Joint Defra / Environment Agency Flood and Coastal Erosion Risk Management R&D Programme

Field trial of a demountable flood defence system between urban structures

Product Code: SCHO1008BOTU-E-P

Environment Agency

defra
Department for Environment Food and Rural Affairs

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Steve Killeen

Head of Science

Executive summary

Demountable flood defences have a part to play in flood risk management, particularly where permanent defences are considered impractical or where the sighting of fixed barriers is visually obtrusive.

They can provide additional opportunities to reduce flood risk and may provide a cost effective solution where the costs of a permanent scheme exceed the benefits. Demountable defences can also be used as a stop gap when the construction of permanent defences is delayed.

Planning, design and construction of a demountable system require careful consideration and four key areas have been singled out for consideration. The key areas are: 1) justification, 2) design, 3) approvals and 4) construction, installation and whole life management.

The demonstration site is at Clementhorpe, York on the River Ouse, a location at real risk of flooding. The groundwork's for the demountable system were put in place in spring 2008. The case study provides examples of some of the issues that may be faced in implementing a scheme of this type and will aid in the delivery of similar schemes in the future.

The justification stage should consist of a feasibility report, which quantifies the flood risk and the costs and benefits of different flood defence options at a particular site. The need for environmental impact assessment and an appropriate flood warning system must also be considered.

A demountable flood defence scheme must be well designed so that the installation forms a reliable, watertight defence. Any demountable defence will form a part of an overall flood protection system. It is particularly important to consider points where the defences meet the existing infrastructure, such as walls, pavements and roadways. It is also essential to consider whether utility apparatus, such as sewers, provide a flow path for water under defences.

During the design phase, local communities, utilities and statutory bodies who are affected by the project should be consulted and given an opportunity to comment.

Gaining approvals for demountable flood defences can be a lengthy process. Negotiations with affected householders and utilities were unexpectedly protracted in the case study described here and led to substantial delays. The experience demonstrates how important it is to have access to good quality information about the performance of the selected demountable flood defence, and to keep lines of communication open.

Construction should not be seen as the final stage of a project. Whole life management of a scheme is important as it reduces the risk of failure. Whole life activities may include inspection, trial deployments, maintenance, performance monitoring during flood events, replacement and decommissioning.

The operation of the system must be carefully assessed and planned so that it can be erected effectively before a flood occurs. This was highlighted by the summer 2007 floods, where delays in getting demountables to site was an issue.

Contents

1. Introduction

A demountable flood defence system is a flood barrier that is either fully pre-installed and requires some form of operation during a flood event, or one that is partly installed and requires further installation in advance of a flood. The full definitions of temporary and demountable defences and products are covered in British Standards Publicly Available Specification 1188 (2003). Demountable systems are generally closer to permanent defences than temporary systems.

The planning, design and construction of a demountable system is no trivial matter, it must make optimal use of the physical geometry of the site, in relation to its normal functions. Environmental and amenity functions must not be overlooked. It must also ensure that the component parts of the demountable system and their operation are well designed and form a watertight flood defence. Further detail on assessing the appropriateness of these systems is provided in *Temporary and demountable flood protection - interim guidance on use* (Joint Defra/Environment Agency Flood and Coastal Defence R&D Programme Publication 130/1).

Current limitations on the use of these systems mainly arise from professional liability issues, which lead to conservative construction practices. This means that Flood risk management practitioners are unwilling to depart markedly from previously successful designs and more importantly these may be less environmentally or economically beneficial than alternatives. This study provides a logical, scientific process of proving a concept at field scale before it is taken into practice.

There have been a number of trials of different innovative flood risk management options. However, prior to this study, the assessment of systems that provide a barrier to the passage of floodwater between urban structures such as buildings and walls have only been assessed to a limited extent. This approach could provide a valuable flood risk management option, but there are a number of issues that need careful consideration. Aside from ensuring that the proposed scheme will be effective in reducing risk, we also need to understand the issues that may arise in establishing a scheme, for example in liaising with utility providers, highways agencies and property owners/occupiers.

The objective of this project is to document the experiences of a pilot project, demonstrating the use of a demountable flood defence system in the city of York. This pilot study is at a real life site which is at risk of flooding and this site is at Clementhorpe Road/Terry Avenue in York on the River Ouse. The pilot study will help both asset managers and those in the flood products market to understand some of the key issues involved with such an installation.

2. Demonstration site

The project team and the City of York Council identified the Clementhorpe area of York where a demonstration of demountable flood defences would be appropriate.

Clementhorpe has been affected by flooding from the River Ouse, but hard flood defences are not possible because of existing infrastructure such as roads. In this area, there are a number of older properties adjacent to the River Ouse which are affected by flooding. These are situated close to newer properties that have been constructed at higher levels and have a lower flood risk (Figure 1).

To reduce the risk of flooding a line of demountable defences at the pilot site can now be installed. The line runs across the junction between Clementhorpe Street and Terry Avenue. The barrier abuts the walls that enclose the higher ground on which the riverside properties stand.

