stacked to a height of 6.0 m (1.5 m in flood control conditions).

3.4 Flexibility with regard to angles in horizontal plane
90° corners due to block system

3.5 Number of vertical joints/sealings (per unit/unit width)
Two
3.6 Number of horizontal joints/sealings (per unit/unit width)
Two
3.7 Width of structure at base
0.5 m at the base. This is wider if supporting ‘T’ walls are used for stability.

4 Structural aspects

4.1 Likely modes of failure
Overtopping and seepage are possible modes of failure for this system.

4.2 Maximum design head of water
MRP has no data on the system’s potential in flood conditions.

4.3 Behaviour subject to seepage
Some seepage will occur with this system. However, the system was designed specifically for radiation resistance and therefore MRP has no data on the system’s potential in flood conditions.

4.4 Behaviour subject to breach (breach growth)
MRP has no data on the system’s potential in flood conditions.

4.5 Increase protection height during service
It is possible to increase the height of the system during service conditions, although the vertical stability of system should also be increased by adding ‘T’ support walls (buttresses).

4.6 Resistance to damage/repair during service conditions
According to MRP, “the blocks are very difficult to damage but if a vandal used a heavy spike with a large sledgehammer, they might inflict some damage — which would be repairable.” The blocks are tough when filled and should resist the impact of debris.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
To construct a wall 100 m long to a height of 0.75 m takes 4 hours.
To construct a wall 100 m long to a height of 1.5 m takes 8 hours.

5.2 Method of installation (including site preparation)
Manual. Blocks should be installed before to loading with preferred fill.

5.3 Likelihood of incorrect installation
Due to the block system’s interlocking features, the risk of incorrect installation is low.

5.4 Storage and transportation requirements (including mobilisation)
Blocks can be stored in the open, but MRP suggests storage ready for deployment in an International Standards Organisation (ISO) freight container. A 6m ISO container can hold about 72 blocks and a 40 m one about 144 blocks. MRP can also provide a ‘grab’ for moving the blocks. Unless the chosen aggregate is available on-site, transport of aggregate to the site must also be considered.

5.5 Adaptability to terrain conditions
The floor on which the modular shielding is to be installed must be level and flat, and preferably have a smooth finish. This allows the MRP system to be used on flat soil, concrete and bank tops.

5.6 Provision of fixings/susceptibility to damage or vandalism
The MRP system is a temporary system and no permanent fixings are therefore required. The fixings between blocks to increase stability are screwed into place.

5.7 Possible locations of use.
These include as a second line of protection, an enclosure around properties, access locations and to protect doors, pipes, airbricks and drains. The system can also be used on bank tops but not in areas subjected to wave activity (such as large reservoir banks or estuaries).
6 Financial aspects

6.1 Maintenance/reuse/durability
   The system has no maintenance requirements and can be reused easily. Polyethylene is resistant to many years of exposure to weather and sun. The blocks are difficult to damage due to their construction materials. The system can be repaired during service conditions. Cleaning can be undertaken with a water hose.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
   Approximately £48,600 including pumps, fixing plates and delivery of freight containers

6.3 Installation resource requirements
   A minimum of two people is required, although three is preferable. Large vehicles are needed to transport the blocks to the deployment site.

6.4 Additional installation and removal costs (training/supervision)
   If requested, MRP can provide assembly and installation services at an extra cost. Additional costs may include aggregate if not using water from the site.

7 Other

7.1 Aesthetic aspects
   Construction is neat. It uses local materials and the aggregate is contained within the blocks.

7.2 Test information
   The system was designed specifically for radiation resistance and, as such, MRP has no data on the system’s potential in flood conditions.

7.3 Performance under service conditions
   The system was designed specifically for radiation resistance and, as such, MRP has no data on the system’s potential in flood conditions.

7.4 Environmental aspects
   Good. The system uses local materials and sand, if employed, is always contained within the blocks. Construction is neat. The blocks can be produced in any colour.

7.5 Additional comments
   The rigidity of the structure means that end jointing details and seepage control at connections of units to each other and the underlying surface are potential issues with this product.
1 Product name and manufacturer details

**Pallet Barrier**

Geodesign AB (manufacturer)
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Pallet Barrier (UK supplier)
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Britt Warg

2 Diagram and general description

![Image 1](image1.png) ![Image 2](image2.png)

2.1 General description
The barrier consists of collapsible galvanised steel supports, which hold a standard wooden Euro pallet. The supports are spaced one pallet width apart. Introduction of a double support beam construction and horizontal connecting rods, which fix the distance between supports to the required 1.2 m, has made construction easier. The pallets are fixed to the supports and covered with a waterproof polypropylene membrane. Sandbags are used to hold down the leading edge of the membrane and clips hold the membrane in place on the top of the pallets. The sand bags are fastened to the membranes by sealer clips.

3 Available sizes/dimensions

3.1 Length per unit
0.8 m for standing pallets
1.2 m for laying pallets

3.2 Maximum number of coupled units
No limit
3.3 **Product height range**
Heights of 0.65 m, 0.95 m, 1.25 m and 1.80 m are available.

3.4 **Flexibility with regard to angles in horizontal plane**
Use of wooden corner elements allows the system to be erected around corners. For smaller changes in direction such as a wide U-shape, the system is very flexible.

3.5 **Number of vertical joints/sealings (per unit/unit width)**
One joint on each side of the pallet

3.6 **Number of horizontal joints/sealings (per unit/unit width)**
Maximum is one joint per pallet (after extension of height) and none when using only one pallet.

3.7 **Width of structure at base**
- 1.15 m pallet support
- 2.15 m pallet support and membrane on wet side
After extension by another pallet, width increases by 1.2 m to 2.35 m and 3.35 m, respectively.

