East Lothian Council

REPORT TO:	East Lothian Council
MEETING DATE:	25 October 2022
BY:	Executive Director for Place
SUBJECT:	Musselburgh Flood Protection Scheme – Update on Scheme Development

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1 PURPOSE

1.1 To update Council on progress made in a number of key areas in advancing the development of the Musselburgh Flood Protection Scheme (the Scheme) and in respect of specific recommendations at the Council meeting in August 2022, and to seek Council approval and authorisation of key elements of project work.

2 RECOMMENDATIONS

2.1 It is recommended that Council:

a) Notes the work undertaken to achieve a full and final review of the Scheme's Hydrology, the development of the Hydraulic 'Model C' to ensure the Scheme is applying the best approach to modelling the flood risk to Musselburgh.

b) Approves the defined flood risk as the relevant flood risk to the town of Musselburgh, and authorises the Scheme to now go and determine the flood defences, and thereby the standard of protection, through which the flood risk to Musselburgh can be reduced, noting that the appropriate defences will be evolved through consultation.

c) Notes the work undertaken on the incorporation of the Ash Lagoons Seawall into the Scheme including the Options Appraisal Process and the identification of an emergent 'Preferred Option' including its range of estimated costs.

d) Approves the Scheme Timeline for the advancement of the Outline Design, including the presentation of the prepared Outline Design for review and approval by a meeting of Council at the end of that timeline.

e) Notes the revised estimate for the £42.1M Preferred Scheme, as approved by Cabinet in January 2020, to £43.5M – which is revised due to the loss of time to programme due to COVID-19 pandemic and inflation between 2020 and 2022.

f) Notes the inclusion of £122k of 100% grant allocated new budget from the Sustrans funded Places for Everyone ‘Musselburgh Active Toun’ project to allow the Scheme’s Project Team to work in partnership with that multiple-benefits project.

g) Notes the high level upper-bound estimate of £52.4M which includes Optimism Bias in line with HM Treasury Green Book, for the emerging ‘Preferred Option’ for the Ash Lagoons Seawall – which will allow the asset to continue to function as a waste containment system whilst also being redesigned to achieve both flood protection and active travel multiple-benefits.

h) Approves the Scheme’s Strategic Communications Plan.

i) Approves the Scheme’s Consultation Plan for the Outline Design.

3 BACKGROUND

3.1 The project presented a report to update on Scheme development to Council in August 2022, and recommended that further work be undertaken in a number of areas with a further update provided to Council in October 2022 – this report provides all of those updates.

3.2 <u>Flood Risk to Musselburgh</u>

3.2.1 On behalf of the Scheme, and thereby the Council, Jacobs have undertaken a full review of all appropriate guidance alongside the public concerns towards ‘Model B’. The process of this review, the revised determination of the appropriate Scheme Hydrology, and the resultant ‘Model C’ including its flood maps – have been documented in a Technical Report produced by Jacobs. This is provided as Appendix A to this report.

3.2.2 The Scheme previously set a Project Objective of aspiring to protect against the 0.5% Annual Exceedance Probability (or AEP) Flood Event (plus an allowance for climate change) – the Project Objectives Report was presented to Cabinet in January 2020. The Scheme continues to consider that protection against the 0.5% AEP Flood Event is the minimum Standard of Protection that should be provided to Musselburgh. This is referred to as the ‘present-day flood risk’ in this report. The flood event of August 1948, as experienced in Musselburgh, was equivalent to this event. This is also the event considered as a minimum for a standard property planning application.

3.2.3 Flood Risk is however not fixed: it changes over time, and due to the impact of climate change flood risk in Scotland is projected to increase.

3.2.4 Increased flood risk due to climate change is accounted for within the Scheme's Hydrology by the determination of an allowance for climate change, and 'Model C' has taken a revised approach to this compared with 'Model B', with the following notable changes being made:

a) The Scheme has produced flood maps for both the present day flood risk and the future with climate change flood risk. Previously the Scheme's 'Model B' flood mapping published the more onerous 'with climate change' scenario. In producing the two sets of flood maps we secure the following: (i) a clarification of the major flood risk that Musselburgh has today; (ii) a presentation of the very much worse 'credible worst-case flood risk' that Musselburgh is expected to be facing by 2100; and (iii) it provides the Project Team with a range of risk so that through the Outline Design, the Scheme may evolve the appropriate flood protection defences against a flood risk within this range. The appropriate defences will be evolved through consultation and may include future-flexibility of a lesser standard of protection if the outcome of the design is that aesthetics and landscape impacts are of more importance to Musselburgh compared with the reduction of the defined flood risk. Future flexibility refers to the potential to increase the level of flood defence measures in the future, should the need be determined.

b) In 'Model B' the time-duration considered for climate change was 100 years so that it aligned with the design life of any flood defences being designed as part of the Scheme. In so doing it was required to extrapolate forward the UKCP18 Climate Change projections for the sea from 2100 until 2125. In 'Model C' the time-duration is not being continued past the date of 2100: the date of 2100 is therefore used in the 'credible worst-case flood risk'. This addresses a concern of the public that the 'Model B' approach to climate change was looking too far into the future. This change has resulted in the flood risk defined in 'Model B' being reduced – the coastal allowance for increase in sea levels are reduced from 1.24m to 0.86m.

c) The recommendations of the new SEPA guidance (i.e. *Climate Change Allowances for Flood Risk Assessment in Land Use Planning – Version 2, (SEPA, 2022)*) which allows Local Authorities to underpin their land use planning decisions with the best evidence available, have been accepted within the 'credible worst-case flood risk' within 'Model C'. It is a requirement for a flood risk assessment associated with a development and / or a Planning Application to consider these climate change allowances. It is therefore appropriate for this up-to-date information to inform the 'credible worst-case flood event' for Musselburgh to be considered within the 'credible worst-case' scenario. This change has resulted in the flood risk defined in 'Model B' being increased. Within the Version 2 Guidance the coastal level increases do not change: but the fluvial (River Esk) allowance increases from plus 40%, onto 'present-day' flow, to plus 56%.

3.2.5 The outputs from 'Model C' have been examined by the Project Team and a suite of maps have been developed in the Scheme's GIS System to present the impact of these flood events to Musselburgh. These maps are provided as Appendix B to this report.

3.2.6 'Model C' has modelled the risk from three different sources of flood risk, namely: (i) the Firth of Forth (i.e. Coastal); (ii) the River Esk (i.e. Fluvial); and (iii) the Pinkie Burn (i.e. Fluvial). The probability of these events happening at the same time is not considered. Each event has its own flood map and thereby a definition of the area of inundation and number of properties flooded by the event. The Scheme will work to remove the flood risk from the three events. For simplicity of presentation the individual maps have been 'blended' into one flood map to define the whole area of flooding in Musselburgh from the three events being looked at. Within the Jacobs report (i.e. Appendix A) and within the additional flood maps provided in Appendix B, examples of both individual and blended maps are provided.

3.2.7 The 'Blended' 'Present-Day' Flood Risk to Musselburgh (0.5% AEP Flood Event) will impact on 923 properties in Musselburgh. This includes: the whole of the High Street and large areas of the town centre; the whole of the Eskmills Business Area; areas of the Racecourse and the Old Golf Course; parts of the Ash Lagoons; the grounds of Pinkie Primary School; Loretto School; one Scottish Water Wastewater Pumping Station; the SGN (i.e. the company who looks after the gas network in Scotland) area Gas Governor; many care homes; and all businesses and residential dwellings in that flooded area.

3.2.8 The 'Blended' 'Credible Worst-Case' Flood Event to Musselburgh (0.5% AEP Flood Event plus the defined allowance for climate change) will impact on 2,962 properties in Musselburgh. This includes: the whole of the town centre; the whole of the Eskmills Business Area; the Racecourse; the Old Golf Course; the Ash Lagoons; the Brunton Theatre; Pinkie Primary School; Fisherrow Harbour; Loretto School; the Bus Depot; three Scottish Water Wastewater Pumping Stations; the SGN area Gas Governor; many care homes; and all businesses and residential dwellings in that flooded area.

3.3 <u>Including the Ash Lagoons Seawall in the Preferred Scheme</u>

3.3.1 Further to being directed by the Council meeting in August 2022 to include the Ash Lagoons Seawall in the Scheme, Jacobs commenced an Options Appraisal Process (OAP). This is equivalent to the Options Appraisal Process undertaken for the Scheme during its Project Stage 3 (named 'The Options Appraisal Process') back in 2019.

3.3.2 At this point the OAP is not fully concluded by Jacobs; however, they have produced an Intermediate Assessment report to summarise the process thus far. This report is provided as Appendix C to this report.

3.3.3 The OAP has undertaken the development of a long-list of options, option consideration, and engagement with the Scheme's Regulatory Working Group (the Roads, Structures & Access Working Group), and then identified a Short-List of Options. At this point a, small number of options are being considered, one of which will become the Preferred Option.

Once the OAP is fully completed Jacobs will present a final report to the Scheme on the conclusion of the OAP. That Preferred Option will then continue into the Outline Design process.

3.3.4 Further to Section 3.3.3 of this report, it is highlighted that the Project Team has been able to identify the most likely preferred option through working with: (i) the Council Team advancing the confidential Seawall Negotiation with Scottish Power; (ii) senior Council Managers; and (iii) under the oversight of the Scheme's Project Board. For the purpose of this report this option will be known as the 'emerging preferred Seawall option'. This is option 'A7' as defined in the Jacobs Technical Report, and it produces the estimated cost of £52.4M for advancing this option that has been analysed and presented through Section 6.1(b) of this report.

3.3.5 The Project Team will continue to advance the incorporation of the Seawall into the Preferred Scheme and Outline Design. In so doing the Scheme will work to achieve the three parallel deliverables (multiple-benefits) associated with this investment, namely:

a) Continuation of its primary environmental function to contain the waste ash.

b) Provision of new, formal, flood protection within the Scheme.

c) Provision of a new active travel pathway along the 2.7km length of the Seawall just inside the existing concrete wall. This carries significant benefit for Musselburgh and wider communities.

3.3.6 It is highlighted that the 'emerging preferred Seawall option' (i.e. option A7) is to undertake works to extend the life of the existing asset, and not the 'Advance the Line' or 'Retreat the Line' options identified in the long-list of options. It is considered that this approach, of significant intervention on the existing structure, provides the best potential for minimising the overall environmental, carbon, and construction impacts etc. – all of which will be assessed by the Scheme's Environmental Impact Assessment which still requires to be undertaken.

3.3.7 The Scottish Power Ash Lagoons Seawall, is already beyond its design life of 50 years, and it will require significant investment to extend its life with or without the flood protection scheme.

3.3.8 Further to Section 3.3.5 of this report, it is also highlighted that the Ash Lagoons Seawall is already functioning as a flood defence, and that its continued functioning and enhancement is essential for flood risk reduction to Musselburgh in the long-term.

3.4 <u>The Scheme Programme and a Timeline for the Outline Design</u>

3.4.1 One key concern identified through the consultation and reported to Council in August 2022 was that the project has been 'off-programme' for some time as a result of the COVID-19 Pandemic. This is now addressed by the development of a revised programme.

3.4.2 The Scheme Programme is driven by the Contractual Work Activities, Key Milestones, and all Timescales / Dates within the Contract Programme that exists between Jacobs and the Council.

3.4.3 The Project Team has developed a new, graphically designed, timeline to illustrate the key Scheme activities / processes and points in time where key decisions will be required. The Timeline for the Outline Design is provided as Appendix D to this report.

3.4.4 The Project Team have also developed a similar Timeline for all further stages of the project (i.e. Project Stage 5 through to Project Stage 9). These graphic illustrations are all intended for publication on the Scheme Website during week commencing Monday 25 October 2022.

3.4.5 It is highlighted that the timescales / estimates of time for all activities up until the moment of Scheme Publication are considered to be a reasonable projection of assumed timescales, based on experience from the delivery of other Scottish flood protection schemes. From the moment of the Scheme's Publication the project is capable of travelling down multiple pathways as defined in the Flood Risk Management (Scotland) Act 2009, including a Public Local Inquiry (PLI) – therefore the Timeline provided is based on a pathway that does not include a PLI. In the event of a PLI, or other alternative pathway at that point in time, the Timeline will be revised.

3.4.6 The Scheme Programme will now include all key dates defined in the Timeline, and will continue to be revised under the responsibilities of the existing contracts and under the oversight of the Project Board.

3.5 <u>The cost of delivering these projects and thereby the Scheme</u>

3.5.1 The project that set out to deliver a flood protection scheme in 2016 was estimated at £8.9M. In January 2020 the Preferred Scheme was valued at £42.1M – as previously reported this financial change was driven by the massive increase in flood risk from the sea deriving from projected sea-level rise as identified though UKCP18. The project is now bringing together three separate individual projects: (i) the flood protection scheme; (ii) the Ash Lagoons Seawall future-proofing; and (iii) parts of the Musselburgh Active Toun project. The emerging total cost of these estimates is therefore not comparable with the estimates previously stated for the Scheme.

3.5.2 The project is being advanced under a PRINCE2 Project Management System, and therefore at any point in the delivery of the project the Council is only liable for the costs authorised within the stage that is open. The project is currently working within Project Stage 4, and this stage is being managed by the Project Board, including the management of the budget delivery which has an estimate of its cost based on the latest best available information. Furthermore, the Scheme is being designed through a process of consultation to evolve the best flood protection scheme possible for Musselburgh within the constraints of the finance available. This will remain under review as the Scheme design evolves.

3.5.3 It is essential that the project can define its Total Scheme Cost, or delivery budget, for the purposes of its: Business Case; grant funding management; and financial management systems: notwithstanding this is an estimated cost. The project undertakes this through standard estimating techniques and assumptions which are overseen by the Scheme's Project Board. This is in line with the approach of all schemes on the national flood protection scheme programme advanced under the Flood Risk Management (Scotland) Act 2009.

3.5.4 Further to authority provided by Cabinet in January 2020, and Council in August 2022, the Scheme is advancing its development working with external partners to achieve multiple-benefits in Musselburgh – e.g. with the Musselburgh Active Toun project; with Scottish Power regarding their Ash Lagoons Seawall; and regarding Musselburgh River Restoration. This partnership working is now yielding real benefits in relation to emerging blended designs where parallel projects overlap. The first such specific financial change is in relation to the Musselburgh Active Toun and is detailed in Section 6.1(b) of this report.

3.5.5 The Scheme is at a point in its timeline where it is extremely difficult / impossible to provide a full update on the Total Scheme Cost. The finances associated with the Seawall continue to sit within the confidential negotiation that is ongoing between the Council and Scottish Power. The process of exploring joint-deliverability between the Scheme and the Musselburgh Active Toun projects is only commencing. This report has therefore endeavoured to provide an update on each of the currently anticipated project funding streams within Section 6 of this report.

3.5.6 Further to Section 3.5.5 of this report, it is highlighted that the estimated cost of the project can be considered to be changing constantly as the design is evolving. The estimates provided are considered to be upper-bound estimates as they include an allowance for Optimism Bias which is derived from the guidance of the HM Treasury 'Green Book. A full update on the Total Scheme Cost will be provided to Council at the end of the Outline Design. This will include a full report on the available sources of funding that are required for East Lothian Council to deliver that Scheme, including a continued assumption that the Scottish Government will continue to fund 80% of scheme costs.

3.6 <u>The Strategic Communications Plan</u>

3.6.1 The Scheme's approach to communication has evolved as the scale of the project has expanded. The Scheme provided a full update to Council in August 2022 on the development of the Strategic Communications Plan in response to the COVID-19 pandemic, and in particular the new communication tools it developed (e.g. the Scheme Website etc.).

3.6.2 The Strategic Communications Plan has been revised since August 2022 to take into account the direction of travel of the project as determined by the authority deriving from Council at that August meeting. This revised plan is provided as Appendix E of this report.

3.7 The Consultation Plan for the Outline Design

3.7.1 Further to the amendment to the recommendations to the August 2022 Council report the Project Team have prepared a Consultation Plan for the Outline Design. This new plan is provided as Appendix F of this report.

3.8 The Next Steps

3.8.1 The Project Team will advance the development of the Scheme's Outline Design through the timescales and key decision points identified in the Timeline for the Outline Design. This will be undertaken through a continuation of the design consultation process that has been successfully used to date, and through the specific approach defined in the Consultation Plan for the Outline Design.

3.8.2 At the end of the development of the Outline Design the Scheme will present the outcome to Council for approval. This will include a full revision of the Total Scheme Cost.

4 POLICY IMPLICATIONS

4.1 The Flood Risk Management (Scotland) Act 2009 places a statutory responsibility on the Local Authority to exercise their flood risk related functions with a view to reducing overall flood risk and complying with the EU Floods Directive. A key responsibility is the implementation of the flood risk management measures in the Local Flood Risk Management Plan.

4.2 The Scheme will contribute towards The East Lothian Plan – 2017-27 focusing on health and wellbeing, safety, transport connectivity, sustainability and protecting our environment.

4.3 The Scheme will support the Council's Climate Change Strategy; however, it is highlighted that this project is an 'adaptation' project due to implications of climate change on Musselburgh.

5 INTEGRATED IMPACT ASSESSMENT

5.1 The Scheme will undergo an Integrated Impact Assessments during its development.

5.2 A Preliminary Environmental Appraisal Report (PEA) was undertaken during Project Stage 3 (the Outline Design), and this was included in the Preferred Scheme Report presented to Cabinet in January 2020.

5.3 The Scheme will undertake an Environmental Impact Assessment on the Outline Design. This will be presented to Council alongside the developed Outline Design at the end of this stage (i.e., Stage 4 – 'Outline Design'), which is now estimated at January 2024 as per the Timeline for the Outline Design which is detailed in Section 3.4 of this report.

6 RESOURCE IMPLICATIONS

6.1 Financial -

(a) The concept named the 'Preferred Scheme' was estimated to cost £42.1M in advance of the report to Cabinet in January 2020. This cost was defined in Q2-2019 and was index linked to the Scheme Programme at that time. This cost has been reviewed and at this point the only revision that has been deemed to be appropriate to make is to re-baseline the costs relative to the Q2-2022 index. This revision to the estimated costs is due to the loss of time relative to the programme, and this is primarily due to the COVID-19 Pandemic impact, alongside inflation over the 2020 to 2022 period. These are considered one-off time losses, however they highlight the risk of cost impact due to time loss. The revised estimate is £43.5M.

(b) The Council is currently advancing a parallel project named 'Musselburgh Active Toun'. There is a direct overlap between these two projects in Musselburgh, and as previously reported to Council this is a key multiple-benefit for the Scheme. Due to the workload being advanced by the Scheme's Project Team to assist the Musselburgh Active Toun project, £122k of new grant funding has been provided by that project to the Scheme. This new money is provided at a rate of 100% by Sustrans from their 'Places for Everyone' grant fund, therefore there is no financial implication for the Council in this internal movement of budget.

(c) The Project Team working with Jacobs have developed an estimated cost of £52.4M for the 'emerging preferred Seawall option' for the Ash Lagoons Seawall. This is estimated relative to Q2-2022 prices and is thus considered an equivalent cost to the revised Preferred Scheme estimate stated in Section 6.1(a) of this report. This element of work will simultaneously deliver multiple-benefits and thus outcomes for the ash waste containment, the flood protection scheme and the active travel network. Just now the final determination of the income matrix to fund this estimated cost is not yet concluded, and it is linked to the confidential negotiation being undertaken between the Council and Scottish Power. It is however confirmed that the Council will only ever lock-in a cost that is affordable by the Council. It is confirmed that just now the Council needs to: (1) advance the confidential negotiation; and (2) develop the Outline Design – so that it is better empowered with the numbers associated with all of this so that it can make a final recommendation to future meeting of Council.

(d) In accordance with the confirmed Scottish Government Flood Protection Programme, the Government will contribute 80% of the eligible costs of the Total Scheme Cost, which will be confirmed when the Construction Works Contract is signed. Within the PRINCE2 Project Management System being applied by this project this is at the end of project Stage 7 (which is named 'Construction Procurement').

(e) The Scheme is already authorised under the Scottish Government's flood protection scheme programme. The Project Team and thereby the Council update the Scottish Government every autumn on the updated estimate for the Total Scheme Cost and its Spend Profile. From this data, and in line with the authorised programme, it is assumed the Council receive the 80% contribution on an annual basis as part of the capital grant settlement.

(f) It is highlighted that, in accordance with the Scheme's PRINCE2 Project Management System, that at any point in the delivery of the project the Council is only liable for the costs authorised within the stage that is open.

6.2 Personnel - None

6.3 Other – None

7 BACKGROUND PAPERS

7.1 Report to Cabinet in May 2016 – approval of the Local Flood Risk Management Plan (Forth Estuary) which included a proposed flood protection scheme for Musselburgh.

7.2 Report to Cabinet in January 2020 – approval of the 'Preferred Scheme' concept to be advanced to an Outline Design.

7.3 Report to Council in August 2022 – Update on Scheme Development.

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DATE	14 October 2022

Determination of present-day and credible worst-case flood risk in Musselburgh

Date:	13 October 2022
Project name:	Musselburgh Flood Protection Scheme
Project no:	701909CH
Attention:	Conor Price
Company:	East Lothian Council
Prepared by:	Jim Baxter
Reviewed by:	Steven Vint
Document no:	701909-JEC-S4-XXX-XXX-TN-Z-0003
Revision no:	P01.3

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Introduction

Musselburgh Flood Protection Scheme (the Scheme) is being promoted by East Lothian Council (ELC) under the Flood Risk Management (Scotland) Act 2009 (The Act). Jacobs was appointed by ELC in December 2017 to develop a scheme for Musselburgh to reduce flood risk from all sources of flooding. The project is being delivered in stages under PRINCE2 Project Management principles and is currently in Stage 4 Outline Design.

The purpose of this technical note is to definitively state what Musselburgh's flood risk is today, and what the credible worst-case flood risk could be by 2100 due to the effects of climate change. The analysis will consider the flood risk due to a 0.5% Annual Exceedance Probability (AEP) event, also known as a 1 in 200-year flood event[1]. The analysis of this particular flood event derives from the Scheme's objectives, which state an aspiration to provide a level of protection against an event of this magnitude. The intention is for this technical note to accompany a report to Full Council[2] and to seek its approval of the flood risk maps contained herein as a true reflection of Musselburgh's present and future flood risk.

Due to the scale and complexity of Musselburgh's flood risk, it is considered appropriate to seek Full Council's approval of this risk. Thereafter, it is acknowledged that Full Council[3] has empowered the Project Board to select the Scheme's response to that risk. This response is known as the Scheme's 'standard of protection'. Once the outline design of the entire Scheme has been completed, it will then be returned to Full Council to seek its approval to proceed to stage 5 of the project – the statutory approvals process under The Act. Only once the Scheme successfully passes through the statutory process, can it be formally 'Approved' under the Act by either ELC or, if required as a result of feedback to the statutory consultation process, the Scottish Ministers.

[1] A 1 in 200 year event refers to an event which has a 1 in 200 chance of occurring in any given year. This is known as the event's return period and is the inverse of its annual exceedance probability. i.e. 1 divided by 200 = 0.005, or 0.5%.

[2] Full Council is the collective term for all East Lothian Council's elected members, of which four represent the Musselburgh ward.

[3] The empowerment of Project Board to take decisions during each stage of the project was confirmed by Full Council on 23rd August 2022.

Consultation Feedback and Media Coverage

During 2022 some members of the public have provided feedback which suggests a lack of acceptance or misunderstanding of Musselburgh's flood risk, and this has been compounded by some aspects of media coverage. Some have also suggested that protecting against the possible worst-case effects of climate change up to 2125 would be overly conservative because the international community may succeed in intervening to limit global temperature rises before then.

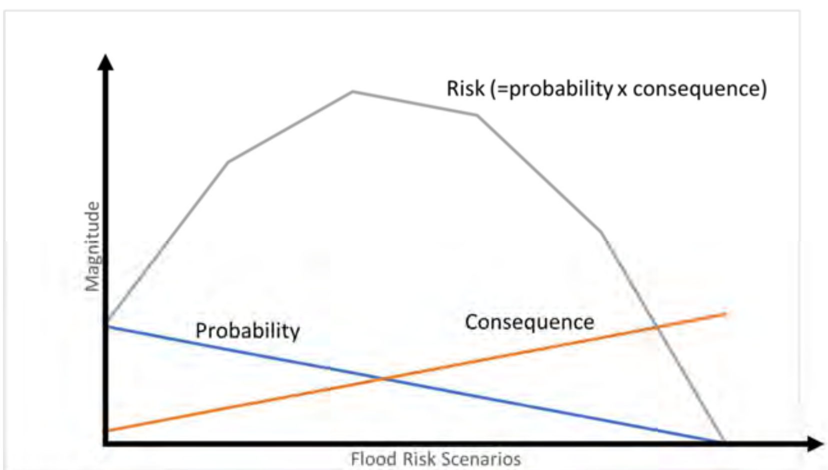
For the avoidance of doubt, Jacobs is satisfied that the hydrology[4] on which its hydraulic model is based was, and remains, correct and appropriate. Notwithstanding this, advice relating to climate change continues to evolve. This technical note aims to provide greater clarity to Full Council and the public about the distinction between flood risk and standard of protection, as well as between present-day flood risk and the possible future risks due to the effects of climate change.

Flood Risk

A risk is a potential event which can be characterised by its probability (how likely it is to occur within a specific timeframe) and consequence (the degree of harm inflicted by it). Flood risk is the potential for a specific location to be flooded by a storm of defined magnitude and AEP. Floods of small magnitude can be considered more likely to occur frequently but with lower consequences, whereas floods of greater magnitude as less likely to occur frequently but with greater consequences. Flood risk can also vary with time due to changes in climate and land use (McBain, 2014). Where multiple higher probability, low consequence flood events occur in a town, the cumulative impact of these can still have a significant impact on the community. This applies particularly to members of the community who are more vulnerable or less resilient to the effects of flooding.

In a sense, communities like Musselburgh can be considered at risk from an infinite combination of flood risk scenarios along a sliding scale (

Figure 1). Risk is measured as the product of probability and consequence. A flood event with high probability and low consequence can therefore have the same level of risk as an event with low probability and high consequence (Mocket and Simm, 2002). Protecting against the higher consequence event will also protect against the lower consequence event with the same level of risk, whereas only protecting against the lower consequence event will not provide any protection against the high consequence event.



[4] Hydrology is the scientific study of the river flows, rainfall, and sea levels which together form the input data for the hydraulic model. The model, meanwhile, is a computer representation of the physical geography of Musselburgh. It includes the shape of the river channel and the floodplain on which the town is built, together with information about surface roughness and other parameters. The hydrology is then 'run' through the model under different scenarios to determine how far the floodwater would spread and how deep it would be.

Figure 1: Sliding scale of flood risk

Musselburgh has multiple sources of flood risk: fluvial (from watercourses such as the River Esk and the Pinkie Burn), pluvial (surface water resulting from rainfall), coastal (high tide levels and wave overtopping), and groundwater. A river gauging station on the River Esk has recorded water levels since the 1960's. This is owned and operated by the Scottish Environment Protection Agency (SEPA). The water level remains predominantly within a certain range, and occasionally extreme water levels, either high or low, can occur in response to rainfall or drought. The resulting dataset can therefore be used to calculate the probability of a specific water level being exceeded during any given year, based on how frequently it has occurred in the past. That relationship between water level and probability can also be extrapolated beyond the time period of the dataset to estimate the probability of extreme events which have never been recorded.

Musselburgh has experienced flooding in the past, with the largest recorded fluvial event occurring in August 1948 (see Figure 2) – the so-called Muckle Flood which devasted parts of south-eastern Scotland and north-east England. That flood was approximately a 0.5% AEP event, and indications of the water depths and flooded areas from that event were used to validate Jacobs' hydraulic model for the Scheme. Furthermore, Jacobs' hydraulic model uses SEPA's historical dataset from the River Esk gauging station as the basis of the fluvial flooding scenarios. In general, the onset of fluvial flooding begins between the 20% and10% AEP events, with out of bank flooding first occurring at the Eskmills Industrial Estate.

Figure 2: Flooding on New Street, looking towards Fisherrow (1948)

A tidal gauging station is also located within Musselburgh which has recorded tidal levels since approximately 2006. Musselburgh has experienced coastal flooding in recent years, albeit on a smaller scale than the 1948 fluvial flood event. A high tide coinciding with a storm surge can cause flooding to originate on the tidal stretch of the River Esk, on its west bank near Loretto Newfield. At present, flood events of low magnitude at this location can be contained by deploying ELC's temporary defences (see Figure 3). Without temporary defences in place, the event of December 2013 (equivalent to a 4% AEP event) could have resulted in flooding across Loretto Newfield and towards Mountjoy Terrace as shown in Figure 4.