Figure 1: Floods at Clementhorpe site in 2000

The outline design of the site and the installation produced by the project team is provided in Annex 1.

3. Key stages of the project

This project concentrates on the challenges faced by asset managers where a line of linear demountables are required to protect a number of properties.

Four key stages from concept to completion are shown in Figure 2. Each stage is discussed in more detail in the remainder of this chapter.

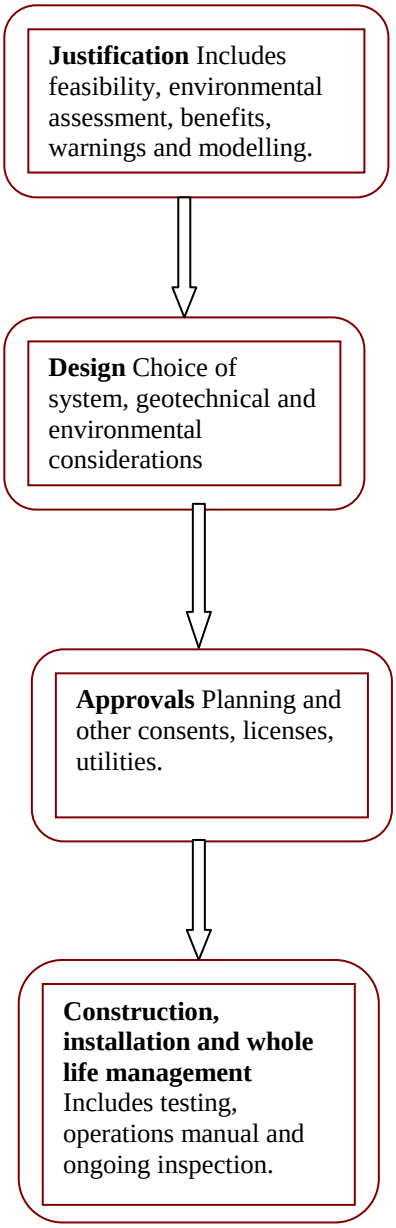


Figure 2. Key stages for implementing a project

3.1 Justification

At the concept stage, it is necessary to consider the options for flood risk management and outline the benefits. This is usually done by a feasibility study, although for smaller projects it may not be a formalised process (Joint Defra/Environment Agency 2002 Flood and Coastal Defence R&D Programme publication 130/1).

A feasibility study identifies flooding problems, looks at a range of options for reducing flood risk and shows their benefits and costs. The case for demountable or temporary defences is established as one of those options.

Permanent structures are not always practical where linear defences are required, because they may interfere with the local landscape of an area. Permanent linear defences could also be too costly to install and maintain throughout the life of the asset.

In the case of Clementhorpe, permanent defences were not practical, as they would need to be built across a road. If the required flood defence height had been less than 0.5m, a defence could have been incorporated into the highway structure by constructing a ramp. In Clementhorpe, the required height was 2m, so the ramp solution was not feasible.

Part of the feasibility stage in assessing any flood risk management scheme is a benefit/cost analysis, undertaken to see whether a scheme is economically viable. Usually, the analysis uses the Flood Hazards Research Centre (2005) report: *The benefits of flood and coastal risk management: a manual (and handbook) of assessment techniques*. Commonly known as *The multi-coloured manual* (MCM), this provides monetary benefits of flood defence for different land use types.

If full costings are not available at this stage, a range of potential costs (including whole life costs) will allow an asset manager to calculate a range of benefit: cost ratios. A minimum benefit: cost ratio of 1:1 is usually needed to justify a scheme on economic grounds.

To quantify the benefits of a flood defence scheme, you need to know the predicted frequency of flooding and the number and types of properties that would be protected. You also need to determine the standard of protection you are aiming to provide. These data sets are usually produced using hydraulic modelling or by local flood risk assessment, both of which may already available. Where there are insufficient or missing data, a modelling and mapping exercise is usually needed.

In the case of Clementhorpe, relevant data was made available to City of York Council by the Environment Agency. This indicated that a 1:100 flood defence standard (1% chance of a flood occurring in any given year) would result in the need for a 2m defence above ground level in the Clementhorpe area, protecting 14 properties.

3.1.1 Environmental impact assessment

Environmental assessment procedures are designed to ensure that the environmental implications of (in this case) flood risk management options are taken into account before major decisions are made. Therefore an environmental assessment officer should be consulted during the feasibility stage.

Analysing the predicted environmental effects of different flood defence options helps to optimise the positive effects and modify or mitigate the negative effects during the project design.

The legislative requirement for Environmental Impact Assessment (EIA) in the UK stems from the *European Directive on assessment of the effects of certain public and private projects on the environment*, known as the *EIA Directive*[1]. This has been transposed into UK legislation through a number of statutory instruments. Those most relevant to flood risk management (FRM) activities are:

- ***The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations (SI 1999 No. 293),*** administered by the Department for Communities and Local government (CLG). The regulations apply to certain categories of project that require planning permission. New FRM structures, including demountables, may fall under these regulations, as did the pilot demountable defences at Clementhorpe.