4 **Structural aspects**

4.1 **Likely modes of failure**
Sliding is the only possible failure for this system. This can occur on thick grass or clayey soil if anchor pins are not used as recommended or on smooth concrete surfaces if not properly fastened to the ground.

4.2 **Maximum design head of water**
1.80 m

4.3 **Behaviour subject to seepage**
The leakage of water is due to groundwater seepage and leakage between the plastic membrane and the ground. Seepage decreases with time due to clogging of the membrane with suspended materials but also due to consolidation of the ground surface and the leading edge of the membrane loaded with the tubular sandbag. One 3–5 high-pressure water pump per 150m of protection (working intermittently) is sufficient to keep the landward side dry.

4.4 **Behaviour subject to breach (breach growth)**
Geodesign states that a breach of the barrier will not worsen progressively as there is a membrane and then a pallet. The flow of water is reduced even if a tear develops in the membrane. Although the pallets are not watertight they reduce the flow of water significantly.

4.5 **Increase protection height during service**
During service, the system height can be increased in three steps depending on how the first build-up step was erected. One possibility is to start with 0.65 m (one horizontal pallet) and add two steps of horizontal pallets to give 1.25 m and 1.8 m. This can be achieved using the system with EUR 125 pallets. Another possibility is to start with 0.95 m (vertical pallet) and add an extension fork to 1.25 m and a vertical pallet to 1.8 m. This can be achieved using the EUR 95 Plus system.

4.6 **Resistance to damage/repair during service conditions**
The membrane is susceptible to puncture from floating debris, however, this can easily be repaired in service conditions using tape and plastics. The system is not susceptible to vandalism, although the barrier should be supervised or guarded during high water. As it is a two-barrier system, the second barrier (wooden pallet) provides protection if the first barrier (plastic membrane) breaches and while it is being repaired.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
1 hour with a team of 18 people
5.2 Method of installation (including site preparation)
Installation is manual, although transport and access to the site are needed to assemble the pallets and their supports. In Cologne, 18 people erected a 500 m barrier in 5 hours. None were pre-trained and they came from three different organisations. If necessary, one person can erect the system as each individual part of the system has a low weight.

5.3 Likelihood of incorrect installation
Geodesign has three simple controls to reduce incorrect installation: the supporting beam is against the axis on the correct side; the EUR pallets in good condition are used and are placed inside the pallet support front beam, and the membrane is loaded on the outer edge.

5.4 Storage and transportation requirements (including mobilisation)
There are no special storage requirements other than being undercover. Storage can be outside. Fifty pallet supports can be stored in a wooden box 1.2 m x 0.8 m x 1.16 m. The supports and pallets are transported on trailers or on lorries.

5.5 Adaptability to terrain conditions
The system is suitable for flat soil, rough concrete (not smooth and hard), a sloping surface (positive not negative slopes), grassed surfaces and wide bank tops. No extra anchor is needed for friction soils (asphalt, sand, silt, moraine and gravel). An extra anchor is needed to secure the system for cohesion soils (clay, mud and thick grass). The anchor pin is placed through the 45 mm holes on the bottom beam.

5.6 Provision of fixings/susceptibility to damage or vandalism
The Pallet Barrier is a temporary protection system and therefore has no permanent fixings.

5.7 Possible locations of use
The system is suitable for all types of banks and levees, as a second line of protection, as an enclosure around properties, as access gates to locations and for specific openings such as breaks in walls or defences.

6 Financial aspects

6.1 Maintenance/reuse/durability
Deterioration with time is generally small except for the plastic membrane, which should be checked and, if necessary, renewed every 10 years (depending on time in service). The supports are galvanised and in use only for the duration of the flood. The quality of the EUR pallets is maintained by the transport companies. The supports are easy to clean with a water hose. The system is totally reusable. The plastic membrane should be assessed before every use. Maintenance requirements are cleaning, occasion provision of new plastic membranes and checking the pallets supplied.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
The cost of the Pallet Barrier system (EUR 95 Plus and EUR 125) including pallet supports, pallet clips, sealer clips, tube sand bags and reinforced plastic membrane is £85-220 per metre, depending on protection height.

6.3 Installation resource requirements
Access for lorries to transport the system to the site and a supply of pallets are required. The number of people needed depends on the warning lead-time; the system can be assembled by just one person.

6.4 Additional installation and removal costs (training/supervision)
Geodesign is both the manufacturer and developer of the Pallet Barrier. The system is available for purchase, client assembly or supplier assembly. Geodesign plans to hire out the system for drainage at construction works. The product does not generally include training or deployment costs.
Fact sheet for Pallet Barrier
Generic group: flood barrier – with frame

7 Other

7.1 Aesthetic aspects
The system is based upon galvanised steel supports, which are durable and have a long life. Once deployed, the system is neat and sturdy.

7.2 Test information
Stability reports and tests have been carried out. There is a long history of successful use.

7.3 Performance under service conditions
The Pallet Barrier has been deployed successfully for a number of years across Europe – the longest being 1.2 km of flood protection at Arvika in Sweden. It has also been used successfully in Norway, France, Germany, The Netherlands and the UK.

7.4 Environmental aspects
The Pallet Barrier does not pollute and has a low environmental impact.

7.5 Additional comments
Field use has shown that this system is resistant to most problems encountered during flood conditions. Geodesign has developed a technique whereby the barrier can be floated into place and then dewatered on the dry side thus allowing it to be used even when flooding has begun. The system can also be used for temporary diversion or dams.
Fact sheet for Portadam
Generic group: flood barrier – with frame

1  Product name and manufacturer details

Portadam

Portadam
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E-mail: portadam@btinternet.com
http://www.portadam.co.uk
Roy Pebody

2  Diagram and general description

2.1 General description
The Portadam system consists of welded rectangular steel ‘A’ frames placed at pre-calculated intervals. A tailored membrane is then suspended from the frames and laid along the ‘A’ frame and the underlying surface to create a hydrostatic seal.