Figure 3: High tide plus storm surge flooding at Loretto Newfield, contained by ELC temporary defences (December 2013)

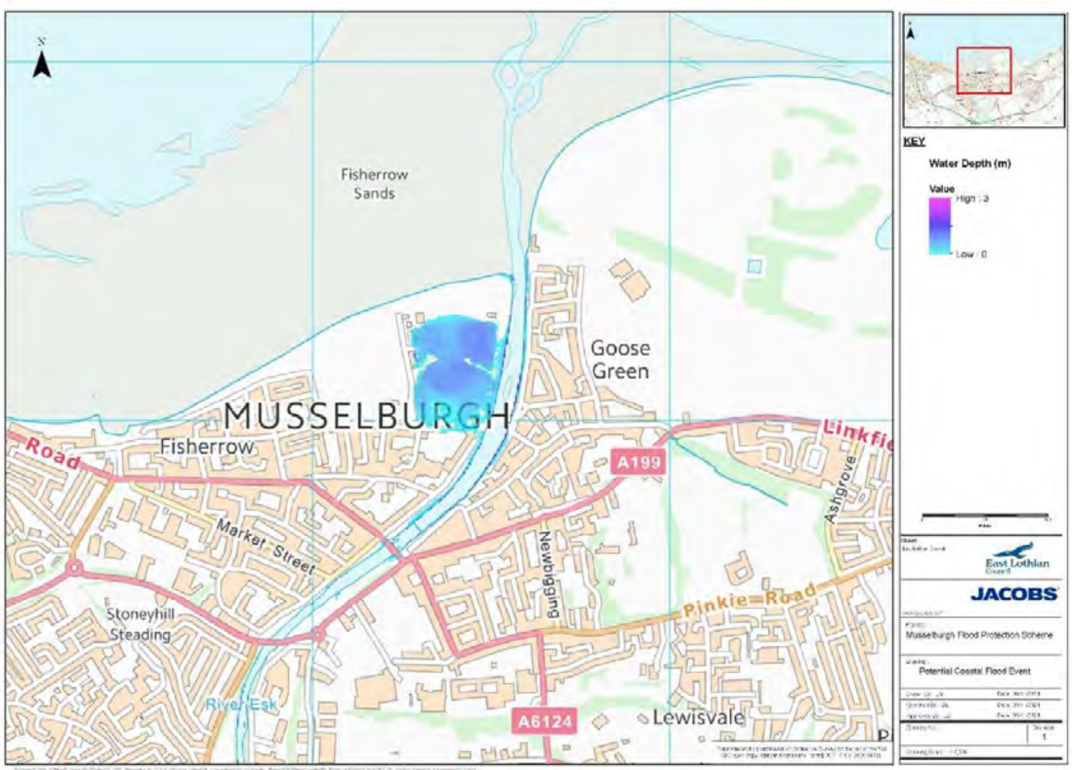


Figure 4: Potential flooded area of December 2013 flood event if temporary defences had not been deployed

Standard of Protection

Flood risk management involves assessing flood risk and providing flood risk reduction measures in response. Examples of flood risk reduction measures include constructing flood storage reservoirs, flood barriers, and surface water pumping stations. The Standard of Protection of a flood risk reduction measure can be thought of as the most extreme flooding scenario that it is designed to protect against. This means that those measures will protect against floods of smaller magnitude, but that they will be overwhelmed if a flood occurs which is greater than they were designed for. ELC has established a scheme objective for the Scheme to provide a standard of protection equivalent to the 0.5%AEP flood event (plus an allowance for climate change).

Flood events which are greater than a flood risk reduction measure is designed to protect against are known as exceedance events. The risk associated with these exceedance events is known as the residual flood risk and it is important to understand that Musselburgh will always have some degree of residual flood risk as it is built on the River Esk and coastal flood plains. The purpose of a flood protection scheme is to reduce the residual flood risk to a broadly acceptable level. Mockett and Simm (2002) noted that the resources required to reduce the risk beyond this level are "*grossly disproportionate to the [additional] risk reduction achieved*".

The standard of protection to be provided by this Scheme can only be selected once the level of flood risk is accepted.

Current Guidance on Climate Change

Musselburgh has a present-day risk of flooding, and climate change would have the effect of increasing that risk. This is because a rise in global atmospheric temperature would lead to a rise in sea level (primarily due to melting polar ice and thermal expansion of the oceans), and an increase in river flows (primarily due to greater rainfall intensity because of the capacity of a warmer atmosphere to hold more water vapour). All these factors would increase flood risk to Musselburgh. This increase in flood risk means that a flood of a given magnitude would become more likely to occur in the future than it would today. It also means that a flood with a specific likelihood would have greater magnitude in future than it would today. There are many different scientific predictions of how much the global temperature will increase by over the next century, all of which are based on the assumed amount of carbon emitted globally each year.

These predictions are known as climate change scenarios, which in the UK are defined as Representative Concentration Pathways (RCP). These are defined within the United Kingdom Climate Projections 2018 (UKCP18), (MET Office, 2018). The RCP scenarios include a wide range of assumptions regarding population growth, economic development, technological innovation and attitudes to social and environmental sustainability. The different RCP scenarios and the corresponding increase in global mean temperature over the 21st century is shown in Table 1.

Table 1: Increase in global mean surface temperature compared to pre-industrial period

RCP	Change in temperature (°C) by 2081-2100
RCP2.6	1.6
RCP4.5	2.4
RCP6.0	2.8
RCP8.5	4.3

Whereas probability, based on SEPA's historic water level data, can be associated with Musselburgh's flood risk in the present day, the same is not true for the effects of climate change. This is because the effects of climate change may be influenced by the actions of the global community in the future. The Paris

Agreement[5] aimed to limit global warming to well below 2, preferably 1.5 degrees Celsius compared to pre-industrial levels. If agreements such as this are successful, then the effects of climate change in the future may be less extreme or may to take longer to occur. Unfortunately, the intended nationally determined contributions of the Paris Agreement's signatories suggests, "that we are currently on a higher emissions pathway than 2°C" (SEPA, 2022). Jacobs has no view as to the probability or timescale of any emissions scenario occurring, and therefore any allowance included within the Scheme for the effects of climate change is considered separate and distinct from its standard of protection.

In May 2022, SEPA published *Climate change allowances for flood risk assessment in land use planning - Version 2,* (SEPA, 2022). This superseded version 1 of the guidance (SEPA, 2019). SEPA (2022) sets out recommended allowances for climate change that can be used for flood risk assessment. It is intended for use by developers and planning authorities, to assist them in making appropriate land use planning decisions.

The allowances use RCP8.5. This is the emissions scenario used in the Intergovernmental Panel on Climate Change's (IPCC) 5th Assessment report (IPCC, 2014). For RCP8.5 the best estimate global average temperature rise is 4.3°C above pre-industrial levels by 2100. Global temperature rise is currently on the trajectory of this scenario, and without further international intervention to mitigate climate change, this could be considered a reasonable outcome.

The SEPA (2022) allowances can be used to increase the values of peak river flow, peak rainfall intensity and sea level rise used in the assessment of flood risk for a given location. For Musselburgh, which lies within the Forth river basin, a 56% increase in peak river flow and a 39% increase in peak rainfall intensity to the year 2100 are recommended. A 0.86m cumulative sea level rise from 2017 to 2100 is also recommended.

During a meeting between the project team and SEPA in July 2022, SEPA acknowledged that these allowances, "use a fairly precautionary scenario," [RCP8.5] which is, "probably not appropriate for economic appraisal of flood schemes as it is likely to increase costs and may overestimate future benefits." The precautionary allowance, however, provides adequate an unambiguous guidance to property developers who may have less expertise in flood risk assessment. The technical background paper to SEPA (2022) also states that,

> *"Potential flood risk management measures are… likely to require assessment against a number of different future scenarios and timescales including a credible worst case – so although use of the same climate change projections… is also recommended for flood schemes, it is not recommended that flood protection measures are solely tested against a single climate change allowance."*

Furthermore, it states that,

> *"The adaptability of measures should be tested against a range of emissions scenarios, probability levels and timeframes, including a reasonable worst case."*

Consequently, these allowances stated are considered by Jacobs to represent a 'credible worst case' for Musselburgh.

Evolution of the Scheme's Flood Model

Jacobs' hydraulic model has evolved since it was first created. This has been done to incorporate new data, comply with changes in guidance, and acknowledge feedback from the public. As a result, the associated flood risk maps have changed over time.

The assessment of flood risk in Musselburgh commenced during Stage 3 of the project, with the production of 'Model A' in 2018. This was replaced in 2020 by Model B to incorporate new gauge data from SEPA, revised climate change guidance, and improved catchment schematisation. In 2022 this was replaced by Model C, the current and most up-to-date flood model for Musselburgh. This latest revision incorporated further changes to climate change guidance, improved coastal survey data, and improved schematisation to better reflect coastal flooding mechanisms.

[5] The Paris Agreement is a legally binding international treaty on climate change, which was adopted by 196 parties at COP 21 in December 2015.

Models A and B considered flood risk as far ahead as the 2125 epoch. This was done to align the allowance for climate change with a 100-year design life for the Scheme. The design life is the length of the time that any flood defence structure is designed to last before having to be replaced. A 100-year life is an industry standard for structures of this nature.

In contrast, Model C only considers flood risk as far as the 2100 epoch. This was done in recognition of public feedback about greater uncertainty associated with climate change projections into the next century. The 2100 epoch also aligns with SEPA's latest climate change guidance. Whilst considering an earlier epoch had the effect of reducing the apparent coastal flood risk to Musselburgh, this was more than offset by increases to the uplifts for peak fluvial flow and peak rainfall intensity contained in the latest climate change guidance. As a result, the blended flood risk maps shown in the later sections of this technical note indicate an overall increase in flood risk to Musselburgh compared to those previously published, which were based on Model B.

Present-day Flood Risk

The flood risk maps in this section represent the latest results from Jacobs' hydraulic model utilising baseline conditions for the present-day scenario. Baseline refers to the flooded area which could occur without the Scheme in place. Present day means the flood which could occur now, in the current era, without any allowance for climate change. The flood risk extent has been determined using the most up to date topographical, hydrological and hydraulic modelling information.

Figure 5 represents the area which would be flooded by a flood event on the River Esk, which has a 0.5% probability of occurring in any given year. This event would flood 920 properties[6]. Figure 6 represents the area which would be flooded by a high tide plus storm surge from the Forth estuary, and which has a 0.5% probability of occurring in any given year. This event would flood 115 properties through tidal inundation along the Esk and wave overtopping along the coast. Figure 7 represents the area which would be flooded by a flood event on the Pinkie Burn, which has a 0.5% probability of occurring in any given year. This event would flood one property. Figure 8 represents the blended flood envelope of the three aforementioned events. This identifies that 923 properties in Musselburgh are currently at risk from a 0.5% AEP flood event on either the River Esk, Forth Estuary or Pinkie Burn. The blended map does not represent all three scenarios happening simultaneously, as the probability of that occurring is infinitesimally small.

[6] Throughout this document, the number of properties affected in each flooding scenario were derived from the number of Basic Land and Property Units (BLPUs) located within the flood extent for that scenario. These property numbers were provided to Jacobs by ELC and are accepted *prima facie*.

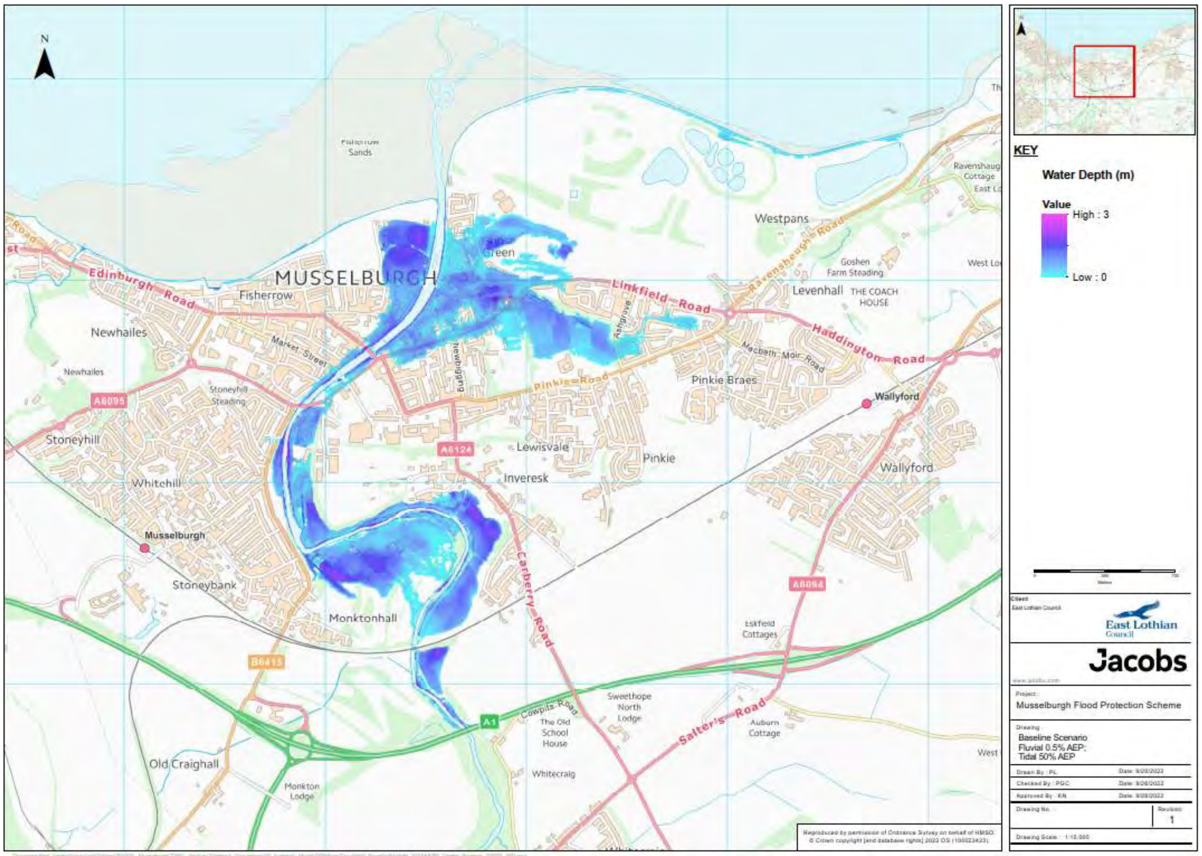


Figure 5: 0.5% AEP fluvial event (River Esk) plus 50% AEP coastal event

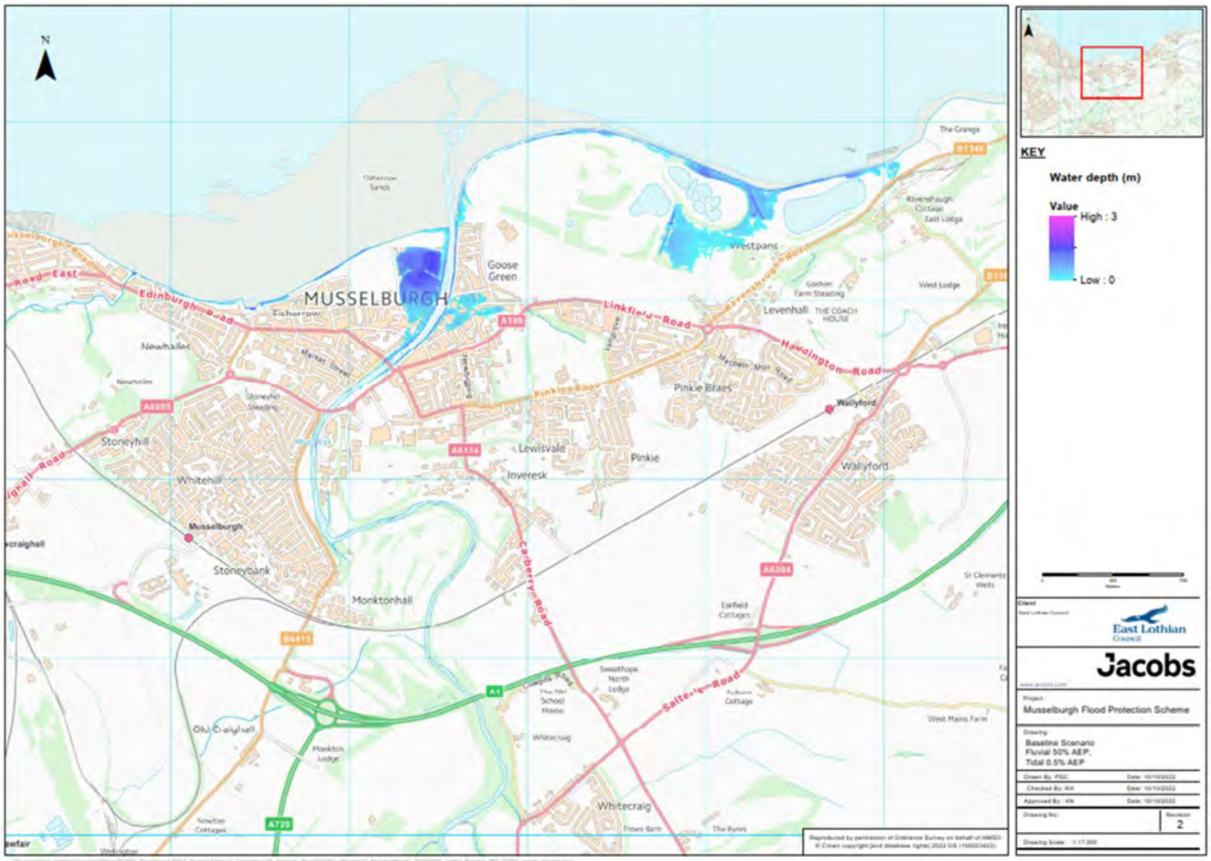


Figure 6: 0.5% AEP coastal event plus 50% AEP fluvial event (River Esk)

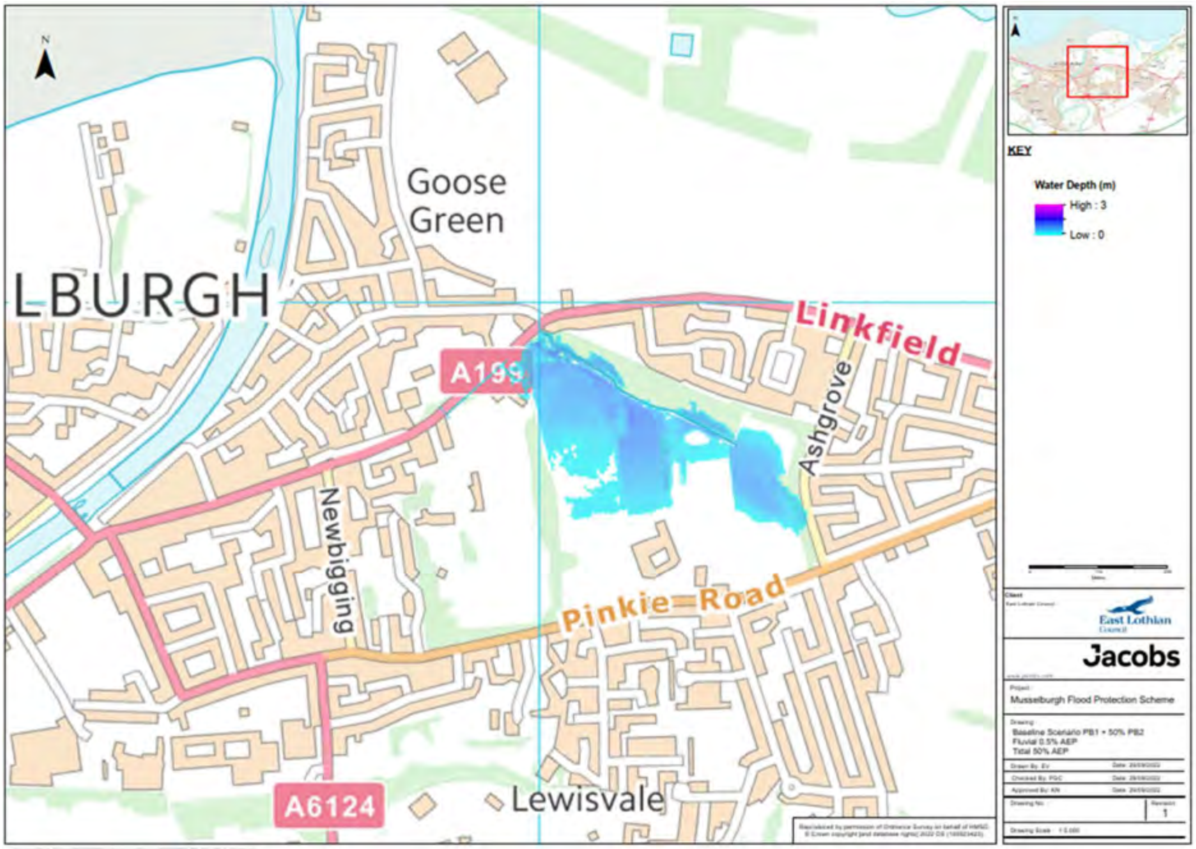


Figure 7: 0.5% AEP fluvial event (Pinkie Burn) plus 50% AEP coastal event

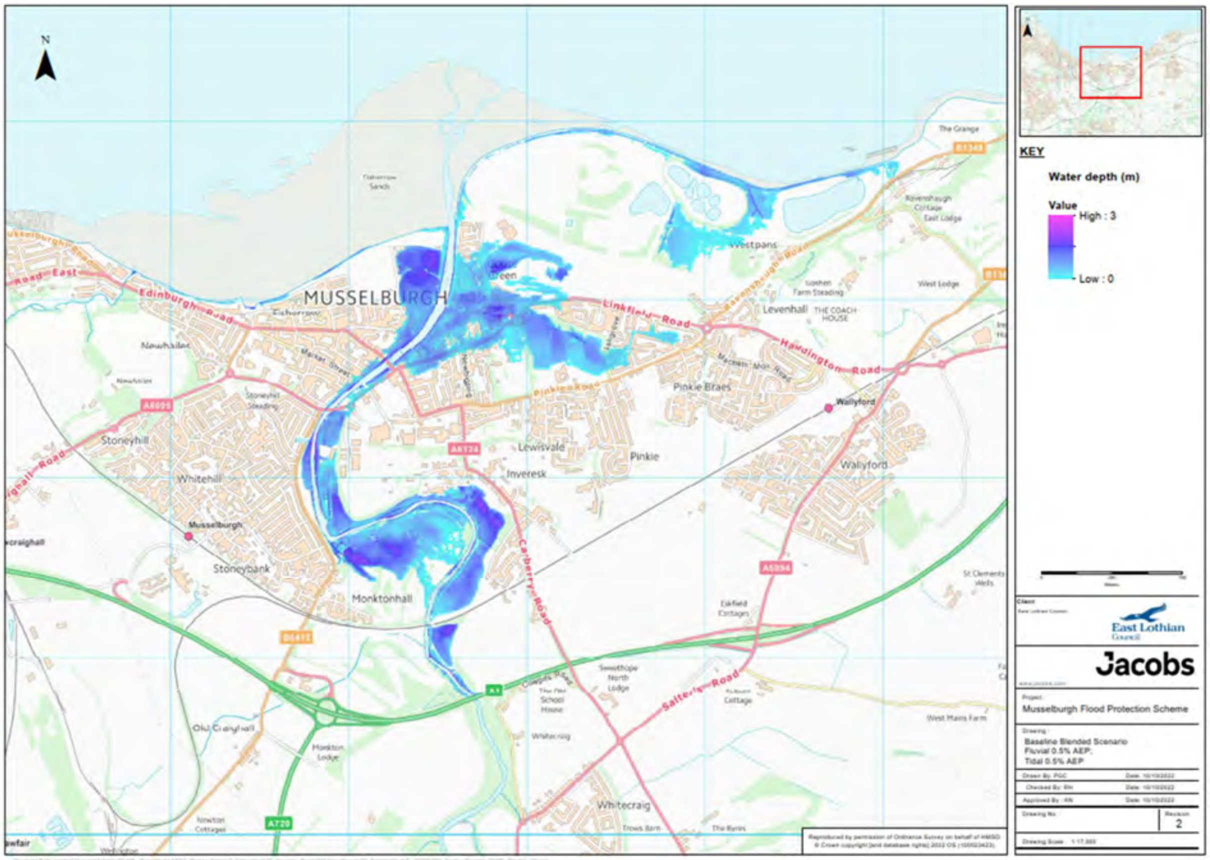


Figure 8: 0.5% AEP blended flood risk

For the purposes of hydraulic modelling, it was necessary to select a nominal probability for the secondary flood component. For example, during a 0.5% AEP flood event on the River Esk, the river would discharge into the Forth Estuary, and its ability to discharge would depend upon the Forth's tidal cycle. It was considered appropriate to use a 50% AEP, or 1 in 2-year tidal cycle for this purpose. Doing so limits the influence of the secondary flood component while continuing to simulate the effect of the tidal cycle on the river's discharge. Conversely, for a 0.5% AEP coastal flood event, a 50% AEP, or 1 in 2-year flow on the River Esk was selected as the secondary component. The process of including a secondary flood component should not be considered equivalent to a joint probability analysis, which was not deemed necessary to understand the flood risk due to the primary flood component.

The same approach was taken for the Pinkie Burn hydraulic model, although the effect of the tidal cycle on this system is slightly different. This watercourse is culverted along most of its length, and discharges through an outfall within the tidal stretch of the River Esk near Goosegreen weir. When the tide rises above the level of the outfall, it prevents the Pinkie from discharging and the flow backs up within the culvert. The water is then released when the tide recedes. This mechanism contrasts with the River Esk, which continues to discharge into the estuary even at high tide.

Credible worst-case flood risk

The flood risk maps in this section represent the latest results from Jacobs' hydraulic model utilising baseline conditions for a credible worst-case scenario for Climate Change (CC). As stated earlier in this document, the credible worst-case scenario for Musselburgh is considered to be RCP8.5 for the 2100 epoch. This means that the following uplifts have been applied relative to the present-day 0.5% AEP conditions:

- 56% uplift in peak fluvial flow on the River Esk

- 39% uplift in peak rainfall intensity on the Pinkie Burn catchment
- 0.86m sea level rise in the Forth Estuary

Figure 9 represents the area which would be flooded by a flood event on the River Esk, which would have a 0.5% probability of occurring in any given year by 2100 in the event of this climate change scenario. This event would flood 2906 properties. Figure 10 represents the area which would be flooded by a high tide plus storm surge from the Forth estuary, and which would have a 0.5% probability of occurring in any given year by 2100 in the event of this climate change scenario. This event would flood 1894 properties through tidal inundation along the Esk and wave overtopping along the coast. Figure 11 represents the area which would be flooded by a flood event on the Pinkie Burn, which would have a 0.5% probability of occurring in any given year by 2100 in the event of this climate change scenario. This event would flood 157 properties. Figure 12 represents the blended flood envelope of the three aforementioned events. This identifies that 2962 properties in Musselburgh would be at risk from a 0.5% AEP flood event by 2100 in the event of this climate change scenario. The blended map does not represent all three scenarios happening simultaneously, as the probability of that occurring is infinitesimally small.

