Rhiwbina Flood Defence Scheme

Pen-y-Dre
Options Report

August 2013

Cardiff County Council

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Rhiwbina Flood Defence Scheme

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Contents

Executive Summary

Mott MacDonald has been appointed by Cardiff County Council (CCC) as designer for a flood defence scheme, which incorporates a number of small construction works to reduce flood risk to residents in the Rhiwbina area of Cardiff. The purpose of this Options Report is to inform CCC to assist them in making a decision on how the flood management scheme within the Pen-y-Dre area shall proceed.

The scheme generally comprises localised improvements to the existing watercourse, reduction in the risk of blockage and the introduction of walls to maintain flows within the bank. The scheme design follows the recommendations of the Project Appraisal Study (PAS) by Edenvale Young (dated July 2010).

This Options Report considers the alternative ideas developed since the public exhibition of February 2013 and the residents meeting of May 2013, which were identified as requiring further consideration by CCC.

Six options have been considered, these are summarised in the table below. The two most viable options are Options 1 and 2 as they have the best benefit-cost ratio, are technically feasible, have a limited impact on the community and businesses during construction and have a low long term visual impact on Pen-y-Dre. Option1 (which incorporates flood walls behind and on the line of the hedge along Pen-y-Dre) has the same Benefit/Cost ratio as Option 2. However, the long-term visual impact on the conservation area will be lower and the inclusion of a wall behind the hedge will be managed more sensitively. Therefore the study has concluded that Option 1 is the preferred option for construction.

Option	Provides defence level	Landscape impacts at Pen-y-Dre	Environmental impact level	Statutory constraints	Construction impact on community, residents and businesses	Benefit/Cost ratio
Option 1 - Flood wall along line of hedge	YES	2	1	1	1	1.23
Option 2 - Flood wall with reduced impact on hedge	YES	3	1	1	1	1.23
Option 3 Culvert Duplicaton	YES	1	1	1	3	1.11
Option 4 - Replacment of exisitng channel wall	YES	3	1	1	3	1.18
Option 5 - channel widening	NO	3	1	1	3	1.15
Option 6 - Attenuation upstream of Pen-y-Dre	NO	1	2	3	2	1.03

1	Minimal impact or provides defence level
2	Moderate level of impact
3	High level of impact or does not provide defence level

1 Introduction

Mott MacDonald (MM) has been appointed by Cardiff County Council (CCC) as designer for a flood defence scheme, which incorporates a number of small construction works to reduce flood risk to residents in the Rhiwbina area of Cardiff. The purpose of this Options Report is to inform CCC to assist them in making a decision on how the flood management scheme within the Pen-y-Dre area shall proceed.

The scheme generally comprises localised improvements to the existing watercourse, reduction in the risk of blockage and the introduction of walls to maintain flows within the bank. The scheme design follows the recommendations of the Project Appraisal Study (PAS) by Edenvale Young (dated July 2010). This Options Report considers the alternative ideas developed since the public exhibition of February 2013 and the residents meeting of May 2013, which were identified as requiring further consideration by CCC.[1]

1.1 Option Evaluation

1.1.1 Technical selection

The report follows a selection process, eliminating first any solutions that are not technically feasible or those that do not meet the design defence requirement. The design defence requirement is the 1 in 100 year event including an allowance for climate change.

A river modelling exercise (based on the existing models) has been undertaken, for the options listed below, to confirm if the design defence requirement can be met.

- Option 1 – Flood wall along line of the hedge
- Option 2 – Flood wall partly in front of hedge
- Option 3 – Culvert duplication
- Option 4 – Replacement of existing channel wall with a taller wall
- Option 5 - Channel widening
- Option 6 – Attenuation upstream of Pen-y-Dre

Those solutions that meet the defence requirement have been subject to a benefit-cost analysis following the same process as that carried out within the Project Appraisal Report dated July 2010[2]. It is noted that the benefit (i.e. reduced flood related damage costs) will be the same for all those options which have passed the technical selection. A ratio of 1 or higher means that over the whole life of the scheme, the benefits derived would be greater than the costs.
Commentary on the following issues has also been included within this report:

- Visual impact (including artist's impression sketches of year 1 and year 5 post construction).
- Environmental/ecological considerations and impact.
- Constructability – including feasibility, impact on residents and businesses during construction and relative construction periods.
- Requirement for human intervention in times of flood.

