

Initial Assessment Form

Project name	River Medway Flood Storage Areas	Date	October 2016
Location	River Medway from Penshurst to Maidstone including the River Teise downstream of Horsmonden and the River Beult downstream of Headcorn	Region	South East
CFMP	Medway Catchment Flood Management Plan	Area	Kent and South London
Recommended CFMP policies	<u>Sub area 3 (Upstream of Tonbridge)</u> Policy 6 – store water to provide an overall reduction in flood risk. <u>Sub areas 6 (Teise), 7 (Beult) and 8 (Lower Medway)</u> Policy 3 – existing flood risk management is generally effective. <u>Sub areas 4 (Tonbridge), 5 (Collier Street / Yalding / East Peckham) and 9 (Maidstone)</u> Policy 5 – take further action to reduce flood risk.		
Is project from a Strategy or previous appraisal?		Middle Medway Strategy 2005 Middle Medway Strategy Review 2010	

Role	Name	Post Title
Project Sponsor	Mark Douch	Environment Agency Area Flood Risk Manager
Senior User	Neil Gunn	Environment Agency Senior User
Senior Supplier	Adam Schofield	Project Director (VBA JV Ltd)
Project Executive	James Kennedy	ncpms Project Executive
Project Manager	Sam Box	ncpms Project Manager

Actions required:

This Initial Assessment (IA) and appended Technical Report documents the assessment of strategic catchment options for improved flood risk management in the River Medway catchment from Leigh to Maidstone. The options include a number of reservoir storage area solutions, including the existing Leigh Flood Storage Area (FSA) on the River Medway upstream of Tonbridge, and potential new FSAs located on the River Beult and River Teise catchments (major tributaries of the River Medway), upstream of the Yalding and Collier Street communities. Consideration has also been given to linear defence and conveyance options. Combining the River Medway, River Beult and River Teise options in a single strategic package recognises the strategic linkages between the three rivers, seeks schemes that deliver opportunities across the whole catchment and is also anticipated to yield efficiency savings.

It is intended that this IA will be appended to the Strategic Outline Case (SOC) document, specifically providing the evidence required to demonstrate the Economic Case. All 5 cases will be developed as part of the SOC.

Consultant	<i>VBA Joint Venture Limited</i>
Project start	March 2015

OBJECTIVES

Objective 1	To assess the technical and economic viability of an increase in the operational storage volume of the Leigh FSA to further reduce the risk of flooding to Tonbridge and downstream communities.
Objective 2	To assess the technical and economic viability of a solution to reduce flood risk in the communities of Yalding and Collier Street utilising a single or cascade of FSAs or other solution on the lower reaches of the River Beult and / or the River Teise.
Objective 3	To confirm, or otherwise, the viability of progressing with option development in the River Medway catchment, to demonstrate confidence in any decision to fund the progression of a detailed appraisal.

Previous studies

A number of studies have previously been undertaken for this part of the River Medway catchment. This previous work provided background information on flood risk in the catchment and aided identification and costing of flood risk management options, as well as determination of the opportunities and constraints associated with these options. A summary of the following previous studies is provided in the Technical Report:

- Pre-feasibility study for “stand alone” flood defence scheme at Yalding, Babbie Brown & Root, 2001;
- Medway Catchment Flood Management Plan (CFMP), published 2004, updated 2008;
- Middle Medway Strategy (MMS), 2005;
- Leigh FSA Additional Storage Railway Track Protection report, Jacobs Babbie, 2006;
- Kent Reservoir Spillway Investigations – Leigh FSA report, Halcrow, 2010;
- MMS Review, Halcrow 2010; and
- Leigh FSA Mechanical Improvements costings, 2012.

Since these studies were completed and approved, there have been a number of changes to flood risk understanding in the catchment as well as project appraisal and prioritisation. This has included:

- Significant flooding during the winter of 2013/14 affecting the communities of Tonbridge, Hildenborough, East Peckham, Collier Street and Yalding;
- Completion of the Medway Catchment Mapping and Modelling Study (JBA, 2015) providing baseline model results which are notably different to those available at the time of the 2010 MMS Review, but considered to more accurately reflect flood risk in the catchment;
- An updated Multi-Coloured Manual (MCM) (new version published 2014, with updated data in 2015); and
- Updated rules for the funding of flood risk management projects, allowing local flood risk management authorities to contribute to schemes that do not qualify for 100% national funding. These updated rules are incorporated into the partnership funding calculator, used to determine Flood and Coastal Erosion Risk Management (FCRM) Grant in Aid (GiA) allocations (v8, 2015-2016).

What needs to be done and when?

This IA brings together all of the previous studies and changes listed above to re-assess the technical and economic viability of flood risk management options in the River Medway catchment, to confirm, or otherwise, the viability of progressing with option development, and to demonstrate confidence in any decision to fund the progression of a detailed appraisal. Separate IAs are being prepared for flood alleviation schemes in Hildenborough and East Peckham. The potential costs and benefits of the Hildenborough scheme have been incorporated into this assessment.

Initial Assessment

Introduction and summary of understanding

Information received

All previous studies listed above.
GIS datasets including LiDAR data, OS MasterMap data and the National Receptor Dataset (NRD).
Property threshold level survey data (where available).
Modelled flood depth grids for the Do Nothing (undefended), Maintain (existing) and option scenarios.