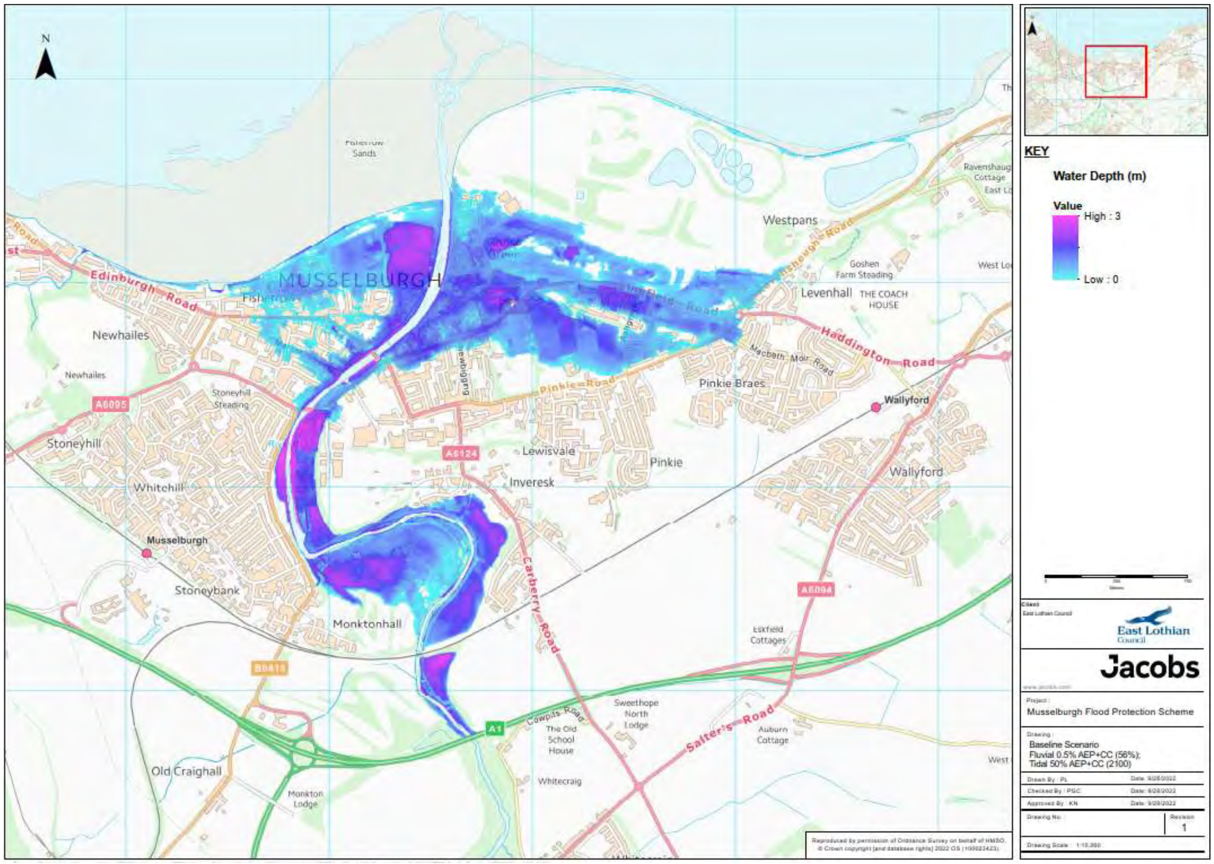


Figure 9: 0.5% AEP+CC fluvial event (River Esk) plus 50% AEP+CC coastal event

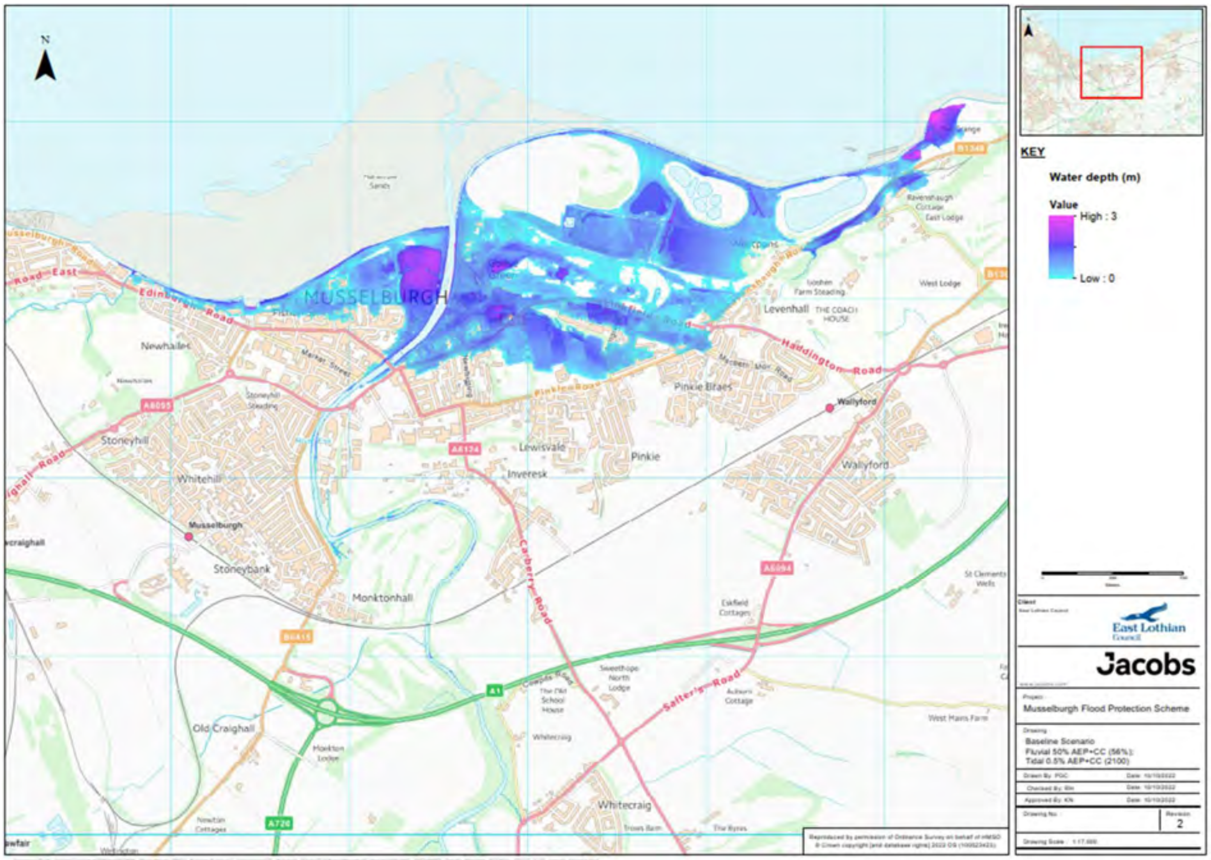


Figure 10: 0.5% AEP+CC coastal event plus 50% AEP+CC fluvial event (River Esk)

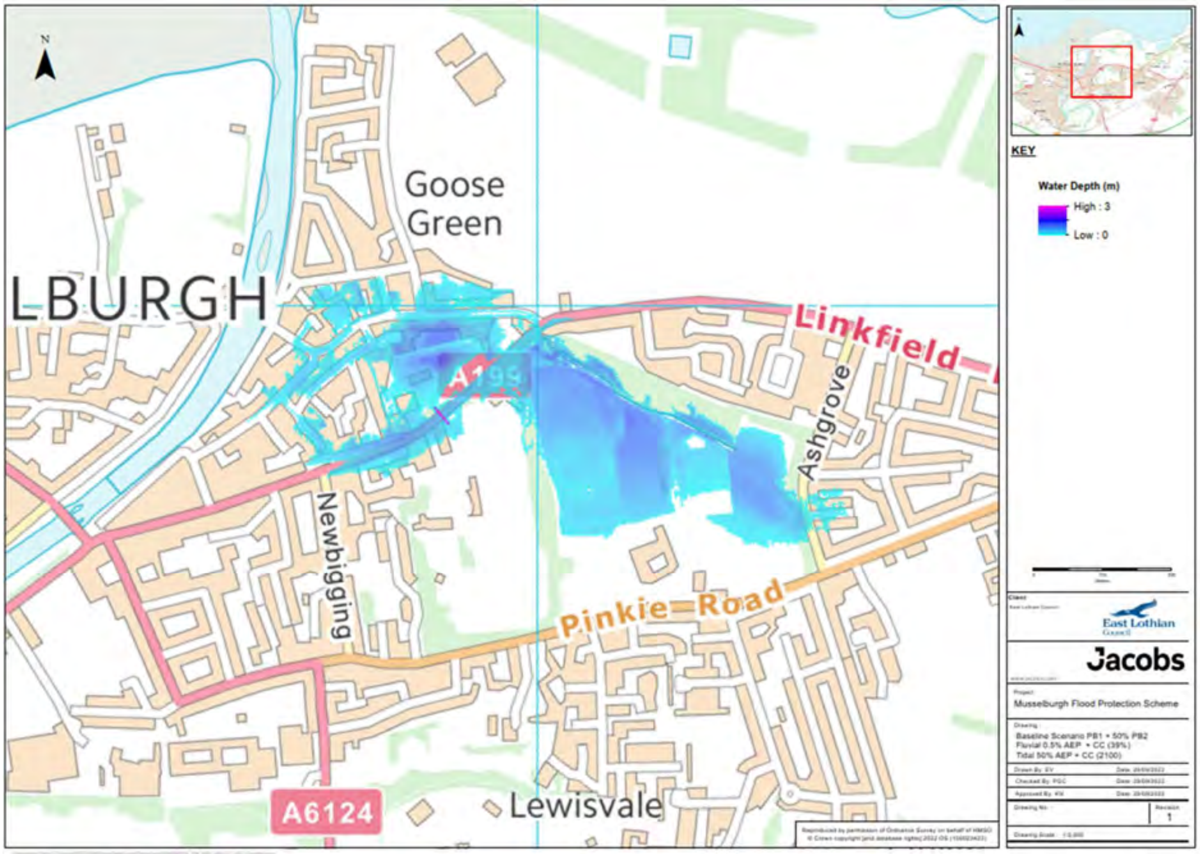


Figure 11: 0.5% AEP+CC fluvial event (Pinkie Burn) plus 50% AEP+CC coastal event

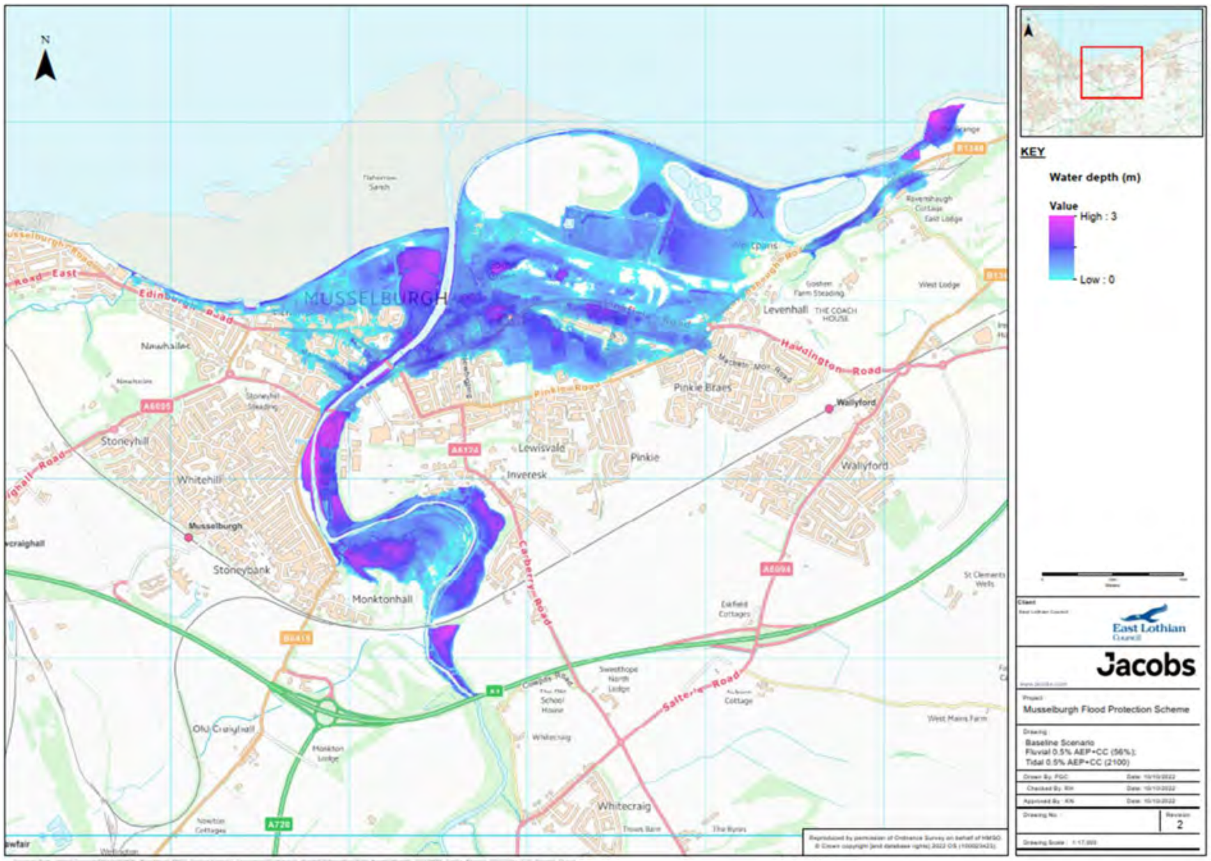


Figure 12: 0.5% AEP+CC blended flood risk

Recommendations

It is recommended that ELC accepts the above flood risk maps as a true reflection of Musselburgh's current flood risk and a credible worst-case flood risk by the year 2100 from the 0.5% AEP events of fluvial and coastal origin.

It is further recommended that work is immediately undertaken by the project team in consultation with the Project Board, statutory stakeholders, and the public to determine an appropriate level for the physical defences in Musselburgh. This is with the understanding that, as a minimum, the level of those defences should be equivalent to a present-day 0.5% AEP standard of protection, as defined in the original project objectives.

In accordance with SEPA's advice relating to climate change, it is recommended that an assessment is carried out to determine what would be required in addition to the Scheme's standard of protection to protect against a range of different emissions scenarios and timescales. Doing so will inform the selection of the Scheme's allowance for climate change and its strategy for future flexibility as part of a managed adaptive approach. This approach could involve protecting against a shorter-term climate change scenario than 2100, and by doing so, give ELC the opportunity at a point in the future to assess what to do next.

References

IPCC (2014). 'Fifth Assessment Report of the Intergovernmental Panel on Climate Change'. Available at www.ipcc.ch (accessed on 04/08/22).

McBain, W. (2012) 'Twenty-first century flood risk management', in Sayers, P.B. (ed) *Floor Risk: Planning, design and management of flood defence infrastructure*. London: ICE Publishing, pp7-20.

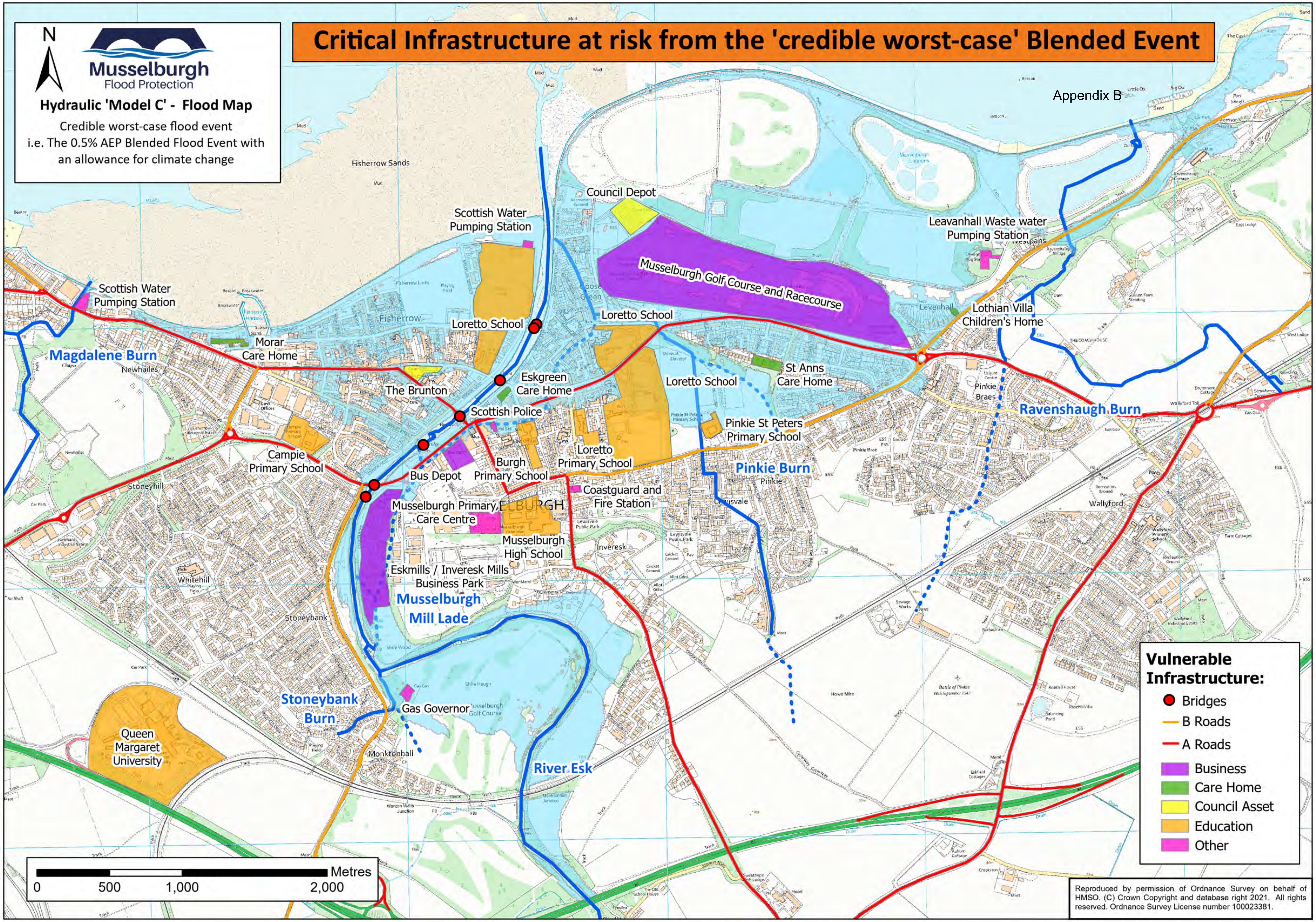
MET Office (2018) 'UK Climate Projections (UKCP)'. Available at www.metoffice.gov.uk/research/approach/collaboration/ukcp (accessed on 15/07/22).

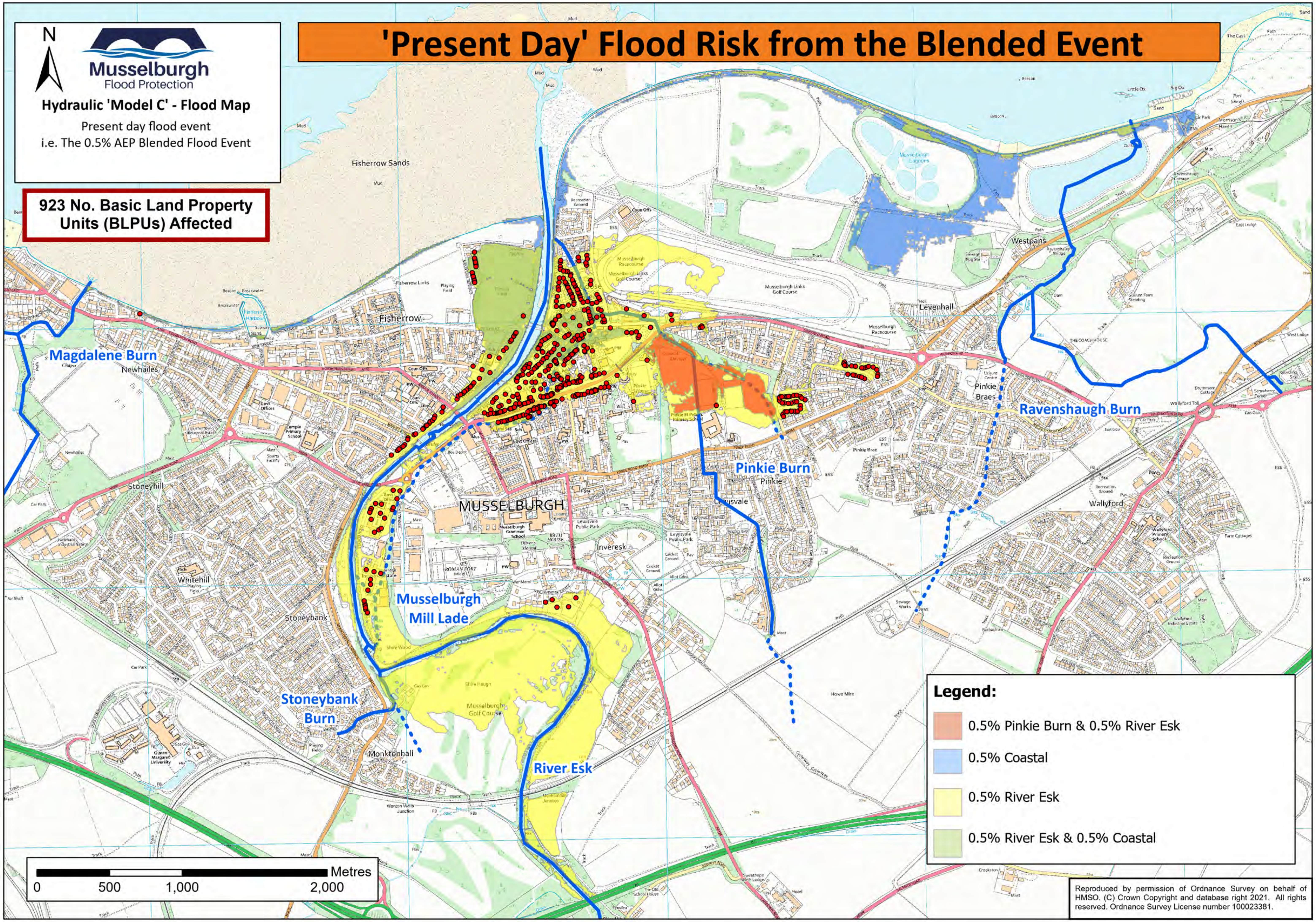
Mockett, I.D. and Simm, J.D. (2002) 'Risk levels in coastal and river engineering: a guidance framework for design'. London: Thomas Telford Publishing.

SEPA (2019) 'Climate change allowances for flood risk assessment in land use planning'. Available at www.sepa.org.uk (accessed on 28/06/22).

SEPA (2022) 'Climate change allowances for flood risk assessment in land use planning - Version 2'. Available at www.sepa.org.uk (accessed on 21/07/22).

Appendix B


Critical Infrastructure at risk from the 'credible worst-case' Blended Event
Musselburgh Flood Protection
Hydraulic 'Model C' - Flood Map
Credible worst-case flood event
i.e. The 0.5% AEP Blended Flood Event with an allowance for climate change
N
Fisherrow Sands
Scottish Water Pumping Station
Council Depot
Scottish Water Pumping Station
Leavanhall Waste water Pumping Station
Musselburgh Golf Course and Racecourse
Loretto School
Loretto School
Lothian Villa Children's Home
Morar Care Home
Magdalene Burn
Eskgreen Care Home
St Anns Care Home
The Brunton
Loretto School
Scottish Police
Ravenshaugh Burn
Pinkie St Peters Primary School
Campie Primary School
Burgh Primary School
Loretto Primary School
Bus Depot
Pinkie Burn
Coastguard and Fire Station
Musselburgh Primary Care Centre
Musselburgh High School
Eskmills / Inveresk Mills Business Park
Musselburgh Mill Lade
Stoneybank Burn
Gas Governor
Queen Margaret University
River Esk
Vulnerable Infrastructure:
Bridges
B Roads
A Roads
Business
Care Home
Council Asset
Education
Other
Metres
0
500
1,000
2,000


'Present Day' Flood Risk from the Blended Event
N
Musselburgh
Flood Protection
Hydraulic 'Model C' - Flood Map
Present day flood event
i.e. The 0.5% AEP Blended Flood Event
923 No. Basic Land Property Units (BLPUs) Affected
Magdalene Burn
Musselburgh Mill Lade
Stoneybank Burn
River Esk
Pinkie Burn
Ravenshaugh Burn
MUSSELBURGH
Fisherrow
Fisherrow Sands
Newhailes
Stoneyhill
Whitehill
Stoneybank
Monktonhall
Inveresk
Pinkie
Pinkie Braes
Levenhall
Westpans
Wallyford
Legend:
0.5% Pinkie Burn & 0.5% River Esk
0.5% Coastal
0.5% River Esk
0.5% River Esk & 0.5% Coastal
Metres
0
500
1,000
2,000
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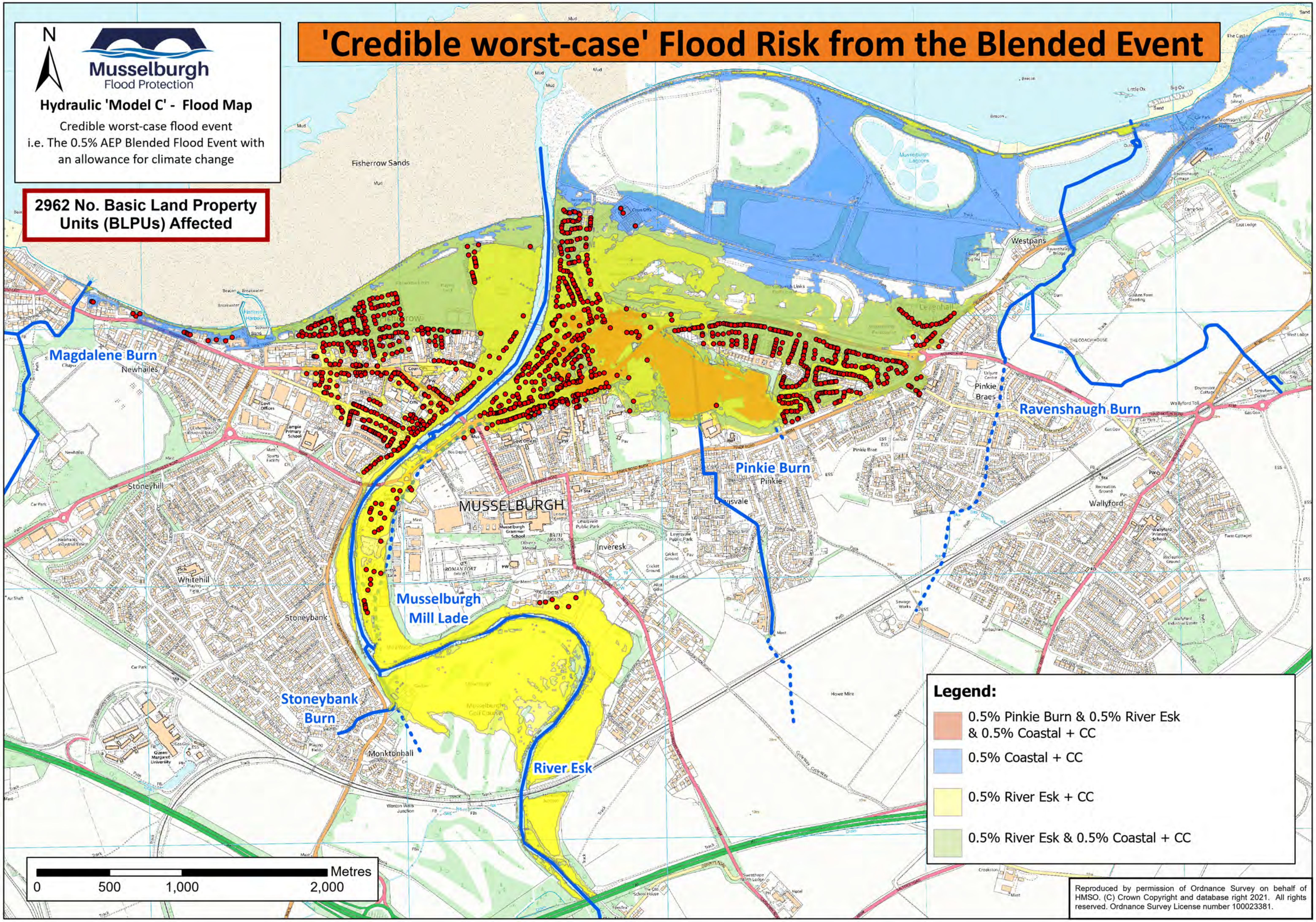