[1] The consultant has followed accepted procedure in providing the services but given the residual risk associated with any prediction and the variability which can be experienced in flood conditions, the consultant takes no liability for and gives no warranty against actual flooding of any property (client's or third party) or the consequences of flooding in relation to the performance of the service.

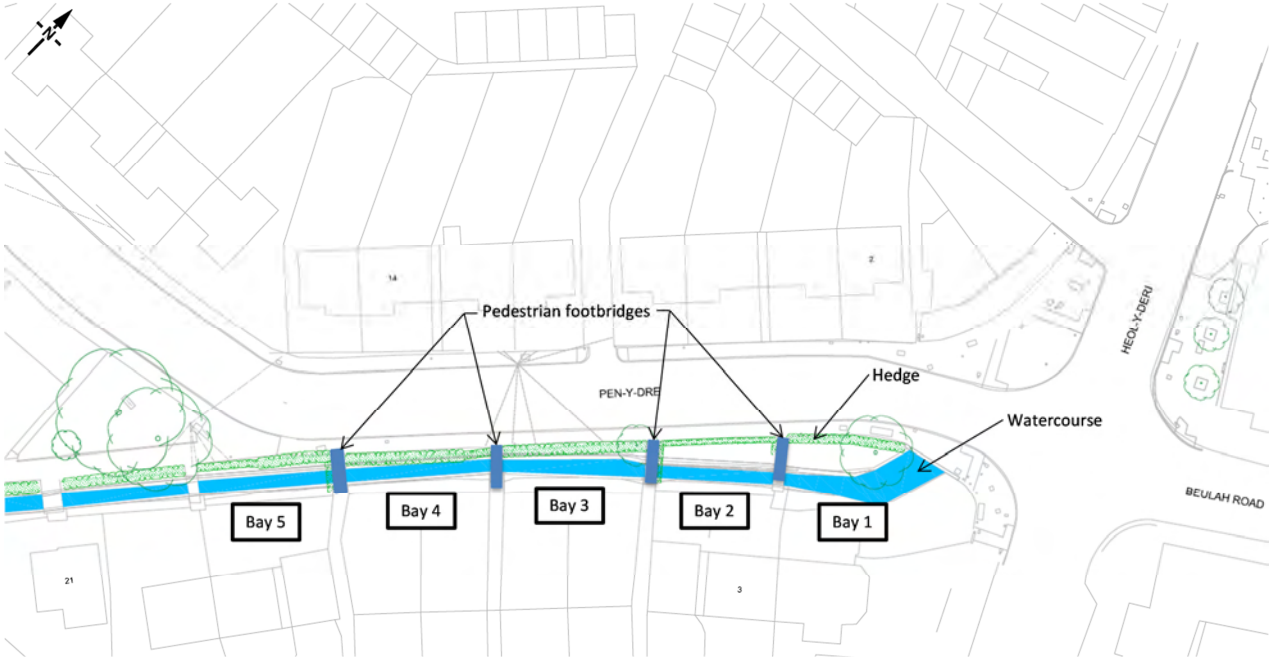
[2] These are not detailed estimates and are produced and provided for comparatory purposes only..

2 Existing conditions

Pen-y-Dre is a residential street in the Rhiwbina area of Cardiff and is within the Rhiwbina Garden Village Conservation Area. Figure 2.1 illustrates the key features within the area that are referenced in this report. The Rhydwaedlyd Brook (hereinafter referred to as “the brook”) flows along the southern side of the street. On the northern side of the street houses are set back from the road with small front gardens. The houses on the southern side of Pen-y-Dre are separated from the road by the brook and are situated within larger front gardens. Access to these properties is obtained via pedestrian footbridges.

A mature hedge runs adjacent to the footpath along Pen-y-Dre (see photos 1-4) and forms a boundary between the road and the brook. The historical architectural features of the Garden Village are protected as the majority of the houses are Grade II listed to preserve the visual character of the area. The hedge does not benefit from any statutory protection and as such can be removed if necessary. However, the hedge is considered to add considerable value to the perception of a rural community within a city setting. The hedge is thus highly valued by some members of the community. Footbridges and access paths effectively split the hedge into bays which have been numbered 1 to 5 for the purposes of this report.