Summary of understanding and issues

Catchment flood risk

Tonbridge, Yalding, East Peckham and other smaller communities are at risk of flooding from the River Medway and its tributaries. Communities in these areas have been affected by flooding in 1960, 1963, 1968, 1974, 1979 and 2000-01. A total of 965 homes were flooded during the winter 2013/14 floods.

The Environment Agency commissioned JBA Consulting to undertake the 'Medway Catchment Mapping and Modelling Study' in 2013 to update the River Medway 2D hydraulic model to use the most up-to-date technology, methods and historic flood information. This provides modelled flood extent and flood depth information for the River Medway catchment for the existing and undefended scenarios. As part of this IA, JBA Consulting were commissioned to undertake modelling of the proposed options to enable quantification of the flood risk benefits.

Leigh FSA

The Leigh FSA, located about 3km upstream of Tonbridge was completed in 1981. The impounding structure consists of a 1.3km long embankment up to 5.7m high, and a flow control structure with 3 gates to provide active flow control. With a Normal Maximum Operating Water Level (NMOWL) of 28.05m AOD, it has a current storage capacity of around 5.5Mm³, which is used to reduce flood risk to homes and businesses, principally in Tonbridge and Hildenborough.

Whilst the Leigh FSA helps to reduce the flows downstream on the River Medway, many communities are still at risk of flooding. Operation of the Leigh FSA during the winter 2013/14 floods for example, substantially reduced the flows in the River Medway and protected 938 homes, but the Christmas 2013 flood was bigger than the Leigh FSA was designed to manage, and many properties were flooded throughout the catchment.

Since the failure of a lead screw on the main gate control structure in 2007, detailed survey work and condition reviews have identified a number of defects, recommending solutions to improve the integrity and reliability of control structure operation. The current Emergency Lifting Scheme installed in 2009 sought to provide some mechanical improvements, with Phase II of the project deferred until strategic decisions had been made about the long term options for Leigh FSA.

Middle Medway Strategy (MMS)

The MMS was completed in 2005 although was not submitted for Environment Agency or Defra approval. The Strategy sets out the overarching framework for future action by all risk management authorities to manage the risk of flooding from the River Medway, the River Beult, and the River Teise in the study area. One identified option was enlarging the capacity of the Leigh FSA by increasing the NMOWL to the embankment crest level (29.15m AOD), giving an additional 2.8Mm³ of storage and thus improving the downstream Standard of Protection (SoP). The Strategy also considered flood storage schemes on the River Beult and River Teise to reduce the risk of flooding to homes and businesses in Yalding, Collier Street and the surrounding communities. The Strategy concluded that these flood storage areas could not be funded given the economic rules in place at the time of publication.

Initial Assessment

Since the Winter 2013/14 flooding, the Environment Agency, Kent County Council, Tonbridge and Malling Borough Council and Maidstone Borough Council have formed a partnership project team to undertake another review of flood risk management options. The results of this IA are presented in this document and the appended Technical Report.

Long List Options

Do Nothing

This option is the economic baseline against which all other options are compared. Operation of the Leigh FSA would cease, increasing flood flows on the River Medway and hence increasing flood risk to Tonbridge, Hildenborough and downstream communities. Flood risk would further increase in the future as a result of climate change. For the purpose of this IA, the Do Nothing option is considered broadly comparable to the undefended scenario and has zero cost.

Maintain Leigh FSA

The Maintain option is as per the existing situation, with operation of the Leigh control structure to impound flood water in the FSA to the NMOWL of 28.05m AOD, reducing downstream flow and flood risk principally through Tonbridge and Hildenborough. However flood risk will increase over time as a result of climate change.

Improve Leigh FSA

Increasing the NMOWL requires a balance of the resulting implications of a higher level directly impacting property and assets upstream, the operating reservoir safety due to increased wave overtopping, and the potential to reduce flood risk downstream with the enhanced storage volume. The existing embankment crest level is 29.15m AOD. Increasing the NMOWL to 29.15m AOD and thus realising all of the potential Leigh FSA additional storage capacity, would require significant works at both the embankment (to mitigate the wave overtopping risk and to assess the hydraulic performance of the control structure) and mitigation works in upstream areas to protect existing assets.

Following a review of these impacts it was considered that this maximum increase in NMOWL to the embankment crest level was not optimal – the cost and direct impacts upstream outweighed the additional potential benefit. The review concluded that the optimum Improve option was to increase the NMOWL to ~28.85m AOD. While this option provides a slightly smaller increase in storage capacity compared to 29.15m AOD and hence will have lower benefits, the costs will also be significantly lower because it will reduce the required works at the embankment and upstream areas.

Hildenborough flood alleviation scheme

A flood alleviation scheme to protect properties in Hildenborough from flooding from the River Medway has been developed separately to this IA. If a Hildenborough scheme is subsequently taken forward to OBC stage it should be considered together with Improve Leigh FSA to ensure a strategic catchment-wide approach to flood risk management.

