Initial assessment report
Bradford IA Wagon Lane and Ash Grove, Bingley
April 2017

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1 Initial Assessment Report

Scheme or project location name	Yorkshire Area Initial Assessments: Bradford IA Wagon Lane and Ash Grove, Bingley

River Aire (19/07/16)

Date	April 2017
Version	0

Version control

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Sign Off

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Senior User Approval:	Name:	Title:	Signature:	Date:
Project Sponsor Approval:				

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APPENDICES

1.1 Introduction and background

Working in partnership with the City of Bradford Metropolitan District Council, 15 locations within Bradford were identified to have been significantly affected by the 2015 Christmas Floods. These locations were subsequently grouped into five main catchment areas to be put forward for initial assessments to be undertaken by CH2M:

- Keighley & Stockbridge
- Bingley & Airedale
- Baildon & Shipley
- Esholt & Apperley Bridge
- Silsden Beck

The inputs for the FCRM Partnership Funding Calculator were obtained through consultation with Bradford Metropolitan District Council and highlighting the properties likely to benefit from a preferred potential scheme at each study site. For the study area of Ash Grove and Wagon Lane, this was achieved through assessing modelled flood extents from the River Aire Modelling Study (Atkins, 2004) and draft 2015 Christmas flood outlines (April 2016) composed by the Environment Agency.

The objective of this initial assessment is to assess the potential for a scheme to alleviate flood risk within the Wagon Lane and Ash Grove areas. If a particular option is found to be economically viable under this high level assessment, there is scope for it to be carried forward to an Outline Business Case (OBC).

1.1.1 Description of Location

Bingley is a small town in the Metropolitan Borough of the City of Bradford, in West Yorkshire. It is situated between the River Aire and the Leeds and Liverpool Canal and has an estimated population of approximately 18,300 people.

The study area of Wagon Lane and Ash Grove is situated in the south-east of the town along the River Aire. Both streets lie beyond the left bank of the river, immediately downstream of the Bradford Road Bridge. Further downstream the river meanders and flows under the A650 road bridge.

According to the Index of Multiple Deprivation (IMD) this area is amongst the 30% least deprived neighbourhoods in the country.

A location plan is shown below in Figure 1 and the study area can be found in Appendix G. The key feature affecting local river hydraulics is Bradford Road Bridge, which will act as a flow constriction during extreme events. Additionally, the A650 road bridge immediately downstream of the site poses a blockage risk - the Environment Agency commissioned emergency shoal clearance works (May 2016) to remove three shoal banks here which accreted as a result of the December 2015 flood.

The sections of main river are shown below in Figure 2.