- ***The Environmental Impact Assessment (Land Drainage Improvement Works) Regulations (SI 1999 No. 1783)***[1], administered by Defra. The regulations apply to improvement works to land drainage infrastructure undertaken by land drainage bodies, including the Environment Agency. Such works are permitted development and therefore not subject to the Town and Country Planning requirements. The regulations require improvement works to be screened, to determine whether they may have significant effects on the environment (Regulation 4). If significant impacts are expected, a statutory EIA will need to be undertaken. The Environment Agency must make a decision as to the significance of any impacts. This legislation could apply to demountable schemes.

Clear descriptions and thresholds are provided by CLG on the applicability of the *Town and Country Planning (EIA) (England and Wales) Regulations*. By contrast, the *EIA (Land Drainage Improvement Works) Regulations* are very broad in their applicability, and Defra has chosen not to set guidelines or thresholds. This is to prevent minor (or small scale) works with potentially significant impacts from being overlooked. Hence all permitted development land drainage improvement works need be screened, to determine the applicability of the regulations and the potential need for an environmental assessment.

For maintenance works the EIA regulations and environmental impact assessments do not apply, although other internal procedures may apply depending on the operating authority.

3.1.2 Flood warning systems

Any proposed demountable or temporary solution should have the support of a local flood warning service and the Environment Agency are able to advise on this matter. It is essential that warnings can be provided with sufficient lead time to ensure that the system is safely erected before the flood occurs. Some demountable systems can take longer to erect than others.

The feasibility study should also investigate whether a scheme is likely to be acceptable at the proposed location and whether there are adequate resources and access to the site during the deployment stage.

[1] Directive 85/337/EEC as amended by Directive 97/11/EC and Article 3 of Directive 2003/35/EC.

At Clementhorpe, flood warnings are sent via the Viking's Gauge upstream of York and a warning to the City Council gives 12 hours notice for deployment of the barriers.

After appraising flood defence options according to all of the above information, the asset manager or engineer will propose a preferred option and level of protection.

Figure 3: The Clementhorpe area. The area to benefit from the Clementhorpe project is outlined in red.

3.2 Design

It is useful in the early stages of a project to have some outline design options. These options will enable consultees to have an overall impression of the scheme and gives them an opportunity to feed into the design process.

The main consultees associated with demountable schemes are likely to be:

- The Highways Agency, where a scheme affects roads, footpaths or highway drainage
- The local authority, especially where a scheme requires planning permission, or affects listed buildings or conservation areas
- The Environment Agency, with respect to flood warnings, consents and environmental assessment
- Utility companies, such as gas, electric, water supply, foul water, telephone, other pipelines and cable
- Local politicians such as MPs and councillors

- The local community
- Land or property owners and agents

The factors to be considered when choosing a particular type of demountable system are covered in depth in chapter four of the Joint Defra/Environment Agency 2002 Flood and Coastal Defence R&D Programme publication 130/1. The key design considerations are summarised in Figure 4.