River Beult & River Teise FSAs

LiDAR, OS Mapping, the NRD and hydraulic model results were used to determine the availability of potential flood storage locations between Smarden and Yalding on the River Beult and between Horsmonden and Laddingford on the River Teise. For each identified location, the maximum feasible storage level was assessed. The natural floodplain in most areas is extensive and stored water levels in any FSA would need to be higher than the existing flood level to achieve any additional storage volume. There are however numerous farms and clusters of properties at or just above the natural floodplain level. The presence of all of the properties means that meaningful flood storage cannot be created in most areas without significant adverse impacts which would be technically difficult and costly to mitigate.

Only four locations were identified to be potentially technically feasible: Headcorn and Chainhurst on the River Beult and Cottage Wood and Stonebridge on the River Teise. For these four locations, volumetric calculations were undertaken using LiDAR and modelled flood extents and levels to understand the potential storage that would be available at the maximum feasible storage level, both above ground level and taking into account the volume already utilised by naturally-occurring floodplain storage. This storage was then compared with the storage volume requirements calculated from the hydraulic model results.

The analysis demonstrated that while storage at Headcorn could provide some local benefits, it would not provide a high SoP and would provide negligible flood risk benefit to the downstream communities (including Yalding) which are the focus of this assessment. For this reason this option was not considered further, and flood storage options for the other three locations were taken forward for detailed analysis and appraisal.

Yalding local defence scheme

Local defences could be constructed to reduce the risk of flooding to Yalding properties on both the left (south-western) and right (north-eastern) banks of the River Beult. In order to provide a 1.3% (1 in 75) SoP the south-western defence is estimated to be 1.5km long, circling most of the left bank Yalding community, and would need to include two road crossings. The right bank defence is estimated as being 275m long. A combination of earth embankments and walls would be required, with space particularly limited on the left bank to the north and south of Yalding Bridge.

Conveyance improvements

Provision of an additional open arch in Yalding Bridge was tested in the hydraulic modelling undertaken as part of the MMS Review. It was found to have a negligible impact on flood risk and consent for work to the Scheduled Monument is anticipated to be difficult. It was therefore not taken forward for appraisal in this IA. A second conveyance improvement option was considered by deepening and / or widening the River Medway channel between Yalding and Maidstone. The prohibitively high anticipated cost and adverse environmental impacts (see environmental appraisal matrix for this option in the Technical Report appendix) meant that this option was not included on the short list for full economic appraisal. A technical assessment was however still undertaken including option costing and simulation in the hydraulic model.

Short List Options

Overview

Option Name	Description
Do Nothing	Undefended scenario used as the economic baseline.
Maintain Leigh FSA	NMOWL of 28.05m AOD. Initial maintenance works including mechanical and electrical refurbishment and improvements to the control structure, as well as provision of southern embankment downstream slope protection. Assumes major capital works (replacement) in years 40 and 80.
Improve Leigh FSA	As above for all maintenance and capital works. Additionally increase NMOWL to 28.85m AOD, requiring works to both the impounding embankment (wave wall construction, embankment raising or provision of embankment protection) to offset the reduction in freeboard and mitigation measures to protect upstream assets. The latter includes the railway line, the cattle arch and pumping stations in Leigh, and two properties, an access track and the sewerage treatment works at Penshurst. The increase in NMOWL will also result in an increase in flood extent, flood depth and flood duration, potentially necessitating landowner compensation.
Improve Leigh FSA plus: Hildenborough flood alleviation scheme	As above for Improve Leigh FSA. Hildenborough scheme (as currently conceptualised) consists of construction of a 1.25km defence with two flood gates, a flow control structure, local drainage works, diversion of a water main and provision of a permanent area of hardstanding for mobile pumps.
Improve Leigh FSA plus: River Beult FSA at Chainhurst	As above for Improve Leigh FSA. New FSA at Chainhurst: <ul style="list-style-type: none"> • 720m length embankment up to 3m high across the Beult valley upstream of Hunton Road / East Street; • 3km of side embankments (1 – 2m high) to the south of the River Beult to prevent re-routing of floodwater into the Lesser Teise; • Local protection for several upstream properties; • 15.75m AOD maximum storage level; and • Passive outfall structure throttling downstream flow to a maximum of 75m³/s.
Improve Leigh FSA plus: River Teise FSAs at Cottage Wood and Stonebridge	As above for Improve Leigh FSA. New FSAs at Stonebridge and Cottage Wood: <ul style="list-style-type: none"> • Two 470m lengths of embankment up to 3.5m high across the Teise valley both upstream and downstream of Stonebridge; • Local protection for one upstream property; • Maximum storage levels of 30.5m and 27.5m AOD; • Passive outfall structures throttling downstream flow to a maximum of 60m³/s.
Improve Leigh FSA plus: One FSA on the River Beult and two FSAs on the River Teise	As above for Improve Leigh FSA combined with the new FSA on the River Beult and the two new FSAs on the River Teise.
Improve Leigh FSA plus: Yalding local defences	As above for Improve Leigh FSA. Walls and embankments providing properties in Yalding with a 1.3% (1 in 75) SoP, on both the left and right banks.

Technical assessment

A technical description of each option has been provided in the sections above. This section summarises the main technical risks and areas of uncertainty.

The contribution to flooding from the tributaries around the River Medway, River Beult and River Teise confluences (for example, in Yalding) can influence the predicted flooding in the area. There is also connectivity between the River Beult and the Lesser Teise in the Chainhurst area. The modelled contribution to flooding from each watercourse is therefore important to understand because of the impact it can have on the modelled benefits of each of the options.