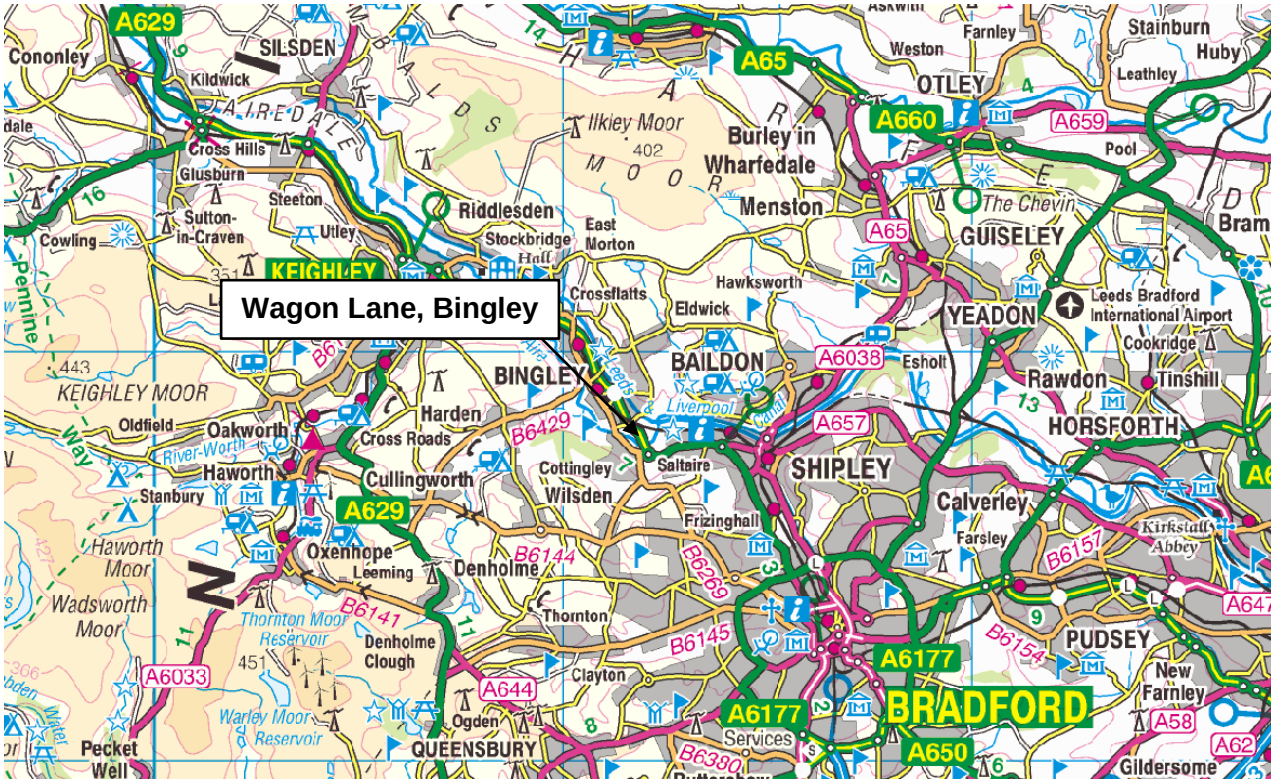

Figure 1: Location Plan

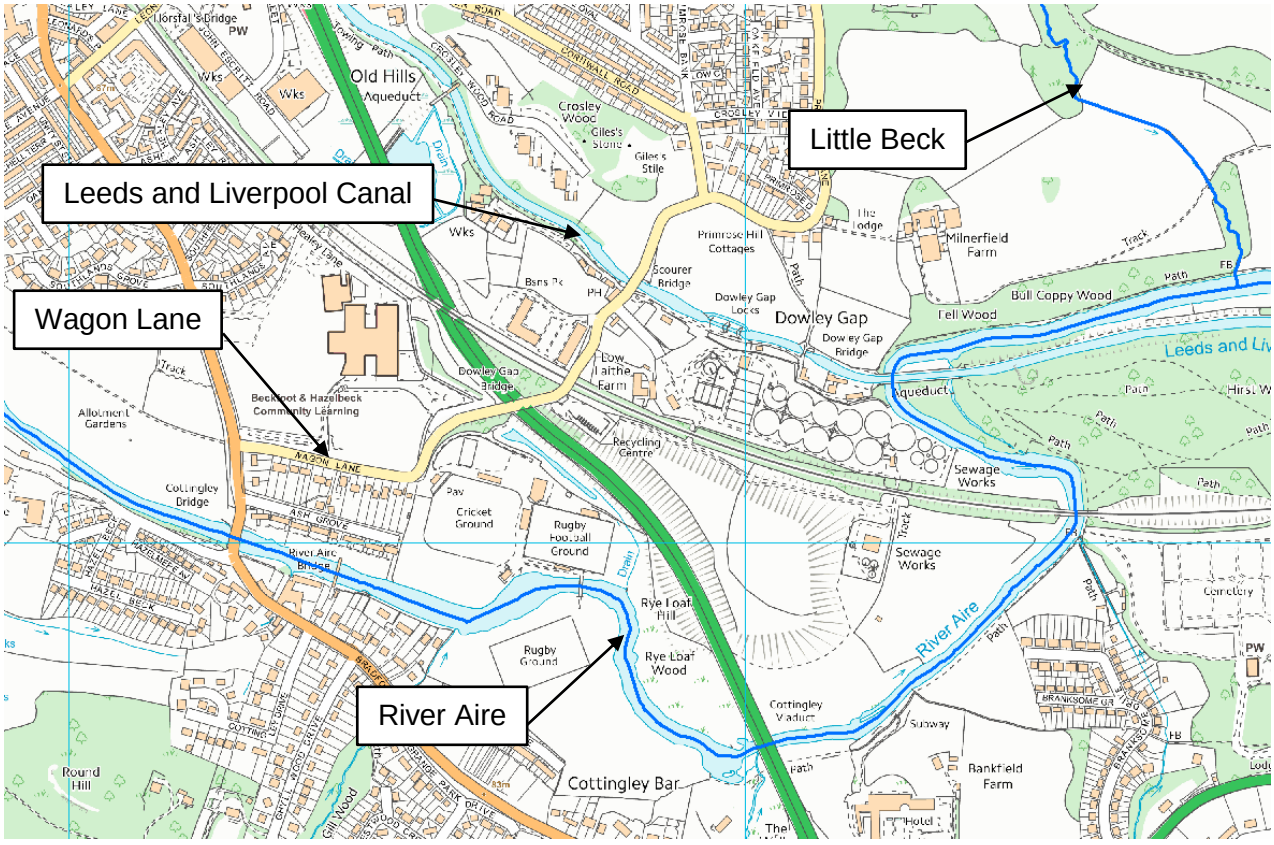

Figure 2: Main Rivers

1.1.2 Description of Watercourses and Geology

The River Aire originates in the Pennine hills near Malham in the Yorkshire Dales, flowing in a south easterly direction until it reaches Castleford, where the river is joined by the River Calder and

turns eastward toward Airmyn. Here, the River Aire meets the River Ouse approximately 148 kilometres from its source.

The River Aire banks have been considerably modified over time for flood risk management purposes. Flood embankments have been built up along much of the channel and there are several controlled washland (floodplain) areas along its length both upstream and downstream of Leeds. These act as both controlled and uncontrolled washlands and significantly attenuate peak flows along the river.

The study area lies in the 'Upper Aire' reach of this large watercourse, which is defined as the reach from upstream of Gargrave Bridge to Leeds Station Weir. The area lies in the high moorland area in the Upper reaches of the catchment, with an average gradient of approximately 1 in 640 (average gradient between Stockbridge monitoring station and Leeds Station Weir).

There are no formal flood defences present within the study area.

The geology of the study area is characterised Millstone Grits, shales, grits and coal seams.

1.1.3 History of Flooding

Major flooding in the catchment occurred in 1946, 1967, 1980, June 2000, October/November 2000, February 2002 and August 2002.

Anecdotal evidence provided by local residents relating to the December 2015 event suggests that prior to the River Aire overtopping its left bank downstream of Bradford Bridge, flooding initiated from seepage through the ground due to the rising water table.