Figure 2.1: Location plan



Photograph 1 Entrance to Pen-y-Dre from Heol-y-Deri (looking southwest)

Photograph 2 View of Pen-y-Dre looking towards Heol-y-Deri (looking northeast)

Photograph 3 - View of Brook Adjacent to Pen-y-Dre (looking northeast)

Photograph 4 - View of Brook Adjacent to Pen-y-Dre (looking northeast)

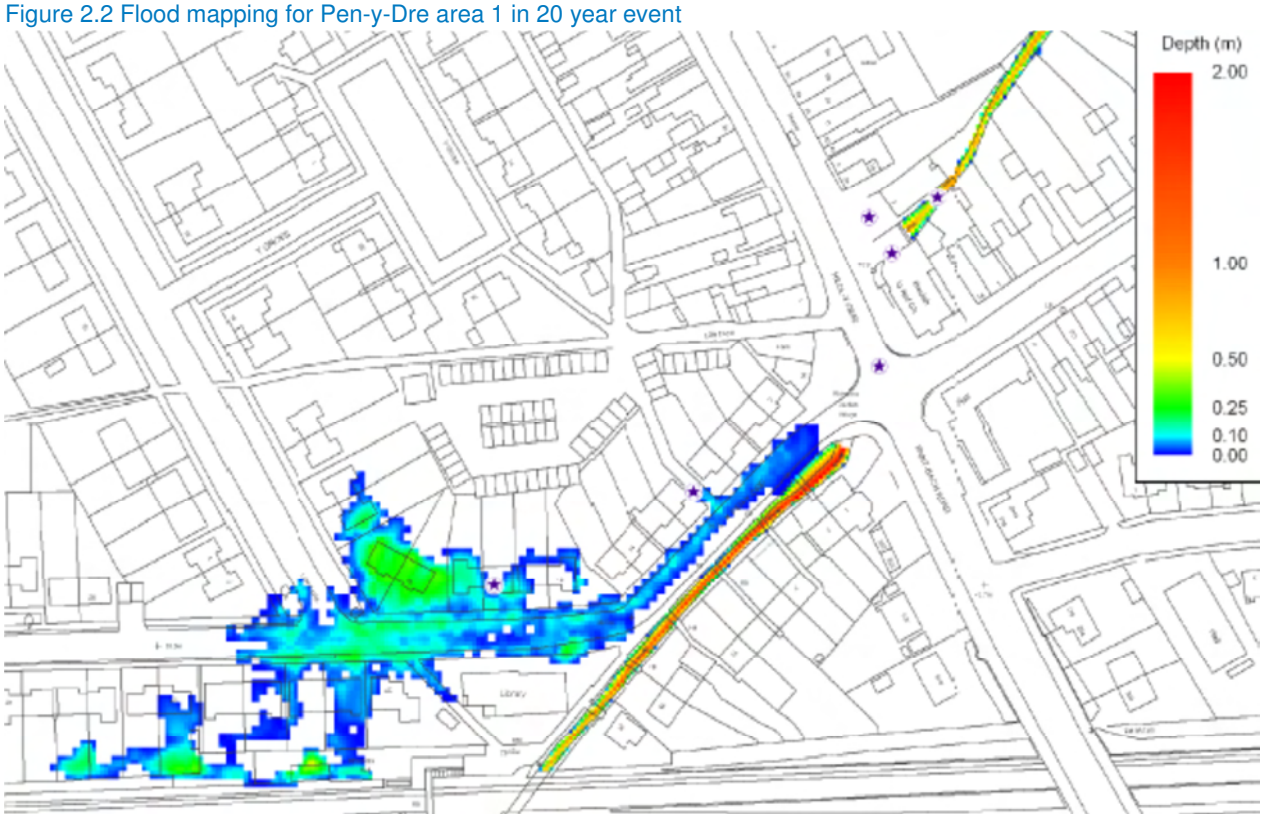
2.1 Existing Flood Risk

The flood risk in the area was quantified through a modelling exercise undertaken by Edenvale Young for the PAS. The PAS demonstrated that Pen-y-Dre was at risk of flooding from the 1 in 20 year event. In this event flooding leaves the main watercourse at the first footbridge, flows along Pen-y-Dre and floods properties beyond the library to the west.

This flooding mechanism has been confirmed anecdotally by local residents who were able to produce photographs from a flood event in 2009 that showed flood waters flowing over the footbridge. In the 1 in 20 year event 24 properties (including the library) are at risk of flooding. The PAS demonstrated that the houses on the southern side of the street are not at risk of flooding in flood events up to and including the 1 in 100 year event. Photographs 5 and 6 were provided by a local resident showing the extent of flooding near Pen-y-Dre.