A set of hydrological inputs for each modelled watercourse, derived using the continuous simulation methodology from the Medway Catchment Mapping and Modelling Study, provides the design event hydrology for each part of the model. The relative flows on each watercourse therefore varies both by location and design event, with the final results a composite of the resulting flood risk mapping outputs. If any of the new FSA options are taken forward to the OBC stage, further modelling will be required to test option benefits under a range of different watercourse flow combinations.

The impact of climate change was not included in the hydraulic model simulations, but was incorporated at the economic appraisal stage by amending the probability of an event causing a certain amount of damage. Percentage increases in river flow were taken from the 2011 Environment Agency guidance. This was current at the time of the assessment, but has since been superseded by new guidance (February 2016). The inclusion of climate change can be refined if options are taken forward for detailed appraisal.

The Redhill to Tonbridge railway line passes through the Leigh FSA, and includes protective berms to mitigate the impact of flood water on the railway embankment. A study in 2006 estimated the cost of mitigation works to raise these berms to be £1.8M. As part of this IA, the need for berm raising with a NMOWL of 28.85m AOD was reviewed and the scope of works reduced with a corresponding reduction in the cost allowance. The revised cost estimate included in this IA is £500k, but in the absence of consultation with Network Rail, the scope of required work remains uncertain and there is a risk that this cost could be significantly higher.

This IA has assumed that a local source of fill material would be available for the construction of the River Beult and River Teise FSA embankments. This assumption is reflected in the relatively low cost of fill material included in the option cost. The schemes, and particularly the FSA at Chainhurst would require significant lengths of new embankment which will be prohibitively expensive if a local source of suitable fill material cannot be secured.

The River Teise typically responds quicker to rainfall than either the River Beult or the River Medway. There is a risk therefore that flood storage on the River Teise with a passive control structure will act to delay the flood peak on the River Teise such that it would then coincide with one or both of the flood peaks on the Rivers Beult and/or Medway, worsening flood risk for some areas downstream. The chance of this occurring is dependent on the amount and spatial pattern of rainfall received, antecedent conditions, operation of Leigh FSA and resulting flows on each of the rivers for any given event at any given location. Providing worthwhile flood risk reduction through the means of passive flood storage on the River Teise is dependent on the rainfall event happening in a particular manner. It is not possible to design a passive structure that provides the same level of risk reduction across the normal variety of rainfall events experienced in the catchment.

Environmental assessment

An environmental appraisal of the improve options has been undertaken. For each option, risks and constraints, opportunities and potential mitigation measures were identified for seven environmental topic areas: air and climate, archaeology and cultural heritage, biodiversity, flora and fauna, land quality, soils and geology, landscape and visual amenity, pollution and human health and water. The latter included an assessment of likely compliance with the Water Framework Directive (WFD). A detailed summary of the findings is documented in the Technical Report, with a brief summary provided here.

Improve Leigh FSA

No significant environmental constraints were identified for the Improve Leigh FSA option. There are no statutory heritage sites, historical assets or statutory designated nature conservation sites within the FSA. Further work should however be undertaken to review the increased risk to Penshurst Bridge (Grade II listed). There is also a risk that habitats (including those in the *River Medway South of Leigh* Site of Nature Conservation Interest (SNCI)) will be adversely affected by the increase in flood depth and duration caused by the higher impoundment water level. Visual impacts, particularly on the *High Weald Area of Outstanding Natural Beauty* (AONB), should be assessed but are not considered to be significant at this stage. The option will include localised protection measures to prevent any worsening of flood risk to upstream assets. Environmental opportunities mostly relate to the reduction in flood risk to downstream properties, including listed buildings, residential properties and businesses. There may also be opportunities for habitat improvement and biodiversity enhancement which should be explored at the next stage.

River Beult FSA

There are environmental constraints associated with the proposed FSA on the River Beult, particularly in relation to the extensive nature of the new embankments and the potential aesthetic and setting impacts on listed buildings. Embankment construction will result in a direct loss of agricultural land and although land within the FSA is already at risk of flooding, flood depth and duration will be higher if water is deliberately impounded. The option includes localised defences to prevent any worsening of flood risk to properties at Stile Bridge, Old Hertsfield and Hurst Green. The River Beult is designated as a SSSI, which is currently in unfavourable condition due to a decline in water quality and change in habitat structure. The proposed FSA may alter the functioning of the clay-river habitats during flood events and will need to be investigated further, with any solution combined with the River Beult Restoration Plan, maximising opportunities to incorporate condition improvements and biodiversity enhancements. Other environmental opportunities relate to the reduction in flood risk to downstream properties (including listed buildings) and agricultural land, although the option generally reduces flood depth across a wide area instead of entirely preventing flooding.

River Teise FSAs

No significant environmental constraints were identified for the proposed FSA at Cottage Wood. There are no statutory heritage sites, historical assets or statutory designated nature conservation sites within the FSA. There is a risk that agricultural land, habitats and public rights of way will be adversely affected by the increase in flood depth and duration caused by the impoundment, and the new embankment is likely to have a moderate impact on the local landscape and visual environment.

There are however more significant environmental constraints associated with the proposed Stonebridge FSA location, particularly in relation to the cultural heritage assets at Share Farm and the potential for visual impacts in a location designated as an AONB. Further work to resolve these areas of uncertainty is recommended as part of the detailed appraisal if the option is taken forward.