3  Available sizes/dimensions

3.1 Length per unit
Portadam has a unique system for joining the tailored membranes. The required length is made from two unit lengths of 6 m and 10 m. The longest dam installed so far ran for over 250 m.

3.2 Maximum number of coupled units
Theoretically unlimited

3.3 Product height range
The standard Portadam system can dam depths of up to 2.5m.

3.4 Flexibility with regard to angles in horizontal plane
Good. The Portadam can be constructed to account for curves, arcs and corners.

3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
One at either end of each membrane unit

3.7 Width of structure at base
The width of the ‘A’ frame is 2 m and the sealing sheet extends 2.5 m past the toe of the frame, giving a total width of 4.5 m.
4 Structural aspects

4.1 Likely modes of failure
The Portadam is liable to failure from bearing capacity, overturning and overtopping. It is vulnerable in high winds causing instability, but can cope with minor waves up to the height of the frame.

4.2 Maximum design head of water
2.5 m

4.3 Behaviour subject to seepage
The system leaks against low water pressures: however, the longer the Portadam is installed, the better the seal becomes. Pumping is required to keep the landward side of the barrier dry.

4.4 Behaviour subject to breach (breach growth)
The Portadam should remain intact if damaged; however, scour may undermine the system and a bearing capacity failure at any of the frames could trigger system collapse.

4.5 Increase protection height during service
No

4.6 Resistance to damage/repair during service conditions
Portadam is susceptible to vandalism. Damage to the membrane can be repaired under service conditions.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
Portadam states 2–5 days depending on the surface conditions, although installation is quicker with a larger team.

5.2 Method of installation (including site preparation)
Manual, but requires some plant to transport the system to the site.

5.3 Likelihood of incorrect installation
Everyone is trained in-house. The system is only available for hire and installation is carried out by Portadam employees.

5.4 Storage and transportation requirements (including mobilisation)
Storage does not have to be undercover and the system can be stored in the open air.

5.5 Adaptability to terrain conditions
Portadam states that the system can be used on all types of surface including bank tops. However, due to the long leading edge, only very wide banks would be suitable. This system is not recommended for use on flood banks.

5.6 Provision of fixings/susceptibility to damage or vandalism
The Portadam system is temporary and therefore requires no fixings.

5.7 Possible locations of use
The Portadam system can be deployed as a second line of protection, as an enclosure around properties, in access locations and adjacent to watercourses.

6 Financial aspects

6.1 Maintenance/reuse/durability
Portadam frames should last up to 20 years. The sealing fabrics are reusable, but will deteriorate and harden with time due to exposure to UV radiation. As the barrier is only available for hire, Portadam ensures the fabrics are in good condition before hire.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
The system is only available to hire and not to buy. Portadam costs approximately £350 per metre – therefore £35,000 for 100 m to a height of 2 m. This price includes installation and dismantling by Portadam employees and 2 weeks hire; after this time, a rental charge is applied.
6.3 Installation resource requirements
2–3 people and a van to transport the system to the site

6.4 Additional installation and removal costs (training/supervision)
Rental charge 2 weeks after the initial payment for hire and installation

7 Other

7.1 Aesthetic aspects
The Portadam system is not very neat due to the ‘A’ frame construction.

7.2 Test information
Tested in 1972 at the National Physics Laboratory at Teddington, UK with tanks and concrete bases. No test results were provided by Portadam.

7.3 Performance under service conditions
Performs well and has been used river engineering projects since the early 1970s.

7.4 Environmental aspects
Does not pollute the watercourse. Minimal damage to the bed of the watercourse and surrounding area.

7.5 Additional comments
Flumes are available to allow a continual flow of water between two dams
1  Product name and manufacturer details

Presray Flood Gates

Presray Corporation
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http://www.presray.com

Dam-It Flood Gates

Dam-It (Flood Protection) Ltd (UK Presray licensee)
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E-mail: mwhite@talk21.com
Malcolm White

2  Diagram and general description

![Diagram of Presray Flood Gates]

2.1 General description
The Presray model FB55 (a bottom-hinged ‘flip-up’ flood gate with inflatable gaskets and the BF44 hinged gate) is one of a series of flood gates and flood panels manufactured in the UK by Dam-it (Flood Protection) Ltd under license from the Presray Corporation in the USA. The products rely on continuous pneumatic seals to the perimeter of the panels. The system can be raised or lowered by either manual or mechanical means as and when emergency situations arise or subside. The gates offer protection up to a height of 2.4 m. Custom-made gates are possible for higher units. The gates are suitable for any commercial, industrial or municipal location. When not in use, the gate is recessed into the floor. The exposed surface is constructed of diamond plate to allow the passage of traffic.

3  Available sizes/dimensions

3.1 Length per unit
3.0 m

3.2 Maximum number of coupled units
No limit

3.3 Product height range
Maximum height of 3.0 m

3.4 Flexibility with regard to angles in horizontal plane
The gates can be designed for corners, but arcs and curves are not possible.
3.5 **Number of vertical joints/sealings (per unit/unit width)**
Two

3.6 **Number of horizontal joints/sealings (per unit/unit width)**
One

3.7 **Width of structure at base**
This depends on the design/model of the gate. As the gate lies flat, the width at the base of the gate is at least equal to its height, plus any further dimension for the gate housing.

4 **Structural aspects**

4.1 **Likely modes of failure**
Overtopping is the only failure mode claimed by Dam-It. In addition, failure of the raising mechanism can result in failure of the barrier.