There is also a secondary flooding mechanism caused by blockage at the upstream end of Heol-y-Deri culvert. This is not considered within this Options Report as it is upstream of the Pen-y-Dre area.

Figure 2.2 Flood mapping for Pen-y-Dre area 1 in 20 year event



Source: Edenvale Young Project Appraisal Study July 2010

Photograph 5 - June 2009 flooding at the bottom of Pen-y-Dre

Source: Photograph taken by local resident

Photograph 6 – View of Heol-y-Deri cross roads towards Pen-y-Dre

Source: Photograph taken by local resident

2.2 Existing landscape constraints

Any constructed scheme must stay in keeping with the general area and must meet any requirements imposed by CCC Conservation Officers. A mature hedge (hereinafter referred to as “the hedge”) runs adjacent to the footpath along Pen-y-Dre and forms a boundary between the road and the brook. CCC Conservation Officers have identified that the hedge is a key feature within the garden village due to its visual impact. The Conservation Officers have confirmed that this does not preclude the removal of the hedge to enable the works, but it is considered essential that the hedge is replanted wherever it is affected.

The hedge currently acts as a barrier between pedestrians and the brook, providing some measure of safety. For a number of the options all or part of the hedge is likely to be removed to facilitate construction access. Sketch 1 shows the use of a “living screen” system which includes an integral fence (which would act as a pedestrian safety fence) and comes ready planted and established with ivy and other suitable plants. This can be placed close to the brook with traditional hawthorn “whips” planted in front. This would

enable the hawthorn to re-establish whilst also maintaining a safety barrier and continued visual hedge line.

Sketch 1: Hedge reinstated including green screen (widening option shown)

2.3 Existing environmental/ecological constraints

The length of the brook along Pen-y-Dre is canalised with residential well maintained gardens to the south and a mature hedgerow to the north. The brook is lit by street lamps which are considered to deter fish species. The hedgerows bordering the brook can offer some potential for breeding birds. As the hedge is next to a public footpath and has regular pedestrian footfall, it is considered that the trees and vegetation in residential gardens may offer more potential and less disturbance to breeding birds. For this reason it is considered that this section of the brook is of low ecological value.

The current drainage arrangement results in the highway drainage outfall flowing into the brook. The brook is located at a cross roads within Rhiwbina and as such there is a potential for pollution of the brook from the road.

3 Options considered

Six options have been considered as part of this report and these are described below.

3.1 Option 1 – Flood wall along line of the hedge

Option 1 comprises a flood defence wall along Pen-y-Dre between the road and the brook, set behind or on the line of the existing hedge. Drawing 1 shows a plan of this option. Construction of the option will require extensive removal and replanting of the hedge. In bays 3 to 5 the replanted hedge would be narrower than the existing hedge. Continuity of the defence is required where it crosses the pedestrian accesses; this will be provided in the form of removable stop logs. The wall heights vary from 1.2m high at bays 1 and 2, 1.1m high at bay 3, 1m at bay 4 and 0.7m high at bay 5. The top water level behind the flood wall would (in extreme events) result in minor flood impact on gardens to the south but will not be high enough to endanger the properties.

3.1.1 River modelling

The river modelling has demonstrated that this solution would meet the design defence requirements.

3.1.2 Visual Impact

Large sections of the hedge would need to be removed in order to gain access for construction. These sections would be replanted upon completion of the works.

The long-term visual impact on Pen-y-Dre would be low. In year 1 the magnitude of change would be relatively low as although the sections of the existing hedge would be removed, a green screen could be incorporated to provide instant infill planting.

In year 5, once the hedge is fully re-established, the views from the road would remain largely unaltered. The wall would, however, be visible from the residences on the southern side of the brook. Additional native climbing species such as honeysuckle, clematis and ivy could be introduced to reduce the visual impact whilst also improving biodiversity.

3.1.3 Environmental/ecological considerations

Although of low ecological value, the hedge proposed for removal will have potential for breeding birds. The programing of the Works together with an ecological check will limit the disturbance to breeding birds until the more diverse hedge re-grows. The proposed species list of native plants will enhance the biodiversity of the hedge and encourage more insects and birds to frequent the area.

3.1.4 Constructability

Access to the construction area may be gained directly from the public highway. The construction area itself is limited as is the scope of construction (albeit that the construction method is complex in order to meet structural design requirements).