Environmental opportunities for both FSAs relate to the reduction in flood risk to downstream communities, particularly to Collier Street. As described above however, there is a risk that flood storage on the River Teise with a passive control structure will act to delay the flood peak on the River Teise such that it would then coincide with one or both peaks on the Rivers Beult and / or Medway, worsening flood risk for some areas downstream.

Yalding Walls local defence scheme

Environmental constraints have been identified for the Yalding local defence option. These relate to work close to Town Bridge Scheduled Monument, likely adverse visual and landscape impacts and technical design challenges associated with the required alignment and the loss of floodplain storage. While these are significant, it is considered that sufficient mitigation measures could be included to adequately manage the environmental risks and that these do not prevent the option from being taken forward for detailed appraisal. Environmental opportunities mostly relate to the ability to design the option to accommodate future climate change and the reduction in flood risk to many Yalding properties, including listed buildings.

Other options

It is noted that an environmental assessment of the Hildenborough flood alleviation scheme was not undertaken because it is assumed that this will be included as part of the separate IA document. An environmental assessment of the River Medway conveyance improvements option was undertaken and is documented in the IA Technical Report, but is not summarised here because the option was not carried forward to the short list.

WFD compliance

A preliminary WFD compliance assessment was undertaken as part of the MMS Review (Halcrow, 2010) for the Improve Leigh FSA and Yalding local defence scheme options. This concluded that both options are likely to be compliant, with no anticipated waterbody deterioration and no prevention of implementation of the mitigation measures. Brief consideration of likely WFD compliance for the other options has been made as part of this IA.

For the new FSAs, channel form or function will not be directly affected and so it is considered unlikely that the option will prevent waterbody objectives from being met. Furthermore, out-of-bank flows and floodplain inundation already regularly occurs in these area and 'normal' flows in the rivers will be unaffected, with only the highest flood flows throttled by the new control structure. There will however be a loss of the natural river channel where the rivers flow through the new embankments, albeit over a very short distance relative to the overall waterbody lengths. All of these options would probably require consideration of, or a need to include some WFD mitigation to ensure that there was no change to the 'normal' flow regime, ensure that any sediment transport issues were addressed and that any natural channel losses were compensated for. Structures conveying the channel through the embankment would need to allow for passage of fish, and FSA drawdown would also need to ensure escape routes for fish to avoid stranding on the floodplain following drawdown of the flood water.

As well as ensuring that options cause no deterioration in waterbody status, and do not prevent the implementation of mitigation measures, any work relating to the WFD should seek to identify opportunities for contributing towards the River Basin Management Plan (RBMP) waterbody objectives. A full preliminary WFD compliance assessment should be undertaken to examine the potential impacts and opportunities associated with all of the options, with confirmation of in-principle compliance recommended for those options being taken forward.

Economic Appraisal

Benefits

Reduction in flood depths

The flood storage options do not provide a specific SoP to whole communities, but instead act to reduce flood depths over large parts of the catchment. This reduction in flood depth will provide an improvement in the SoP, but the magnitude of this improvement varies on a property-by-property basis depending on variables such as property location and threshold level. For areas at risk from multiple watercourses (for example Yalding), it will also depend on the relative contribution of each watercourse to flooding during any given event. Table 1 documents the reductions in flood depths modelled to occur for the 1% (1 in 100) AEP event for five key communities in the study area. The location at which model results were taken is documented in the IA Technical Report.

Table 1 Modelled flood depths

Option	Maximum flood depths at specific locations within key communities for 1 in 100 year event (1% AEP) (m)				
	Tonbridge	Hildenborough	East Peckham	Collier Street	Yalding
Do Nothing	0.78	0.75	1.04	0.41	1.64
Maintain	0.22	0.38	0.71	0.41	1.47
Improve Leigh FSA	0.10	0.23	0.67	0.41	1.40
Maintain Leigh FSA, Beult FSA	-	-	-	0.41	1.35
Maintain Leigh FSA, Beult & 1 Teise FSAs	-	-	-	0.26	1.32
Maintain Leigh FSA, Beult & Teise x 2 FSAs	-	-	-	0.20	1.31
Improve Leigh FSA, Teise x 2 FSAs	-	-	-	0.20	1.35
Improve Leigh FSA, Beult & Teise x 2 FSAs	-	-	-	0.20	1.17

Table 1 illustrates the benefit of Maintain (existing Leigh FSA) with flood depths reduced at the specific locations by 0.56m in Tonbridge, 0.37m in Hildenborough, 0.33m in East Peckham and 0.17m in Yalding. An increase in storage at Leigh would further reduce these depths. FSAs on the River Beult and the River Teise have been modelled to reduce flood depths in Yalding by up to 0.3m when constructed in combination with the Leigh FSA improvements. Flood depths however remain high at over 1m. Collier Street would not benefit from works to Leigh FSA, but flood depths could reduce if FSAs were constructed on the River Teise. In Yalding the conveyance improvement scenario for the 2% (1 in 50) AEP event, was modelled to give a 240mm reduction in water levels from 1.09m AOD to 0.85m AOD.