4.2 **Maximum design head of water**
2.5 m

4.3 **Behaviour subject to seepage**
The gates showed zero leakage in factory tests. Pumping is recommended during heavy rain to keep the area behind the gate on the landward side from becoming waterlogged. When the gate is recessed, a hinged diamond plate, trench cover drops into place to bridge the gap between the bottom edge of the gate and the adjacent surface of the recessed frame.

4.4 **Behaviour subject to breach (breach growth)**
The flood gates are sturdy constructions and breaching is not considered a possible form of failure. Due to the nature of its construction, the system will not worsen progressively if a breach occurs.

4.5 **Increase protection height during service**
No. Gates are constructed to a design height. No extension sections are available.

4.6 **Resistance to damage/repair during service conditions**
Repairs can be made to the dry side of the flood gate during service conditions. The gate itself is resistant to damage and vandalism. Floating debris is not considered a risk to the gate due to its strong metal construction.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
Dam-It states that 15 minutes per panel should be allowed for deployment. One person would therefore take about 8 hours to deploy a 100 m long gate. With the automatic model, the time for deployment is almost immediate.

5.2 **Method of installation (including site preparation)**
After installation of the gate itself, deployment can be controlled manually, using plant or with an automated system.

5.3 **Likelihood of incorrect installation**
Cannot be installed incorrectly.

5.4 **Storage and transportation requirements (including mobilisation)**
None – the barrier is stored and activated from its contained housing.

5.5 **Adaptability to terrain conditions**
The system can only be installed in concrete.

5.6 **Provision of fixings/susceptibility to damage or vandalism**
Vandalism is not considered a problem with this type of barrier as all moving parts and seals are below the covering plate. The gate is not fixed to the adjoining walls but has pneumatic seals, which inflate to create a seal with the upright walls/barriers.
5.7 Possible locations of use
Presray flood gates are suitable for use for all locations including bank tops, as a second line of protection, as enclosures around properties, for access locations and for specific openings.

6 Financial aspects

6.1 Maintenance/reuse/durability
Maintenance of the gate consists of regular inspection of the seals, inspection of electrical parts (if applicable) and greasing of mechanical parts. The seals should be replaced after 5 years to ensure a good seal is maintained during service conditions. Regular cleaning should be carried out using either a water or pressure hose. The gate itself is fabricated from durable material and Dam-It states that its deterioration over time is slow.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
A manual deployment system costs £250,000–£300,000.

6.3 Installation resource requirements
Depend on whether the gate is automatic or manually operated. No plant or machinery is needed as all pumps and motors required to operate the gates are included in the construction.

6.4 Additional installation and removal costs (training/supervision)
The cost of the product includes training. Replacement of seals or parts may be an additional cost.

7 Other

7.1 Aesthetic aspects
Although the barrier is quite large when deployed, the housing is flush to the ground surface and neat before deployment.

7.2 Test information
Flood barriers should be designed with a minimum factor of safety of 2:1 based on material yield strength and provide an effective seal against the design flood level.

7.3 Performance under service conditions
Presray flood gates have been installed successfully in the USA for a number of years. No evidence of performance under service conditions was submitted.

7.4 Environmental aspects
Presray flood gates are non-polluting and have no environmental impact on an area. They are aesthetically pleasing as they are contained in storage underground.

7.5 Additional comments
None
Fact sheet for Quick Damm Flood Safety System
Generic group: filled container – permeable/impermeable

1 Product name and manufacturer details

Quick Damm Flood Safety System

Quick Damm GmbH
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http://www.quick-damm.de
Peter Lökkös

2 Diagram and general description

![Diagram of Quick Damm Flood Safety System]

2.1 General description
The Quick Damm Flood Safety System consists of a simple steel tube (aluminium tubing is an option for smaller sizes) covered with a specially formed, flexible geotextile fleece (permeable container), or for tensile strength, a waterproof PVC-covered polyester textile (impermeable container). The open containers are trapezoidal in shape and can be filled with sand, gravel, soil, stones, rock or cinders (geotextile fleece) and water (waterproof high tensile polyester textile).

3 Available sizes/dimensions

3.1 Length per unit
2.0 m, 6.0 m and 12.0 m

3.2 Maximum number of coupled units
No limit

3.3 Product height range
0.5 m, 1.0 m and 1.5 m unit heights

3.4 Flexibility with regard to angles in horizontal plane
Specially designed units allow the construction to follow curves, arcs and corners.

3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
Joints are all 1.5 m or 3.0 m along unit length. The actual number depends on the length

3.7 Width of structure at base
0.8 m, 1.3 m and 2.7 m depending on unit size
4 Structural aspects

4.1 Likely modes of failure
Overtopping, seepage and collapse are possible forms of failure with the Quick Damm system. However, lashing and ground pins can be used to further secure the system against rolling, overturning or sliding.

4.2 Maximum design head of water
Not stated, but the height of the floodwater must be less than the level of the infill material.

4.3 Behaviour subject to seepage
Seepage depends on type of surface. The impermeable system is watertight, while the permeable one is nearly watertight as a result of the width of the system. Seepage may occur through the subsoil.

4.4 Behaviour subject to breach (breach growth)
Quick Damm states that the system may worsen progressively after damage depending on the extent of the initial damage.

4.5 Increase protection height during service
The height of the system can be increased during service conditions by stacking, but only if the containers are filled with an aggregate and not water.