Construction would disrupt traffic and parking in the area and the footpath adjacent to the wall would be closed in sections as work progresses. There is, however, scope for this to be well managed, such that during weekends and holidays the construction site could be left in a neat, safe condition, with all construction plant removed from the area and stored within a separate construction compound.

There would be some disruption to residents accessing the southern properties on Pen-y-Dre, but it is expected that this would be limited to a few days disruption per footbridge, which could be managed sensitively (residents would be able to access their home via adjacent footbridges).

This scheme could be expected to be completed within 3 months.

3.1.5 Benefit/Cost analysis

The benefit/cost analysis has identified a benefit/cost ratio of 1.23

3.1.6 Operational Regime

This option requires the Lead Local Flood Risk Authority (CCC at the time of writing) to ensure that stop logs are placed at the pedestrian access points across the footbridges at Pen-y-Dre. This would require a monitoring/warning system (such as on-site telemetry) and for CCC to arrange for operatives to deploy the stop logs at short notice.

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Option 1 Drawings and Visualisation

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3.2 Option 2 – Flood wall partly in front of hedge

Option 2 is similar to Option 1 as it comprises a flood defence wall along Pen-y-Dre to run between the road and the brook. The wall, however, is set in front of the hedge in bays 3 to 5. Drawing 2 shows a plan of this option. In order to construct the wall in bays 3 to 5, the hedge would be trimmed back close to its centreline and the wall installed as close as possible to the hedge. Part of the wall would be built into the existing footpath, but a shorter section of hedge would require removal than for Option 1. The wall heights vary from 1.2m high at bays 1 and 2, 1.1m high at bay 3, 1m at bay 4 and 0.7m high at bay 5. The top water level behind the flood wall would (in extreme events) result in minor flood impact on gardens to the south but will not be high enough to endanger the properties.

3.2.1 River modelling

The river modelling has demonstrated that this solution would meet the design defence requirements.

3.2.2 Visual Impact

The visual impact resulting from Option 2 would be moderate to high; although some sections of the hedge should not need to be removed prior and during construction, the inclusion of a wall on the street side will alter the appearance of Pen-y-Dre from the perspective of residents on the north of the street and any commuters along Pen-y-Dre. The visual impact of the wall can be softened with climbing plants as mentioned in Option 1 and the hedge would eventually grow and cover the top of the wall

3.2.3 Environmental/ecological considerations

Although of low ecological value, the hedge proposed for removal will have potential for breeding birds. The programing of the Works together with an ecological check will limit the disturbance to breeding birds until the more diverse hedge re-grows. The proposed species list of native plants will enhance the biodiversity of the hedge and encourage more insects and birds to frequent the area.

3.2.4 Constructability

Access to the construction area may be gained directly from the public highway. The construction area itself is limited as is the scope of construction (albeit that the construction method is complex in order to meet structural design requirements).

Construction would disrupt traffic and parking in the area and the footpath adjacent to the wall would be closed in sections as work progresses. There is scope, however, for this to be well managed such that during weekends or holidays the construction site could be left in a neat, safe condition, with all construction plant removed from the area and stored within a separate construction compound.

There would be some disruption to residents accessing the southern properties on Pen-y-Dre, but it is expected that this would be limited to a few days disruption per footbridge which could be managed sensitively.

This scheme could be expected to be completed within 3 months.

3.2.5 Benefit/Cost analysis

The benefit/cost analysis has identified a benefit/cost ratio of 1.23

3.2.6 Operational Regime

This option requires the Lead Local Flood Risk Authority (CCC at the time of writing) to ensure that stop logs are placed at the pedestrian accesses across the footbridges at Pen-y-Dre. This would require a monitoring/warning system and for CCC to arrange for operatives to deploy the stop logs at short notice.

Option 2 Drawings and Visualisation

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3.3 Option 3 – Culvert duplication

Option 3 comprises the construction of an additional bypass culvert under Pen-y-Dre. Drawing 3 shows a plan of this option. This would divert some of the floodwater further downstream, returning flows back to the main watercourse at a point where there is sufficient capacity. It is anticipated that the culvert would be constructed using precast concrete box-culvert units.

3.3.1 River modelling

The river modelling has demonstrated that this solution would satisfy the design defence requirements. A residual risk due to blockage would, however, remain.