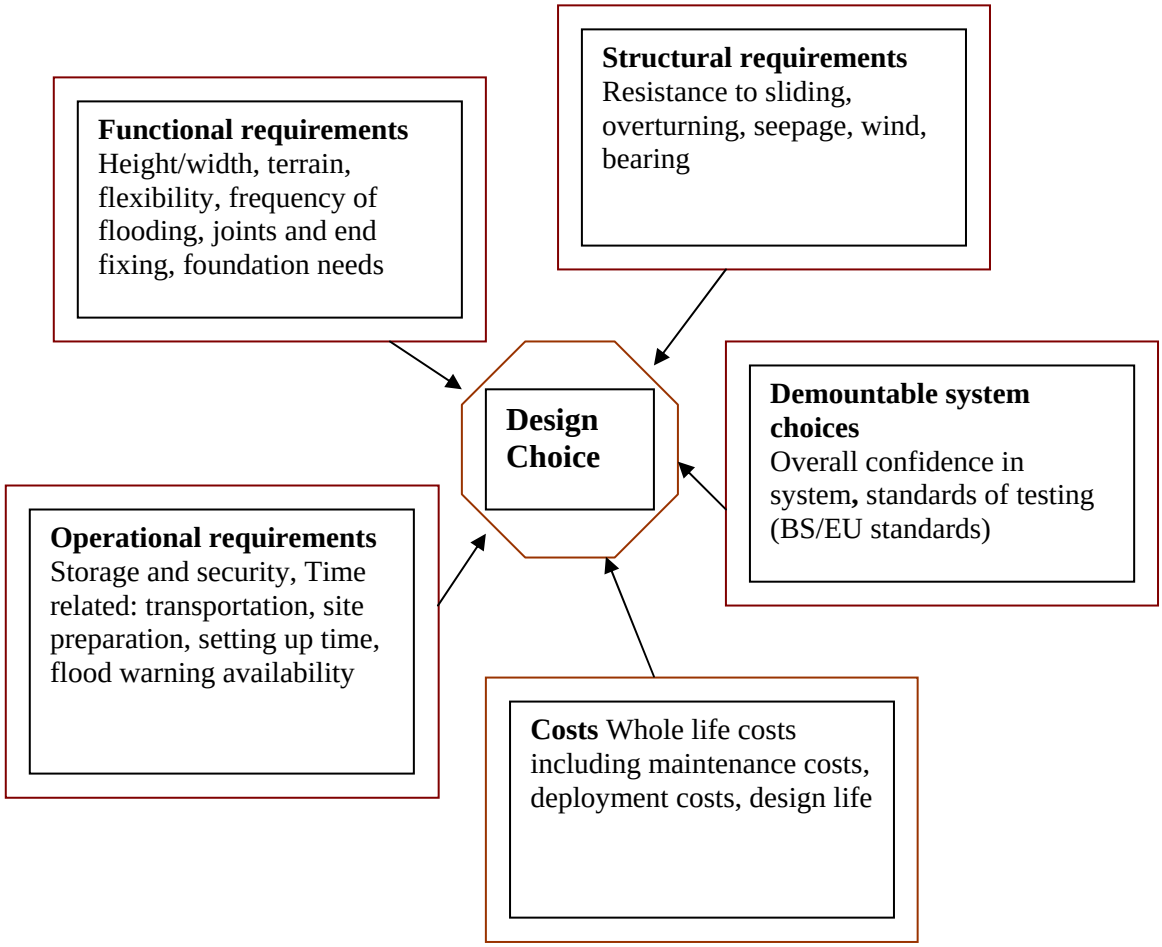


Figure 4: Design considerations for demountable flood defences

The choices of system were very limited when this pilot study was initiated, as the project was carried out in collaboration with the suppliers of the Aquabarrier system. Whilst the choice of demountable system was therefore limited, the Aquabarrier system was assessed as appropriate for the site and the remaining stages of design consideration (costs, operational, functional and structural requirements) were carried out in full (see Appendix 1).

The Aquabarrier system uses hollow 'L' shaped units made from medium density polyethylene (MDPE), which are linked together upon deployment to form a continuous barrier wall of the required length. Each barrier module is 1.5m high with a footprint 2.2m long and 1m wide. A number of holes are incorporated in the sloping front face, which allow the module to fill with rising flood water. The weight and hydrostatic downward

force created by internal and external water enables the module to maintain its stability as water levels rise and fall.

Figure 5: The Aquabarrier system

The foundation is in the form of a 0.5m concrete slab across the street, rising above pavement level to form a flat surface to ensure that the height of the barrier is above the expected flood level. This forms a speed ramp in the carriageway. It does not inconvenience vehicles, as it is located at a junction where speeds tend to be low.

In the design of demountables, it is important to consider where the defences meet the existing infrastructure or high ground. These points are potential weak spots where seepage of water could occur. At York, bespoke metal channel units have been specially made to accommodate the units, which bolt to the walls of the buildings either side of the road. The metal channel units are designed to the required thickness so that the line of units fits the exact width of the street.

Figure 6: One of the bespoke steel channels used to attach Aquabarrier units to walls at Clementhorpe

3.3 Approvals

The Environment Agency has a general supervisory duty relating to all flood defence matters. The extent of the Environment Agency's operational role depends upon the designation of a watercourse. Responsibility for main river, sea and tidal defences rests primarily with the Environment Agency and for other watercourses with the appropriate local authority or Internal Drainage Board. Sections 165 and 172 of the *Water Resources Act* give the Environment Agency specific powers to maintain defences and gain entry onto land, respectively.

Under the *Water Resources Act*, formal consent is required from the Environment Agency for the erection, alteration or repair of any structure in, over or under a main river, if the work is likely to affect the flow of water. Written consent is required for works listed in the *Land Drainage and Sea Defence Byelaws*, such as for works within eight metres of a main river, or works in a river or coastal floodplain.

For private individuals who want a demountable system, the legal route is governed by common law. The person taking preventative action should ensure they have the legal right to install the defence.

3.3.2 Communication

Communication with the public is key in achieving a successful project and a communications plan is a tool to assist with the process.

In the pilot study, the City of York held numerous public consultations with the local population. During the period of negotiations with homes identified as properties at risk of flooding, concerns were raised that property prices would fall as a consequence of the investigations and publicity associated with the works.

The scheme gained acceptance by the vast majority of the community when the benefits of the scheme were explained. A risk register at the start of the design process, identifying critical issues, would assist in the managing of risks.

During these consultations, project staff liaised with the owners of the two properties to which the barrier units would be fixed. We sought permission to adjoin the barriers to the two properties. Unfortunately, during this period, ownership of both properties changed hands and this delayed the project by two years.

Both new property owners were concerned for the structural integrity of their buildings, should the defence collapse. The manufacturer supplied supporting calculations to assist with this matter. The solicitors acting for both property owners required a permissions licence to be put in place to safeguard their clients' properties, and the wording of this document was difficult to agree upon, contributing to the delay. A licence from the property owners was eventually agreed in October 2007.

This experience shows how important it is to have supporting documentation and calculations available to demonstrate the features of the system from the outset. When planning such a scheme it is essential to allow sufficient time and resources to consult with and reassure people who will be affected by it, and to maintain close contact with them throughout the project.