4.6 Resistance to damage/repair during service conditions
Depending on the type and degree of damage to the system, the system may worsen progressively. However, minor damage can be repaired while in service.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
1 hour to deploy with a team of 4–6 people

5.2 Method of installation (including site preparation)
Manual, but filling the containers requires loading vehicles or pumps

5.3 Likelihood of incorrect installation
Simple construction. System easy to erect without tools.

5.4 Storage and transportation requirements (including mobilisation)
Quick Damm can supply a space-reducing, weather-proofed, roll-down storage container. These can be loaded onto trucks and transported to the place of deployment. One container can hold 250 m of Quick Damm system to a height of 1.0 m. The containers can be accessed on three sides, allowing fast and easy unloading.

5.5 Adaptability to terrain conditions
Quick Damm can be deployed on any flat surface (grass, soil or concrete), but is not suitable for sloping surfaces. Quick Damm states that the installation should be at a location in a suitable condition for people to walk on.

5.6 Provision of fixings/susceptibility to damage or vandalism
Quick Damm is a temporary system and therefore fixings are not required

5.7 Possible locations of use
Used as a second line of protection, enclosures around buildings and access locations. The Quick Damm system can be deployed in areas with wave activity, but only when filled with aggregate and not water.

6 Financial aspects

6.1 Maintenance/reuse/durability
The Quick Damm system does not deteriorate with time. However, regular cleaning, inspection and repairs to tears are important – particularly after use. The system’s shape and construction make cleaning easy.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
Approximately € 25,000 for all components (unpacked)
Fact sheet for Quick Damm Flood Safety System
Generic group: filled container – permeable/impermeable

6.3 Installation resource requirements
A ‘roll-on’ container lorry is needed to move the packed Quick Damm to the deployment site. No further plant is necessary apart that required to fill the system. The container also holds an air-wheeled cart (suitable for off-road use) to assist with deployment. Installation is manual and requires 4–6 people.

6.4 Additional installation and removal costs (training/supervision)
Additional costs may include those for aggregate if not using water or local aggregate.

7 Other

7.1 Aesthetic aspects
Construction is neat. Uses local materials and the aggregate is contained.

7.2 Test information
Quick Damm has an extensive record of successful deployment in Germany. It has been used on the Rhine, Elbe and Nidda rivers. An extensive list of references is available on the Quick Damm website.

7.3 Performance under service conditions
Very good. The Quick Damm system has received extensive praise from German organisations.

7.4 Environmental aspects
The Quick Damm system is an environmentally friendly design. It does not pollute or cause contamination to the environment.

7.5 Additional comments
The system is available as permeable and impermeable containers.
1 Product name and manufacturer details

Rapidam

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http://www.hydroscience.co.uk
James Salikeld and Nic Ward

2 Diagram and general description

2.1 General description
Rapidam is a portable, reusable flood protection system. There are two versions of the barrier. The first is a bolt-down demountable barrier (flood barrier – flexible) for planned use in urban areas. Threaded sleeves are pre-installed into a prepared surface. During deployment, eyelets on the barrier are aligned with these sleeves and the barrier is secured into place using eyebolts. The second version of the barrier is a temporary freestanding design, which needs no prior work before deployment. It can be transported and deployed in emergencies or for planned applications. It is suitable for both urban and rural ground conditions. The system consists of PVC-coated linen fabric sections, which are joined to form a barrier. The barrier is to a height of 1.0 m and triangular in cross-section.

3 Available sizes/dimensions

3.1 Length per unit
   Minimum: 4.0 m
   Maximum: 30.0 m
3.2 Maximum number of coupled units
   No limit
3.3 Product height range
   Maximum height currently 1.0 m (system with a height of over 2.0 m is under development)
3.4 Flexibility with regard to angles in horizontal plane
   The system is designed to take account of curves, arcs and corners (special corner and end wing sections are available).
3.5 Number of vertical joints/sealings (per unit/unit width)
   Two per length
3.6 Number of horizontal joints/sealings (per unit/unit width)
   None
3.7 **Width of structure at base**
- 1.34 m – bolt-down version
- 4.42 m – free-standing version

4 **Structural aspects**

4.1 **Likely modes of failure**
Over topping, breach and sliding are possible forms of failure in extreme conditions. Sliding is only applicable to the free-standing version.

4.2 **Maximum design head of water**
Currently 1.0 m

4.3 **Behaviour subject to seepage**
Hydroscience states that the bolt-down system is 99% watertight and that there is no increased seepage with time. Pumping is only required to keep the landward side dry in the event of heavy rain or groundwater issues.

4.4 **Behaviour subject to breach (breach growth)**
Tests have shown that a tear or puncture has no impact on the barrier’s structural characteristics other than the leak that the puncture creates. Punctures or cuts (even a full-length vertical cut of the back wall of the barrier) do not spread beyond the original damage.

4.5 **Increase protection height during service**
No

4.6 **Resistance to damage/repair during service conditions**
The Rapidam is made from a heavy PVC-coated linen fabric with anti-UV and fungicide additives. A debris screen can be built into the barrier to prevent or reduce debris from reaching the back wall of the barrier where more serious damage could occur. The system itself is susceptible to vandalism, but capscover the threaded sleeves to prevent tampering.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
Two people can deploy the system in 3 hours.

5.2 **Method of installation (including site preparation)**
Manual. Plant such as 4x4 vehicle is needed to transport the system to the site. No site preparation is required, but removing large objects helps seal the system to the ground.

5.3 **Likelihood of incorrect installation**
The system has been designed to cope with the potential harsh conditions that occur during emergencies. The fittings are simple and designed to be installed only in the correct manner.

5.4 **Storage and transportation requirements (including mobilisation)**
Storage out of direct sunlight, in the dry and away from harmful chemicals will increase the life of the system. The compact nature of the system means that only a small storage area is required: for example, a Rapidam 10.0 m long x 1.0 m high can be stored in an area 1.4 m long x 0.45 m high. Transport requirements depend on product volume. Shorter lengths of Rapidam can be carried by hand or using the purpose-built trolley designed by Hydroscience. For larger amounts, a trailer system can be used.