'Credible worst-case' Flood Risk from the Blended Event
N
Musselburgh Flood Protection
Hydraulic 'Model C' - Flood Map
Credible worst-case flood event
i.e. The 0.5% AEP Blended Flood Event with an allowance for climate change
2962 No. Basic Land Property Units (BLPUs) Affected
Fisherrow Sands
Magdalene Burn
Newhailes
Stoneyhill
Whitehill
Stoneybank
Stoneybank Burn
Monktonhall
MUSSELBURGH
Musselburgh Mill Lade
River Esk
Inveresk
Pinkie Burn
Pinkie
Lewisvale
Pinkie Braes
Ravenshaugh Burn
Wallyford
Westpans
Musselburgh Lagoons
Legend:
0.5% Pinkie Burn & 0.5% River Esk & 0.5% Coastal + CC
0.5% Coastal + CC
0.5% River Esk + CC
0.5% River Esk & 0.5% Coastal + CC
Metres
0
500
1,000
2,000
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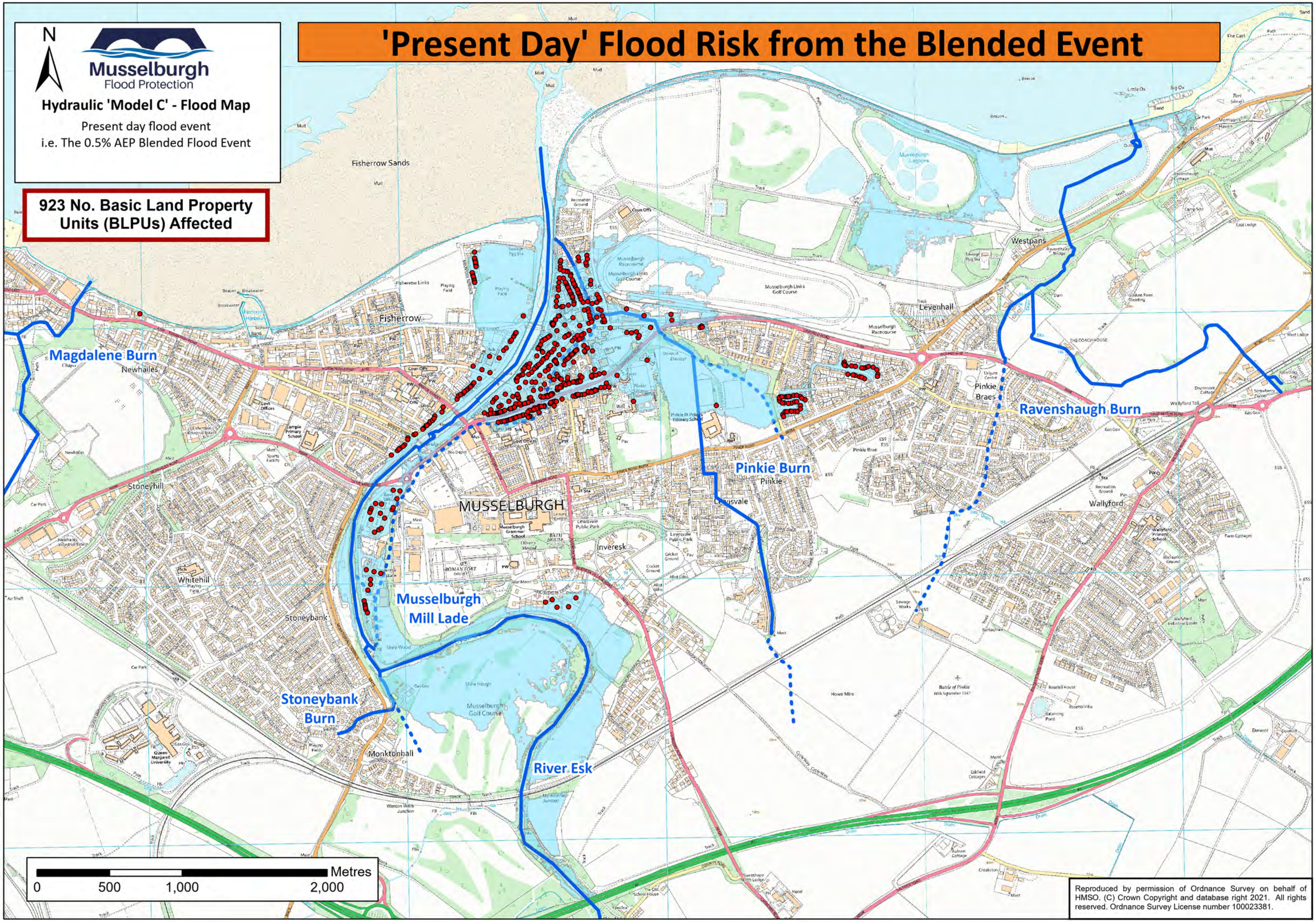
'Present Day' Flood Risk from the Blended Event
N
Musselburgh
Flood Protection
Hydraulic 'Model C' - Flood Map
Present day flood event
i.e. The 0.5% AEP Blended Flood Event
923 No. Basic Land Property Units (BLPUs) Affected
Magdalene Burn
Musselburgh Mill Lade
Stoneybank Burn
River Esk
Pinkie Burn
Ravenshaugh Burn
MUSSELBURGH
Fisherrow
Fisherrow Sands
Newhailes
Stoneyhill
Whitehill
Stoneybank
Monktonhall
Inveresk
Pinkie
Pinkie Braes
Levenhall
Westpans
Wallyford
Metres
0
500
1,000
2,000
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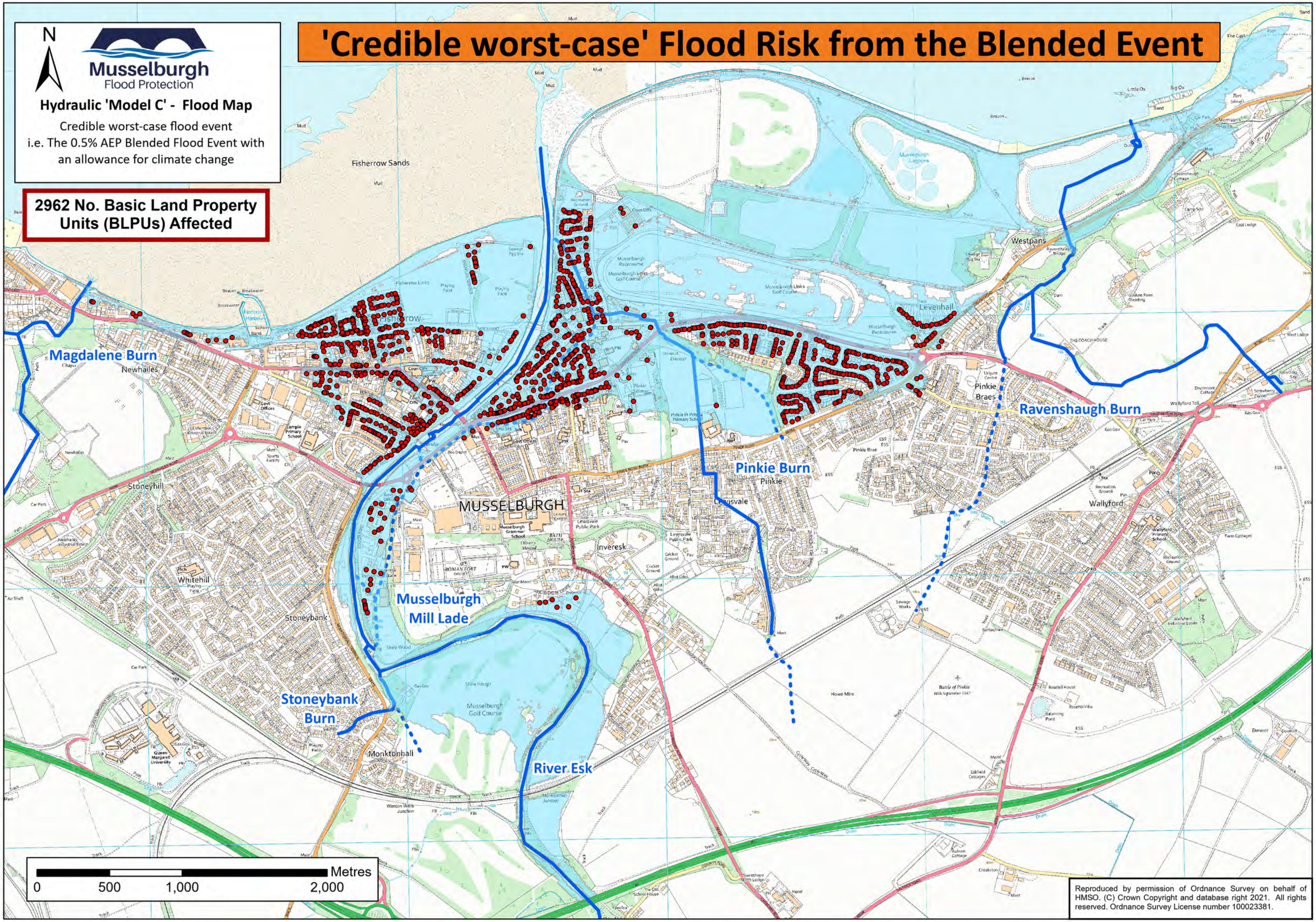
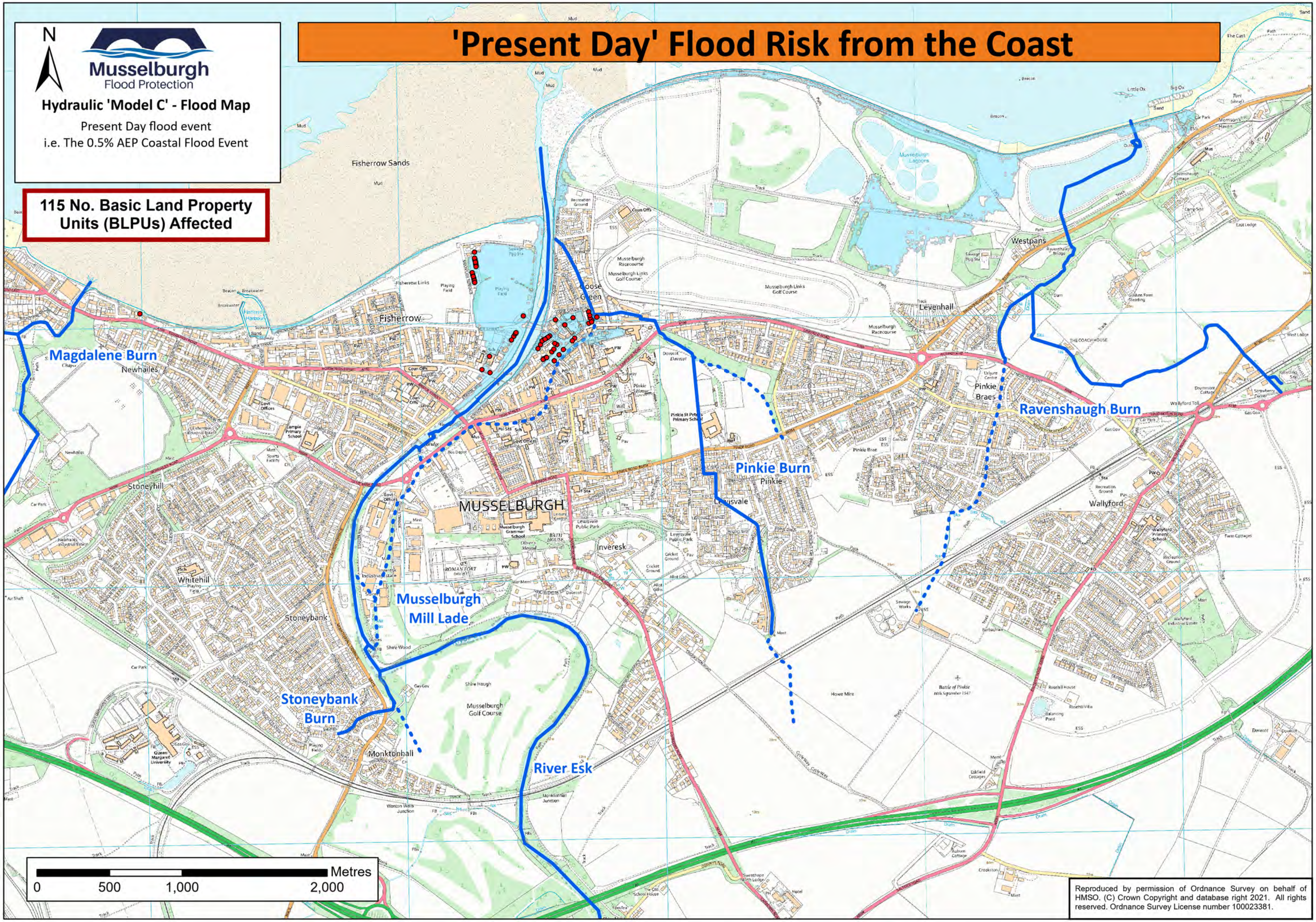
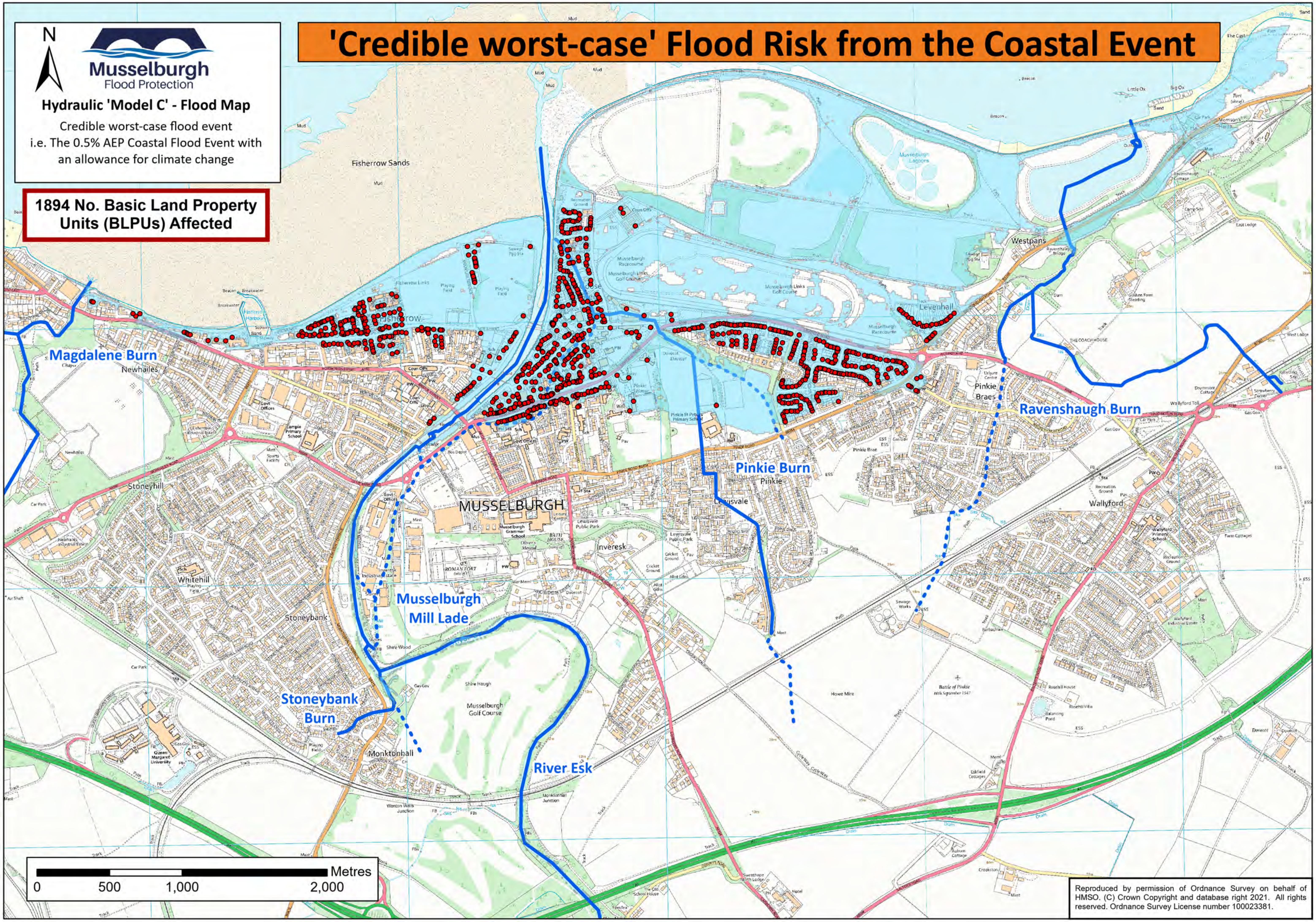
'Credible worst-case' Flood Risk from the Blended Event




'Present Day' Flood Risk from the Coast
N
Musselburgh
Flood Protection
Hydraulic 'Model C' - Flood Map
Present Day flood event
i.e. The 0.5% AEP Coastal Flood Event
115 No. Basic Land Property Units (BLPUs) Affected
Magdalene Burn
Musselburgh Mill Lade
Stoneybank Burn
River Esk
Pinkie Burn
Ravenshaugh Burn
MUSSELBURGH
Fisherrow Sands
Fisherrow
Newhailes
Stoneyhill
Whitehill
Stoneybank
Monktonhall
Inveresk
Pinkie
Pinkie Braes
Levenhall
Westpans
Wallyford
Musselburgh Golf Course
Metres
0
500
1,000
2,000

'Credible worst-case' Flood Risk from the Coastal Event



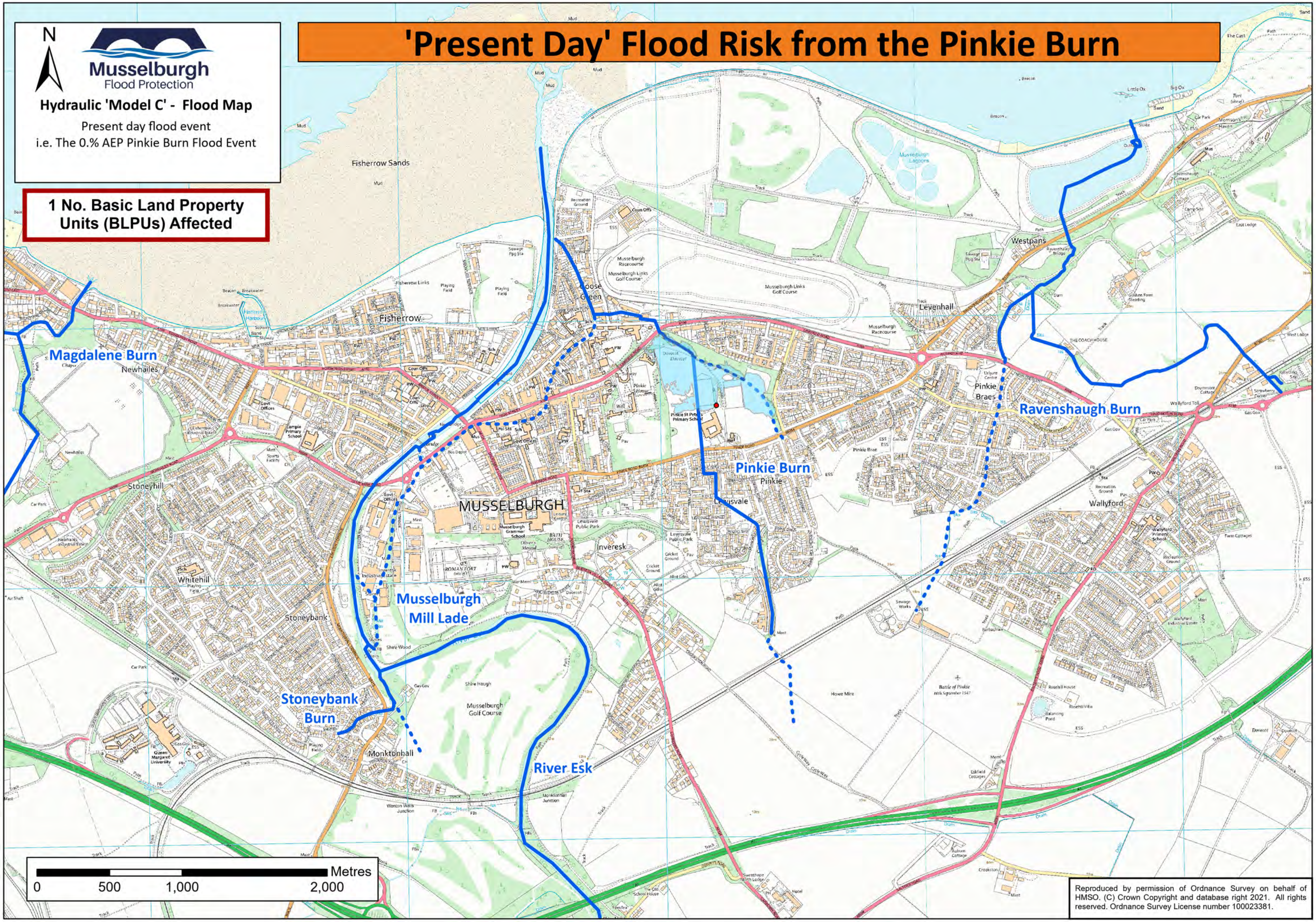
'Present Day' Flood Risk from the Pinkie Burn