Reduction in flooded properties

Table 2 lists the number of residential properties at risk of internal (above floor level) flooding, for a range of design flood events for the Do Nothing and Maintain options. The bottom part of the table highlights the number of properties that benefit from the existing Leigh FSA.

Table 2 Internal flooded residential property counts: Do Nothing and Maintain

Location and Option	Residential properties at risk of internal flooding					
	20% (1 in 5)	5% (1 in 20)	2% (1 in 50)	1.3% (1 in 75)	1% (1 in 100)	0.4% (1 in 250)
Do Nothing (undefended)						
Tonbridge & Malling Borough	79	357	705	855	1,039	1,368
Maidstone Borough	46	269	492	683	707	886
Total	125	626	1,197	1,538	1,746	2,254
Maintain (Existing situation with Leigh FSA storing to 28.05m AOD)						
Tonbridge & Malling Borough	47	62	216	490	593	1,196
Maidstone Borough	34	223	436	648	642	799
Total	81	285	652	1,138	1,235	1,995
Maintain						
	Residential properties benefiting (no longer at risk of internal flooding under Maintain compared with Do Nothing)					
Tonbridge & Malling Borough	32	295	489	365	446	172
Maidstone Borough	12	46	56	35	65	87
Total	44	341	545	400	511	259

Table 3 lists the number of residential properties that benefit from the various improve options compared with the Maintain option (existing situation). Property counts are not shown for the Tonbridge & Malling BC area for the River Beult and River Teise FSA options as no properties in this area would benefit from the new FSAs.

Table 3 Reduction in residential properties at risk of flooding with improve options

Location and Option	Residential properties benefiting (no longer at risk of internal flooding compared with the existing situation (Maintain))					
	20% (1 in 5)	5% (1 in 20)	2% (1 in 50)	1.3% (1 in 75)	1% (1 in 100)	0.4% (1 in 250)
New River Beult FSA, Leigh FSA unchanged						
Maidstone Borough	0	36	18	32	49	24
New River Beult FSA and new single River Teise FSA, Leigh FSA unchanged						
Maidstone Borough	0	49	78	76	126	48
New River Beult FSA and two new River Teise FSAs, Leigh FSA unchanged						
Maidstone Borough	0	55	94	128	164	88
Improve Leigh FSA (increase stored water level to 28.85m AOD)						
Tonbridge & Malling Borough	0	0	36	165	94	94
Maidstone Borough	0	21	56	48	88	57
Total	0	21	92	213	182	151
Improve Leigh FSA plus Hildenborough flood alleviation scheme						
Tonbridge & Malling Borough	0	1	37	227	210	343
Maidstone Borough	0	21	56	48	88	57
Total	0	22	93	275	298	400
Improve Leigh FSA plus new River Beult FSAs						
Tonbridge & Malling Borough	0	0	36	165	94	94
Maidstone Borough	0	57	74	80	137	81
Total	0	57	110	245	231	175
Improve Leigh FSA plus two new River Teise FSAs						
Tonbridge & Malling Borough	0	0	36	165	94	94
Maidstone Borough	1	40	132	144	203	121
Total	1	40	168	309	297	215
Improve Leigh FSA plus new River Beult FSA and two new River Teise FSAs						
Tonbridge & Malling Borough	0	0	36	165	94	94
Maidstone Borough	0	76	150	176	252	145
Total	0	76	186	341	346	239
Improve Leigh FSA plus Yalding local defence scheme 1.3% (1 in 75) SoP						
Tonbridge & Malling Borough	0	0	36	165	94	94
Maidstone Borough	2	52	124	178	88	57
Total	2	52	160	343	182	151

Monetary benefits

The economic assessment has followed the principals of the Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG) (Environment Agency, 2010), as updated by supplementary guidance on the Defra website. Depth damage data has been taken from the Multi-Coloured Manual (MCM) (Flood Hazard Research Centre, 2015). Calculation of Average Annual Damages has included residential and non-residential property damages, evacuation costs, vehicle damages, cost of emergency services and risk to life. The benefits of a reduced risk of flooding on the human intangible effects of health and stress were also included, measured directly as a benefit. At this IA stage there was no inclusion of damages from agriculture or infrastructure (for example traffic disruption due to road closure, damage to railways or utility transmission infrastructure). The impact of climate change was incorporated into the economic appraisal in accordance with the Environment Agency guidance (Environment Agency, 2011) current at the time of the assessment and using a high-level approach suitable to the stage of this appraisal.

The full economic flood damage methodology is detailed in the IA Technical Report.

Table 4 summarises the Present Value damage (PVd) calculated for each of the options. The final row in the table provides the human intangible results which are expressed as a Present Value benefit (PVb).