5.5 **Adaptability to terrain conditions**
Hydroscience states that the system is adaptable to all typical terrain conditions. However, the use of the free-standing version for flood banks is limited by the bank crest width.

5.6 **Provision of fixings/susceptibility to damage or vandalism**
The Rapidam is available as a temporary or demountable system. Only the demountable system requires the use of fixings. These are threaded sleeves, which are sunk into suitable foundations such as concrete at regular intervals.
and are covered by tamper-proof caps. The demountable system can still operate effectively with only one in every two fixings operational.

5.7 **Possible locations of use**
Hydrosience states that the Rapidam is suitable for use in all locations other than doorways or openings of less than 3.0 m.

6 **Financial aspects**

6.1 **Maintenance/reuse/durability**
If stored properly, the system should be usable for 5–10 years depending on its service length during those years. Rapidam is a low maintenance product requiring only simple cleaning and inspection after use. Unclipping the internal battens and straps allows the system to be laid flat for ease of cleaning and drying. The system is totally reusable. Once the system is dry, it can be rolled and stored. The metal quick connectors may need to be oiled before packing.

6.2 **Installation costs (100 m long x 1 m high – excluding resources)**
£26,160 (excluding VAT) for a straight barrier (for all components)

6.3 **Installation resource requirements**
Installation requires two people, one barrier, one eyebolt per sleeve position and one bolt-down plate per two bolt positions. Plant requirements depend on how far from the site the system is stored and the length of the barrier (and thus its weight).

6.4 **Additional installation and removal costs (training/supervision)**
The cost of the system does not include training or deployment costs.

7 **Other**

7.1 **Aesthetic aspects**
The Rapidam is neat in construction and modern in design.

7.2 **Test information**
The demountable version recently completed a three-month test programme in a wave basin at HR Wallingford. Satisfactory results were obtained with in the tests, which covered waves; inertia forces; overtopping; debris and water pressure. Tests on the free-standing version are ongoing.

7.3 **Performance under service conditions**
The Rapidam has shown in tests and field trials to perform well under service conditions.

7.4 **Environmental aspects**
The Rapidam system has been designed to have as little environmental impact as possible. Apart from the threaded sleeves left in the ground for the bolt-down barrier, Rapidam has no environmental impact. The Rapidam system is available in a range of colours. Rapidam plans to print important information such as emergency contact numbers or first aid instruction on the back wall of the barrier.

7.5 **Additional comments**
The Rapidam is a new design of flood barrier, which is lightweight and can be deployed with the minimum of effort.
1 Product name and manufacturer details

Richardson flood control panel barriers

Richardson Flood Control Products
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2 Diagram and general description

2.1 General description
Richardson Flood Control Products offers sheet metal and precast concrete panel barriers of varying sizes. These can be used separately or mounted on traffic barriers (of US design). Some designs are lightweight for hand installation with interconnecting gaskets to accommodate corners and bends. All require a relatively flat surface for installation.

3 Available sizes/dimensions

3.1 Length per unit
2.4–6 m depending on design type and barrier model

3.2 Maximum number of coupled units
No limit

3.3 Product height range
0.4–1.5 m

3.4 Flexibility with regard to angles in horizontal plane
The Richardson panel barriers are connected with large flexible interconnecting gaskets. Bends and arcs can be constructed.

3.5 Number of vertical joints/sealings (per unit/unit width)
One

3.6 Number of horizontal joints/sealings (per unit/unit width)
None. If stacked, then there is one joint.

3.7 Width of structure at base
0.6–1.2 m depending on the type of construction. The width at the base increases with stacking to accommodate the extra height support.
Fact sheet for Richardson flood control panel barriers
Generic group: panel barrier

4 Structural aspects

4.1 Likely modes of failure
Overtopping, bearing capacity and seepage are the likely modes of failure for the panel barriers.

4.2 Maximum design head of water
To the apex height of each barrier

4.3 Behaviour subject to seepage
No details given by the company, but pumps would probably be needed (especially in urban areas) to keep the landward side dry due to the flat bases and rigidity of the barriers.

4.4 Behaviour subject to breach (breach growth)
Richardson states that barrier damage would not worsen progressively due to the weight and stability of the panel barriers.

4.5 Increase protection height during service
Yes – but only by stacking the barriers

4.6 Resistance to damage/repair during service conditions
The barriers are made of steel and concrete, and thus resistant to damage (especially vandalism).

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
No information on the time needed to install the barrier was supplied. The manufacturer claims the barrier products can be deployed rapidly and that the time is less than that for a similar sand bag barrier.

5.2 Method of installation (including site preparation)
Manual and plant. Site preparation is required to level the ground sufficiently to ensure a good seal between the barrier and the ground. Some barriers can be carried by hand; larger protection systems require plant for installation. All Richardson panel barriers are constructed using general tools and equipment and no specialist training is necessary to install them.

5.3 Likelihood of incorrect installation
No response was received. The system, however, is modular and installation is simple.

5.4 Storage and transportation requirements (including mobilisation)
The system does not fold or pack down, so storage requirements are those of the size of the required protection. Trucks and cranes are required to transport the barrier units to the deployment site. Mobilisation should be taken into account as this increases the deployment time considerably.

5.5 Adaptability to terrain conditions
The nature of the barrier means it is best suited to softer ground (to ensure a better seal). Richardson states that soil, grass and bank tops are the preferred surfaces for its barriers. One model can be installed on concrete but requires fixing to traffic barriers (such as Dura-bull and K Rails).

5.6 Provision of fixings/susceptibility to damage or vandalism
The Richardson barriers are temporary and damage of fixings is therefore not an issue.