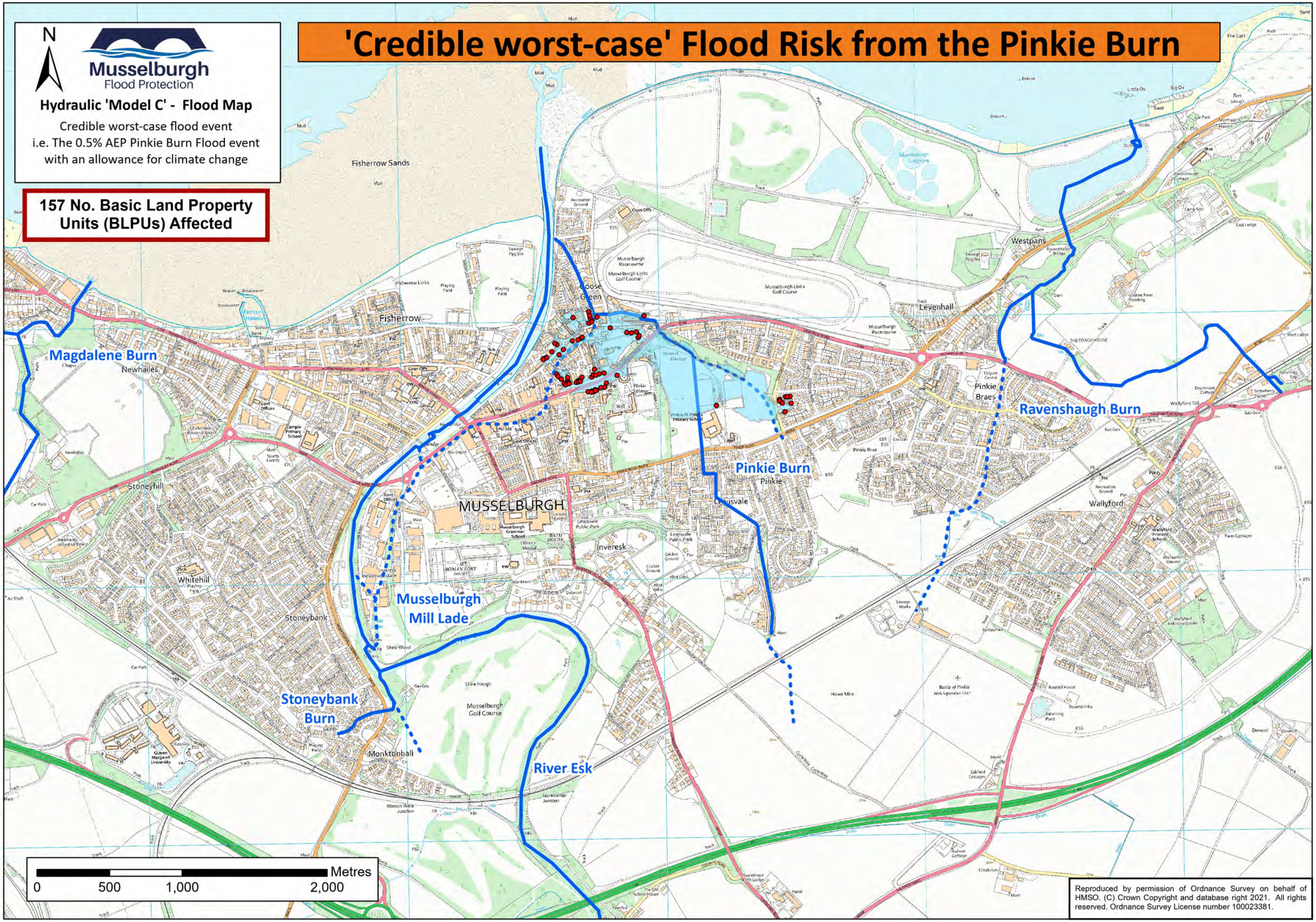
Musselburgh Flood Protection

Hydraulic 'Model C' - Flood Map

Present day flood event
i.e. The 0.% AEP Pinkie Burn Flood Event

1 No. Basic Land Property Units (BLPUs) Affected




'Credible worst-case' Flood Risk from the Pinkie Burn
N
Musselburgh
Flood Protection
Hydraulic 'Model C' - Flood Map
Credible worst-case flood event
i.e. The 0.5% AEP Pinkie Burn Flood event
with an allowance for climate change
157 No. Basic Land Property
Units (BLPUs) Affected
Magdalene Burn
Ravenshaugh Burn
Pinkie Burn
Musselburgh
Mill Lade
Stoneybank
Burn
River Esk
MUSSELBURGH
Fisherrow Sands
Fisherrow
Newhailes
Stoneyhill
Whitehill
Stoneybank
Monktonhall
Inveresk
Levenhall
Westpans
Pinkie Braes
Wallyford
Musselburgh Golf Course
Metres
0
500
1,000
2,000
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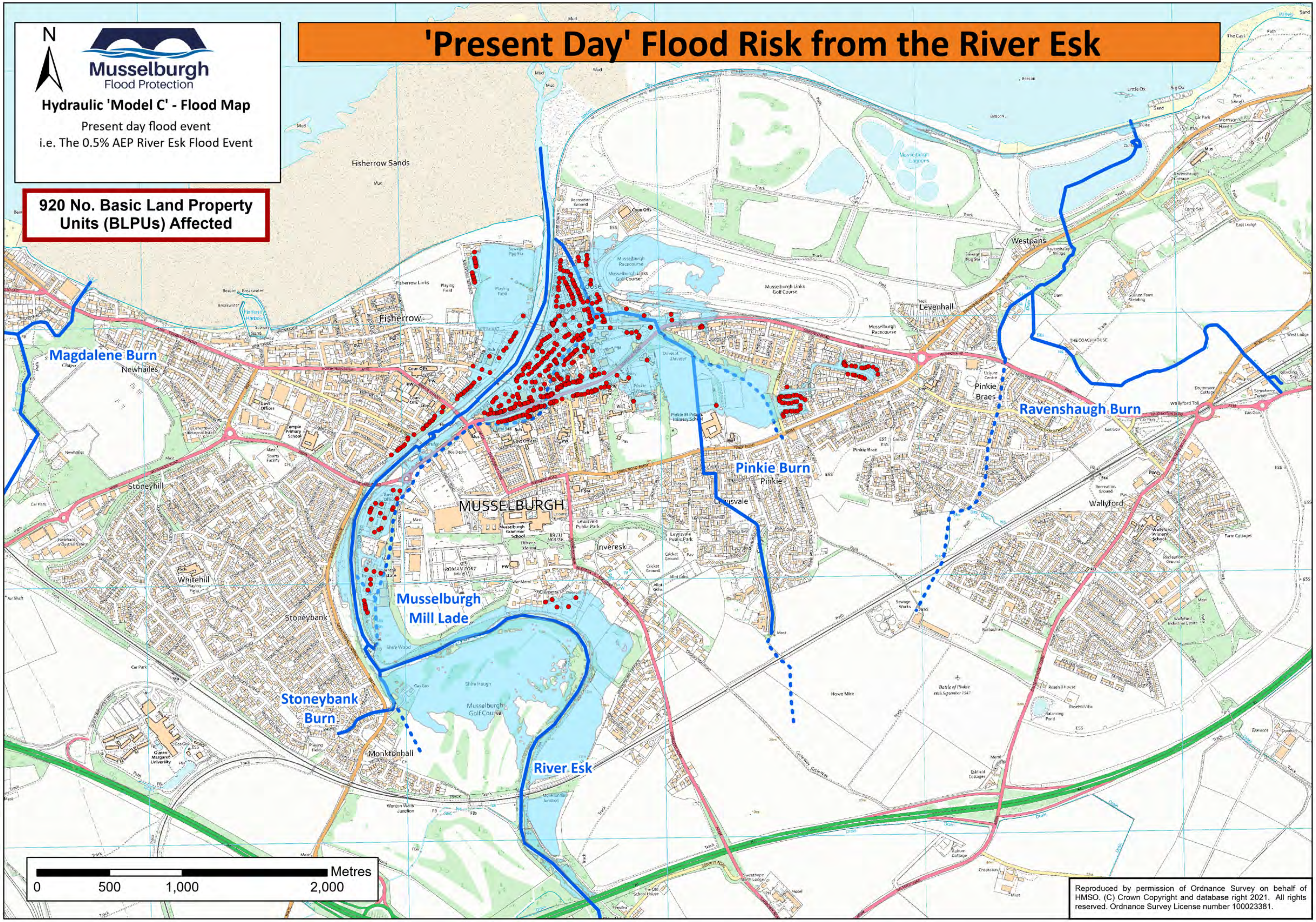
'Present Day' Flood Risk from the River Esk
N
Musselburgh
Flood Protection
Hydraulic 'Model C' - Flood Map
Present day flood event
i.e. The 0.5% AEP River Esk Flood Event
920 No. Basic Land Property Units (BLPUs) Affected
Fisherrow Sands
Fisherrow
Magdalene Burn
Newhailes
Stoneyhill
Whitehill
Stoneybank
Stoneybank Burn
Monktonhall
Musselburgh Mill Lade
MUSSELBURGH
Inveresk
River Esk
Pinkie Burn
Pinkie
Lewisvale
Levenhall
Westpans
Pinkie Braes
Ravenshaugh Burn
Wallyford
Metres
0
500
1,000
2,000
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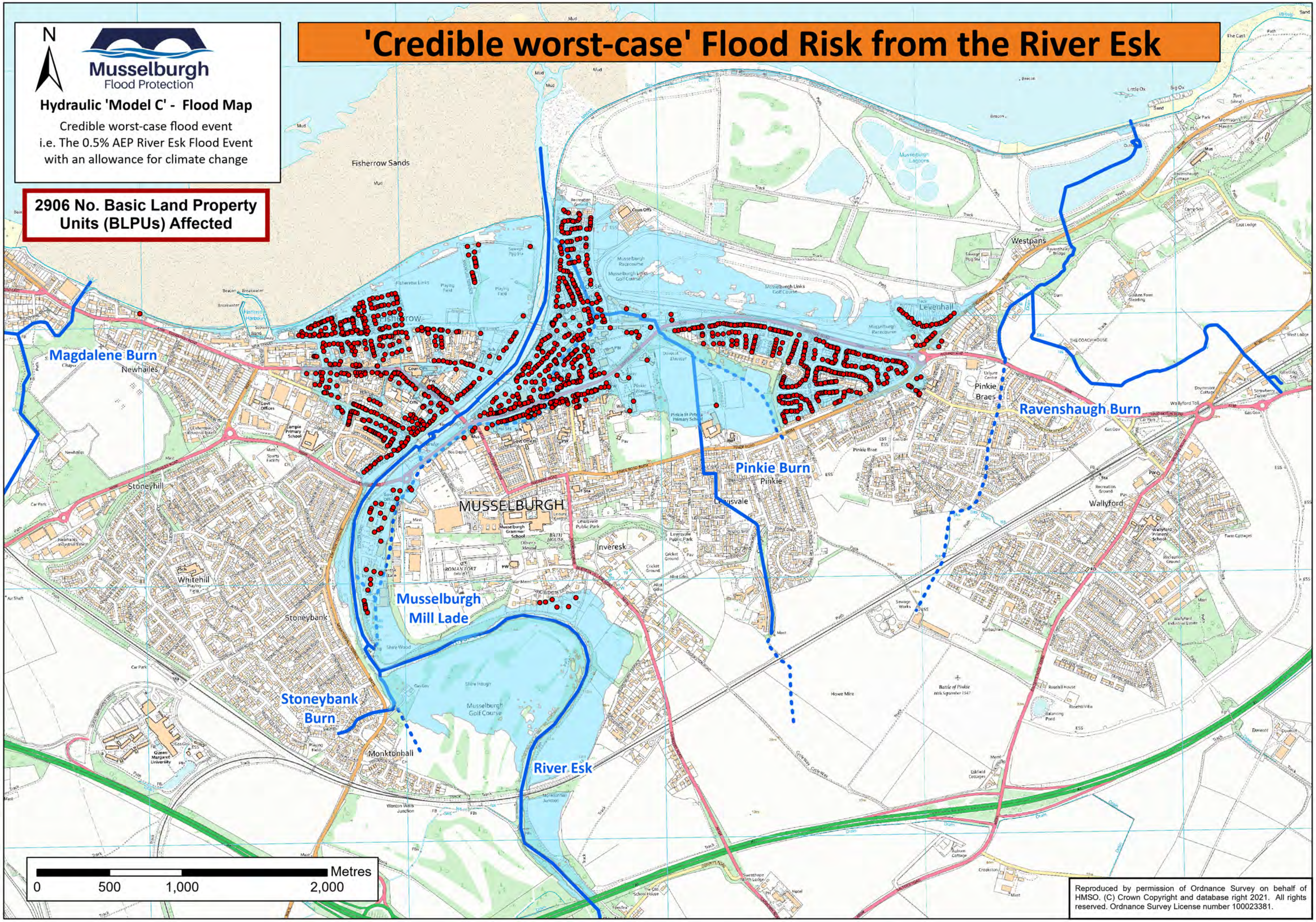

'Credible worst-case' Flood Risk from the River Esk
N
Musselburgh
Flood Protection
Hydraulic 'Model C' - Flood Map
Credible worst-case flood event
i.e. The 0.5% AEP River Esk Flood Event
with an allowance for climate change
2906 No. Basic Land Property Units (BLPUs) Affected
Magdalene Burn
Musselburgh Mill Lade
Stoneybank Burn
River Esk
Pinkie Burn
Ravenshaugh Burn
MUSSELBURGH
Fisherrow Sands
Newhailes
Stoneyhill
Whitehill
Stoneybank
Monktonhall
Inveresk
Pinkie
Pinkie Braes
Levenhall
Westpans
Wallyford
Metres
0
500
1,000
2,000
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Jacobs

Ash Lagoon Seawall Options Study – Intermediate Assessment

Date:	11 October 2022
Project name:	Musselburgh Flood Protection Scheme
Project no:	701909CH
Attention:	Conor Price
Company:	East Lothian Council
Prepared by:	Faye Wright/ Leanne Baker
Reviewed by:	Kirsteen Nixon, Steven Vint
Document no:	701909-JEC-S4-C06-ZZZ-TN-C-0001
Revision no:	P02
Copies to:	East Lothian Council, Jim Baxter (Jacobs)

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1. Purpose and Scope

Jacobs have been requested by East Lothian Council (ELC) to consider options for incorporating the Seawall for the Ash Lagoons into the Musselburgh Flood Protection Scheme. The coastal revetment is 2.7km long, extending from the mouth of the River Esk eastward towards the site of the old Cockenzie power Station.

The Seawall was constructed in the 1960s and was built to contain ash waste from the Cockenzie Power Station. The Flood Protection Scheme's components are required to have a 100-year design life. As the Seawall is already beyond its original design life, incorporating within the Scheme would be a considerable extension to its design life.

The purpose of this Technical Memorandum is to summarise the options study progress to date and the next steps required to complete the options appraisal and to make a recommendation for a preferred option which could be implemented as part of the Flood Protection Scheme.

This technical memorandum has been prepared in advance of completion of the Ash Lagoon Seawall Options Study. The information presented is indicative for discussion purposes only and subject to confirmation.

1.1 Musselburgh Flood Protection Scheme Background

Musselburgh Flood Protection Scheme (the Scheme) is being promoted by East Lothian Council (ELC) under the Flood Risk Management (Scotland) Act 2009. Jacobs were appointed by ELC in December 2017 to develop a scheme for Musselburgh to reduce flood risk. The project is being delivered in stages under PRINCE2 Project management principles and is currently in Stage 4 Outline Design.

In November 2019, Stage 3 Option Appraisal was completed and a Preferred Scheme selected. The aim of Stage 4 outline design is to establish sufficient confidence in the deliverability of the components within the Preferred Scheme such that an outline cost estimate can be prepared and ELC can publish the Scheme under the Stage 5 Statutory Approvals process.

The Ash Lagoon Seawall is situated within Flood Cell 6 within the Scheme. The structures were built to contain ash waste from Cockenzie Power Station and to protect against erosion and inundation from the sea.

Discussion with ELC at the submission of the Preferred Scheme Report (Jacobs, 2019) identified that Scottish Power owned Cell 6 therefore the options for Cell 6 were not to be considered further until negotiations regarding the transfer of ownership had been undertaken. ELC has subsequently approved the inclusion of the Ash Lagoons Seawall into the Preferred Scheme in August 2022 and Jacobs have been instructed to undertake an Options Study for the Ash Lagoons and determine a Preferred Solution to bring it in line with the ongoing Scheme.

1.2 Existing Information

The following data and information have been used to inform the development of the options:

- records and photographs of historic construction of the Ash Lagoon Seawall
- drone survey
- various environmental reports
- details of existing structure and related inspection, specifically:
  - Cockenzie Sea Wall Assessment – Phase 2 – Detailed Investigation and Testing (Mott MacDonald,1999)
  - Musselburgh Seawall - Principal Inspection Report - Rev B (Amey, 2015)
  - Musselburgh Seawall – Review of Survey Data and Assessment of Suitability of Cathodic Protection - Rev 2 (Amey, 2015)
  - Musselburgh– Ash Lagoons Seawall and Electric Bridge Survey 2014 - Rev 1 [Draft] (Amey, 2015)
  - Musselburgh Seawall Inspection 701909-JEC-S4-ZZZ-XXX-RE-S-0002 Rev 1.0 (Jacobs, 2022)

Further studies, investigations and surveys may be required to inform the design stage, a gap analysis will be undertaken as part of the finalisation of the Options Study, refer to Section 0.

2. Ash Lagoons Seawall Site overview

The Ash Lagoons Seawall is located in Musselburgh, to the east of Edinburgh on the southern coastline of the Firth of Forth.

Figure 1 – Location (Microsoft® Bing™ Maps screen shot(s) reprinted with permission from Microsoft Corporation)

The structure was constructed circa 1963 to form the Musselburgh (ash) Lagoons as part of the now demolished Cockenzie power station. It is 2.7km in length running west to east, from the mouth of the River Esk, and its extents are shown in Figure 1.

2.1.1 Current Management Approach

In Countryside and Coast Supplementary Planning Guidance the Musselburgh frontage is included in "Area 2: Levenhall" and notes that the concrete Seawall requires maintenance to avoid discharge of pulverised fuel ash into the Forth. It notes a Shoreline Management Plan (SMP) policy of hold the line (East Lothian Council, 2018).

The flood risk management strategy (SEPA, 2021) designates Musselburgh a potentially vulnerable area and outlines a number of general actions for managing flood risk in the area and the following are applicable to reducing coastal flood risk and the economic damages caused by coastal flooding:

- The Musselburgh Flood Protection Scheme has a preferred scheme that is to progress to outline design. Coastal elements of the scheme potentially include new sea defences, demountable sea defences, Natural Flood Management and the continued use of existing defences including the Scottish Power Ash Lagoons Seawall.
- Additional actions related to coastal flooding for 2022 to 2028 include; flood defence maintenance, community engagement, flood warning maintenance, Strategic mapping improvements.
- Additional actions for after June 2028 include Flood warning maintenance.

2.1.2 Current Defence

The defence is a composite defence combining rock and concrete elements. A whinstone rock lower revetment placed on a slope of 1:2 protects the embankment below approximately Mean Sea Level. Above the lower revetment is a mass concrete reinforced toe beam with a top level of +1.22mOD approx. Above the toe beam is an upper revetment formed of interlocked precast concrete blocks placed on a slope of 1:1.5. In a limited number of locations this appears to have been replaced with a single surface in-situ concrete revetment (Prior to the 1999 assessment (Mott MacDonald, 1999)). Above the upper revetment is an in-situ concrete headwall with a top level of +6.25mOD approx. Both the upper and lower revetment are founded on a layer of smaller whinstone and then lager whinstone, determined anecdotally from historical drawings (James Williamson and Partners, 1963). These layers are founded on a limestone rock fill core. Each element of the composite defence will provide support to the elements above. The existing defence is illustrated in Figure 2 and the location of the defence in Figure 3.

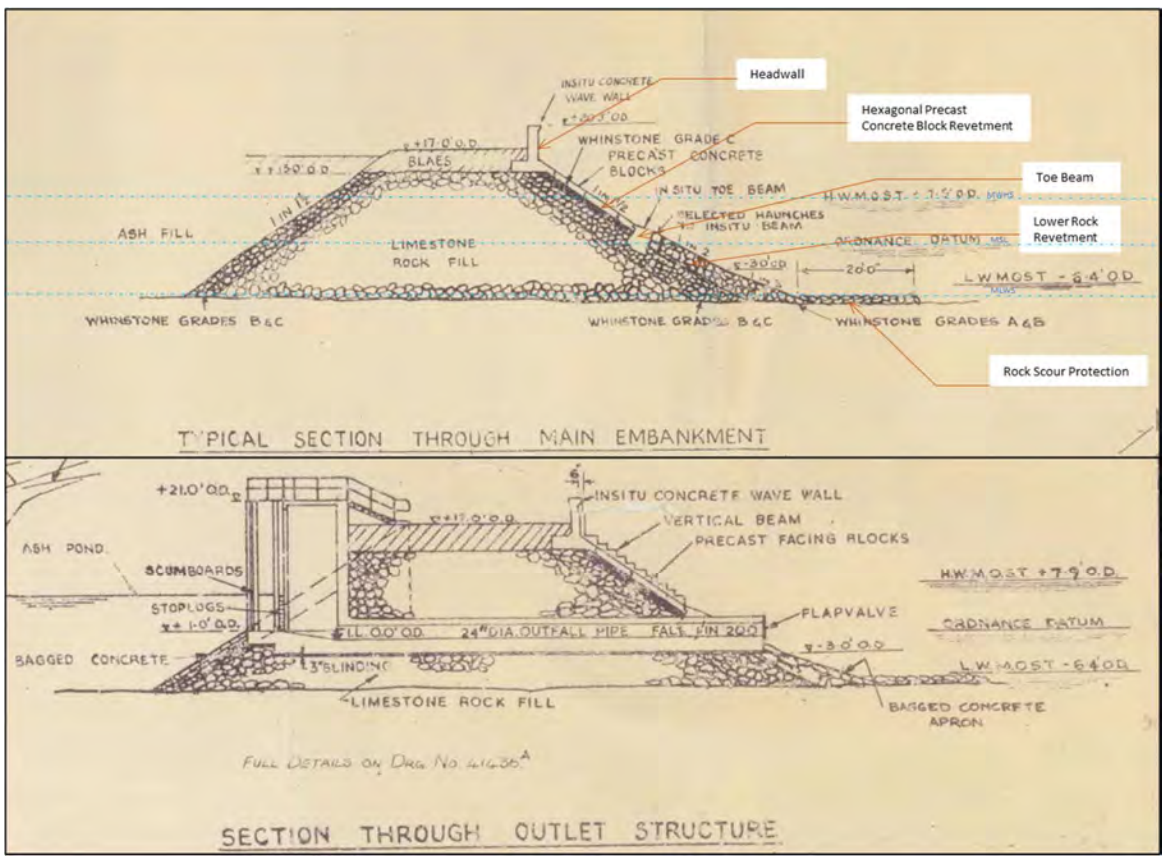

Figure 2 - Seaward facing revetment sections [Extract taken from Drawing Number 35672c General Layout & Typical Cross Sections of Embankments, (James Williamson and Partners, 1963)]

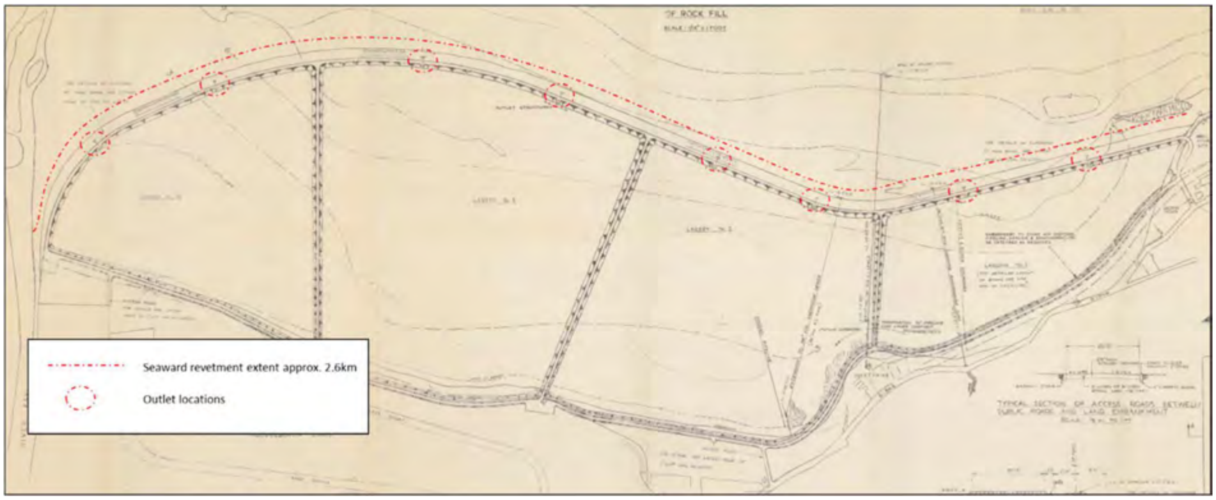

Figure 3 - Location of seaward revetment [Extract taken from Drawing Number 35672c General Layout & Typical Cross Sections of Embankments, (James Williamson and Partners, 1963)]

The frontage consists of 89 panels, with each panel approximately 30.5m between two cast in situ stepped beams. The following provides a brief condition overview of the Seawall's components:

Limestone Rock Fill – The rock fill forms the foundation of the structure and is assumed to be in a good condition, although not visually inspected. The structural integrity and condition would need to be confirmed through further investigations. The existing rockfill bund presents an obstruction to construction activities such as piling and drilling. Other obstructions such as cobbles and boulders are also within the natural superficial deposits. There is a potential for geochemical attack of concrete from the existing embankment construction containing blaes (a hardened shale or mudstone) if sulphates were to be found within the material.

Headwall - The headwalls are not at risk of failure in the short term but do display a number of defects consistent along its length. These defects include cracking, spalling and delamination as well as rusting of the reinforcement. Extensive repairs are required to slow further deterioration. For the medium to long term life of the structure, surface repairs would likely not be sufficient due to the observed lack of expansion joints and inadequate cover to the reinforcement, when compared to modern standards. Defects generally appear to be due to the long-term exposure of the concrete which has likely led to chloride ingress and corrosion of the reinforcement or the lack of expansion joints within the headwall. For repairs to the seaside of the headwall, access may be an issue due to the steep revetment slope. (Jacobs, 2022).

Hexagonal Block Arrangement - The general condition of the upper revetment shows fairly sporadic defects, namely spalling, cracking and some surface voids with good interlock still present between units, the toe beam and the headwall. The defects that are present will continue to worsen over time increasing the risk of blocks failing or becoming displaced and exposing the underlayers. There are some blocks that are starting to be displaced on panel 13 and the whinstone underlayer is visible with some voiding in the exposed area. This displacement will make this section vulnerable to damage due to wave and water levels. The panels adjacent to panel 13 - panels 11 and 12 - appear to have been replaced by a concrete surface revetment (Prior to the 1999 assessment (Mott MacDonald, 1999)). and this suggests a similar failure mechanism was present in the past at the adjacent revetments (Jacobs, 2022), (Mott MacDonald, 1999).

Stepped Beams - The vertical stepped beams 'bookend' each revetment panel and are generally in a stable and reasonable condition with no signs of major movement. Again, there are defects that are consistent with all of the stepped beams throughout the length of the entire revetment. The most common of these is the lower steps – around the water line - have eroded or spalled to such an extent that the stepped feature has completely disappeared. This is often accompanied by cracking and exposed reinforcement (Jacobs, 2022).

Toe Beams - The condition of the toe beam is consistent along the length of the defence and is generally in reasonable condition. A general rounding off of edges and weathering to the top surface of the concrete was observed and there is some cracking at the joints between panels. In a couple of locations reinforcement has been exposed but this is rare. In a few locations the toe beam has sunk and concrete has been used to fill the gap between the toe beam and the hexagonal blocks. A full condition assessment was not possible due to the marine growth and the toe beam being buried in some areas (Jacobs, 2022).

Lower Rock Revetment - The lower revetment rock armour condition varies along the length of the lower revetment, but the general condition is poor. There are locations where larger stones are observed to be missing from the grading and locations where rock has fallen away and left the toe beam exposed. In some areas concrete has been used to bind and stabilise the rock but this was not successful in all locations. Some areas of the toe beam are completely exposed after the rock has fallen away or the rock has started to be undercut. There are areas where sediment has buried the rock revetment and these areas are likely to be of less concern (Jacobs, 2022); however, this would depend on the stability of the beach in front of the revetment. Considering Figure 2, the lower revetment was formed without a typical rock toe feature as described in CIRIA; CUR CETMEF, 2007 which would help stabilise the upper slope and this may partly explain rock falling away from the toe beam in locations where the beach has been stripped away.

2.1.3 Shoreline Change

From 1907 to 1999 a maximum shoreline change of 750m seaward was observed for the Musselburgh ash lagoons frontage from review of OS maps. This has resulted in moving the Mean High Water Spring Level further seawards than would naturally occur. This could lead to potential erosion of the frontage in the future due to sea level rise and increasing storminess.

There are no natural beaches along this frontage with mainly a sand foreshore with gravel/rubble present. The dominant wave direction is likely from the north-eastern sector. There is a low westerly drift present, however a weak anti-clockwise gyre (circulating current) is thought to drive localised easterly littoral transport in this area (SMP, 2001).

Along the Musselburgh frontage the construction of flood defences has the potential to modify wave conditions and disrupt local sediment erosion and accretion patterns. The presence of a hard, fixed structure such as a wall or embankment has the potential to reflect waves leading to localised beach erosion at the toe of the defence, disruption to local sediment transport and minor lowering of beach levels and slope.

In the last decade, adjacent areas have shown limited erosion and these areas would be expected to continue to display erosional tendencies in the future under rising sea levels and increasing storminess. Figure 4 presents the anticipated shorelines for each decade to 2100, driven by sea level rise expected based on current greenhouse gas emissions (Dynamic Coast, 2022).

Figure 4 - *dynamiccoast.com. (2022.). Dynamic Coast. [online] Available at: https://www.dynamiccoast.com/ [Accessed 31 Aug. 2022].*

2.1.4 Outline of the problem

The Ash Lagoon Seawall is beyond its original design life. Jacobs (2022) Inspection Report noted some areas of concern and deterioration but generally found the Seawall to be in a stable condition.

There are approximately 5,200 people and 2,700 homes and businesses currently at risk from flooding within the Scheme. This is likely to increase to 6,900 people and 3,500 homes and businesses by the 2080s due to climate change (SEPA, 2021). If the Ash Lagoons Seawall were to fail this would likely increase.

The short-listing exercise and hydraulic modelling for the Scheme confirmed that the integrity of all the preferred scheme components on the right bank of the River Esk could be significantly compromised if the Ash Lagoon Seawall deteriorates in any way. If the headwall was to fail, the 0.5% Annual Exceedance Probability event in year 100 has the potential to inundate and saturate the ash lagoons causing it to quickly liquefy. The liquification of the ash within the Lagoon could create a health and safety and environment risk (Jacobs, 2019).

Further modelling is currently being undertaken as part of the Scheme, therefore homes and businesses currently at risk are subject to change.

Figure 5 - Flood risk to the east side of the town due to potential failure of the entire Ash Lagoon Seawall (Jacobs (2019))

2.1.5 Issues, Constraints and Opportunities

The study area frontage around Musselburgh is located in the Outer Firth of Forth estuary, downstream of Queensferry, which is defined as a coastal water body. The intertidal areas between Mean Low Water Springs (MLWS) and Mean High Water Springs (MHWS), excluding the tidal Esk, are designated under the Firth of Forth Special Protection Areas under the European Council Directive on the conservation of wild birds (Birds Directive 2009/147/EC), a wetland of international importance under the Ramsar Convention on Wetlands and Site of Special Scientific Interest (SSSI) under the Nature Conservation (Scotland) Act 2004. This includes the intertidal areas of the Firth of Forth up to MHWS.

The Firth of Forth SSSI (Scottish Naturel Heritage (SNH), 2003, Site Code 8163) qualifying features include the following physical features:

- Coastal Geomorphology of Scotland; Maritime cliff; Mudflats; Quaternary geology and geomorphology; Saline lagoon; Saltmarsh; and Sand Dunes.

Within the Firth of Forth Special Protection Area (SPA) and Ramsar, qualifying features principally relate to bird species and habitat. The study area is nationally (SSSI) and internationally (RAMSAR) designated.

There is substantial contamination risk due to preventing the contamination from the demolished Cockenzie powerplant, saturation of the ash lagoon causing liquefaction, ash redepositing in residential areas such as nearby Goose Green properties. If coal ash deposits do contaminate the local areas, this also has an adverse impact to public health once it is dry or disturbed and released into the air. Other contamination risks include from the riffle range, oil mills, gas works, brick and tile work.

Musselburgh Lagoons is regarded as a prime location for bird watching. Over the years the lagoons have been capped and landscaped and two of the lagoons have been transformed into wetlands. Further landscaping and wetland works are ongoing at the time of writing.

There have been several development ideas presented over the years. The lagoons provide an opportunity for future development.

An existing path runs along the back of the seawall and this provides an opportunity for incorporating greater access along the frontage. Incorporation of Active Travel Route could be accommodated. An effective Desirable Minimum width for shared pedestrian footpath and cycle way is 4.0 metres. This accommodates two-way traffic for up to 300 cycles per peak hour per direction. Thus, a 'high level of service' in relation to the comfort of the end users would be achieved.

The Ash Lagoons ground conditions consist of soft and compressible cohesive deposits present within the natural superficial deposits within and beneath the ash lagoons (made ground).

There is potential for ground gas and for recorded or unrecorded shallow mine-workings and mine entries across the site.

There may also be buried sewers and pipelines present beneath the ash lagoons and existing seawall. A number of outlets pass through the seawall and a site visit undertaken in September 2022 by ELC indicated the following issues:

- Non-Return / Flap Valves on the outside of the outlet pipes appear to have broken off.
- Condition of the outlets are unknow due to sand accumulation

Further investigation of the outlets, culverts and outfalls is required to confirm their condition, purpose and continued use for the Scheme period.

3. Options Appraisal Approach

The following approach has been adopted in the development of the Options Study:

- Define Options
- Short Listed Options Development
- Appraise Options

3.1 Define Options

The following process has been undertaken to define the options for consideration:

- Options defined through optioneering to identify appropriate long list of potential options.
- Appraisal of long list options to define a draft proposed short list of options.
- Engagement with ELC to develop options long list and present proposed short listed options.

Each option was assessed using a RAG (Red, Amber, Green) analysis against the same factors used within the Scheme Preferred Scheme Report. This qualitative process facilitated a holistic approach to the options appraisal and enabled each option to be categorised as either ‘consider’, ‘reject’, or ‘can’t decide’.

Each option was assessed using the following six key appraisal categories:

- Economics – Relative cost e.g. low, medium or high, of undertaking the option
- Technical – Engineering considerations and anticipated complexity of the option
- Environment – Impact of the option on the environment (built and natural)
- Social and stakeholder – Impact of the option on harbour users and stakeholders
- Health and safety – Health and safety considerations associated with both the construction and operation of the option
- Flooding – considerations associated with flood risk and the standard of protection afforded by the option

Each appraisal category above (for each option) was assigned a colour coding at this stage:

Red	**Generally significant/unacceptable/insurmountable risks/impacts/constraints**
Amber	**Moderate impacts/risks/constraints**
Green	**Generally feasible with minor/mitigable impacts/risks/constraints**

Utilising the RAG analysis against the six key appraisal categories assisted in the determination of the preferred solution to take forward.

3.2 Short Listed Options Development

Each of the proposed short listed options was considered and initially developed to allow a high level whole life cost assessment to be undertaken, refer to Section 5.2.

The whole life cost of the short listed options will inform the next stage of the options appraisal.

3.3 Appraise Options

On confirmation of the proposed short listed options by ELC, further option development can be undertaken to allow refinement of whole life cost estimates and final appraisal to identify the preferred option.

This is still to be undertaken.

4. Long List of Options

The long list of potential options was developed and categorised into the following:

1. Do nothing - means walking away from the defences, undertaking no further work, including no maintenance or repair. Do nothing option will be retained for the short list appraisal to provide a baseline against which other options can be compared.
2. Do Something – identification of a range of potential measures that could be adopted as part of the options (packages of measures) to manage the flood risk along this frontage.

Following the development of the long list of Options and Jacobs initial appraisal a virtual workshop was carried out on Monday 12th September 2022 with ELC. The workshop presented a short list of feasible options by screening out long list options based on technical suitability, economic viability, and social, environmental, health & safety and flooding factors. The outcome of this workshop has been incorporated within the following long list options and proposed short listed options.