It took six months of liaison with the utility companies to obtain the appropriate approvals at Clementhorpe. Some Yorkshire Water apparatus had to be altered to

prevent back-flow from the sewer beneath the street at times of flooding. Measures were built into the overall design to allow an inflatable bladder to be manually fitted to the gullies during a flood.

Leading up to construction at York in March 2008, it was also necessary to obtain permission under the *New Road and Street Works Act* to close the highway, to construct the ramp and to install additional gullies in the highway. This process took another six months before approvals were sanctioned.

Sufficient time for these negotiations needs to be built into the overall project plan.

3.4. Construction, installation and whole life management

Construction should not be seen as the final stage of a project. Rather, the whole life management of a scheme should be considered, as this can reduce the risk of failure. Whole life activities may include: an inspection regime including trial deployments, maintenance, performance monitoring during flood events, replacement and decommissioning.

In the Clementhorpe project, construction was a simple and straightforward process that involved building a ramp, installing two gullies and making the buildings suitable for the steel channel units. These works took four weeks to complete.

A good operational plan is important for demountable flood defences. It should describe what triggers the barriers to be put up, where they will be stored, and how they will be transported to the site and erected. The key stages of the plan for Clementhorpe are summarised below. Vandalism, training of operatives and lead times were considered in this plan.

It is vital to regularly review the operational plan, as key information such as contact details can quickly become outdated.

To test the plan, we installed the demountable defences on two occasions, with the media and community present at one of the trials. The dummy deployments did not highlight any errors or omissions in the operational plan.

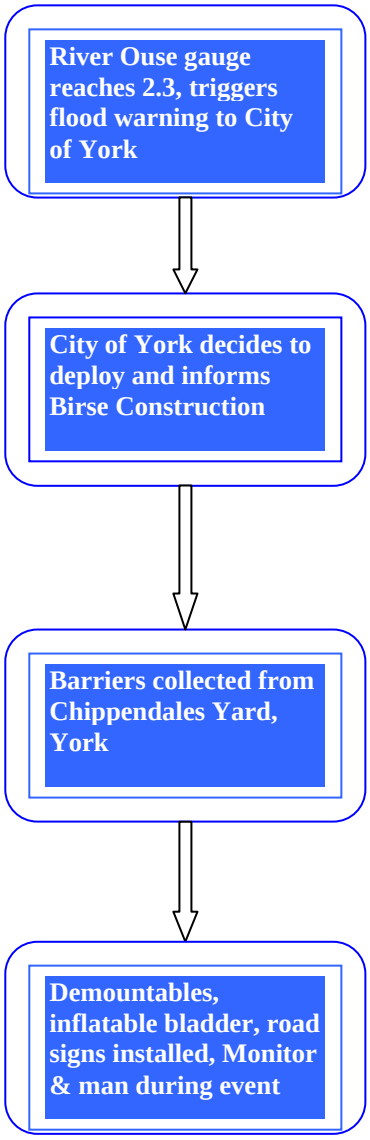


Figure 7: Summary of operational plan

3.5 Flood event September 2008

On the 6th Sptember 2008 the barriers were deployed for the first time in a real life situation, which took 1Hour 15Minutes. The River Ouse Peaked at 2300 Hours on 7 September, which resulted in 600mm of water up against the barriers. Some seepage was experienced as a result of the seals not been correctly seated and this has been logged as a lesson learnt. This seepage of water was approximately 88 Litres/minute, which was managed by the highway drainage system . The constant upwards seepage through the road construction on the "dry" side of the defence caused the surface of the carriageway to be buoyant in locations and the geotechnical aspects of this are being investigated by the City of York.

The recent event offered normal access to the Dukes Wharf apartments by keeping their access dry. The water level for this flood event did not reach a level where properties would have ordinarily flooded.

Figure 8: Deployment 6 September 2008

4. Conclusion

We have used a pilot project to illustrate the important stages in using demountable flood defences as part of a flood risk management system.

We single out four stages to the process: justification, design, approvals and construction, installation and whole life management.

The justification stage involves a feasibility study, assessing different flood defence options for costs and benefits. To justify a demountable flood defence system, the benefits should exceed the costs. The need for environmental impact assessment and a suitable flood warning system must also be considered at this stage.

In the design of demountables, it is important to consider where the defences meet the existing infrastructure or high ground. These points are potential weak spots where seepage could occur.

Consultations with the adjoining property owners took two years to complete in the pilot study. This was partly due to anxieties about the failure and impact of the system. Therefore having available supporting documentation, calculations and being able to demonstrate the system is important when making approaches of this kind. When planning such a scheme it is essential to allow sufficient time and resources to consult with and re-assure those concerned and to ensure that close contact is maintained throughout the project.

The approvals stage can be lengthy and these time delays should be allowed for in the project plan. In the pilot project it took over two years to negotiate permission from house owners, the water company and the Highways Agency, before construction could begin.