5.7 Possible locations of use
Richardson recommends that its barriers are used for banks, second line of protection and enclosures; some models are suitable for access locations. The company do not recommend their use for specific openings or in wave conditions.
6 Financial aspects

6.1 Maintenance/reuse/durability
Maintenance requirements consist of rust proofing/treatment and cleaning after use. The barriers are easy to clean and can be reused. They are long-lasting and durable as they are fabricated from steel and concrete.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
No cost were supplied by Richardson Flood Control Products, which designed the system and hold the patent. Richardson sells the manufacturing drawings for fabrication.

6.3 Installation resource requirements
Richardson has not specified resource requirements, giving only general guidance on the type of resources necessary. These include lifting machinery for larger barriers, a lorry/truck for transportation, a deployment team and standard tools.

6.4 Additional installation and removal costs (training/supervision)
Installation manuals and training are available but are not included in the cost of the manufacturing drawings.

7 Other

7.1 Aesthetic aspects
The use of steel and concrete to construct the barriers means that they are not aesthetically pleasing. However, they are designed to reduce the problems associated with extreme seasonal high flows such as snowmelt and are not expected to be in place for long periods of time.

7.2 Test information
No test information was submitted, although the manufacturer claims these barriers have been used successfully in the USA.

7.3 Performance under service conditions
There is no evidence of the performance of these barriers in service conditions

7.4 Environmental aspects
These barriers are totally removable and non-polluting.

7.5 Additional comments
None
1. **Product name and manufacturer details**

**Self Closing Wall (SCW)**

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Fydro BV (supplier)
Postbus 96, NL-6710 BB, Ede, The Netherlands
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2. **Diagram and general description**

2.1 **General description**

The SCW consists of a basin with a floating wall underground. A lid locks the wall. The basin is made of steel and the wall of fiberglass. When the water level is normal, the wall is practically invisible. When the water rises to approximately 0.2 m beneath the top of the bank or quay, the basin of the SCW fills up through a filling pipe. The fiberglass wall rises and floats. When the basin is full, the closing surface locks the water dam watertight. The river can now rise further without overflowing into the protected area. When the water level subsides to a normal level the basin is drained off into the river through a drainpipe with a one-way check valve or using a pump. Once the water has left the basin, the wall returns to rest within the basin and the lid on top of the wall closes to keep debris out. The SCW system can also be filled and drained via an inspection pit. A connection with water works will ensure checks on the system operation.

3. **Available sizes/dimensions**

3.1 **Length per unit**

1.0–6.0 m

3.2 **Maximum number of coupled units**

Theoretically no limit, but Fydro recommends a maximum length of 100 m.
3.3 Product height range
0.5–2.0 m in 0.5 m increments

3.4 Flexibility with regard to angles in horizontal plane
The system can be constructed in any corner or angle.

3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
None

3.7 Width of structure at base
0.75 m for the SCW 1000

4 Structural aspects

4.1 Likely modes of failure
Overtopping is a possible form of failure as the wall rises to a fixed height. The system is designed to avoid blockage of the pipes. Connection to a water supply is recommended.

4.2 Maximum design head of water
2.0 m

4.3 Behaviour subject to seepage
In tests, the system was watertight for up to 34 days.

4.4 Behaviour subject to breach (breach growth)
After damage to the system, the wall continues to float and give protection. The system does not worsen progressively.

4.5 Increase protection height during service
No – the wall heights are predetermined.

4.6 Resistance to damage/repair during service conditions
The SCW is not prone to vandalism, as the system is stored underground before deployment. Although the system is robust, it can be damaged. Minor damage can be repaired, but major damage necessitates replacement of sections of wall after the flood has subsided.

5 Operational aspects

5.1 Time required for installation (100 m long x 1 m high)
Once installed and when the water level has reached the required height for activation, the SCW deploys itself within a few minutes.

5.2 Method of installation (including site preparation)
Automatic

5.3 Likelihood of incorrect installation
Fydra states that the SCW system is installed under its supervision. Fydra guarantees the system in proper use for many years.

5.4 Storage and transportation requirements (including mobilisation)
None

5.5 Adaptability to terrain conditions
Fydra states that the SCW can be installed in all typical terrain conditions.

5.6 Provision of fixings/susceptibility to damage or vandalism
The SCW system is not prone to vandalism as the workings of the SCW are contained underground and covered by the security lid.
Fact sheet for Self Closing Wall
Generic group: flood barrier – rigid

5.7 Possible locations of use
The SCW is suitable for all locations including banks, as a second line of protection, enclosures around properties, access locations and specific openings.

6 Financial aspects

6.1 Maintenance/reuse/durability
The SCW requires only one service maintenance check per year. The SCW is totally reusable; Fydro states that it is suitable for tidal reaches where it could be activated twice a day through tidal cycles. The SCW is durable and has a quoted design life of 50 years. It is easy to clean with a water hose.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
€200,000

6.3 Installation resource requirements
None after permanent installation

6.4 Additional installation and removal costs (training/supervision)
No – price includes training and installation costs.

7 Other

7.1 Aesthetic aspects
As the SCW is stored underground until deployment, its aesthetic qualities are high as it is not visible when not in use.

7.2 Test information
The system has been comprehensively tested, examined and developed in The Netherlands during a period of over five years by a consortium of companies – AUCO (Associated Dutch Constructors), Betonson BV (concrete factory), Decostone BV (polyester factory) and Unihorn BV (civil engineering company). A special basin was built for the tests. A total of 72 tests were carried out over a period of 25 months. Calculations concerning the foundations, basin and walls at different heights were also performed. Geotechniek Rotterdam examined the whole system in collaboration with the Technical University Delft. The test reports (in Dutch) are available on request.