4.1 Do Nothing

This means walking away from the defences, undertaking no further work, including no maintenance or repair. Where defences exist, these would deteriorate over time and fail, and natural processes would be allowed to take their course. Erosion and flood risk would increase over time as defence condition worsens.

The current preferred scheme relies on continued operation of the Seawall structure for the design life of the scheme to be met (Jacobs, 2019). This implies a do nothing approach would undermine the flood management measures put into place in other flood cells.

The following describes the Do Nothing option consequence for the whole structure and individual structural elements:

(A.) **Whole Structure -** residual whole structure life assumed to be 10 years, with the failure of the toe beam and rock revetment the whole structure is at risk.

(B.) **Headwall -** In the short term the wall would likely continue to provide flood protection to the current standard of protection with similar defects continuing to occur and a worsening of the currently observed defects.
In the medium to long term, increases in water level and storminess due to climate change increase the exposure of the wall to hydrodynamic actions. This may accelerate the deterioration of the observed defects and increase the occurrence of new defects resulting in an increased risk of defence breach.

(C.) **Hexagonal Units** - In the short term the revetment panels would continue to provide protection to the embankment with similar defects continuing to occur and a worsening of the currently observed defects.
In the medium to long term, increases in exposure to more significant hydrodynamic actions would accelerate the deterioration of the observed defects and increasing the occurrence of new defects. Blocks may become displaced, leading to the loss of underlying embankment material, and eventual failure. Failure of the revetment would also accelerate the failure of the headwall with reduced support, increasing the risk of breach to the defences.

(D.) **Stepped Beams -** In the short to medium term the stepped beams would likely continue to function as designed with similar defects continuing to occur and a worsening of the currently observed defects. In the long term the failure of the vertical beams would contribute to the failure of the upper revetment panels.

(E.) **Toe Beams** - In the short term the wall would likely continue to provide support to the upper revetment and headwall with similar defects continuing to occur and a worsening of the currently observed defects.
In the medium to long term, increases in exposure to more significant hydrodynamic actions likely accelerate the deterioration of the observed defects, increasing the occurrence of new defects resulting in an increased risk of failure to the toe beam. This would reduce the support it provides to the upper defence elements.

(F.) **Lower Rock Revetment** - In the short term the areas where rock has already fallen away from the toe beam and undercut will result in significantly reduced support to the toe beam and localised risk of collapse. This risk will continue to increase where further scour of the material from under and eventually behind the toe beam occurs.
In the medium term, increases in storminess due to climate change would likely result in a significant reduction to the stability of the revetment resulting in increased movement and displacement of the rock away from the toe beam further increasing the risk of collapse and or scour of the founding or underlying material. Failure of the rock revetment will also likely result in failure of the upper revetment and headwall due to the reduction in support to the toe beam and upper revetment.

4.2 Do Something Options

Options can be categorised into whole structure options and individual element options, the general advantages and disadvantages of which are explained below.

Whole structure approach requires replacing the existing defence with a new defence. This has the advantages of a longer design life which can be achieved as there is no reliance on the existing components and also benefits from lower maintenance requirements. With this option type the option is likely to have a greater economic capital cost and a greater impact on the environment if the structure footprint changes, especially also due to the disposal of materials. It would conversely likely have a lower long term maintenance requirements and more likely to achieve the required design life.

An **individual element approach** targets the refurbishment or replacement of individual structure elements. This can have a lower impact on the environment as likely to follow the existing structure layout and footprint and can target the parts of the structure in the worst condition so less short-term capital cost is required. However, it is often harder to achieve the required design life as there is reliance on parts of the original structure which require increased maintenance. It is likely that additional capital would be required in the future to achieve a long design life.

An individual element approach requires consideration of combining element options to achieve the Scheme objectives. This has been undertaken with consideration of the proposed Short Listed Options, refer to Section 5.

A detailed appraisal for the long list of options can be found in Appendix A, Table 1 to Table 6 present an extract of the results and justification of the proposed short listed options.

Table 1 - (A.) Whole Structure Long List Options RAG Summary

	Option	Description	RAG	Comment
A.1	Do nothing - see element specific 'Do Nothing' as baseline option also.	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	CONSIDER	Taken forward as required baseline option
A.2	Do minimum	This option would consist of reactive patch and repair maintenance works, to the existing coastal defence assets, to prolong the life of the asset and meet Health & Safety legislation.	CONSIDER	Continuation of asset management (required second baseline option)
A.3	Complete removal of seaward face and replacement with rock revetment and new crown wall	Remove headwall, hexagonal units, toe beam and lower rock revetment to the existing core and replace with new rock revetment and crown wall.	CONSIDER	Expensive option, however, would meet scheme objectives with low future capital cost and maintenance. Allows for incorporation of additional requirements [increased flood protection/ erosion protection / active travel routes and any further masterplan requirements to improve the landscape and amenity value of the frontage].
A.4	Managed Realignment - Retreat	Remove existing defences, rock core bund and ash deposits and form a new defence line working with coastal processes allowing the sea to reclaim some of the ash lagoon.	REJECT	Due to magnitude of the temporary works required to realign the defences - this is not feasible.
A.5	Secondary defence line	Form a setback secondary defence line from primary defence line to ensure flood protection to scheme design life.	REJECT	Not feasible due to containment requirement of the existing bund for the ash material.
A.6	Reclaim seaward of defence to form new defence line- Advance the line	Form a new defence line forward of the existing line, backfill to existing coastline.	REJECT	Not feasible due to the increased footprint on the marine environment and further potential erosion protection measures required.
A.7	Whole structure rock revetment	Form new rock revetment over the existing structure with crest level to the top of the new headwall.	CONSIDER	Would be a significant capital cost. Would increase flood protection due to material properties and extend the design life due to new headwall.
A.8	Whole Structure open stone asphalt (OSA) Revetment	Form a new OSA revetment over the existing structure with repairs to the headwall.	REJECT	May be difficult to incorporate stepped beams without significant thickness of OSA. May not be suitable for scheme design life or wave climate. Would also require works to headwall to provide flood protection

	Option	Description	RAG	Comment
A.9	Create Beach fronting existing structure	Create a new beach in front of the existing seawall along with the associated beach control structures	REJECT	It may smother existing biodiversity. Would be difficult to maintain sufficient beach levels to ensure structure remains covered therefore impacting stability without providing significant beach control structures and ongoing import of beach material. Introduction of new beach control structures likely to impact adjacent frontages, interrupt sediment supply.

Table 2 - (B.) Headwall Long List Options RAG Summary

	Option	Description	RAG	Comment
B.1	Do nothing at headwall	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	CONSIDER	Taken forward as required baseline option
B.2	Do minimum - General surface level repairs.	This option would consist of reactive patch and repair maintenance works to the existing headwall, to prolong the life of the asset.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.
B.3	Concrete repairs	This option would consist of proactive patch and repair maintenance works to the existing headwall	CONSIDER	Should be used in conjunction with B.4, B.5, B.6, B.7, B.8
B.4	Sacrificial anodes added to the structure [which should be undertaken in conjunction with concrete repairs in Option B.3].	This option would consist of providing protection against chloride attack with the use of sacrificial anodes, to prolong the life of the asset. The addition of anodes would be to control the incipient anode effect (provide protection from corrosion for areas adjacent to the repair)	CONSIDER	Would not provide increased level of flood protection. Success of solution is dependent on the success of other elements being refurbished successfully. Future capital would likely be required to achieve scheme design life.
B.5	Protective system of Impressed Current Cathodic Protection (ICCP) [in conjunction with concrete repairs in Option B.3].	This would require the structure to be electrically continuous (which the reinforcement is not as it is split into panels)and localised patch repairs to be undertaken.	REJECT	Not considered feasible due to high associated costs of the installation due to the unlinked reinforcement along the 2.7km of seawall, as well as the permanent cabling required.
B.6	Protective system of corrosion inhibitor [in conjunction with concrete repairs in Option B.3].	This option would involve concrete patch and repair where corrosion inhibitors are added to the structure. A corrosion inhibitor (a chemical solvent) can be added as an admixture to concrete patch repairs and on the remaining existing structure it will be applied on the hardened concrete.	CAN'T DECIDE YET	Additional trials will be required to determine the depth of penetration and suitability of option
B.7	Electrochemical chloride extraction [in conjunction with concrete repairs in Option B.3].	This option would involve removal of chloride from the concrete. It would not address existing defects within the wall	REJECT	Not considered feasible due to high associated costs, time required for installation and complexity of option.
B.8	Application of protective coating [in conjunction with concrete repairs in Option B.3].	This option would involve applying protective coating.	CONSIDER	This approach would require ongoing repairs to the structure.
B.9	Removal of damaged wall aspects and repaired with spray concrete to existing top level	This option would involve concrete patch and repair.	CONSIDER	This approach would require ongoing repairs to the structure.
B.10	Remove top portion (500mm) of the headwall and replace.	The top 500mm of the parapet wall with large deterioration will be removed and will be replaced, the existing structure will undergo proactive maintenance and repairs to prolong the life of the asset.	REJECT	Option does not address the expansion joint issue and high level of cost compared to other patch and repair approaches or complete replacement.
B.11	Remove the damaged panels of the headwall and replace	Complete removal of damaged panels within headwall and proactive repair work.	REJECT	Option does not address the expansion joint issue and high level of cost compared to other patch and repair approaches or complete replacement.
B.12	Full replacement of the fixed headwall.	Complete removal of the headwall and replacement.	CONSIDER	Highest capital cost, longest design life. Options to include changes to area behind for improved amenity use.
B.13	In combination with another option, the installation of retro fit expansion joints	This would involve retrofitting of joints through saw-cutting to enable the structure to account for thermal cycles. This would prevent future cracking caused by restraint	REJECT	Reject due to potential to further damage the wall through the retrofitting of the joints - allowing further routes for chloride ingress and potential loss of strength in the reinforcement.

Table 3 – (C.) Hexagonal Units Long List Options RAG Summary

	Option	Description	RAG	Comment
C.1	Do nothing on facing slope at the upper revetment.	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	CONSIDER	Taken forward as required baseline option
C.2	Do minimum - Patch up works over existing hexagonal units	This option would consist of reactive patch and repair maintenance works, to the existing facing blocks, to prolong the life of the asset.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.
C.3	Remove displaced/ damaged hexagonal units and relay units which are repaired or replaced.	This option would consist of removing the displaced or damaged hexagonal units on the structure, ensure fill material is regraded, repair good condition units and replace damaged units before replacing them on the structure.	REJECT	H&S grounds - heavy units and access restrictions. Majority of the units are soundly in place if removed could unsettle/ reduce their existing integrity.
C.4	Remove all hexagonal units and fill bays with insitu concrete revetment.	This option would consist of removing the hexagonal units on the structure, ensure fill material is regraded and cover the slope face in concrete layer.	CONSIDER	Wave protection in moderate to high wave energy environments and would hold the line of the upper beach. Smoother surface finish may increase overtopping, does not offer any additional benefit other than encasing the existing structure - significant concrete usage. Has been adopted on panels 11 and 12 prior to 1999, no significant defects observed. Therefore, has been used at this site with some success although achieving scheme design life may be difficult without significant maintenance in the medium to long term.
C.5	Cover the facing blocking with a concrete mattress layer	This option would consist of removing the hexagonal units on the structure, ensure fill material is regraded and cover the slope face in concrete mattress layer.	REJECT	High cost, access restrictions for construction and maintenance difficulties
C.6	Cover the facing blocking with an Open Stone Asphalt Layer	This option would consist of covering the face blocking with an Open Stone Asphalt Layer	REJECT	Not suitable in the short lengths required between the bookends, introduces weaknesses into the structure. May not be suitable for scheme design life or wave climate.
C.7	Cover the facing blocks with sprayed concrete	This option would include spraying concrete a layer onto the facing blocks.	REJECT	May be difficult to get required thickness to ensure integrity of the concrete surface with existing blocks in place.
C.8	Localised repairs to the hexagonal units	This option would consist of proactive inspection and repair of units depending on level of deterioration. Namely reinforcement exposure recovering.	CONSIDER	Condition assessment noted blocks are in generally fair condition. This could extend life of structure marginally and delay requirement for significant capital expenditure.
C.9	3D Printing of Revetment Blocks	Replace existing concrete revetment blocks with 3D printed alternatives	REJECT	Likely to be little benefit over more traditional forming techniques. Condition of blocks would mean there may be more benefit to more localised repairs. Wave climate likely too high if material is light.

Table 4 - (D.) Stepped Beam Long List Options RAG Summary

	Option	Description	RAG	Comment
D.1	Do nothing at stepped beams	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	CONSIDER	Taken forward as required baseline option
D.2	Do minimum- General surface level repairs	This option would consist of reactive patch and repair maintenance works to the existing stepped beams, to prolong the life.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.
D.3	Concrete repairs	This option would consist of proactive patch and repair maintenance works to the existing stepped beam	CONSIDER	Would not provide increased level of flood protection, would likely require an additional capital expenditure in the medium term
D.4	Extensive repairs to slow deterioration and add sacrificial anodes to the structure.	This option would provide protection against chloride attack of exposed reinforcement in vertical beam using sacrificial anodes, to prolong the life.	CONSIDER	Would not provide increased level of flood protection, would likely require an additional capital expenditure in the medium term
D.5	Replace stepped beams	Replace stepped beams, which would include the need to remove hexagonal blocks and then reform vertical and replace.	REJECT	Not feasible due to the scale of disruptions, cost and difficulty of removing entire structure.
D.6	Encase the stepped beam in mass concrete	Provide concrete cover to existing stepped beam.	CONSIDER	Corrosion may be expected to continue until such a time that oxygen is reduced at the surface of the reinforcement. To ensure reflective cracking does not occur within the overlay concrete, a significant thickness of concrete may be required.
D.7	Apply waterproof coasting to the stepped beam after repairs	In this option whichever option is used, a waterproof coating would be applied in order to slow down the corrosion process on the repairs.	CONSIDER	Enhances the maintenance free life of the structure. Similar applications to that intended here may not be common place so would need further appraisal.

Table 5 - (E.) Toe Beam Long List Options RAG Summary

	Option	Description	RAG	Comment
E.1	Do nothing at toe beam	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	CONSIDER	Taken forward as required baseline option
E.2	Do minimum - General surface level repairs	This option would consist of reactive patch and repair maintenance works to the existing toe beam, to prolong the life.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.
E.3	Extensive repairs to slow deterioration and add sacrificial anodes to the structure.	This option would consist of proactive patch and repair maintenance works to the existing toe beam and provide protection against chloride attack of exposed reinforcement using sacrificial anodes, to prolong the life.	CONSIDER	Repairs to toe beam need to ensure stability to the revetment above.

	Option	Description	RAG	Comment
E.4	Replace toe beam with Rock Toe	In this option the existing toe beam would be removed and replaced with a rock toe, where the armour is sized to stabilise the upper slope and against hydraulic action.	REJECT	Extensive temporary works required to support hexagonal units, H&S issues with structural integrity of the remaining structure while works ongoing.
E.5	Replace toe beam with gabion mattress	In this option the existing toe beam would be removed and replaced with a gabion mattress, with the function to stabilise the upper slope against hydraulic action.	REJECT	Extensive temporary works required to support hexagonal units, H&S issues with structural integrity of the remaining structure while works ongoing. Design life of gabions may not achieve scheme objectives.
E.6	Replace Toe Beam with Grouted Rock Toe	In this option the existing toe beam would be removed and replaced with a grouted rock toe, with the function stabilise the upper slope and against hydraulic action.	REJECT	Extensive temporary works required to support hexagonal units, H&S issues with structural integrity of the remaining structure while works ongoing.
E.7	Apply waterproof coating to the toe beam after repairs	In this option whichever option is used, a waterproof coating would be applied in order to slow down the corrosion process on the repairs.	CONSIDER	Enhances the maintenance free life of the structure. Similar applications to that intended here may not be common place so would need further appraisal.
E.8	Overlay the existing toe beam with mass concrete	In this option, the toe beam is covered with mass concrete and the existing toe beam is encased	REJECT	Access issues and ongoing complicated maintenance.

Table 6 - (F.) Rock Armour Long List Options RAG Summary

	Option	Description	RAG	Comment
F.1	Do nothing at lower revetment rock armour	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	CONSIDER	Taken forward as required baseline option
F.2	Do minimum-reactive maintenance, moving the rock armour back to the toe beam.	This option would consist of reactive patch and repair maintenance works to the existing lower revetment armour, to prolong the life of the toe beam from scour.	REJECT	With no import of material there is no benefit in moving material. Will not halt ongoing undercutting.
F.3	Patch and repair works utilising suitably sized rock armour where required	This option would consist of proactive patch and repair maintenance works to the lower revetment utilising appropriate rock sizing for stability within the design life.	CONSIDER	Broadly in keeping with what is there already.
F.4	Patch and repair by concrete cover to stabilise rock armour	This option consists of moving rock which had moved from the toe beam and then applying concrete to secure all rock armour.	REJECT	Unfeasible due to technical and environmental reasoning
F.5	Enhance rock armour to suitable size and form to protect from further scour and support toe beam	This option involves enhancing the current armour, filling any voids and sizing and sourcing (or reusing) rock armour of a suitable size for its stability at the toe beam.	CONSIDER	Rock could be sized to achieve the scheme design life and standard of protection. Rock is a sustainable material that could be reused as part of a future solution or could be adapted or added to form a whole structure rock revetment. Ensuring

	Option	Description	RAG	Comment
				existing voids are filled may be difficult.
F.6	Remove and replace rock armour, the new lower slope revetment could consist of OSA/concrete lower revetment.	This option involves removing any remaining armour and then, sizing and sourcing OSA or concrete of a suitable size for its stability at the toe beam	REJECT	OSA only suitable in low to moderate wave climates and difficult to justify scheme design life. Difficult to remove the rock armour and replace lower revetment with OSA or concrete. Would likely need to be a whole structure solution to adopt these materials.
F.7	Replacement with vertical toe (sheet piles)	This option involves removing any remaining armour or piling through armour and core and then sheet piling a toe	REJECT	Unfeasible due to the difficulties in access, noise and increase in the potential scouring processes against a vertical toe.
F.8	Import beach material and continue beach nourishment to bury rock armour and toe beam	This option involves encasing the existing structure in beach nourishment material in a similar way as is currently seen at Panel 1.	REJECT	It may smother existing biodiversity. Would be difficult to maintain sufficient beach levels to ensure structure remains covered therefore impacting stability without providing significant beach control structures and ongoing import of beach material.

5. Short listed options

Initial development of the proposed short listed options has been undertaken to inform the next stage of the options appraisal. The proposed short listed options are presented below:

(A.) Whole Structure

- A.1 Do Nothing – base case
- A.2 Do Minimum - reactive patch and repair maintenance works, to the existing coastal defence assets, to prolong the life of the asset and meet Health & Safety legislation.
- A3 Complete removal of seaward face and replacement with rock revetment and new crown wall

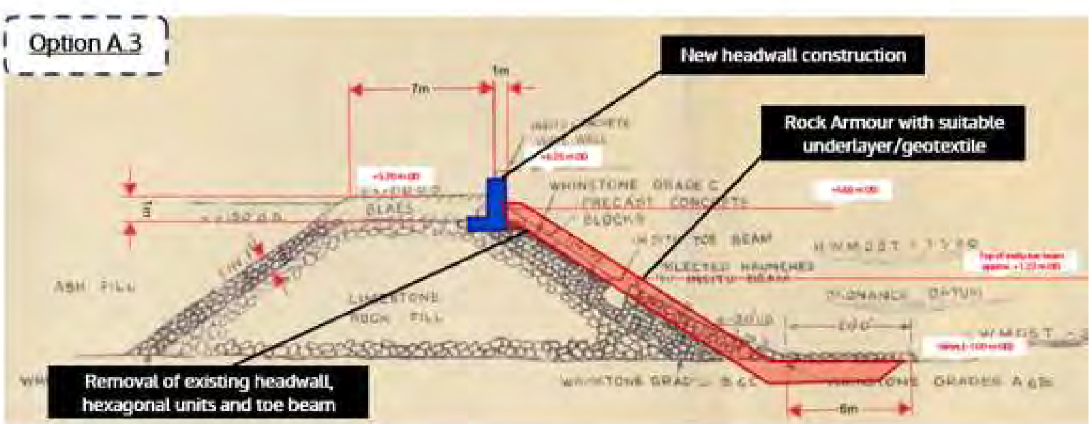

Figure 6 - (A.) Whole Structure Short Listed Option A.3 indicative sketch

- A.7 Whole structure rock revetment form new rock revetment over the existing structure with crest level to the top of a new headwall.

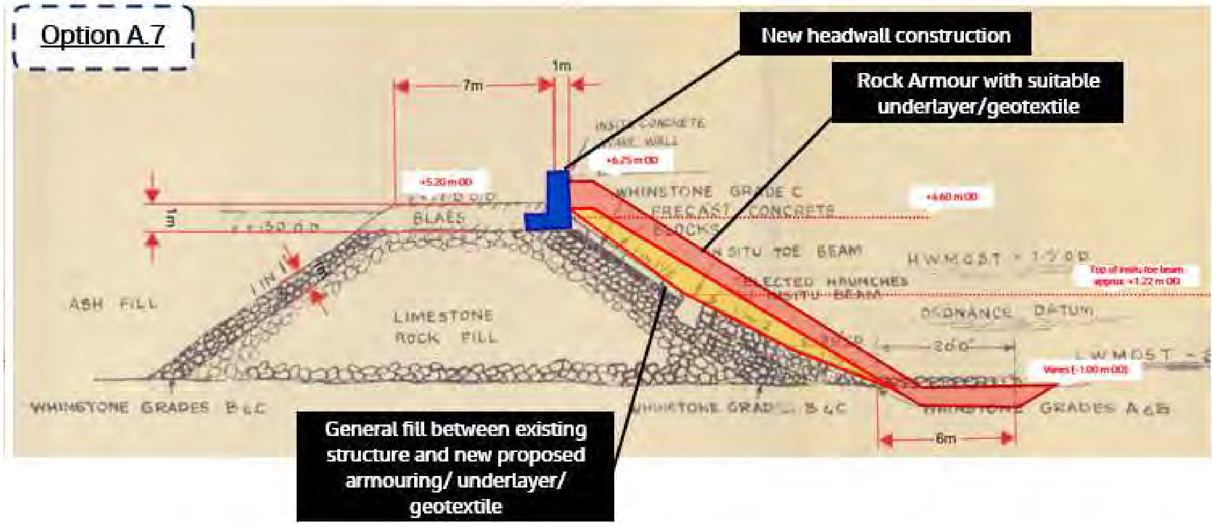

Figure 7 - (A.) Whole Structure Short Listed Option A.7 indicative sketch

(B.) Headwall

- B.3/ B.4/ B.6/ B.7 / B.8 Extensive repairs and measures to slow deterioration – dependant on the material investigations undertaken possible means of this could be as follows:
  - B.3 Concrete repairs.
  - B.4 Sacrificial anodes to the structure [in conjunction with concrete repairs in Option B.3].
  - B.6 Protective system of corrosion inhibitor [in conjunction with concrete repairs in Option B.3].
  - B.7 Electrochemical chloride extraction [in conjunction with concrete repairs in Option B.3].
  - B.8 Application of protective coating

- B.12 Full replacement of the fixed headwall.

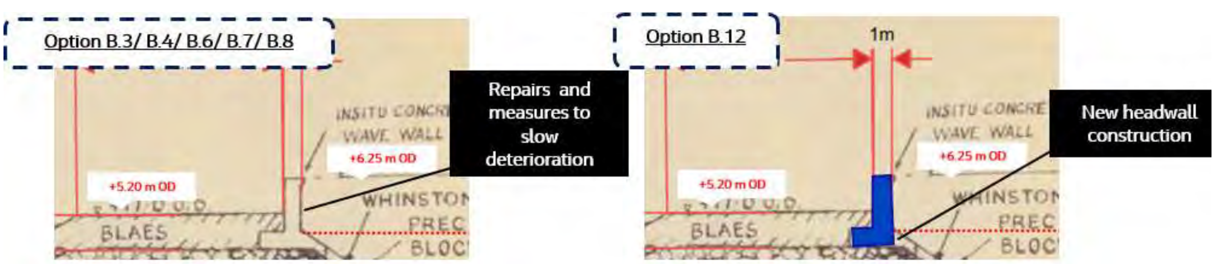

Figure 8 - (B.) Headwall Short Listed Options B.3/ B.4/ B.6/ B.7 / B.8 and B.12 indicative sketch

(C.) Hexagonal Units

- C.4 Remove all hexagonal units and fill bays with insitu concrete revetment - This option would consist of removing the hexagonal units on the structure, ensure fill material is regraded and cover the slope face in concrete layer.
- C.8 Localised repairs to the hexagonal units - This option would consist of proactive inspection and repair of units depending on level of deterioration. Namely reinforcement exposure recovering.

Figure 9 - (C.) Hexagonal Units Short Listed Option C.4 and C.8 indicative sketch

(D.) Stepped Beam

- D.3/ D.4/ D.6/ D.7 Extensive repairs and measures to slow deterioration – dependant on the material investigations undertaken possible means of this could be as follows:
  - D.3 Concrete repairs
  - D.4 Extensive repairs to slow deterioration and add sacrificial anodes to the structure.
  - D.6 Encase the stepped beam in mass concrete
  - D.7 Apply waterproof coating to the stepped beam after repairs

Figure 10 - (D.) Stepped Beam Short Listed Options D.3, D.4, D.6, D.7 indicative sketch

(E.) Toe Beam

- E.3/ E.7 Extensive repairs and measures to slow deterioration – dependant on the material investigations undertaken possible means of this could be as follows:
  - E.3 provide protection against chloride attack of exposed reinforcement using sacrificial anodes, to prolong the life.
  - E.7 A waterproof coating would be applied in order to slow down the corrosion process on the repairs.