3.3.2 Visual Impact

The visual impact of this option after completion is relatively low. To construct the culvert a short section of the hedge would require removal and replanting. In all other respects the culvert would be hidden from view to the general public. The incorporation of a green screen would, however, provide instant infilling until such time as the replanted hedge is fully reinstated.

Once the hedge is reinstated, the visual change would be negligible. The culvert exit would be visible from the front gardens of numbers 15 and 17 Pen-y-Dre. The visual impacts on Pen-y-Dre during construction would be significant.

3.3.3 Environmental/ecological considerations

Although of low ecological value, the hedge proposed for removal will have potential for breeding birds. The programing of the Works together with an ecological check will limit the disturbance to breeding birds until the more diverse hedge re-grows. The proposed species list of native plants will enhance the biodiversity of the hedge and encourage more insects and birds to frequent the area.

3.3.4 Constructability

This option would require considerable engineering work as the majority of this section of Pen-y-Dre would be subject to excavation. This would lead to a full road closure and the loss of parking spaces for the majority of the construction period. The contractor may be able to agree a suitable phasing strategy that would lead to only parts of the road being closed at any given time. It is unlikely that a full width closure of the road could be avoided. Access to properties would thus be restricted to pedestrians only.

A closure of part of Heol-y-Deri would also be required to construct the connection to the existing culvert. This would result in disruption to a wider area around Rhiwbina.

It is anticipated that this option would not require the closure of any of the existing pedestrian bridges along the brook.

This option would require additional survey and ground investigation work to be completed prior to the completion of the detailed design. This would effectively delay the start of construction. This option could also require considerable utility diversions to be completed.

The construction period for this option is estimated at approximately 6 months

3.3.5 Operational Regime

This option would not require any human intervention during a flood event. However, the culvert would require regular monitoring and inspection as part of the Highway Authority's regular maintenance regime, as it would now be a culvert structure under a highway.

3.3.6 Benefit/Cost analysis

The benefit/cost analysis has identified a benefit/cost ratio of 1.11

Option 3 Drawings and Visualisation

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3.4 Option 4 – replacement of existing channel wall with a taller wall

Option 4 consists of constructing a new wall on the edge of the existing channel, raising the height to a level sufficient to avoid flooding on Pen-y-Dre. Drawing 4 shows a plan of this option.

3.4.1 River modelling

The river modelling has demonstrated that this solution would meet the design defence requirements.

3.4.2 Visual Impact

Construction of the wall over the existing channel wall will require large sections of the hedge to be removed and replanted for access with machinery. The incorporation of a green screen would provide instant infilling until such time as the replanted hedge is fully reinstated.

Once the hedge is reinstated the visual impact of this proposal would be moderate as much of the wall would be screened by the existing hedge. The wall would, however, be visible from the southern side of the brook and this would potentially disrupt views. It is also predicted that the increase in wall height would be noticeable by pedestrians using Pen-y-Dre as well as from the first floor windows within the houses to the north of the Street. Native climbing plants would go some way to softening the proposed wall.

3.4.3 Environmental/ecological considerations

Although of low ecological value, the hedge proposed for removal will have potential for breeding birds. The programing of the Works together with an ecological check will limit the disturbance to breeding birds until the more diverse hedge re-grows. The proposed species list of native plants will enhance the biodiversity of the hedge and encourage more insects and birds to frequent the area.

3.4.4 Constructability

This option would require considerable heavy engineering work in order to construct the wall on suitable foundations. This is likely to involve the removal of the existing channel wall and channel bed. This would lead to a full or partial road closure and the loss of parking spaces for the majority of the construction period. Temporary works would require careful consideration and method statements from the contractor to reduce the risk of construction causing pollution to the brook. In particular careful management of the existing flow would be required, which may include impoundment of flows and over-pumping while works in the channel are taking place.

Continuity of the wall across the footbridges would be essential and this would require careful construction and detailing to ensure a watertight seal at the bridges whilst maintaining their structural integrity.

There would be some disruption to residents accessing the southern properties on Pen-y-Dre, but it is expected that this would be limited to a few days to a week's disruption per footbridge which could be managed sensitively.

Construction would disrupt traffic and parking in the area. There is scope, however, for this to be well managed such that during weekends or holidays the construction site could be left in a neat, safe condition, with all construction plant removed from the area and stored within a construction compound.

This option could require additional survey and ground investigation work to be completed prior to the completion of the detailed design. This would effectively delay the start of construction.