No further information on site specific flooding was found during the course of this assessment.

1.1.4 Summary of Modelling Analysis

In 2001 Atkins were commissioned to deliver Phase 1 of the River Aire Modelling Study. This further lead onto the development of a robust calibrated model, which was then used to undertake a series of design runs.

The River Aire model reach was defined from Gargrave at its upstream extent, to its confluence with the River Ouse downstream of Airmyn. In order to accommodate this long stretch, the River Aire was subdivided into the following three reaches and modelled accordingly:

- "Upper Aire" - from upstream of Gargrave Bridge to Leeds Station Weir (FDMS reaches 16-29)
- "Lower Aire" - from Leeds Station Weir to Fairburn Ings (FDMS reaches 12-15) and the Lower Calder from Stanley Ferry to its confluence with the Aire (FDMS reaches 1-3)
- "Tidal Aire" - from Fairburn Ings to the River Ouse at Airmyn (FDMS reaches 1-11)

This study area falls within the 'Upper Aire' reach. The final three models combined to form a catchment wide one-dimensional hydrodynamic (ISIS) model which was deemed to effectively capture the flow attenuation within the catchment. The only fluvial design event to be assessed in this study was the 1 in 100 year (1% AEP) event. The study was completed in autumn 2004.

Following on from this, the Upper Aire Flood Risk Management Strategy (Atkins, 2006) was completed, which looked at developing a strategic plan for future flood risk management on main rivers in the Aire catchment, between Bell Busk and Fleet Weir. The study area of this initial

assessment was covered by this update, and fluvial flood outlines derived from this study have been used to inform flood risk in this initial assessment.

The existing hydraulic model has allowed for climate change up to the year 2105 with a 30% increase to the hydrological inflow. However the guidance for climate change analysis has been updated since the Upper Aire Modelling Study and therefore these results are likely to be superseded by the new guidance. Climate change modelled flood outlines were not considered in this initial assessment with analysis using present day outlines to assign flood risk bands. The model has not been calibrated since the work undertaken in 2002 to 2004 and should be updated to include recent events if any scheme progresses to OBC stage.

Downstream of the study area there are three weirs which influence water levels at the site. Detailed modelling work on the three weirs is currently being undertaken by the EA National Flood Modelling team. At this stage an initial review indicates there may be limited benefit from removing or lowering the weirs.

1.1.5 Drivers, Constraints, Opportunities

Bingley falls under the River Aire Catchment Flood Management Plan[1] (CFMP), and is covered by sub-area 3 Worth and Aire. The designated policy for residential areas at risk is Policy Option 5: *areas of moderate to high flood risk where we can generally take further action to reduce flood risk.* This policy will tend to be applied to those areas where the case for further action to reduce flood risk is most compelling. The CFMP vision is to improve the co-ordination between the multiple organizations that manage the various sources of risk.

The following drivers, constraints and opportunities have been identified within the study area.

Political Drivers	**Exist?**	**Summary Description**
Catchment Flood Management Plan	Yes	River Aire CFMP 2010
Catchment Flood Management Policy	Yes	Policy 5: Areas of moderate to high flood risk where we can generally take further action to reduce flood risk
Economic Drivers	**Exist?**	**Summary Description**
Enable Development	Yes	There is potential development at this site but is dependent on flood risk and the outcome of this options analysis.
Technological Drivers	**Exist?**	**Summary Description**
Improved Public Safety	Yes	Via reduced flood risk.
Environmental Constraints	**Exist?**	**Summary Description**
World Heritage Site	Yes	World Heritage Site lies approximately 500m east of the Benefits area. A full impact assessment should be conducted if the scheme progresses to Outline Business Case.

[1] https://www.gov.uk/government/publications/river-aire-catchment-flood-management-plan

1.2 Problem and objectives

1.2.1 Problem

Due to a lack of formal flood defences the area adjacent to Wagon Lane and Ash Grove suffered extensive flooding during the December 2015 event. This flooding is believed to be as a result of the River Aire overtopping its left bank both upstream and downstream of Bradford Road Bridge. Evidence from residents along Ash Grove indicates that water initially began to seep up through the ground as the river levels rose (suggesting a link between ground water levels and river levels). Subsequently, as the river levels increased, the river began overtopping its left bank upstream and downstream of Bradford Road Bridge, and therefore inundating the study area.

The bridge on Bradford Road acts as a throttle, posing a flow constriction risk during high flows. During the December 2015 event flow backed up at this structure, increasing water levels upstream, which in turn overtopped the left bank and flooded the study area from the west.

This second overland flow pathway conveyed eastwards across Bradford Road and over the study area, returning to the river via the grounds of the Bradford and Bingley Sports Club. The standard of service provided by the natural river banks within the study area has been estimated as 1 in 25 year (4% AEP).

Bradford Road was also inundated south of the river from South of Beckfoot Lane to Bingley Fencing where a dip in the road occurs and frequently floods. The most likely cause of this flooding is judged to be surface water. Appendix J, shows a surface water flood map provided by BMDC.

Bradford Bridge itself was not inundated or overtopped and remained dry for the duration of the December 2015 flood event.

In addition to flood risk beyond the left bank of the River Aire, modelled flood outlines used to inform this initial assessment also highlight potential flood risk to the properties behind the right bank between Bradford Road and the river.