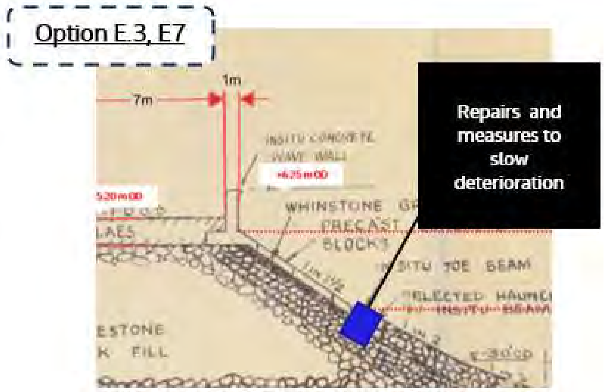

Figure 11 - (E.) Toe Beam Short Listed Options E.3 and E.7 indicative sketch

(F.) Rock Armour

- F.3 Patch and repair works utilising suitably sized rock armour where required
- F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam

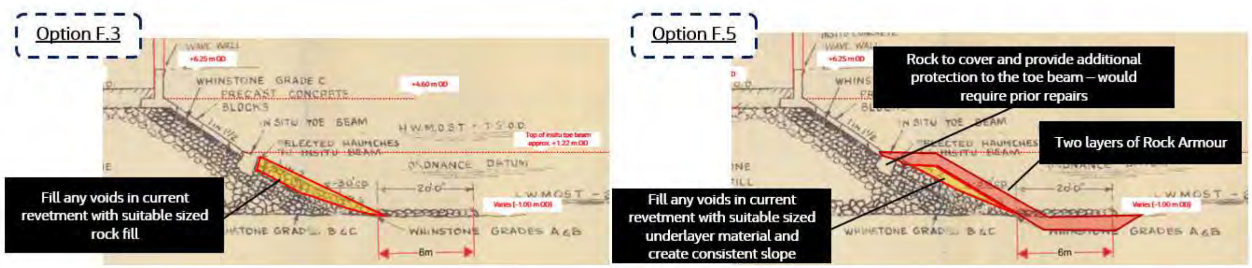

Figure 12 – (F.) Short Listed Option F.3 and F.5 indicative sketch

5.1 Combined options

An individual element approach requires consideration of combining individual element options to achieve the Scheme objectives. This has been undertaken with consideration of the proposed Short Listed Options to produce the following options:

Combined Option 1

- Headwall - B.3/ B.4/ B.6/ B.7 / B.8 Extensive repairs and measures to slow deterioration
- Hexagonal Units - C.8 Localised repairs to the hexagonal units
- Stepped Beams - D.3/ D.4/ D.6/ D.7 Extensive repairs and measures to slow deterioration
- Toe beam - E.3/ E.7 Extensive repairs and measures to slow deterioration
- Rock Armour -F.3 Patch and repair works utilising suitably sized rock armour where required

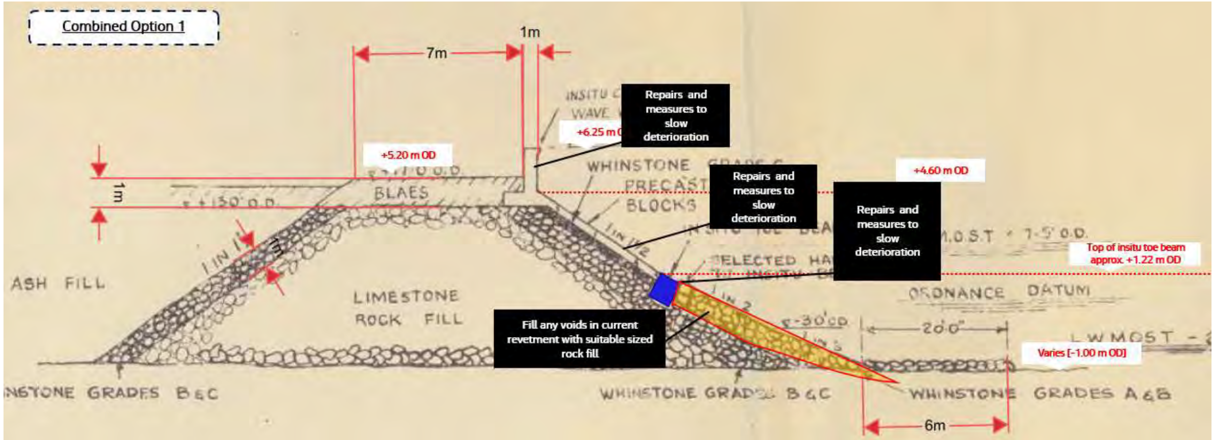

Figure 13 – Combined Option 1 indicative sketch

Combined Option 2

- Headwall - B.12 Full replacement of the fixed headwall.
- Hexagonal Units - C.4 Remove all hexagonal units and fill bays with insitu concrete revetment
- Stepped Beams - D.3/ D.4/ D.6/ D.7 Extensive repairs and measures to slow deterioration
- Toe beam – refurbishment of the toe beam included within Rock Armour F.5 enhancement works
- Rock Armour - F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam

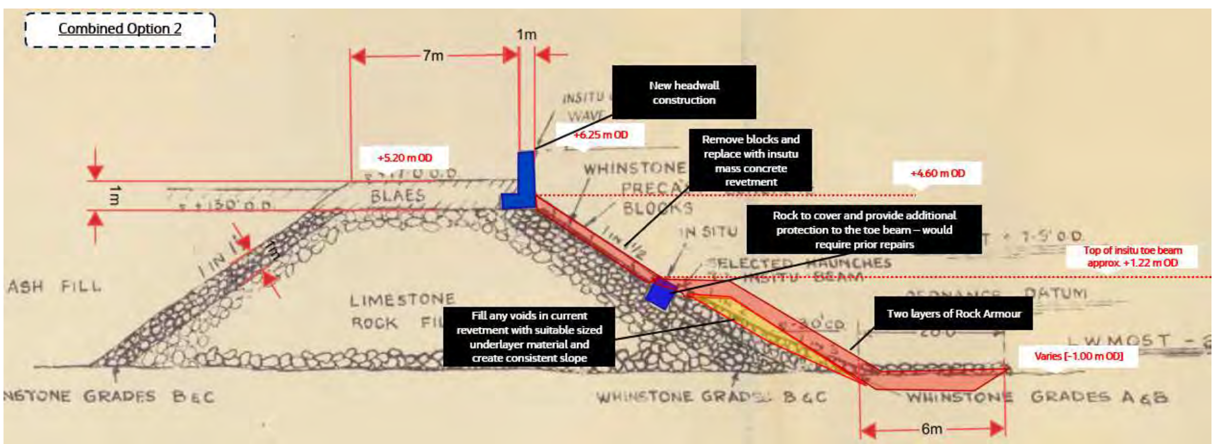

Figure 14 – Combined Option 2 indicative sketch

Combined Option 3

- Headwall - B.12 Full replacement of the fixed headwall.
- Hexagonal Units - C.8 Localised repairs to the hexagonal units
- Stepped Beams - D.3/ D.4/ D.6/ D.7 Extensive repairs and measures to slow deterioration
- Toe beam – refurbishment of the toe beam included within Rock Armour F.5 enhancement works
- Rock Armour -F.3 Patch and repair works utilising suitably sized rock armour where required

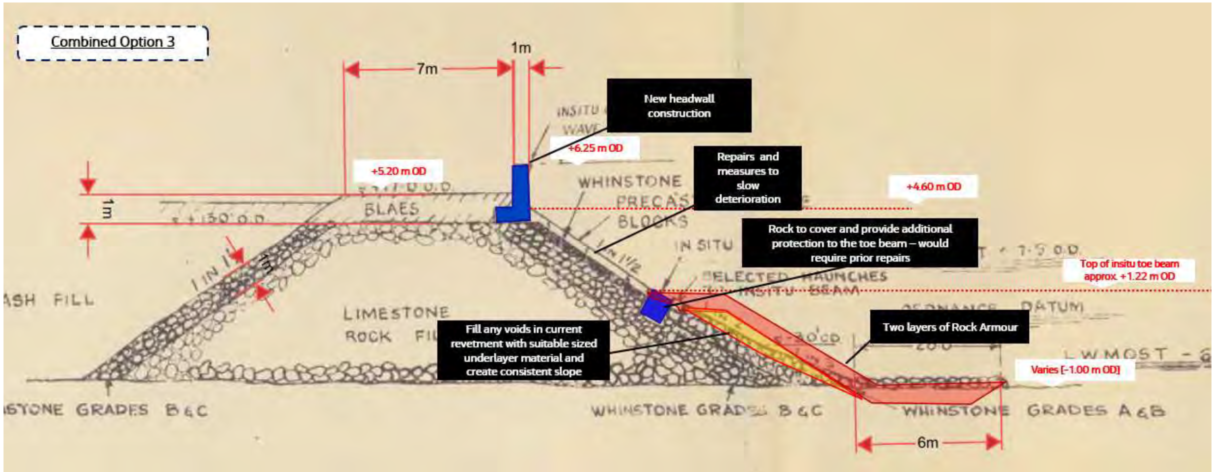

Figure 15 – Combined Option 3 indicative sketch

5.2 Whole Life Cost Estimates

Costs have then been estimated for each shortlisted option. In accordance with the Flood Risk Management (Scotland) Act 2009, Chapter 5, costs are estimated over the 100 year appraisal period to derive a Present Value (PV) cost for each option. This PV cost includes all costs that can reasonably be foreseen over the appraisal period including:

- Capital works costs;
- Design costs (consultancy and client fees);
- Maintenance costs.

All options were costed using a combination of the Environment Agency's 'Flood Risk Management Estimating Guide – Update 2010' and an internal costs database compiled by Jacobs. The Jacobs database consists of a collation of cost estimates and cost rates from a range of similar projects and from industry pricing guides. Costs were updated to 2022 base date using price indices.

The total PV cost over the life of the scheme is subjected to an Optimism Bias (OB) adjustment. For initial feasibility stage, the recommended OB allowance is 60% and this has been applied to all options and costs developed as part of the Options Study.

In accordance with current HM Treasury guidelines, costs have been discounted at the approved rates (3.5% for years 0-30, 3.0% for years 31-75, and 2.5% thereafter).

5.2.1 General Cost Assumptions

The following general assumptions were adopted in the development of the option costs:

- It is assumed that do minimum is based on a regime of reactive maintenance which involves monitoring the structures following significant storm events and making necessary interventions.
- Where new structures are installed, it is assumed that a proactive maintenance regime will be put in place whereby structures are monitored and maintained periodically and therefore a different rate for this has been included.
- Some solutions call for a proactive rather than reactive maintenance regime to be part of the solution and in these instances a small additional capital cost at the start will be included to account for some limited refurbishment to bring the structure up to maintainable state.
- For all extensive concrete measures to prolong structures residual life a cost based on Impressed Current CP system has been assumed. This is to be confirmed and is dependent on further material test results and any further required investigations.

- Due to ongoing uncertainty with cost rates the estimates provided should be viewed with caution. Further consideration of sensitivities to rate changes should be undertaken once further development of the short listed option has been undertaken.

5.3 Cost Estimates

The cost estimates for each Short Listed Option are summarised in Table 7 to Table 14 with full cost breakdown of the whole life costs for each of the considered options, including capital costs, maintenance and risk. The base date for the costs is Quarter 2 (Q2), 2022.

Table 7 - (A.) Whole Structure – Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Do Nothing	10	-	0.0	0.0	0.0	0.0	0.0
Whole Structure A.2 Do Minimum	15	0	0.7	0.0	0.6	0.6	0.9
Whole Structure A.3 Complete removal of seaward face and replacement with rock revetment and new crown wall	100	0	40.7	33.1	2.2	35.3	56.5
Whole Structure A.7 Whole structure rock revetment form new rock revetment over the existing structure with crest level to the top of the new headwall.	100	0	33.7	26.1	2.2	28.3	45.3

Table 8 - (B.) Headwall – Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Headwall B.3/ B.4/ B.6/ B.7 / B.8 Extensive repairs to slow deterioration	50	0	30.7	10.9	9.5	20.4	32.6

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Headwall B.12 Full replacement of the fixed headwall.	100	0	15.8	13.8	0.6	14.4	23.1

Table 9 - (C.) Upper Revetment Facing Blocks – Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Hexagonal Units C.4 Remove all hexagonal units and fill bays with insitu concrete revetment	100	0	25.8	18.4	0.5	18.8	30.2
Hexagonal Units C.8 Localised repairs to the hexagonal units	50	0	4.6	4.0	0.1	4.1	6.5

Table 10 - (D.) Stepped Beam Whole Structure – Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Stepped Beams D.3, D.4, D.6, D.7 Extensive repairs to slow deterioration	50	0	1.1	0.5	0.3	0.8	1.2

Table 11 - (E.) Toe Beam – Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV) Capital Works	Present Value (PV) Maintenance and Operation Works	Present Value (PV) Total cost (PVc)	Present Value (PV) Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Toe beam E.3, E.7 Extensive repairs to slow deterioration	50	0	25.2	5.5	9.5	14.9	23.9

Table 12 - (F.) Rock Armour – Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV) Capital Works	Present Value (PV) Maintenance and Operation Works	Present Value (PV) Total cost (PVc)	Present Value (PV) Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Rock Armour F.3 Patch and repair works utilising suitably sized rock armour where required	100	0	10.0	3.8	1.6	5.4	8.7
Rock Armour F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam	100	0	21.2	15.6	1.6	17.2	27.5

Table 13 - Combined Options 1– Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV) Capital Works	Present Value (PV) Maintenance and Operation Works	Present Value (PV) Total cost (PVc)	Present Value (PV) Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Headwall *B.3/ B.4/ B.6/ B.7 / B.8 Extensive repairs to slow deterioration*	50	0	30.7	10.9	9.5	20.4	32.6
Hexagonal Units *C.8 Localised repairs to the hexagonal units*	50	0	4.6	4.0	0.1	4.1	6.5

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Stepped Beams *D.3, D.4, D.6, D.7 Extensive repairs to slow deterioration*	50	0	1.1	0.5	0.3	0.8	1.2
Toe beam *E.3, E.7 Extensive repairs to slow deterioration*	50	0	25.2	5.5	9.5	14.9	23.9
Rock Armour *F.3 Patch and repair works utilising suitably sized rock armour where required*	100	0	10.0	3.8	1.6	5.4	8.7
Combined Option_1	50 to 100	0	71.6	24.7	21	45.6	72.9

Table 14 - Combined Options 2– Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Headwall *B.12 Full replacement of the fixed headwall.*	100	0	15.8	13.8	0.6	14.4	23.1
Hexagonal Units *C.4 Remove all hexagonal units and fill bays with insitu concrete revetment*	100	0	25.8	18.4	0.5	18.8	30.2
Stepped Beams *D.3, D.4, D.6, D.7 Extensive repairs to slow deterioration*	50	0	1.1	0.5	0.3	0.8	1.2
Toe Beam *[Included within Rock Armour F.5]*	-	-	-	-	-	-	-

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Rock Armour *F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam*	100	0	21.2	15.6	1.6	17.2	27.5
Combined Option_2	50 to 100	0	63.9	48.3	3.0	51.2	82.0

Table 15 - Combined Options 3– Short Listed Option cost summary

Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2022)	Present Value (PV)			
				Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m	£m	£m	£m
Headwall *B.12 Full replacement of the fixed headwall.*	100	0	15.8	13.8	0.6	14.4	23.1
Hexagonal Units *C.8 Localised repairs to the hexagonal units*	50	0	4.6	4.0	0.1	4.1	6.5
Stepped Beams *D.3, D.4, D.6, D.7 Extensive repairs to slow deterioration*	50	0	1.1	0.5	0.3	0.8	1.2
Toe Beam *[Included within Rock Armour F.5]*	-	-	-	-	-	-	-
Rock Armour *F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam*	100	0	21.2	15.6	1.6	17.2	27.5
Combined Option_3	50 to 100	0	42.7	33.9	2.6	36.5	58.3

6. Conclusions and Recommendations

The purpose of this Technical Memorandum was to summarise the options study progress to date and the next steps required to make a recommendation for a preferred option which could be implemented as part of the Scheme.

The options were defined through optioneering to identify an appropriate long list of potential options. Appraisal of the long list options was undertaken to define a draft proposed short list of options. Engagement with ELC through a workshop on Monday 12th September 2022 was undertaken to allow an opportunity to develop the options long list and present proposed short listed options.

Each long list option was assessed using a RAG (Red, Amber, Green) analysis against the same factors used within the Scheme. Appendix A provides this appraisal.

An initial development of the proposed short listed options was undertaken to allow a high level whole life cost for each option to be calculated. Further short listed option development, refinement of whole life cost estimates and final appraisal to identify the preferred option is to be undertaken.

A summary of the proposed short listed options for whole structure and combined options, description and whole life costs are summarised in Table 16.

Table 16 - Short Listed Option Summary – Whole Structure and Combined Options

Option	Description	Residual Life/ Design Life	Present Value Capital Works*	Present Value Total cost (PVc)*	Present Value Total cost with Optimism Bias (PV(OB)c)*
		Year	£m	£m	£m
Do Nothing	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.	10	0.0	0.0	0.0
Whole Structure A.2 Do Minimum	This option would consist of reactive patch and repair maintenance works, to the existing coastal defence assets, to prolong the life of the asset and meet Health & Safety legislation.	15	0.0	0.6	0.9
Whole Structure A.3 Complete removal of seaward face and replacement with rock revetment and new headwall	Remove headwall, hexagonal units, toe beam and lower rock revetment to the existing core and replace with new rock revetment and crown wall.	100	33.1	35.3	56.5
Whole Structure A.7 Whole structure rock revetment. Form new rock revetment over the existing structure with crest level to the top of the new headwall.	Form new rock revetment over the existing structure with crest level to the top of the headwall.	100	26.1	28.3	45.3

Option	Description	Residual Life/ Design Life	Present Value Capital Works*	Present Value Total cost (PVc)*	Present Value Total cost with Optimism Bias (PV(OB)c)*
		Year	£m	£m	£m
Combined Option_1	Headwall - B.3/ B.4/ B.6/ B.7 / B.8 Extensive repairs and measures to slow deterioration Hexagonal Units - C.8 Localised repairs to the hexagonal units Stepped Beams - D.3, D.4, D.6, D.7 Extensive repairs and measures to slow deterioration Toe beam - E.3, E.7 Extensive repairs and measures to slow deterioration Rock Armour -F.3 Patch and repair works utilising suitably sized rock armour where required	50 to 100	24.7	45.6	72.9
Combined Option_2	Headwall - B.12 Full replacement of the fixed headwall. Hexagonal Units - C.4 Remove all hexagonal units and fill bays with insitu concrete revetment Stepped Beams - D.3, D.4, D.6, D.7 Extensive repairs and measures to slow deterioration Toe beam – refurbishment of the toe beam included within Rock Armour F.5 enhancement works Rock Armour - F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam	50 to 100	48.3	51.2	82.0
Combined Option_3	Headwall - B.12 Full replacement of the fixed headwall. Hexagonal Units - C.8 Localised repairs to the hexagonal units Stepped Beams - D.3, D.4, D.6, D.7 Extensive repairs and measures to slow deterioration Toe beam – refurbishment of the toe beam included within Rock Armour F.5 enhancement works Rock Armour - F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam	50 to 100	33.9	36.5	58.3
** The base date for the costs is 2022.* ***Due to ongoing uncertainty with cost rates the estimates provided should be viewed with caution.***					

Table 16 presents a summary of present value cost rates, these are based on the current development of the options being considered and subject to confirmation as the design is developed.

6.1 Consultation

Further engagement with ELC through a meeting on Monday 3rd October 2022 was undertaken to allow an opportunity to review the Ash Lagoon Seawall progress to date and the short listed options. Through the appraisal process and the discussion with ELC the following two options have been considered favourable:

- **Whole Structure - A.7** Whole structure rock revetment. Form new rock revetment over the existing structure with crest level to the top of the new headwall.

  Total Q2 2022 Present Value Capital Cost (£26.1 million) + 60% Optimism Bias = £41.8 million

- **Combined Option_3:**

  - **Headwall** - B.12 Full replacement of the fixed headwall
  - **Hexagonal Units** - C.8 Localised repairs to the hexagonal units
  - **Stepped Beams -** D.3, D.4, D.6, D.7 Extensive repairs and measures to slow deterioration
  - **Toe beam** – refurbishment of the toe beam included within Rock Armour F.5 enhancement works
  - **Rock Armour -** F.5 Enhance rock armour to suitable size and form to protect from further scour and support toe beam

  Total Q2 2022 Present Value Capital Cost (£33.9 million) + 60% Optimism Bias = £54.2 million

6.2 Next steps

The next steps required to make a recommendation for a preferred option which could be implemented as part of the Scheme are outlined below:

- **Gap Analysis** - to establish where there are gaps in information, surveys and investigations that should be undertaken to inform the next stage of works. This could include topographical surveys, site investigations, non-destructive testing etc. These investigations will not be costed. The outcome of this section will be informed through reviewing the information supplied and the nature of the options that are to be taken forward. Specialists in materials (such as a concrete expert) and geotechnical engineering will be consulted to determine if further investigations should be carried out on the existing structure in order to progress the design.

- **Further Short Listed Option Development** – further consideration of the short listed options and combinations will be undertaken.

- **Preferred Solution Selection** - An options appraisal report will present proposed short listed options developed for the project, appraising their technical merit and buildability. Each option will have a high-level environmental appraisal. This will outline any environmental concerns and what licences or assessments will need to be carried out prior to constructing each solution. This will also inform any overlap or addition to the main flood scheme requirements. An Options Study report will be developed capturing the appraisal undertaken and Preferred Solution Selection.

7. References

Amey, 2015. Musselburgh– Ash Lagoons Seawall and Electric Bridge Survey 2014 - Rev 1 [Draft]

Amey, 2015. Musselburgh Seawall - Principal Inspection Report - Rev B

Amey, 2015. Musselburgh Seawall – Review of Survey Data and Assessment of Suitability of Cathodic Protection - Rev 2

CIRIA; CUR; CETMEF, 2007, The Rock Manual – The use of rock in hydraulic engineering, 2nd Edition, C683, CIRIA, London, UK

East Lothian Council, 2019, local development plan 2018 - Countryside and Coast Supplementary Planning Guidance, Available from: https://www.gov.scot/publications/east-lothian-council-planning-authority-core-documents/, Last Accessed: 25 July 2022

Environment Agency (2010) Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG)

Jacobs, 2019. Musselburgh Flood Protection Scheme: Preferred Scheme report. Document number MFPS-JEC-S3-XXX-XXX-RE-Z-0002 version 0.1. Prepared for East Lothian Council, November 2019.

Jacobs, 2022, Musselburgh Flood Protection Scheme - Sea Wall Inspection, Document Number 701909-JEC-S4-ZZZ-XXX-RE-S-0002 Revision1.0, January 11, 2022 For: East Lothian Council

Jacobs, 2022. Musselburgh Seawall Inspection 701909-JEC-S4-ZZZ-XXX-RE-S-0002 Rev 1.0

James Williamson and Partners (1963). Historical Photographs and drawings.

James Williamson and Partners. 1963, General Layout & Typical Cross Sections of Embankments, South of Scotland Electricity Board Cockenzie Generating Station, Drawing Number 35672c

Mott MacDonald, 1999, Cockenzie Sea Wall Assessment – Phase 2 Detailed Investigation and Testing, For Scottish Power, Document Number 54383/002

James Williamson and Partners. 1963, General Layout & Typical Cross Sections of Embankments, South of Scotland Electricity Board Cockenzie Generating Station, Drawing Number 35672c

SEPA. 2015, Flood Risk Management Strategy – Forth Estuary

SEPA. 2021, Flood Risk Management Plan – Forth Estuary Local Plan District

Appendix A - Ash Lagoons Seawall Options Study - Long List RAG Analysis

Appendix A - Musselburgh Flood Protection Scheme - Ash Lagoons Seawall Options Study - Long List RAG Analysis

REF	OPTION	Description	GRADI	ECONOMIC COMMENTS	GRADI	TECHNICAL COMMENTS	GRADI	ENVIRONMENT / ECOLOGY COMMENTS	GRADI	SOCIAL & STAKEHOLDER COMMENTS	GRADI	HEALTH & SAFETY COMMENTS	FLOODING GRADING	FLOODING COMMENTS	PROPOSAL	COMMENTS	OPPORTUNITY / MULTIPLE BENEFIT
A. Baseline/Whole Structure Options																	
A.1	Do nothing - see element specific 'Do Nothing' as baseline option also.	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.		No capital investment required, only costs required are for immediate health and safety concerns. Adhoc maintenance unpredictable and difficult for funding.		The deterioration of the structure would continue to increase in rate, exacerbated by the impacts of climate change		Deteriorating structure may pollute the sea. In addition the ash dumping pits protected by the current seawall would be exposed to pollute the sea and land under flood events.		Reduced levels of flood protection in Musselburgh. Amenity use of the ash lagoons and promenade would be lost over time if they are eroded during flood events. Loss of primary function to contain the ash deposits would be of concern to some stakeholders.		Would need to reduce access to structure as it deteriorates for public safety. Liquification of the ash lagoons due to water inundation would be a risk to safety.		Risk of flooding would increase and eventually be inevitable once breach has occurred.	CONSIDER	Taken forward as required baseline option	
A.2	Do minimum	This option would consist of reactive patch and repair maintenance works, to the existing coastal defence assets, to prolong the life of the asset and meet Health & Safety legislation.		No upfront capital cost associated with scheme delivery. Capital investment likely required in the medium term as it becomes less feasible to repair the structure.		May not be possible to undertake maintenance into the medium term due to structure deterioration.		Emergency repairs not likely to be the most sustainable solution, likely to lead to a more carbon heavy use of materials. Eventually (medium term) repair may not be feasible and failure may occur. When failure occurs the deteriorating structure may pollute the sea. In addition, the ash dumping pits protected by the current seawall would be exposed to pollute the sea and land in a flood event.		Reduced levels of flood protection in Musselburgh. Amenity use of the ash lagoons and promenade would be lost over time if they are eroded during flood events. Loss of primary function to contain the ash deposits would be of concern to some stakeholders.		Ongoing frequent intervention increases health and safety risks. Possible reduction of access provision in the medium term. Possible liquefaction of the ash lagoon due to water inundation would be a risk to safety.		Risk of breach if damage not repaired between successive storms. In medium term may be difficult to maintain and then risk similar to 'do nothing'.	CONSIDER	Continuation of asset management (required second baseline option)	
A.3	Complete removal of seaward face and replacement with rock revetment and new crown wall	Remove headwall, hexagonal units, toe beam and lower rock revetment to the existing core and replace with new rock revetment and crown wall.		Very high capital cost but with design life of the new structure in line with the flood defence scheme, very little maintenance required		Complete removal and replacement allows the design life of the structure to meet the design of the flood defence scheme. Armouring with rock provides significant wave energy dissipation offering a hard defence solution to the frontage. Compared to a concrete seawall this structure has the advantage of having a longer life and of reducing the wave reflection (also reducing toe erosion). The crown wall can increase the crest level to acceptable overtopping levels to reduce inundation for both flooding and environmental reasons. Due to increased dissipation, crest wall height may be able to be optimised compared to existing.		The disturbance to existing species within the vicinity is moderate from construction noise and duration. Full structural rock revetment will provide new possible habitat creation. High carbon cost with demolition of existing seaward face.		Would be seen to be providing proactive repairs and flood protection scheme/life. Longer construction period would mean reduced access to seawall. Area required for site compound. Option to increase amenity use of seawall, i.e. active travel route.		Main consideration is the structural integrity of the core bund during construction of the new face in the exposed wave conditions and inundation of the ash which could lead to liquefaction. Full designers risk assessment required to capture full health and safety comments from storage of materials, logistics for delivery access and restrictions of access to the area in construction, to the signage to prevent climbing on the rock armour and necessary demolition sequence.		Flood protection could be provided for full flood protection scheme life. Construction risk due to exposed core should there be significant storm events during the works.	CONSIDER	Expensive option, however would meet scheme objectives with low future capital cost and maintenance. Allows for incorporation of additional requirements [increased flood protection/ erosion protection / active travel routes and any further masterplan requirements to improve the landscape and amenity value of the frontage].	Works could be undertaken in conjunction with the creation of an active travel route.
A.4	Managed Realignment - Retreat	Remove existing defences, rock core bund and ash deposits and form a new defence line working with coastal processes allowing the sea to reclaim some of the ash lagoon.		Very high capital cost for demolition of existing structure and to ensure that removal of ash deposits does not contaminate the area or become airborne on removal. Relocation of the ash deposits expensive and will need new containment system. There may be an opportunity to re-use ash deposits as an embankment fill material, but this would require testing for suitability. PFA is used within road or other embankment construction and could reduce the requirement for ash re-disposal. Also opportunity to re-use materials from existing rock core bund.		Would need significant studies to understand the effect of abandoning defence. Medium to long term position of setback line would need considering.		Loss of environmental designations on the ash lagoons: potential impact on Firth of Forth SSSI, Firth of Forth SPA/ Ramsar Site and Potential Wildlife Site		Would be seen as not protecting the amenity value of the land, reducing the quality of life of local residents and removing the hard structural defence against flooding- unfavourable.		Ash deposits would require careful extraction prior to retreat as liquification of the ash lagoons due to water inundation would be a risk to safety. In addition, there is a risk of contamination. Excavation of ash creates significant dust risk requiring management.		This does not necessarily improve the flood risk of Musselburgh due to the unobstructed flood route.	REJECT	Due to magnitude of the temporary works required to realign the defences - this is not feasible.	Opportunity for the creation of wetland habitat from removing defence (although tempered by loss of amenity use).
A.5	Secondary defence line	Form a set back secondary defence line from primary defence line to ensure flood protection to scheme design life.		Depending on the line chosen High capital cost to ensure that removal of ash deposits does not contaminate the area or become airborne on removal.		Straightforward methods of construction on land, but preventing ash contamination in removal technically challenging. The solution does not rely upon the existing seawall for the design life of the scheme although in time the secondary defence may need to be adapted to dynamic coastal action. Dependent on nature of secondary defence adopted and method of construction, potential soft and compressible nature of ash may cause construction difficulties. Another alternative is to drive piles immediately behind the existing defence which would reduce the ash deposit volume that would need removing although the deterioration and abandoning of the sea defence could mean that the sheet pile defence would require adaption to coastal processes in the medium term.		Unsustainable use of materials, high carbon footprint solution. The disturbance to existing species within the vicinity is moderate from construction noise and duration. Potential impact on Firth of Forth SSSI / SPA		May be seen as wasteful due to the loss of coastline including the current promenade and cuts into amenity space.		Ash deposits would require careful extraction between the new and old containment structure as liquification of the ash lagoons due to water inundation would be a risk to safety. In addition, there is a risk of contamination. Excavation of ash creates significant dust risk requiring management. Existing seawall would fall into disrepair without ongoing maintenance.		Flood protection could be provided for full flood protection scheme life if the defence can be adapted for future coastal actions as the existing defence deteriorates,	REJECT	Not feasible due to containment requirement of the existing bund for the ash material or the likelihood the existing defence would need demolition at some point in the scheme life.	
A.6	Reclaim seaward of defence to form new defence line- Advance the line	Form a new defence line forward of the existing line, backfill to existing coastline.		Very high capital cost to construct whole new structure without reuse of existing core material and whinstone.		Investigation would be required on how this impacts the surrounding coastline would be required. Defence seaward of current position would likely be subject to more significant hydrodynamic conditions.		Unsustainable use of materials, high carbon footprint solution with high volume of backfill would be required. Loss of biodiversity on existing structure and foreshore in front of the defence. May be difficult to acquire consent. Potential impact on Firth of Forth SSSI / SPA		Would be seen to be providing proactive approach to flood protection and containment of ash. But may not be understood why the previous wall was not repaired. Would provide additional land which could have amenity use. Large site compound required.		Construction in difficult exposed and tidal marine conditions. To meet the design life the structure would need to assume that the migration of PFA fines would not occur in the short term and be adequate for containment.		Flood protection could be provided for full flood protection scheme life.	REJECT	Not feasible due to the increased footprint on the marine environment and further potential erosion protection measures required.	New land creation and opportunity to increase amenity use of area behind defence. Works could be undertaken in conjunction with the creation of an active travel route.