The construction period for this option is estimated at approximately 4-6 months

3.4.5 Operational Regime

This option requires the Lead Local Flood Risk Authority (CCC at the time of writing) to ensure that stop logs are placed at the pedestrian accesses across the footbridges at Pen-y-Dre. This would require a monitoring/warning system and for CCC to arrange for operatives to deploy the stop logs at short notice.

3.4.6 Benefit/Cost analysis

The benefit/cost analysis has identified a benefit/cost ratio of 1.18

Option 4 Drawings and Visualisation

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3.5 Option 5 - Channel widening

Option 5 comprises a widened section of the river channel adjacent to Pen-y-Dre to increase the capacity of the channel. Drawing 5 shows a plan of this option. This includes widening towards the road in addition to widening within a number of the properties to the south of the brook. The channel is widened towards the road in bays 1 and 2 to limit impact on building foundations in this area, as properties 1-5 are closer to the brook than property 7 onwards.

3.5.1 River modelling results

The river modelling has concluded that implementation of this option would not fully meet the design defence levels, although it would reduce flooding depths. A wall would still be required to defend properties.

3.5.2 Visual Impact

The final scheme would have a significant visual impact as the nature and shape of the existing channel would be changed.

Furthermore, it is highly likely that the hedge along Pen-y-Dre would be removed in order for the contractor to gain sufficient safe access to the brook with heavy machinery. Due to the type of excavation and retaining measures three large existing trees (which are subject to a tree protection order) to the south of the channel would also be removed, significantly altering the general context of the area. There would also be a significant reduction to the area of private gardens.

Whilst it is anticipated that the hedge would re-grow, houses to the south would no longer be screened by the mature trees on the approach into Pen-y-Dre.

In year one the magnitude of change would be relatively low as although the sections of the existing hedge, would be removed, a green screen could be incorporated, which would provide instant infill planting. The impact of the loss of the existing mature trees would, however, remain significant.

3.5.3 Environmental/ecological considerations

There are limited ecological constraints in this section, the watercourse is canalised and the banks are either residential gardens, hedgerow or a continuation of the reinforced wall. The hedge proposed for removal will have potential for breeding birds, programing of the works together with an ecological check will limit the disturbance to breeding birds until the hedge re-grows. The proposed species list of native plants will enhance the biodiversity of the hedge and encourage insects and birds to frequent the area than is currently occurring.

Furthermore three mature trees would be removed as part of the scheme, thereby reducing local biodiversity.

An additional consideration for this option will be the debris generated and deposited in this section during a flood event, this will require additional management to ensure that accumulated debris is removed as it is in close proximity to the residential properties.

3.5.4 Constructability

This option would require considerable heavy engineering work as the existing wall would be demolished and a new wall constructed up to 1.5 m behind. It would also require work to ensure the ongoing stability of any existing structures and the replacement of the footbridges and the services that are carried across the brook. Temporary works would require careful consideration and method statements from the contractor to reduce the risk of construction causing pollution to the brook. In particular careful management of the existing flow would be required, which may include impoundment of flows and over-pumping while works in the channel are taking place.

The footbridges across the stream would require replacement and therefore access for residents would be affected for a number of weeks per property. Throughout the Works it is likely that car parking along Pen-y-Dre would be severely limited due to the construction site safety fencing and contractor's vehicles. However, there is scope for this to be well managed such that during weekends or holidays the construction site could be left in a neat, safe condition, with all construction plant removed from the area and stored within a construction compound.

This option would require additional survey and ground investigation work to be completed prior to the completion of the detailed design. This could effectively delay the start of construction.

It is anticipated that due to the scale of works, construction could be expected to continue for approximately 6 months.

3.5.5 Benefit/Cost analysis

The benefit/cost analysis has identified a benefit/cost ratio of 1.15.

3.5.6 Operational Regime

This option would not require any human intervention during a flood event and would have minimal maintenance requirements.

Option 5 Drawings and Visualisation

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3.6 Option 6 – Attenuation upstream of Pen-y-Dre

Option 6 comprises the construction of an attenuation facility upstream of Pen-y-Dre. The only suitable area for this has been identified as being the park area to the north of All Saints Church. (see Photograph below). Drawing 6 shows a plan of this option.