Table 4 Summary of Present Value damages

	PVd (£m) (over 100 year appraisal period)							Human Intangible PVb
	Residential	Non Residential	Evacuation Costs	Emergency Services	Vehicles	Risk to Life	Total PVd	
Do Nothing	116.8	288.8	22.6	15.7	9.9	3.3	457.0	0
Maintain	65.3	175.2	12.5	9.8	7.5	2.1	272.4	3.4
Maintain Leigh FSA, Beult FSA	61.4	172.6	11.7	9.6	7.4	2.0	264.7	3.6
Maintain Leigh FSA, Beult & 1 Teise FSAs	58.9	167.2	11.2	9.3	7.3	2.0	255.9	3.8
Maintain Leigh FSA, Beult & Teise x 2 FSAs	57.5	164.7	10.9	9.2	7.3	1.9	251.4	4.0
Improve Leigh FSA	59.8	157.3	11.4	8.8	7.1	1.9	246.2	4.6
Improve Leigh FSA plus Hildenborough flood alleviation scheme	57.1	156.9	10.8	8.6	6.9	1.8	242.2	5.3
Improve Leigh FSA plus Beult FSA	55.9	154.7	10.6	8.5	7.0	1.8	238.5	4.8
Improve Leigh FSA plus Teise x 2 FSAs	55.8	149.4	10.6	8.4	7.0	1.8	232.9	5.0
Improve Leigh FSA plus Beult & Teise x 2 FSAs	51.9	146.8	9.8	8.2	6.9	1.7	225.2	5.2
Improve Leigh FSA plus Yalding local defence scheme 1.3% (1 in 75) SoP	55.1	155.8	10.5	8.5	6.7	1.8	238.6	5.1

Costs

A full breakdown of the costs for each option is included in the IA Technical Report and the total PV cost (capital, maintenance and optimism bias) is listed in Table 5 in the section below.

With the exception of the Hildenborough flood alleviation scheme and the Yalding local defence scheme, a lower level of Optimism Bias (risk) at 30% rather than the standard 60% for strategies and initial assessments has been applied to all costs, reflecting the understanding and knowledge of the existing assets, and previous studies undertaken.

Present Value costs and benefits

In accordance with Treasury guidance a 100 year appraisal period has been used and the Treasury variable discount rate has been applied. Table 5 provides a summary of the PV costs, damages and benefits calculated for each option and the resulting Benefit Cost Ratio (BCR) and incremental Benefit Cost Ratios (iBCR).

Table 5 Present Value costs, benefits and Benefit Cost Ratios

Option	PVc (£k)	PVd (£k)	PVb (£k)	BCR	iBCR (against Maintain)	iBCR (against Improve Leigh FSA)
Do Nothing	-	457,028	-	-	-	-
Maintain	15,261	272,414	188,000	12.3	-	-
Maintain Leigh FSA, Beult FSA	24,854	264,709	195,938	7.9	0.8	-
Maintain Leigh FSA, Beult & 1 Teise FSAs	29,213	255,943	204,913	7.0	1.2	-
Maintain Leigh FSA, Beult & Teise x 2 FSAs	32,766	251,431	209,610	6.4	1.2	-
Improve Leigh FSA	19,125	246,196	215,442	11.3	7.1	-
Improve Leigh FSA plus Hildenborough flood alleviation scheme	22,546	242,202	220,084	9.8	4.4	1.4
Improve Leigh FSA plus Beult FSA	28,718	238,491	223,379	7.8	2.6	0.8
Improve Leigh FSA plus Teise x 2 FSAs	27,037	232,919	229,114	8.5	3.5	1.7
Improve Leigh FSA plus Beult & Teise x 2 FSAs	36,630	225,214	237,051	6.5	2.3	1.2
Improve Leigh FSA plus Yalding local defence scheme 1.3% (1 in 75) SoP	24,121	238,556	223,607	9.3	4.0	1.6

Non-Financial Benefits Appraisal

Where possible, costs and benefits have been quantitatively valued and included in the economic appraisal. This included risk to life and the human intangible effects on health and stress. Non-financial benefits therefore mostly relate to environmental benefits, identified and described for each option as part of the environmental assessment matrices included in Appendix E of the Technical Report and summarised earlier in this IA. Scoring of these qualitative benefits has not been undertaken at this stage.

Analysis of Options

Analysis of the options has been based on the FCERM-AG decision rule. Improve Leigh FSA has the second highest BCR (11.3) and a strong iBCR of 7.1.

The options to improve Leigh FSA in combination with the Hildenborough flood alleviation scheme, the two new FSAs on the River Teise and Yalding local defences all have iBCRs greater than one and can therefore be selected as additional elements. The iBCRs for these three additional Improve options are however relatively low (1.4 to 1.7) with respect to Improve Leigh FSA. The iBCR for the Beult FSA option is less than one, and cannot be selected.

The Yalding Local defence scheme has the potential to make the depth of flooding worse for properties outside of the benefitting area. It will not be possible to progress development of a scheme that worsens risk for others unless it can be mitigated.

The property threshold dependent benefits for the Teise FSA's does not give an even SoP across the catchment. There is also the potential for storage to result in a peak flow on the River Teise which could coincide with the peak flow on the River Medway and / or the River Beult, worsening flood risk in some areas. It is noted that there remains uncertainty relating to the River Teise FSAs associated with the assumed cost of imported fill for embankment construction and the environmental constraints at the Stonebridge site.

Significant partnership contribution will be required for all of the options, particularly the Teise FSA and Yalding Walls. This will form part of the Financial Case and will need to be considered as part of the SOC, affordability is not considered in detail at IA stage. The lower BCRs and higher costs of the various combined options, compared with the option to improve Leigh FSA in isolation, means that significantly higher contributions will be required for these options to be taken forward.

The economic information derived from the IA work should be used to build up the economic case in the SOC. The SOC should consider all 5 business cases to build up the preferred option for OBC.