There is evidence to suggest that gravel accretion downstream of the site presents an increased flood risk to upstream areas. Immediately upstream of the A650, the Environment Agency identified three shoal locations for clearance post Boxing Day 2015 event (see Appendix H).

Further photos and a video of the flood event are in Appendix I.

1.2.2 Objectives

The objectives of this initial assessment are to assess the current condition of the site and evaluate the possible options for reducing flood risk within the study area.

The purpose of this report is to undertake a high level appraisal and, where applicable, provide a preliminary business case for further development and a more detailed future appraisal. The report aims to achieve the following:

- Confirm the need for a project;
- Identify the issues and Political, Environmental, Societal, Technological, Legislative and Economic (PESTLE) drivers and opportunities related to the need;
- Identify the options to address the project needs and problems;
- Demonstrate that viable options exist based upon the available information;
- Provide sufficient information to allow the packaging and optimisation of packages of future appraisal, design and construction packages;
- Provide sufficient information for the appraisal scope to be prepared;
- Make an assessment on the deliverability of the project;
- Provide a basis/starting point for discussion with communities and partner organisations for use in the development of potential schemes and negotiations regarding funding contributions.

1.3 Benefits

In this area the primary benefit associated with a reduction in flood risk would be the reduction in economic damages to the affected properties. Potential options could also reduce disruption to local transport, businesses, schools and other infrastructure.

The properties at risk include residential, commercial and public buildings.

Social benefits relate primarily to a reduction in stress, health effects (including risk to life) and loss of memorabilia for those at risk.

An appraisal period of 100 years is assumed, over which the current Standard of Protection of existing assets is expected to decrease as a result of climate change.

The property figures in Table 1-1 have been estimated based on the modelled flood outlines from the Upper Aire Flood Risk Management Strategy (see Section 1.1.4).

Table 1-1 Number of Properties at Risk (based on Dec 2015 flood)

Property Type	Flood Risk	Number of Properties
Residential	≥1 in 25 year (4% AEP) (Very Significant Risk)	56
	<1 in 25 year (4% AEP) ≥1 in 75 year (1.33% AEP) (Significant Risk)	4
	<1 in 75 year (1.33% AEP) ≥1 in 200 year (0.5% AEP) (Moderate Risk)	4
Non-Residential	≥1 in 25 year (4% AEP) (Very Significant Risk)	3
	<1 in 25 year (4% AEP) ≥1 in 75 year (1.33% AEP) (Significant Risk)	1
	<1 in 75 year (1.33% AEP) ≥1 in 200 year (0.5% AEP) (Moderate Risk)	0

Detail of the methodology used for assessing the benefits of each option is detailed in Appendix C.

1.4 Options

A long list of options has been compiled for the study area and is summarised in the table on the following page. The table shows the range of options considered and the reasoning for or against them being taken forward to the shortlist of options to be assessed.

Table 1-2 Long List of Options

Category	Long List Option	Description	Take Forward for assessment?	Reasoning / Notes / Past Study Reference
Do nothing	Do nothing	All operational and maintenance activities cease	Yes	Required to support development of business case and benefit cost ratios.
Do minimum	Do Minimum	Continue with current operational and maintenance activities.	Yes	Represents current approach to asset maintenance and repair. Minor works to retain necessary performance.
Non-structural (by EA)	Improved flood warning	Enhanced flood warning to allow residents to prepare plus appropriate implementation of flood action plans	No	Not funded via the capital programme. A Flood warning system is already in place for the River Aire at Ash Grove and Wagon Lane. Improving the current system would require further modelling which is beyond the scope of this study and therefore this option is not considered at this stage.
Non-structural (by EA)	Flood action plans	Improved direction of reactionary flood defence measure (fire crews, temporary pumps, etc.)	No	This option is not funded via the capital programme, however it is recommended that community members are actively involved in setting up a Flood Action Plan if one is not already in place. A flood action plan would be beneficial to reduce reaction times as residents reported only receiving sand bags after Boxing Day event. The study area is already within a Flood Warning and Flood Alert area

				operated by the Environment Agency. However, this is considered to be outside of the scope of this appraisal and has not been undertaken at this stage.
Property level protection	Property level protection	Protection to individual properties (e.g. via air brick covers, door guards etc).	Yes	PLP is assumed to be viable for all ground floor residential properties in the very significant risk band. However, the depth of flooding at these properties would have to be analysed at the next stage, as PLP is only suitable where the flood depth is less than 500mm and duration less than 3 days. PLP could be offered as an option in combination with other options.
Operational (by Others)	Improve operation/design	Improve operation/design of assets not owned by the EA	No	No third party assets known to significantly contribute to flood risk in the study area.
Urban drainage	Improve urban drainage.	Improved surface water drainage system.	No – But further analysis are needed	Evidence provided by BMDC shows that flooding in the vicinity of Bradford Road to the south of the River Aire may be attributed to surface water (see Appendix J). More detailed information is required to gain a better understanding of all flood sources.
Structural	Earth bunds	Bank raising	Yes	Raised flood embankments to prevent or reduce overtopping of riverbanks. Where there is insufficient space for an embankment footprint, a sheet piled wall will be considered.