Photograph 8 - All Saints Park area

3.6.1 River modelling

The river modelling has demonstrated that this solution would meet the design defence requirements, however no “freeboard” allowance would be included. Freeboard is an allowance included in flood defence designs to take into account potential wave/eddy action on flood waters (as river models use a still water level). The modelling suggests that in this scenario the flood water in the channel would be near to full and therefore there is a potential for some overtopping due to the characteristics of flood flows. Therefore, a small wall of approximately 300mm height would be required in bays 1 and 2 in Pen-y-Dre to reduce the risk of flooding caused by wave action etc.

3.6.2 Visual Impact

There would be minimal visual impact of this option within Pen-y-Dre. Within The All Saints area there would be a significant visual impact as a large number of trees would be removed and the ground profile altered to create an attenuation basin or buried storage To mitigate the visual impact, a number of trees would be replanted and a suitable landscaping design scheme could be incorporated which would go some way to restoring the visual characteristics of the area.

3.6.3 Environmental/ecological considerations

This scheme would have no impact on the environment/ecology at Pen-y-Dre.

At the All Saints area, there will be a requirement for approximately thirty no. trees (which range in maturity and diversity) to be removed. Therefore the scheme would have a potential negative effect on the environment/ecology at All Saints during the construction phase. The nature of this option is considered to have the potential to enhance the long term biodiversity in the area.

The trees are likely to have a potential for breeding birds and bats. There are three trees that are classified as a high potential for bats and will require further investigation. Most of the trees are subject to a Tree Preservation Order and this could prove to be a significant obstacle to obtaining statutory consents.

The proposal does not include for the removal of trees on the west side of the watercourse, which will still act as a commuting feature for bats should they use this area for commuting. This proposal could potentially enhance an area of biodiversity for the local community with careful planning and a cost effective design. Ecologically, if a wetland area was created it would encourage feeding by bats, birds and invertebrates.

3.6.4 Constructability

This scheme would have a limited impact on residents or businesses in the Pen-y-Dre area. Whilst there would still be some disruption due to the construction of the short wall, this would be less significant than for the other options considered.

Within the All Saints area there would be some disruption with parking spaces taken up by contractor's equipment and vehicles. There are a number of parking spaces available in the area and access to properties would not be affected.

The All Saints area is also well used by the community as a walking/commuting route. Therefore, any changes (either during construction or permanent) would have a significant impact and the introduction of impounded water could pose a hazard. Furthermore, the impact upon the community cannot be gauged at this time as the potential for large scale works in this area has not been presented to the community.

This option would require considerable additional design and investigation work and would have an impact upon all of the designs downstream, which could effectively delay the start of construction.

Construction could be expected to last approximately 3 months.

3.6.5 Benefit/Cost analysis

The benefit/cost analysis has identified a benefit/cost ratio of 1.03

3.6.6 Operational Regime

This option would not require any human intervention during a flood event. The final design may incorporate an underground attenuation system which may require a pump to empty the attenuation system following a flood event. If required, the pump system would require ongoing maintenance, but a failure of the pump during a flood event is unlikely to lead to the flooding of any properties.

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Option 6 Drawings and Visualisation

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4 Conclusions

Table 4.1 summarises the proposed options. The two most viable options are Options 1 and 2 as they have the best benefit-cost ratio, are technically feasible, have a limited impact on the community and businesses during construction and have a low long term visual impact on Pen-y-Dre. Option1 (which incorporates flood walls behind and on the line of the hedge along Pen-y-Dre) has the same Benefit/Cost ratio as Option 2. However, the long-term visual impact on the conservation area will be lower and the inclusion of a wall behind the hedge will be managed more sensitively. Therefore this report concludes that Option 1 is the preferred option for construction.

Table 4.1: Options comparison

Option	Provides defence level	Landscape impacts at Pen-y-Dre	Environmental impact level	Statutory constraints	Construction impact on community, residents and businesses	Benefit/Cost ratio
Option 1 - Flood wall along line of hedge	YES	2	1	1	1	1.23
Option 2 - Flood wall with reduced impact on hedge	YES	3	1	1	1	1.23
Option 3 Culvert Duplicaton	YES	1	1	1	3	1.11
Option 4 - Replacment of exisitng channel wall	YES	3	1	1	3	1.18
Option 5 - channel widening	NO	3	1	1	3	1.15
Option 6 - Attenuation upstream of Pen-y-Dre	NO	1	2	3	2	1.03

1	Minimal impact or provides defence level
2	Moderate level of impact
3	High level of impact or does not provide defence level