Finally, in planning the construction stage of the project, whole life considerations such as inspection, monitoring and maintenance are vital for ensuring optimum performance. Monitoring how well the defences work in a real flood situation is particularly important.

A good operational plan must be in place, describing when the demountable defences will be deployed, who will collect them, and from where, and how they will be installed. This operational plan must be regularly updated, to ensure that key details are correct.

With advances in science, technology and engineering, an increasing range of flood products is available in the UK. A follow up science project (SC080019) will identify all the currently available flood products and update *Temporary and demountable flood protection - interim guidance on use* (Joint Defra/Environment Agency Flood and Coastal Defence R&D Programme Publication 130/1 - 2002).

The York site is now fully operational and deployment took place in a real life situation for the first time on 6 September 2008. Some minor seepage was experienced as a result of the seals not been correctly seated and this has been logged as a key learning area.

Appendix 1: Outline design proposals and Design Basis

aquabarrier international limited

Member of the: FPA Flood Protection Association

York City Council

Aqua Barrier pilot scheme
Clementhorpe Road

Outline design proposals
and Design Basis Statement

Outline Design Basis Statement

Ref: Clementhorpe Road, York City.

Site Location:

Following a location review with the Technical Officers of York City Council the location of the Aqua Barrier has been confirmed. It is proposed to locate it approximately 30m from the junction with Terry Avenue, which is the main road running parallel with the Great Ouse.

This location has been confirmed on site and the main reasons for its selection are:

- The barrier will abut brick retaining walls and not directly to any house.
- The existing retaining walls are currently retaining approximately 1.0 - 1.5m of soil and as such are likely to easily withstand the hydrostatic load during a major flood event. This will equate to the barrier holding back 1.5m of water.
- There is a existing manhole on the existing combined sewer in the immediate vicinity that will enable easy adaptation of the sewer pipes to facilitate a non-return valve/penstock to be constructed.
- All road gulleys river-side of the barrier flow towards the river, all gulleys upstream flow away from the river hence mitigating by-pass flow through the road drainage system.

Ground Infrastructure:

Ground Slab: This will consist of a ground bearing slab which will act as the connecting platform for the barrier system. The slab will consist of a reinforced ground slab designed to have a spanning capability and crack mitigation. The slab will be approximately 300mm thick and will be set to a line a level to suite existing footpath level. The slab will be approximately 2.5m wide. It will be designed to incorporate a deep ground water cut-off toe to the downstream edge.

The slab will run between the garden walls noted above, back of footpath to back of footpath, a length of approximately 11m. The finished slab will be set at approximately 8.7m AOD (detailed survey will confirm).

The concrete ground slab will have to be blended into the existing carriageway and disguised as a road hump. It will be designed so that it will permit vehicles to pass at 30 mph (although it is so close to the junction that

it is likely that actual transient speeds will be significantly less). Due account will also be given to the fact that an adjacent caravan site also uses the route through Clementhorpe Road for access to their park.

The permanent ground slab will contain the necessary cast-in channels required to secure the barriers during deployment. These channels will be protected by dense rubber inserts during normal times, permitting the safe passage of traffic and pedestrians.

Sewer adaptation: There is an existing 225mm combined sewer which runs down Clementhorpe Road, between River Street and Terry Avenue (detailed survey will confirm invert levels). The barrier will constructed over this sewer line. It is proposed to intercept the sewer and reconstruct it under the barrier to incorporate a non-return valve or penstock. This will mitigate the risk of back-flow by-passing the barrier during flood events.

A pump sump will be incorporated into the sewer line on the dry-side of the barrier (detailed design consideration of population flows etc. will determine size). Information from York CC to date gives a clear indication that the head of the combined sewer coincides with the junction of River Street, whereby the sewer falls in both directions at this point. The pumping sump would need only cope with flow towards the river.

Portable pumping equipment will be mobilised during a flood event to dispose of any build up within the combined sewer behind the barrier.

Works to adjacent Alleyway: York CC have indicated that there may be a slight risk that flood flows could flow down an adjacent alley and by-pass the barrier, causing some flooding to adjacent property. Site visit indicates that the level at the top of the alley stairs is below (approximately 2-brick courses) the maximum height of the barriers in Clementhorpe Road. This will be investigated as part of detailed design considerations but an easy flood mitigation measure is likely to be a simple stop-log arrangement at the top of these stairs.

Ground water flow mitigation: Very limited information is available at this time as to the permeability characteristics of the sub-soil. Detailed design will consider the issue of ground water flow during a design flood event. However the constraints on the site will inherently limit the types of techniques that could be considered. Because of residential property immediately adjacent to the barrier site, garden walls and statutory services, there will be limited scope for any major construction works. It may be that existing building foundations, garden wall foundations, proposed slab toe and the

impermeable nature of the surrounding roads and footpaths will mitigate the need for significant works in this regard.

Detailed design and flow net analysis will determine flow path risks during the peak of a flood event.

Services: Limited information on services within the footpaths and carriageway is known at this time. It is thought that services include gas, electricity, water and telecoms. There are no major constraints on design known at this time.