Structural	Flood walls	Flood walls	Yes	Use of flood wall to prevent overtopping of riverbanks and to protect properties at risk.
Structural	Conveyance	Channel deepening or widening, including routine dredging.	No	River channel is well defined and of considerable width already. There was no clear evidence of gravel accretion at either Bradford Road Bridge or the A650 Bridge downstream from the site visit.
Structural	Conveyance	River restoration and/or pinch point improvements (bridges, culverts and weirs)	No	Both Bradford Road and the A650 bridges are large structures to which no adjustments will be considered for this study due to cost far outweighing benefit. This could be looked at in the future under a different project, should the council ever consider structure works/replacement.
Flood storage area	Online	Use of active structures and re-profiling to store water online.	No	There is not sufficient space to create FSAs of the required size in or near the study area. A large scale FSA system was considered in the Upper Aire SFRA that would have a large impact beyond the study area, and is considered to be outside of the scope of this appraisal.
Flood storage area	Offline	Gravity or pumping to offline storage area	No	As above, there is not sufficient space to create FSAs of the required size in or near the study area.

1.4.1 Shortlisted Options Description

The options below were chosen to be taken forward for assessment in the initial assessment

Do Nothing

The Do Nothing option is defined as taking no action whatsoever; under this option all management activities would cease, including maintenance and repair work to existing assets.

There could be some advantages of this option in the form of habitat creation due to wetting of dry areas and naturalisation of channel, however, this is also likely to increase the risk to wildlife and people.

The Do Nothing option is not to be taken forward as a viable option as it results in an unacceptable increase in flood risk to people and property due to failure and deterioration of assets and blockages to the channel.

For appraisal purposes the Do Nothing option is used as the baseline against which all other options are measured against.

Do Minimum

The Do Minimum option is defined as the minimum level of action or intervention necessary to sustain the standard of service (SOS) presently offered throughout the study area. It will form the appraisal baseline.

There are no existing defence assets that lie in the study area therefore this option is limited to maintenance for the channel itself and Bradford Road Bridge. However given that three locations along the River Aire immediately downstream of the study area were identified for shoal clearance post Boxing Day 2015 event, it suggests that gravel deposition within the river channel can contribute to flood risk upstream (see Appendix H).

The advantage of Do Minimum is that it sustains current standard of service within the study area and there are no increase in costs associated with this option. It ensures that the risk of blockages and a reduction in channel conveyance capacity are reduced.

The disadvantages of Do Minimum is that the current maintenance regime is not believed to significantly reduce the flood risk to people and properties in the study area. It does not account for the increase in flood risk due to climate change. A further solution would therefore be required in order to reduce the effect of higher frequency flood events.

There are no indicators to suggest that this option is non-viable or undeliverable.

Option 1 – Property level protection

This option considers property level protection (PLP) to those properties at greatest risk of flooding. PLP can take the form of barriers in doorways, non-return valves fitted to drains, and airbrick/vent covers. Properties can also be made more flood resilient, using waterproof plaster, solid concrete floors or tiled floor coverings in order to reduce the amount of time and money needed to recover from a flood event. PLP is generally used as an option for properties that experience less than 500mm of flooding.

Advantages of this option include the fact that defences have minimal visual and land impact, and do not remove any of the flood plain area. PLP will protect against surface water as well as fluvial flooding.

Disadvantages of this option include the requirement for residents to receive sufficient alert and for them to be available and trained in deploying PLP measures. Furthermore, PLP does not provide

any wider environmental benefits and does not prevent the flooding of areas surrounding the property. PLP is only deemed effective for return periods of up to a 1 in 50 (2% AEP) chance of occurrence in any given year and where flooding is less than 500mm deep. The efficacy of PLP reduces with long duration floods due to seepage.

Option 2 – Combination of earth embankments and sheet piled wall

This option is to construct flood defences around the low-lying properties on Ash Grove and Wagon Lane at risk from flooding. The proposed scheme would consist of earth embankments and a sheet piled floodwall (defence schematic shown in Figure 3).

The Standard of Protection offered by the scheme will be 1% AEP plus climate change. The alignment of the bunds and their dimensions have been approximated for the purpose of this initial assessment, with final alignment and dimensions to be decided upon should the option progress to OBC stage. The costs are based on an embankment with a total length of 1,075m, 2m height and 14m width at the base (assuming a 1 in 3 side slope). Additionally, clay cut-offs will need to be incorporated into the final design to block seepage paths, like those which occurred during the Dec 2015 event.

A sheet piled wall has also been considered to protect the properties lying beyond the right bank downstream of Bradford Road Bridge. A sheet piled wall will cut off any flood risk from seepage (provided that the piles are of sufficient length to intercept the seepage path). For the purpose of this high level assessment the wall dimensions considered are 4m high and 345m long.