Sensitivity Analysis

The IA Technical Report details the sensitivity testing that was undertaken to determine the impact of varying assumptions made during the cost and benefit calculations. While the BCR and iBCRs changed, the changes were not sufficient to change the identified preferred options. Sensitivity testing was also undertaken on the partnership funding calculations (see below), the results of which are also reported in the IA Technical Report.

Funding Considerations

Capital works schemes can be (partially) funded through the Flood Defence Grant in Aid (FDGiA) funding stream. The Partnership Funding Score provides an indication of the scheme costs which will be eligible for central Government funding and hence the likely financial viability of the option. The results of the funding calculations for the various options are presented in Table 6, with the leading economic options in bold.

The duration of benefits was set at 40 years for all options, driven by the need for significant works to the existing Leigh FSA control structure after this timescale. PV costs and benefits were calculated over the 40 year period in accordance with the partnership funding mechanism, and hence are different to those previously reported for the 100-year appraisal period.

Table 6 Partnership funding calculations (raw scores prior to receipt of any contributions)

Option	% score	PV cost for approval (£m)	PV cost for duration of benefits (£m)	Contribution required (£m)	PV GiA for approval (£m)	PV GiA for future spend (£m)
Maintain	94%	7.0	10.0	0.6	6.4	3.0
Maintain Leigh FSA Beult FSA	48%	14.9	19.1	9.2	5.7	4.2
Maintain Leigh FSA Beult & 1 Teise FSAs	45%	18.7	23.3	12.9	5.8	4.6
Maintain Leigh FSA Beult & Teise x 2 FSAs	40%	21.6	26.6	16.0	5.6	5.0
Improve Leigh FSA	79%	10.5	13.8	2.9	7.6	3.3
Improve Leigh FSA plus: Hildenborough flood alleviation scheme	66%	13.5	17.1	5.8	7.7	3.6
Improve Leigh FSA plus: Beult FSA	50%	18.4	22.9	11.5	6.9	4.5
Improve Leigh FSA plus: Teise x 2 FSAs	55%	17.2	21.3	9.6	7.6	4.1
Improve Leigh FSA plus: Beult & Teise x 2 FSAs	40%	25.1	30.4	18.2	6.9	5.3
Improve Leigh FSA plus: Yalding local defences 1.3% (1 in 75) SoP	61%	10.6	18.7	7.2	3.4	8.1

The Partnership Funding Raw Score for all options is less than 100%; contributions from other sources would therefore need to be secured for any of the options to be implemented. There are a number of potential sources of funding, including Kent CC, Tonbridge & Malling BC, Maidstone BC, Southern Water (for Penshurst STW), Network Rail (for works to the railway embankment in Leigh FSA) and local businesses.

Conclusions

Maintaining Leigh FSA has a viable business case, with a benefit cost ratio of 12.3. It reduces flood risk to over 1,200 residential properties, with 341 of these moved out of the very significant risk category (at risk of flooding in a 5% (1 in 20) annual chance event). The Maintain option includes completion of the mechanical and electrical refurbishment and further improvements to the control structure.

Improving the flood risk benefit provided by the Leigh FSA can be achieved by raising the NMOWL to 28.85m AOD. This reduces flood risk to an additional 231 residential properties, and with a BCR of 11.3 and a strong iBCR of 7.1 can be selected under the FCERM-AG decision rule. Under current funding arrangements, around £2.9M of contributions would be required to implement this option. No significant environmental constraints have been identified for this option. If it is progressed, it is recommended that the Hildenborough scheme is considered as part of the Improve Leigh option due to the potential efficiencies that could be achieved.

This IA demonstrates the flood risk management benefits in Yalding, Collier Street and the wider community in the surrounding area that could be achieved through construction of local defences for Yalding, and/or two new FSAs on the River Teise in combination with improving the Leigh FSA. Although the iBCRs are relatively low (1.4 to 1.7), they are sufficient to select these options under the FCERM-AG decision rule. The SOC will need to consider the viability of these options for all 5 business cases.

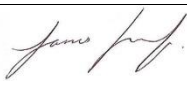
This IA includes optimism bias of between 30% and 60%. While environmental constraints have been identified for these options, it is considered that sufficient mitigation measures could be included to adequately manage. The development of the SOC will consider the financial case which includes affordability. This will need to consider the likelihood of the schemes progressing given the high levels of partnership funding required. The benefits derived through these schemes are not universal and they will leave the majority of properties within the study area at risk of flooding, the SOC will need to consider this to select the preferred option.


The detailed investigation of creating a new FSA facility on the River Beult has confirmed that there are no economically or technically viable options, this information should inform the SOC.

Given the high level of contributions required for all options this IA does not have a preferred option, the IA presents the raw economic data, this is shown in the IA tables above. The preferred option decision should be deferred to the SOC so that all 5 business cases can be considered.

Proposed Implementation Plan

2016	River Medway FSA IA and SOC completed. Ongoing work to investigate the option of active storage on the River Teise and other local schemes to reduce flood risk.
2016 - 2018	Scheme development, detailed appraisal and land negotiation.
2018 – 2021	Detailed design and construction.

Project Executive Approval:	Name: James Kennedy	Title: Project Executive	 Signature:	Date: 10 October 2016
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Approval to continue to full SOC stage:	Name: James Kennedy	Title: Project Executive	 Signature:	Date: 10 October 2016
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