There may be a critical path issue with regards to construction sequencing and the electricity services. The power company may require up to 3 months notice of any diversion work to their cables. This issue can be worked as part of the detailed design and construction planning.

The Site:

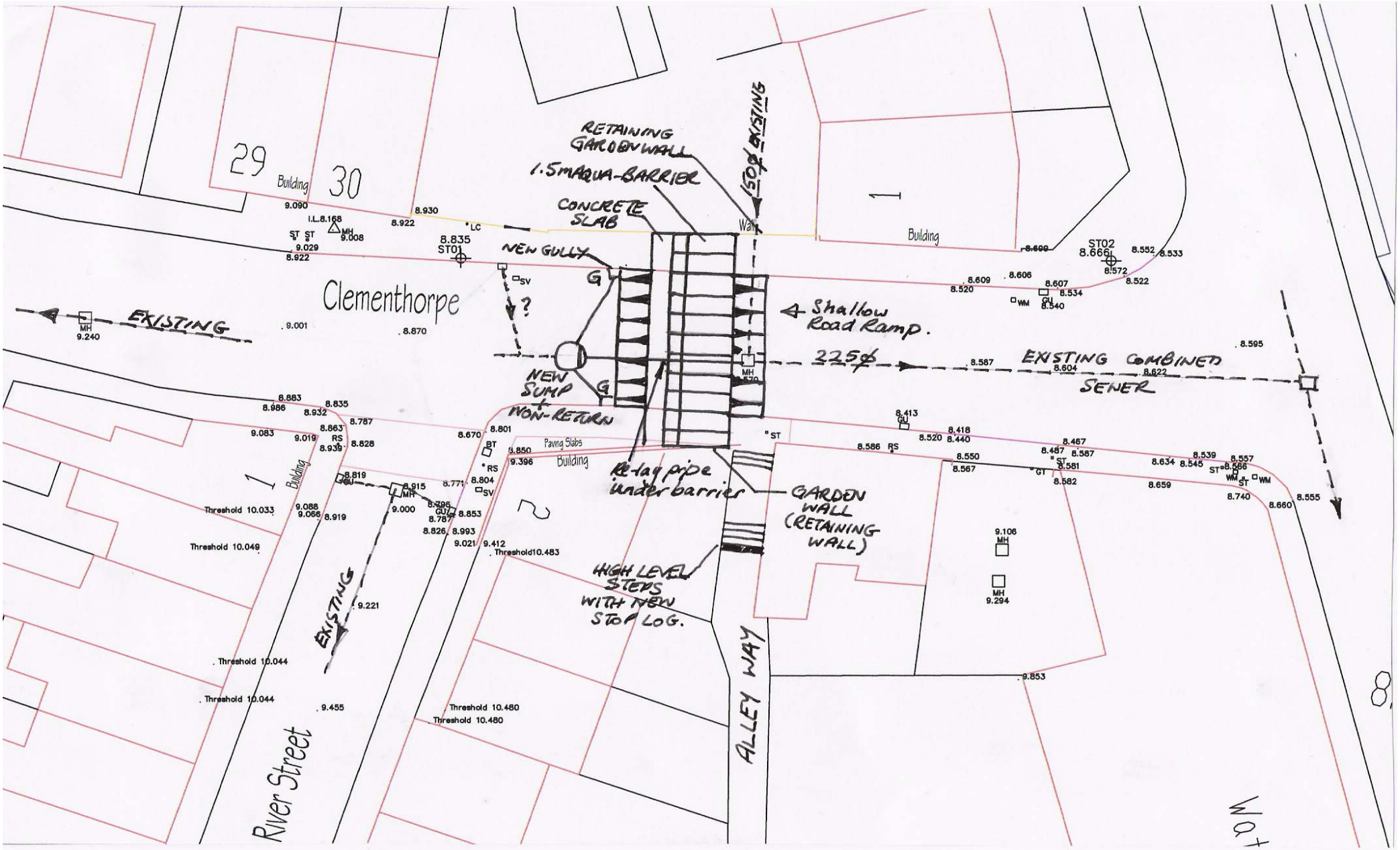
The extent of the construction Site is yet to be confirmed but to facilitate porta-cabins and welfare facilities; it is likely that the Construction Contractor will take over the whole of the bottom end of Clementhorpe Road, between River Street and Terry Avenue.

All necessary road closure notices and diversions will be agreed with York CC.

Third Party Liabilities:

A number of third party liabilities exist and may exist as a result of The Works:

- The barrier crossing will be across Public Highway as such is in the control of York CC, as The Employer. Works as such are not unusual and will be covered off by the normal liability insurances.
- The liabilities with regard to the statutory services are no different to any highways works.
- The design of the road ramp will be undertaken to ensure that it is not deemed a traffic calming measure and there will be a need for liaison with residents and the local caravan park to make sure the proposals are made clear.
- The boundary garden walls are not owned by the highway authority and as such there will be a potential liability both during the construction and deployment. This will be considered in the detailed design and as part of the Deployment Management Plan. Liaison with these householders will require the close support of York CC.