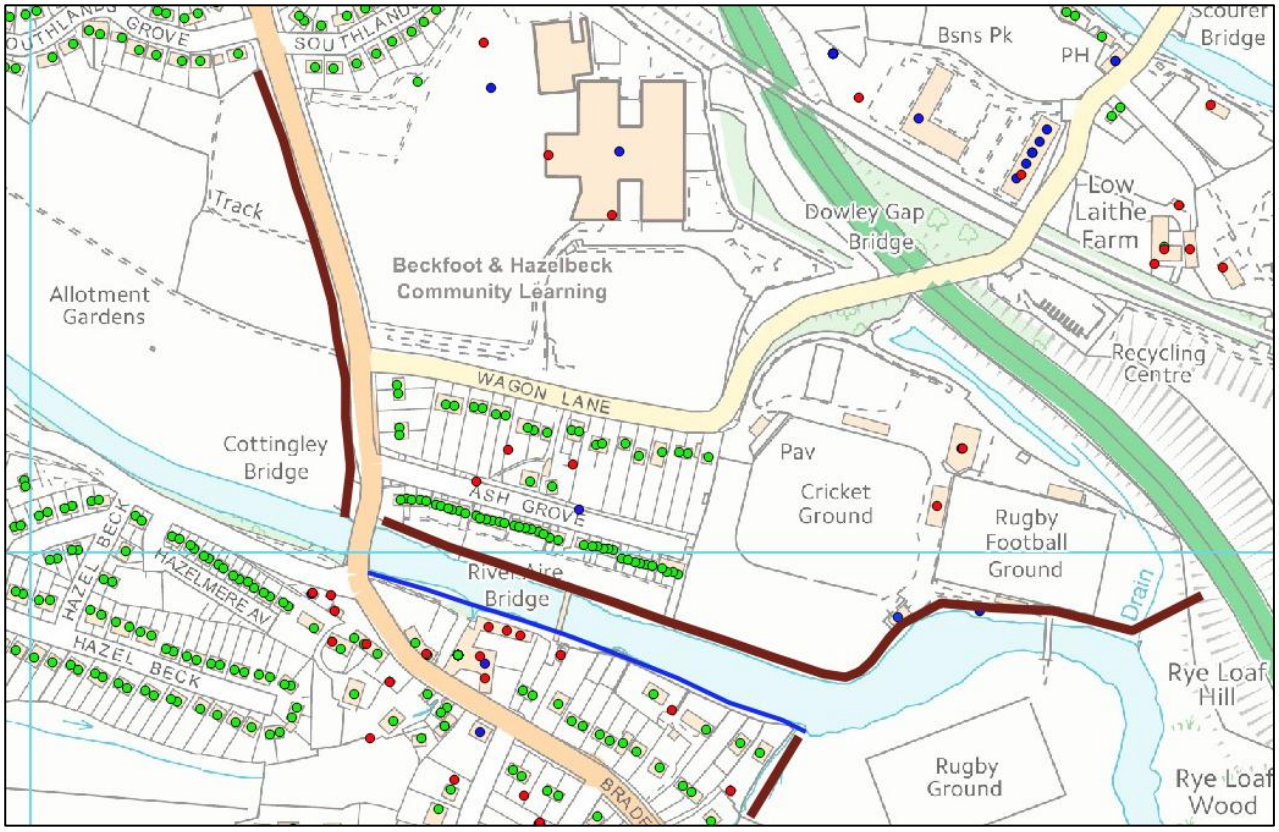

Figure 3: Alignment of the assets. Embankments showed in brown, sheet piled wall showed with the blue line.

If this option is taken forward, alignment and dimensions will need to be optimised in order to consider all potential sources of flooding and to meet the required standard of protection. This option proposes a permanent structure and does not require any operational input.

Further modelling will be required in order to assess the impact of removal of floodplain on communities further downstream due to the construction of these flood defences. Compensatory floodplain storage may be required, adding to the costs of the scheme. The modelling work shall ensure that the compensatory storage is hydraulically linked to the floodplain lost, otherwise the benefits from it may not be fully realised. With this option, impact on groundwater and surface water flooding will also need to be investigated.

A higher bund would not be a viable option, as the bunds will have side slopes of 1 in 3, and therefore for each increase in height of 1m the footprint increases by 6m which would result in large footprint for high bunds. Its design should be made to fit visually in to the surrounding area. Construction of the bund has the potential to cause temporary disruption to roads and properties.

Option 3 – Concrete floodwalls with cutoff

This option retains the alignment of option 2, but the flood defences will consist entirely of reinforced concrete walls. For a standard of protection of 1 in 100 years (1% AEP) plus climate change, the height of the wall above the ground level has been estimated at 2m. The height of the defence will need to be refined following detailed modelling information should the option be carried forward to OBC stage.

Piled cutoff is required, especially where the wall is built along the riverbank, to reduce seepage under the wall and to help to provide resistance against sliding failure.

The main advantage of the reinforced concrete wall, is that it will require a smaller footprint than an embankment. Some of the properties at risk are located along the river bank where space for construction is limited. The smaller footprint of floodwalls will also reduce the amount of compensatory floodplain creation needed when compared against bunds.

Cladding of brick may be required for the stretches of wall which are more visually exposed (not hidden behind property gardens) to make the scheme visually attractive to the surrounding area (for example along the Bradford and Bingley Sports Club perimeter).

1.4.2 Costs of options

The costs for the options were calculated using the Environment Agency's Project Cost Tool and Long Term Costing Workbook.

It is assumed that a major replacement of assets will be required at some point during the appraisal period after the initial construction phase. The timing of these replacements is based on the Environment Agency's Asset Deterioration Guidance (2013), an appraisal period of 100 years has been used and the assumptions are outlined in Appendix B. Table 1.1 shows the initial costs for the options, it is assumed that replacement of the assets will be required when the assets reach Condition Grade 5 (CG5):

- Option 1 - 20 years (PLP)
- Option 2 - 60 years
- Option 3 - 90 years

Table 1-3 Project costs (£k)

Item	Option 1	Option 2	Option 3
Construction Base Cost	428.13	2600.70	3849.24

Item	Option 1	Option 2	Option 3
Environment Agency staff	65.50	184.65	273.30
Consultant fees (appraisal)	23.98	127.43	188.61
Consultant fees (Design)	82.63	351.09	519.65
Consultant fees (construction)	21.41	148.24	219.41
Surveys (Ground investigation)	3.85	85.82	127.02
Surveys (Archaeological)	1.71	13.00	19.25
Land purchase	0.29	13.00	19.25
Sub-total	627.50	3523.94	5215.72
Optimism Bias (44%)	276.10	1550.53	2294.92
TOTAL	903.60	5074.48	7510.64

Further details can be found in Appendix B.