7.3 Performance under service conditions
Fydro has not submitted any information on the system’s performance in service conditions. However, the SCW performed well when tested under a variety of conditions.

7.4 Environmental aspects
The system is completely concealed and non-polluting.

7.5 Additional comments
After the initial installation, maintenance is low. Once installed the protection height cannot be increased.
Fact sheet for Water-Gate™
Generic group: flood barrier – free-standing

1  Product name and manufacturer details

Water-Gate™ instant water barrier

MegaSecur Inc
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http://www.megascur.com
Jacques Lauzon

2  Diagram and general description

2.1 General description
Water-Gate™ is a portable, reusable ‘self-filling’ water barrier. As water enters over the front ‘bib’, the barrier forms a wedge shape and thus creates the barrier. The pressure exerted by the water on the barrier holds it in place. The horizontal force exerted on the barrier is equal to the vertical force. The base of the Water-Gate™ is wider than the depth of the water being held back, making the pressure (force/area) applied to the base greater. Individual units are joined together to form a barrier.

3  Available sizes/dimensions

3.1 Length per unit
7.5–15.2 m for the smallest Water-Gate™(0.38 m high)
9.1–15.2 m for a Water-Gate™ of height 0.53 m
10.7–22.9 m for a of height 0.71 m
The 75 m Water-Gate™ model is specifically designed for flood control and has a height of 2.0 m.

3.2 Maximum number of coupled units
No limit

3.3 Product height range
0.38–2.0 m

3.4 Flexibility with regard to angles in horizontal plane
Water-Gate™ can be deployed in slight arcs. No information supplied about corner joints.

3.5 Number of vertical joints/sealings (per unit/unit width)
None

3.6 Number of horizontal joints/sealings (per unit/unit width)
Two
3.7 **Width of structure at base**
2.4 m for the 0.71 m high Water-Gate™

4 **Structural aspects**

4.1 **Likely modes of failure**
MegaSecur has not provided details. Due to the nature of the system’s construction, possible forms of failure are overtopping, seepage and sliding. MegaSecur states that the Water-Gate™ does not crumble, tear or rupture.

4.2 **Maximum design head of water**
No details have been provided by MegaSecur. The maximum product height is 2.0 m.

4.3 **Behaviour subject to seepage**
No details have been provided by MegaSecur. Seepage will depend on the seal maintained with the ground surface under the barrier. Some seepage is expected with this type of product, especially at low heads of water. MegaSecur has stated that pumping is not required to keep the landward side of the barrier dry.

4.4 **Behaviour subject to breach (breach growth)**
No details have been provided by MegaSecur. The Water-Gate™ is a continuous barrier up to 75m long. Breach should not be a form of failure with this product.

4.5 **Increase protection height during service**
No – this product is manufactured to set heights.

4.6 **Resistance to damage/repair during service conditions**
The heavy duty materials used, the laboratory strength tests and the safety standards set by MegaSecur Inc. should ensure that the water barrier is a high quality product. No details have been provided by MegaSecur.

5 **Operational aspects**

5.1 **Time required for installation (100 m long x 1 m high)**
MegaSecur states that it takes about 20 minutes to install a system 0.71 m high x 100 m long.

5.2 **Method of installation (including site preparation)**
Manual. Little or no site preparation is required, but could include the removal of large boulders to aid the seal with the ground surface.

5.3 **Likelihood of incorrect installation**
Very low. The product is simple to install and easy to roll out. The Water-Gate™ has no parts or fixings. Water-Gate™ barriers can be linked together using simple attachments.

5.4 **Storage and transportation requirements (including mobilisation)**
Storage is minimal as the Water-Gate™ can be rolled up. Transportation is also minimal due to its small size and weight. A 30.5 m length of the 0.71 m high Water-Gate™ packs down to a roll 0.65 m in diameter and 0.55 m in height with a total weight of 75 kg.

5.6 **Adaptability to terrain conditions**
The Water-Gate™ adapts to most terrain conditions. However, the nature of its construction means that it is not suitable for narrow bank tops (due to the ‘bib’ length) and sloping surfaces.

5.7 **Provision of fixings/susceptibility to damage or vandalism**
The Water-Gate™ is a temporary barrier and therefore has no fixings.

5.8 **Possible locations of use**
MegaSecur states that the Water-Gate™ is suitable for use on flood banks, reservoir banks, as a second line of protection and as enclosures around properties.
6 Financial aspects

6.1 Maintenance/reuse/durability
The Water-Gate™ is totally reusable and easy to clean using a water hose. The material is hard-wearing and has undergone laboratory strength tests.

6.2 Installation costs (100 m long x 1 m high – excluding resources)
No details have been provided by Megasecur.

6.3 Installation resource requirements
The Water-Gate™ can be deployed by just one person, although two people may be preferable with the larger barriers. The larger Water-Gate™ may need transporting to the deployment site by a small pick-up truck or similar vehicle.

6.4 Additional installation and removal costs (training/supervision)
None. Training is not included in the product price; however, Megasecur does provide a ‘water barrier’ users guide and a video on its installation.

7 Other

7.1 Aesthetic aspects
The Water-Gate™ is simple and easy to install. It is available only in a distinctive yellow colour. It is self-contained and does not unduly affect the watercourse in which it is deployed.

7.2 Test information
The materials have undergone laboratory strength tests. No further test information was submitted by Megasecur.

7.3 Performance under service conditions
The Water-Gate™ performs well under service conditions. It has won various awards in Canada including three international awards in the fire services, emergency response and in environment categories.

7.4 Environmental aspects
The Water-Gate™ is environmentally friendly and does not pollute.

7.5 Additional comments
The Megasecur Water-Gate™ has been in use and subject to further development since 1999.