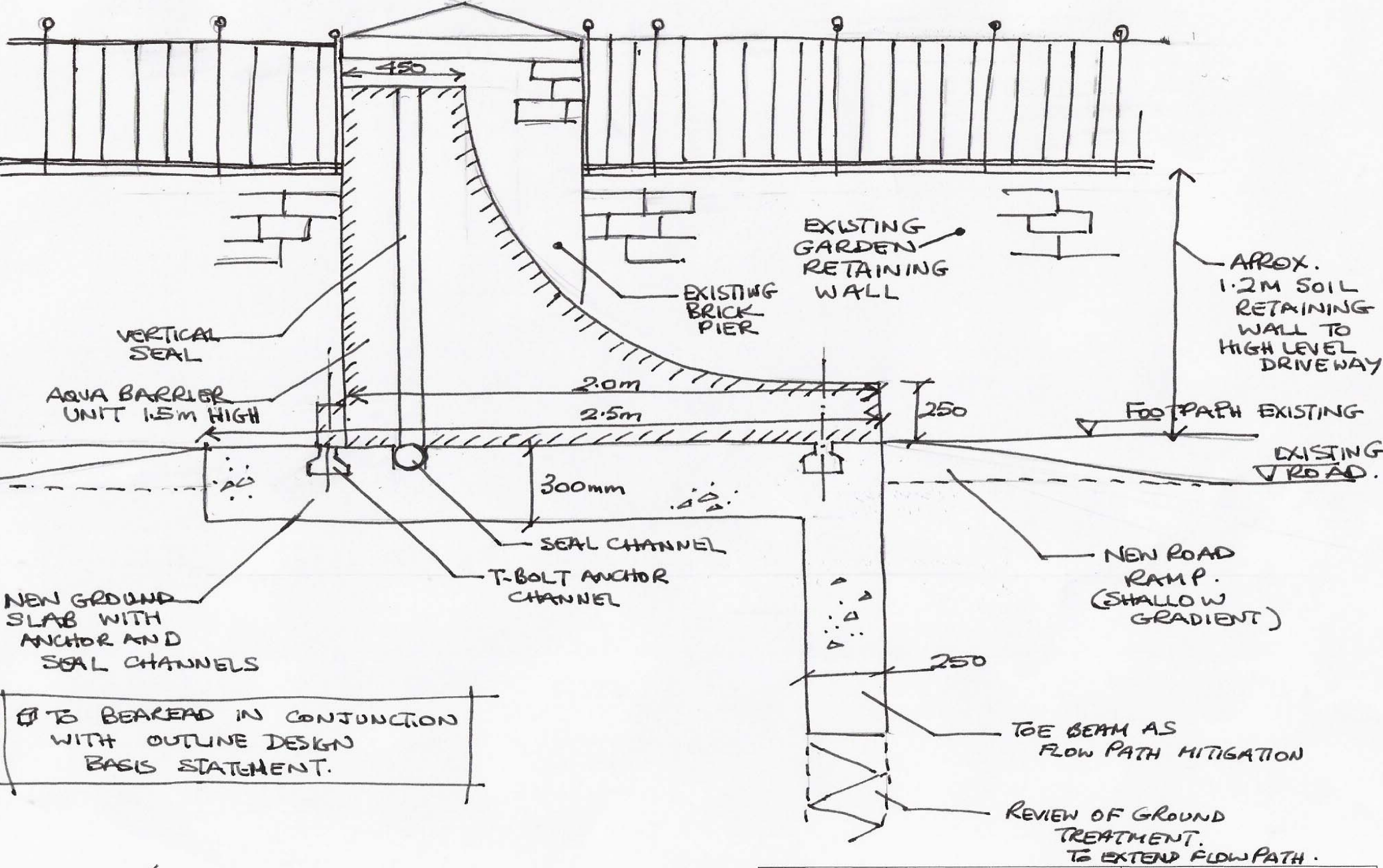
YORK CITY COUNCIL
AQUA BARRIER PLOT SCHEME

aquabarrier international limited

Not to scale

Site Plan
Clementhorpe
Barrier

SK01



TO BE READ IN CONJUNCTION WITH OUTLINE DESIGN BASIS STATEMENT.

YORK CITY COUNCIL
AQUA BARRIER PILOT SCHEME

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TYPICAL CROSS-SECTION THRU' BARRIER

SK02

View down Clementhorpe Road from Terry Avenue. Barrier will cross the road approximately in front of the white van.

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View across from the end of River Street towards the north side of Clementhorpe Road. The retaining wall on the far side shows the brick pier (with notice attached). The strength of the retaining wall can be seen.

See SK02 Typical cross section Thru' Barrier.

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View to the south side of Clementhorpe Road showing the garden retaining wall on that side. This wall is retaining approximately 1.5m of rear garden to No2 River Street.

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View down alley way on south side of Clementhorpe Road showing high level steps that may require some permanent works by way of a removable stop-log arrangement on the top step. This will mitigate the risk of a back door by-pass flow during an extreme flood event.

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We are The Environment Agency. It's our job to look after your environment and make it **a better place** – for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

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