1.5 Initial environmental assessment

The study area lies in the south eastern part of the town of Bingley. Any defence scheme considered in this initial assessment will need to work towards having a minimal impact on the surrounding environment especially due to its close proximity to properties. Possible environmental impacts of all options considered in this study are listed below.

Table 1-4 Key environmental impacts, mitigation and opportunities

Key positive impacts	Key negative impacts	Mitigation/ enhancement opportunity
Option 1		
- Low aesthetic effect - Low risk of pollution incidents and disruption to area during construction		
Option 2		
- Reduced risk of fluvial flooding - Low aesthetic effect	- Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction - Possible temporary increase to noise/vibration levels during construction	- Best practice should be followed including referring to EA Pollution Prevention Guidance - Early engagement with residents recommended to promote awareness and minimise negative impacts of construction phase
Option 3		
- Reduced risk of fluvial flooding	- Construction work takes place alongside watercourse. Risk of pollution incidents and disruption to area during construction - Possible temporary increase to noise/vibration levels during construction - Visual Impact on area	- Best practice should be followed including referring to EA Pollution Prevention Guidance - Early engagement with residents recommended to promote awareness and minimise negative impacts of construction phase

A calculation of the total carbon emissions of each option has been done and is reported in Appendix F.

1.6 Consultation

The options in this appraisal were developed in consultation with the Environment Agency. No public consultations were held at this stage as the work is a high-level assessment of potential options. Stakeholder engagement will take place at subsequent stages of the project.

If this project is taken forward for further appraisal it is recommended that consultation is focused on, but not limited to, the following:

- Statutory Stakeholders
- Residents in the area at risk
- Riparian landowners, especially owners of riverside walls acting as formal/informal defences.

1.7 Economic summary and preliminary preferred option

Table 1-5 summarises the economic assessment carried out for all options. The calculations for PV benefits are shown in Appendix D. These benefit values are estimates based on the methodology detailed in Appendix C. There is significant uncertainty in these estimates and if further appraisal is carried out the benefits for the preferred option should be more accurately assessed through detailed hydraulic modelling.

Modelled flood outlines produced for the Upper Aire Flood Risk Management Strategy were used to inform these benefit calculations. A count of properties falling within each flood outline was carried out using the National Receptor Dataset (NRD), and all the properties in the study area, were classed into the Very Significant, Significant and Moderate risk bands (see Table 1-1). Details of the methodology used is presented in Appendix C.

Table 1-5 Benefit-cost assessment (£m)

	PV costs (£m)	PV benefits (£m)	Av. BCR	Incr' BCR	Option for iBCR calc	Comments
Do Nothing						
Do Minimum	0.04	0.72	18.51			
Option 1	1.87	2.97	1.59	1.23	Do Minimum	All use Do Minimum as base case
Option 2	5.76	5.20	0.90	0.78	Do minimum	
Option 3	7.70	5.66	0.70	0.61	Do minimum	

Option 1 is the recommended option to be carry forward for further appraisal. Option 1 scores an incremental BCR >1 and would succeed in reducing flood risk and protecting properties for lower order extreme events. Option 1's BCR>1 suggests that it can also be economically viable.

With the uncertainties in the evaluation of costs and benefits, and the value of the BCR value close to one, Option 2 could also be considered for further analysis. Informed by more detailed hydraulic modelling mapping overland flow pathways and flood depth, Option 2's benefits may prove to be greater than this high level assessment suggests. The total benefits achievable for Options 2 and 3 differ slightly due to defence type design life according to the Asset Deterioration Guidance Report (SC060078).

Note that in Table 1-6 the values differ slightly as they are total benefits and costs over the initial benefit period rather than the 100 year appraisal period as is the case for Table 1-5. When considering the benefit period alone, Option 1 scores an increased BCR of 2.35.

Table 1-6 Benefit-cost ratios and outcome measures

Contributions to outcome measures	Option 1	Option 2	Option 3
OM1 – Economic Benefit:			
Benefit period used for Partnership Funding calcs	*20*	*60*	*90*
PV Benefits (£m)	*2.00*	*4.67*	*5.32*
PV Costs (£m)	*0.92*	*5.11*	*7.55*
Benefit/Cost ratio	*2.35*	*0.91*	*0.70*
OM2 – No. of households moved out of any flood probability category to a lower category	60	60	60
OM2b – No. of households for which the probability of flooding or coastal erosion is reduced from the very significant or significant category to the moderate or low category	0	60	60
OM2c – No. of households in the 20% most deprived areas moved from the very significant or significant flood probability category to the moderate or low category	0	0	0
OM4a – Hectares of water dependent habitat created or improved to help meet the objectives of the Water Framework Directive	0	0	0
OM4b – Hectares of intertidal habitat created to help meet the objectives of the Water Framework Directive for areas protected under the EU Habitats/Birds Directive	0	0	0
OM4c – Kilometres of rivers protected under the EU Habitats/Birds Directive improved to help meet the objectives of the Water Framework Directive	0	0	0
Partnership Funding (PF) Score	23%	10%	8%
Contributions required for a PF score of 100% (£m)	0.71	4.58	6.92
Contributions required for a PF score of 120% (£m)	0.74	4.67	7.02

As stated in the Multi-Coloured Handbook 2016 (page 4-13), the benefits referred to for option 1 (PLP) are factored by 0.75 to take account of the risk of incorrect use.

1.7.1 Funding and contributions

A funding analysis tool was used to identify potential direct and indirect beneficiaries of the scheme. This is included in Appendix E. Based on these beneficiaries potential funding sources identified include:

- Community Infrastructure Levy
- Benefitting local businesses
- Council Tax
- Local Enterprise Partnerships

There are a large number of commercial properties at risk within the town. Further consultation would be required to identify potential contributions.

1.7.2 Key delivery risks (economic, social and environmental)

Table 1-7 Risks and mitigation

Risk	Key Mitigation
Estimate of benefits highly uncertain	Undertake more detailed benefit analysis at OBC stage
Estimate of costs highly uncertain	Undertake more detailed benefit analysis at OBC stage
Risk of pollution incidents and disruption to area during construction	Ensure a detailed site action plan is in place prior to any site work commencing
PLP may not be effective for the properties due to flood depths, durations and presence of groundwater risk.	Detailed modelling to use flood depth grids to assess total depth to properties
The height of the flood defences have been estimated and may be insufficient for the SoP required for an event of the magnitude of Boxing Day 2015	Undertake further modelling to establish the correct level of the defences for such an event.

1.8 Project scoring

The data used in this assessment has been subjected to a RAG assessment. A green score is well defined, not likely to be an issue; amber score, needs development, but is manageable; red score is poorly defined, lots of uncertainty, likely to cause significant problems. The RAG assessment gives a three figure score with the first number being the number of reds, the second and third numbers are the number of amber and green respectively. The results are shown below:

- A – Problem Definition: The fluvial flood risk is well understood but more accurate information are needed about the flood path and the ground water – **AMBER**
- B – Economic Case: The benefits assessment has been based on moving properties from flood risk bands and weighted average annual damages – **GREEN**
- C – Funding: All The options require external funding. Work will be needed to obtain funding but there are opportunities – **AMBER**
- D – Engineering case: Solutions taken to outline design are common defence options, no particular issues are expected – **GREEN**
- E – Permissions & Consents: Solution are unlikely to require unusual permissions or consents, but permission for third party properties is required – **AMBER**
- F – Environmental sensitivities: An Environmental check list has been completed and the options will not have any impact on any nearby sites of interest – **GREEN**
- G – Opportunities: Some potential opportunities for partnership working but minimal environment opportunities – **AMBER**

Model. A	Econ B	Funding C	Eng. D	Permission E	Env. F	RAG	Opps. G
2	3	2	1	2	1	132	2

1.9 Further work requirements

If the project is taken forward for further appraisal it is recommended that the following work is undertaken to confirm the feasibility of the options:

- Hydraulic modelling is undertaken to predict likely flood depths, duration and overland flow pathways. The modelling will also be used to inform crest heights required for different standard of protection levels.
- Effect on groundwater and surface water run-off of the options.
- Update the PV benefits and re-assess the partnership Funding score.
- Consultation with landowners.

1.10 Conclusions and Recommendation

The aim of this initial assessment is to give an overview of the principal flood risk issues affecting the study area, propose suitable flood risk reduction options and assess their viability. The resultant outcome is an analysis of a number of agreed options and further recommendations to carry forward those which exceed the required benefit versus cost threshold to OBC stage.

The economic assessment developed at this stage includes a high margin of uncertainty. The modelled flood outlines used to evaluate the benefits are outdated, and need to be calibrated using recent flood events. For a more detailed assessment the main requirement will be detailed hydraulic modelling to understand the current standard of protection provided to the properties, clarify the flow pathways and better quantify the Do Nothing damages and the benefits the potential options would provide.

Further analysis is recommended to evaluate the risk of groundwater and surface water flooding; if there is significant risk present this will reduce the effectiveness of the proposed options. Option 1, which considers PLP for each property at risk is the only Do Something option to score an incremental BCR > 1, and is therefore recommended to be carried forward to OBC stage.

Based on the final Partnership Funding scores none of the Do Something options score high enough to avoid the need for external funding. Option 1 gains the highest BCR of 2.35; however, there are considerable uncertainties in the assessed costs and benefits and the preferred option may change with further appraisal. Furthermore, considering the number of properties at risk and the frequency of flooding in the study area, it is also recommended to consider Option 2 for further appraisal as this option may demonstrate greater benefits when informed by detailed hydraulic modelling.

The study area is already within a Flood Warning and Flood Alert area but flood action plan could be improved to reduce reaction times; this would work well with Option 1, ensuring enough time is given to property owners to erect the defences.

A large scale Flood storage area (FSA) within the system is considered in the long list of options. This is a large-scale scheme that will have significant impacts beyond the study area and is considered to be outside the scope of this initial assessment. It is recommended that this is considered in future work to provide protection to Ash Grove and Wagon Lane. Under this option, one of the possible FSA locations is near the Bingley Bypass, this area is made up landfill/ waste material, and so will involve the movement of potentially contaminated material, which will bring in significant additional cost and environmental risk.

Appendices