Appendix A - Musselburgh Flood Protection Scheme - Ash Lagoons Seawall Options Study - Long List RAG Analysis

REF	OPTION	Description	GRADI	ECONOMIC COMMENTS	GRADI	TECHNICAL COMMENTS	GRADI	ENVIRONMENT / ECOLOGY COMMENTS	GRADI	SOCIAL & STAKEHOLDER COMMENTS	GRADI	HEALTH & SAFETY COMMENTS	FLOODING GRADING	FLOODING COMMENTS	PROPOSAL	COMMENTS	OPPORTUNITY / MULTIPLE BENEFIT
A.7	Whole structure rock revetment	Form new rock revetment over the existing structure with crest level to the top of the existing headwall. New headwall.		Moderate to high capital cost depending on the availability to source and transport rock.		Armouring with rock provides significant wave energy dissipation offering a hard defence solution to the frontage. Compared to a concrete seawall this structure has the advantage of having a longer life and of reducing the wave reflection (also reducing toe erosion). The existing defences would still require remedial measures to prolong their life and ensure their stability, although the addition of rock after the remedial measures have been taken will reduce the exposure to environmental conditions and extend the life of these elements.		The disturbance to existing species within the vicinity is moderate from construction noise and duration. Rock is a sustainable material that be reused following the life of the structure.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound to store rock.		Laying geotextile should be easy to place to prevent the need for divers or operatives in the tidal zone. Installation may require large plant to place and transport the rock (dependent on size required). People may climb on rock when installed, trip and fall hazard.		Reduces risk of structural breach of the structure in a storm event. Rock increases structural roughness and as a consequence Overtopping compared with smooth surface so may reduce flood risk without increasing wall height.	CONSIDER	Would be a significant capital cost. Would increase flood protection due to material properties and extend the design life due to new headwall.	
A.8	Whole Structure open stone asphalt (OSA) Revetment	Form a new OSA revetment over the existing structure with repairs to the headwall.		Moderate capital cost		Open stone asphalt is a flexible revetment material constructed from crushed rock and asphalt in a mix that retains some porosity whilst providing a continuous revetment that is resistant to light and moderate wave attack. Residual design life is 25 years, however a revision of this is being considered as schemes have shown that this may be longer. Important that the correct mix is adopted and reliant on proprietor to ensure it is suitable. May be difficult to incorporate stepped beams without significant thickness of OSA		Opportunity for marine growth. Moderate disturbance to species during construction. Temporary adverse visual impact from new material. Risk of contamination when pouring bitumen.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall.		Bitumen based OSA is poured hot onto the surface during construction so ensure site staff are trained and have correct equipment. Operatives on the seaward side to guide the plant movements.		Reduces risk of structural breach of the structure in a storm event. Does not reduce flood risk due to the smooth surface of OSA and no change in crest height.	REJECT	May be difficult to incorporate stepped beams without significant thickness of OSA. May not be suitable for scheme design life or wave climate. Would also require works to headwall to provide flood protection	
A.9	Create Beach fronting existing structure	Create a new beach in front of the existing seawall along with the associated beach control structures		Very high capital costs. There would be a significant volume of sand. This would either need to be replaced frequently or held in place with groyne structures which could be made from rock or timber.		It would be possible to create a stable beach if the correct size and number of groynes are also installed. Beach maintenance will still likely be required periodically. A significant number of studies would be required to first model the hydrodynamic processes and then to design stable beaches. Also the risk of downdrift effects would need to be fully understood or it could impact the feed of material to the adjacent coastline (Fisherrow frontage). Beach may draw down significantly after storm meaning structure is again exposed. This beach can be corrected with maintenance recycling or nourishment regime. However, it would not fix areas were toe has started to be undermined and because of this some remedial works to the existing structure would still be advised		Difficult to source, covering a bigger footprint than structure impacting the intertidal habitat. Source of material issues/ large footprint may smoother existing marine biodiversity. Knock on effects to wider frontage would need to be understood.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound, to store material and a logistical plan of beach nourishment deliveries. Beach may provide amenity benefits (assuming access is created) which would be good for the local community.		If beach is provided public would likely try to access the beach and therefore adequate access would be required. If beach is drawn down during storm structure may be at risk of failure.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	REJECT	It may smother existing biodiversity. Would be difficult to maintain sufficient beach levels to ensure structure remains covered therefore impacting stability without providing significant beach control structures and ongoing import of beach material.. Introduction of new beach control structures likely to impact adjacent frontages, interrupt sediment supply.	There would be opportunities for increased amenity use of the foreshore area.
B. Headwall																	
B.1	Do nothing at headwall	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.		No capital investment required, only costs required are for immediate health and safety concerns. Adhoc maintenance unpredictable and difficult for funding.		Headwall damage currently includes cracks, spalling and delamination as well as reinforcement rusting. The deterioration of the structure would continue to increase in rate, exacerbated by the impacts of climate change.		If the wall was to breach, which is likely in the medium term, increased overtopping of the seawall would inundate the ash pits potentially leading to liquefaction. As the structure fails it may release pollutants and material into the protected areas. No disturbance to species initially but drastic impact once breach of the headwall occurs.		Reduced levels of flood protection in Musselburgh as structure deteriorates. Lack of action may not be seen favourably particularly to bird watchers using the area and for residents of Musselburgh as amenity use of the ash lagoons and promenade would be lost over time if they are eroded during flood events. Loss of primary function to contain the ash deposits would be of concern to some stakeholders.		Would need to reduce access to structure as it deteriorates, for public safety, by closing the gravel seawall path and potential evacuation if erosion causes the PFA to become airborne where it is a risk to human health. Liquification of the ash lagoons due to water inundation would also be a risk to safety.		Wall will continue to provide flood protection in the short term, as the wall continues to deteriorate the wall will fail and breach will occur.	CONSIDER	Taken forward as required baseline option	
B.2	Do minimum - General surface level repairs.	This option would consist of reactive patch and repair maintenance works to the existing headwall, to prolong the life of the asset.		Patchwork repairs are low capital cost with ongoing frequent maintenance required increasing in severity as structure life continues. Capital investment likely required in the medium term as it becomes less feasible to repair the structure. This failure of the headwall also depends on investment to the other aspects of the structure which support it.		Does not address lack of expansion joints and inadequate cover for the reinforcement (required for modern standards). Patch repairing is not usually adequate to stop further deterioration in the presence of chloride attack, patched areas caused "incipient anode effect" accelerating corrosion elsewhere. Patching is not considered an appropriate stand alone option as, due to structure deterioration, it may not be possible to undertake maintenance into the medium term.		Initially, save on increased carbon footprint particularly from low use of new materials low construction traffic and transport and little waste, and very low disturbance to wildlife which would occur from building a new structure and removing the existing structure concrete. Without frequent maintenance of the headwall as flood protection the PFA can liquify with overtopping or with inundation contaminate local residential areas which is a risk to human health. Maintenance would increase in frequency over time which would also increase disturbances from the associated works.		Minimal disruption during scheme construction period. Lack of more substantial/long-lasting action may not be seen favourably. Amenity use of the ash lagoons and promenade would be lost over time if they are eroded during flood events.		Access for the repairs may be an issue due to the steep revetment slope. One access path behind the seawall will accommodate construction access. Structure will continue to deteriorate, possibly leading to a reduction of access in the medium term, unless maintenance keeps pace with deterioration.		No additional flood protection. In medium term may be difficult to maintain and then risk similar to 'do nothing'.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.	

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B.3	Concrete repairs	This option would consist of proactive patch and repair maintenance works to the existing headwall		Low capital costs with ongoing Operation and Maintenance cost. Additional capital costs are likely in the future to achieve medium to long structure life.		No technical challenges to proactive repair work. Does not consider inadequate cover for the reinforcement, should be used in conjunction with a reinforcement protection option. Would not solve the reason for the deterioration noted in the condition report, i.e. lack of expansion joints.		The additional solution required in the medium to long term may have environmental implications. Concrete patch repair products are CE marked to BS EN 1540-3 which limits the ability to reduce the carbon footprint of the repair material.		Minimal disruption during construction of scheme.		Access for the repairs may be an issue due to the steep revetment slope. Protection from concrete alkaline burns ensuring trained workforce utilised.		No additional flood protection. Additional work required to maintain this in medium to long term.	CONSIDER	Should be used in conjunction with B.4, B.5, B.6, B.8, B.9	
B.4	Sacrificial anodes added to the structure [which should be undertaken in conjunction with concrete repairs in Option B.3].	This option would consist of providing protection against chloride attack with the use of sacrificial anodes, to prolong the life of the asset. The addition of anodes would be to control the incipient anode effect (provide protection from corrosion for areas adjacent to the repair)		Medium capital cost solution for longevity of the headwall, maintenance of the sacrificial anodes are important for the success of the option. Additional capital costs are likely in the future to achieve medium to long structure life.		May not be possible to achieve medium to long term design life. Sacrificial anodes tied to exposed reinforcement at the boundary of each concrete repair prevents the corrosion of the reinforcement within the concrete to prevent their further deterioration. Provides up to 15 years of protection.		Safeguarding the steel currently used within the structure, preventing its replacement reduces the carbon footprint of the project. Save on increased carbon footprint which would occur from deteriorated patchwork repairs in the short term and alternative solution being required. The additional solution required in the medium to long term may have environmental implications.		Minimal disruption during construction of scheme. Would be seen to be providing fairly low impact but proactive repairs.		Access to the front face would require installation of formwork to enable safe access.		Reduces risk of structural breach of the structure in a storm event. Additional work required to maintain this in medium to long term. Does not increase the standard of flood protection for flood defence.	CONSIDER	Would not provide increased level of flood protection. Success of solution is dependent on the success of other elements being refurbished successfully. Future capital would likely be required to achieve scheme design life.	
B.5	Protective system of Impressed Current Cathodic Protection (ICCP) [in conjunction with concrete repairs in Option B.3].	This would require the structure to be electrically continuous (which the reinforcement is not as it is split into panels)and localised patch repairs to be undertaken.		Very high capital cost and design life of approximately 30 years. Ongoing operational cost of energy which may continue to rise.		Concrete repair techniques similar to Option B.3. The panel reinforcement is not connected within the structure making the feasibility of the option reliant of the connection of reinforcement. The accessibility of a power source to the seawall is impractical and the volume of power that would be required is high. Even individual panels may not be electrically continuous and it may be difficult to determine.		This system would require an external power source to be continuously connected to the reinforcement and would require extensive repairs prior to installation. Detailed testing (destructive testing) would be required prior to installation that would also require repair.		Significant works would be required to create electrical continuity between segments causing disruption. Permanent cabling would be required to be connected from the reinforcement to the power source which would be visible to public may impact on rights of way.		Access to install the ICCP limited and logistically difficult. It is not considered feasible on the seaward face due to access.		Reduces risk of structural breach of the structure in a storm event. Additional work required to maintain this in long term. Does not increase the standard of flood protection for flood defence.	REJECT	Not considered feasible due to high associated costs of the installation due to the unlinked reinforcement along the 2.7km of seawall, as well as the permanent cabling required.	
B.6	Protective system of corrosion inhibitor [in conjunction with concrete repairs in Option B.3].	This option would involve concrete patch and repair where corrosion inhibitors are added to the structure. A corrosion inhibitor (a chemical solvent) can be added as an admixture to concrete patch repairs and on the remaining existing structure it will be applied on the hardened concrete.		Capital cost relatively low. Corrosion inhibiting application can significantly reduce maintenance costs		Initial trials would be required to determine the depth of penetration of the corrosion inhibitor to ensure the solution is suitable. Whilst corrosion inhibitors have been used since the 1950's, there is conflicting information regarding the effectiveness of corrosion inhibitors on chloride saturated concrete. Medium design life (depending on product chosen)		Corrosion inhibitors reduce the consumption of concrete within the design life of the structure, reducing the carbon footprint. The disturbance to existing species within the vicinity is relatively low and of short duration. Risk of chemicals being released into the environment during construction.		Would be seen to be providing proactive repairs and flood protection. Minimal disruption during construction of scheme.		One gravel path could be used for construction access, will require closure to public.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	CANT DECIDE YET	Additional trials will be required to determine the depth of penetration and suitability of option	
B.7	Electrochemical chloride extraction [in conjunction with concrete repairs in Option B.3].	This option would involve removal of chloride from the concrete. It would not address existing defects within the wall		Very high capital cost compared to other concrete protection systems		This technique is rarely used as it is time consuming and complex. It also does not prevent chlorides from re-entering the structure or address existing defects concrete repair techniques see option B.3.		No applicable comments		Would be seen to be providing proactive repairs and flood protection. Significant disruption during construction of scheme.		Works may be undertaken from the gravel path that would require the path to be closed during construction.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Not considered feasible due to high associated costs, time required for installation and complexity of option.	
B.8	Application of protective coating [in conjunction with concrete repairs in Option B.3].	This option would involve applying protective coating.		Moderate capital cost. Additional capital costs are likely in the future to achieve medium to long structure life.		Standard repair technique. Through application of a coating, moisture ingress through the structure would reduce until such a time that corrosion in unable to continue. The expected design life of this repair is 20 years.		No applicable comments		Would be seen to be providing proactive repairs and flood protection. Minimal construction period.		Access to apply the coating may be an issue due to the steep revetment slope.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	CONSIDER	This approach would require ongoing repairs to the structure.	
B.9	Removal of damaged wall aspects and repaired with spray concrete to existing top level	This option would involve concrete patch and repair.		Moderate capital cost with ongoing Operation and Maintenance cost.		This would require removal of defective concrete with removal depths to extend beyond the depth of the reinforcement. For areas at the top of the wall, this option would not be feasible and would be most appropriate for repairs beyond the depth of the reinforcement or for full thickness repairs. Galvanic anodes would be required within the repair area to avoid incipient anode effect. May not solve the reason for deterioration noted in the condition report i.e. lack of expansion joints		Concrete mixes may be developed to reduce the carbon footprint of placed concrete.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall.		Repairs to the seaward face of the wall would have limited access opportunities. Full depth repairs may be undertaken from the gravel path that would require the path to be closed during construction. Protection from concrete alkaline burns ensuring trained workforce utilised.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	CONSIDER	This approach would require ongoing repairs to the structure.	

Appendix A - Musselburgh Flood Protection Scheme - Ash Lagoons Seawall Options Study - Long List RAG Analysis

REF	OPTION	Description	GRADI	ECONOMIC COMMENTS	GRADI	TECHNICAL COMMENTS	GRADI	ENVIRONMENT / ECOLOGY COMMENTS	GRADI	SOCIAL & STAKEHOLDER COMMENTS	GRADI	HEALTH & SAFETY COMMENTS	FLOODING GRADING	FLOODING COMMENTS	PROPOSAL	COMMENTS	OPPORTUNITY / MULTIPLE BENEFIT
B.10	Remove top portion (500mm) of the headwall and replace.	The top 500mm of the parapet wall with large deterioration will be removed and will be replaced, the existing structure will undergo proactive maintenance and repairs to prolong the life of the asset.		Moderately high capital cost relative to the repair options. Maintenance of the existing structure and repairs will still be required.		Previous inspection report Amey (2015) noted the greatest number of defects are in the upper portion of the parapet wall. A reduction factor needs to be applied if the re-casting is to be taken forward to reflect the number of defects within this section of wall. Tying into previous wall might be challenging and may introduce weakness at joint. May not solve the reason for deterioration noted in the condition report i.e. lack of expansion joints.		Concrete pouring risk of contamination. Carbon cost of making concrete is high as well as the disposal of existing concrete. The disturbance to species in the are is moderate due to volume of construction noise and duration but likely justifiable for maintaining PFA containment.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound and reduced amenity use in the short term.		Comprehensive formwork needed to reduce health and safety risks. Site compound required. Protection from concrete alkaline burns ensuring trained workforce utilised.		Opportunity to increase seawall height, increasing flood protection, protecting flood defence for longer.	REJECT	Option does not address the expansion joint issue and high level of cost compared to other patch and repair approaches or complete replacement.	
B.11	Remove the damaged panels of the headwall and replace	Complete removal of damaged panels within headwall and proactive repair work.		Moderately high capital costs compared with full replacement. Reduced maintenance required although non-replaced panels will still require maintenance.		Removing some panels and then tying the new panels into the existing panel structures may be difficult. May not solve the reason for deterioration noted in the condition report i.e. lack of expansion joints.		Concrete pouring risk of contamination. Carbon cost of making concrete is high as well as the disposal of existing concrete. The disturbance to species in the area is moderate due to volume of construction noise and duration but likely justifiable for maintaining PFA containment.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Comprehensive formwork needed to reduce health and safety risks. Protection from concrete alkaline burns ensuring trained workforce utilised.		Protection against breach in weakest panels. But, without additional crest raising no additional flood protection will be provided.	REJECT	Option does not address the expansion joint issue and high level of cost compared to other patch and repair approaches or complete replacement.	
B.12	Full replacement of the fixed headwall.	Complete removal of the headwall and replacement.		High capital costs, low maintenance required.		Long design life. Need to analyse the wall height suitable for the design life.		Concrete pouring risk of contamination. Carbon cost of making concrete is high as well as the disposal of existing concrete. The disturbance to species in the area is high due to volume of construction noise and duration but likely justifiable for maintaining PFA containment.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound. Raised crest level visual impact. Option to increase amenity use of seawall, i.e. active travel route.		Comprehensive formwork needed to reduce health and safety risks. Protection from concrete alkaline burns ensuring trained workforce utilised.		Crest level can be raised to tolerable level for any determined level of protection, increasing flood protection.	CONSIDER	Highest capital cost, longest design life. Options to include changes to area behind for improved amenity use.	Works could be undertaken in conjunction with the creation of an active travel route.
B.13	In combination with another option, the installation of retro fit expansion joints	This would involve retrofitting of joints through saw-cutting to enable the structure to account for thermal cycles. This would prevent future cracking caused by restraint		Low capital cost (considering only installation of joints)		This option should also consider the simultaneous repair of existing defects. The repairs cannot be considered a permanent solution as the concrete will remain contaminated with chloride. Therefore, the design life will not be achievable.		Carbon cost of making concrete is high as well as the disposal of existing concrete.		Would be seen to be providing proactive repairs and flood protection. Medium construction period when compared to partial or full replacement options and would mean reduced access to seawall.		Joints may be installed from the gravel road however, access to the seaward face would be required to undertake repairs.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Reject due to potential to further damage the wall through the retrofitting of the joints - allowing further routes for chloride ingress and potential loss of strength in the reinforcement.	
C. Facing Blocks/Upper Revetment																	
C.1	Do nothing on facing slope at the upper revetment.	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.		No capital investment required, only costs required are for immediate health and safety concerns. Adhoc maintenance unpredictable and difficult for funding.		The deterioration of the structure would continue to increase in rate, exacerbated by the impacts of climate change. At the upper slope damage currently shows fairly sporadic defects, namely spalling, cracking and some surface voids with good interlock still present between units, the toe beam and the headwall. There is block displacement on panel 13 (whinstone underlayer visible). The panels adjacent to panel 13 - panels 11 and 12 - appear to have been replaced by a concrete surface revetment.		Emergency repairs not likely to be the most sustainable solutions, likely to lead to a more carbon heavy use of materials. Eventually (medium term) repair may not be feasible and failure may occur. Facing slope supports the seawall. Failure of the sloping face would inundate the rock core of the structure and the ash pits potentially leading to liquefaction. This is coupled with the lack of support for the headwall which will cause failure and greater overtopping. As the structure fails it may release pollutants and material into the protected areas. No disturbance to species initially but drastic impact once breach of the headwall occurs.		Reduced levels of flood protection as structure deteriorates in Musselburgh. Lack of action may not be seen favourably. Amenity use of the ash lagoons and promenade would be lost over time if they are eroded during flood events.		Would need to reduce access to structure as deteriorates for public safety. Ongoing frequent intervention increases health and safety risks. Possible reduction of access in the medium term. Liquefaction of the ash lagoon due to water inundation would be a risk to safety.		In the short term flood protection would be provided. Similar defects will continue and worsen. In the medium to long term: acceleration of deterioration, and acceleration of failure. Breach eventually inevitable.	CONSIDER	Taken forward as required baseline option	
C.2	Do minimum - Patch up works over existing hexagonal units	This option would consist of reactive patch and repair maintenance works, to the existing facing blocks, to prolong the life of the asset.		Low capital cost. Structure difficult to maintain without removal of the patchwork provided in this option, increasing costs of maintenance.		This approach only provides short term relief for the deteriorating structure which is difficult to address later in the structure's design life. It may not be possible to undertake maintenance into the medium term due to structure deterioration.		Concrete pouring risk of contamination. Carbon cost of making concrete is high as well as the disposal of existing concrete.		Minimal disruption during scheme construction period. Lack of more substantial/long-lasting action may not be seen favourably. Amenity use of the ash lagoons and promenade would be lost over time if they are eroded during flood events.		Structure will continue to deteriorate, unless maintenance keeps pace with deterioration. Concrete can be slippery it is important that public do not climb on the structure to fish etc.		In the short term flood protection would be retained In the medium to long term: risk of flooding is a consequence of the blocks failing and washout/scour of material putting wall above at risk.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.	
C.3	Remove displaced/ damaged hexagonal units and relay units which are repaired or replaced.	This option would consist of removing the displaced or damaged hexagonal units on the structure, ensure fill material is regraded, repair good condition units and replace damaged units before replacing them on the structure.		Relatively low cost. These revetments require on-going maintenance and may not address best the problem observed in panel 13 with blocks lifting therefore, a solution may still be required into the medium term considering the effects of climate change and the increased storminess.		In some locations, blocks have displaced exposing underlying material and this failure mechanism is likely to continue to be observed with increase storminess. The condition of the hexagonal units is fair but only limited displacement has been observed therefore, removing all blocks may be considerable work for little gain.		Limited scope for plant colonisation. Best use of materials from sustainability perspective.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Difficult to replace individual units, require skilled labour. Difficult access for plant to access construction of sloping face, long reach required. The hexagonal units can be slippery it is important that public do not climb on the structure to fish etc.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	H&S grounds - heavy units and access restrictions. Majority of the units are soundly in place if removed could unsettle/ reduce their existing integrity.	

Appendix A - Musselburgh Flood Protection Scheme - Ash Lagoons Seawall Options Study - Long List RAG Analysis

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C.4	Remove all hexagonal units and fill bays with insitu concrete revetment.	This option would consist of removing the hexagonal units on the structure, ensure fill material is regraded and cover the slope face in concrete layer.		Moderately high capital cost option, long residual life, maintenance will be required in the medium term.		The failure mechanism of the hexagonal units would need to be understood in order to understand if this is a suitable solution, however it has been implemented in two panels prior to 1999 and the condition of these could be used to validate the option. Concrete creates an erosion resistant barrier. However, wave reflection from this structure is high. It does not prevent the erosion of the foreshore. This option can increase overtopping potential in moderate wave environments. Rockfill (with likely void space) shown behind existing pre-cast hexagonal panels. In situ concrete pour would need to consider the interface with the fill behind it to avoid concrete migrating through fill.		Insitu concrete works within the SSSI and SPA. Reduced opportunities for plant colonisation. Low carbon concrete options may be considered.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Commonly used successfully and can be used in exposed environments. Protection from concrete alkaline burns ensuring trained workforce utilised. Concrete can be slippery it is important that public do not climb on the structure to fish etc. Protection from concrete alkaline burns ensuring trained workforce utilised.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	CONSIDER	Wave protection in moderate to high wave energy environments and would hold the line of the upper beach. Smoother surface finish may increase overtopping, does not offer any additional benefit other than encasing the existing structure - significant concrete usage. Has been adopted on panels 11 and 12 prior to 1999, no significant defects observed. Therefore, has been used at this site with some success although achieving scheme design life may be difficult without significant maintenance in the medium to long term.	
C.5	Cover the facing blocking with a concrete mattress layer	This option would consist of removing the hexagonal units on the structure, ensure fill material is regraded and cover the slope face in concrete mattress layer.		For long design life may need to consider replacing within life of scheme. High maintenance costs.		This type of revetment cannot be patched and fixed, so maintenance is more difficult.		Reduced opportunities for plant colonization. Low carbon options may be considered. Moderate disturbance to species during construction.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Installation requires relatively large, long-reach plant to install requiring good landside access. Protection from concrete alkaline burns ensuring trained workforce utilised. Concrete mattresses can be slippery it is important that public do not climb on the structure to fish etc.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	High cost, access restrictions for construction and maintenance difficulties	
C.6	Cover the facing blocking with an Open Stone Asphalt Layer	This option would consist of covering the face blocking with an Open Stone Asphalt Layer		Medium capital cost, long residual life and low maintenance requirement.		Open stone asphalt is a flexible revetment material constructed from crushed rock and asphalt in a mix that retains some porosity whilst providing a continuous revetment that is resistant to light and moderate wave attack. Residual design life is 25 years, however a revision of this is being considered as schemes have shown that this may be longer. Important that the correct mix is adopted and reliant on proprietor to ensure it is suitable. May be difficult to terminate at toe beam and most susceptible to failure at transitions or where material meets other structures.		Opportunity for marine growth. Moderate disturbance to species during construction. Temporary adverse visual impact from new material.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound. Visual impact improves as OSA discolours and marine growth occurs.		Bitumen based OSA is poured hot onto the surface ensure site staff are trained and have correct equipment. Operatives on the seaward side to guide the plant movements.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Not suitable in the short lengths required between the bookends, introduces weaknesses into the structure. May not be suitable for scheme design life or wave climate.	
C.7	Cover the facing blocks with sprayed concrete	This option would include spraying concrete a layer onto the facing blocks.		Low capital cost but likely to require long term maintenance. Longevity issues with solution.		Sprayed concrete is sprayed into place rather than using framework or pouring. The thickness can be varied to suit wave exposure but limited wave energy dissipation. Requires a concrete toe beam or sheet pile.		Insitu concrete works within the SSSI and SPA. Pollution risk from concrete in marine environment. Reduced opportunities for plant colonisation. Low carbon concrete options may be considered.		Would be seen to be providing proactive repairs and maintaining flood protection but frequent maintenance unlikely to be favoured. May be difficult to achieve a consistent finish.		Protection from concrete alkaline burns ensuring trained workforce utilised. Concrete can be slippery it is important that public do not climb on the structure to fish etc.		Reduces short term risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	May be difficult to get required thickness to ensure integrity of the concrete surface with existing blocks in place.	
C.8	Localised repairs to the hexagonal units	This option would consist of proactive inspection and repair of units depending on level of deterioration. Namely reinforcement exposure recovering.		Low capital cost. Periodic inspection and maintenance required but simple in nature. The ultimate design life continuation with this approach is limited.		The units are believed to be lightly reinforced, special attention should be made to any exposed reinforcement.		Effective use of materials in terms of carbon footprint, localised short term disturbance to species		Would be seen to be providing a low amount of repairs and maintaining flood protection.		Maybe difficult to access sloping face. Protection from concrete alkaline burns ensuring trained workforce utilised.		Increases structural longevity of the defence but no additional flood protection to flood defence.	CONSIDER	Condition assessment noted blocks are in generally fair condition. This could extend life of structure marginally and delay requirement for significant capital expenditure.	
C9	3D Printing of Revetment Blocks	Replace existing concrete revetment blocks with 3D printed alternatives		Not likely to be any cheaper than traditional precast concrete techniques.		Could be effective if concrete printing can match a typical marine specification but uncertain if a true concrete material or alternative could be used and whether there would be sufficient weight. Even if a marine spec is achievable. If blocks are 3D printed then the same failure mechanism may still be present. Wave environment likely to high unless a marine spec concrete or alternative can be printed.		Likely high carbon if concrete printing is possible. Could explore the use of more environmentally beneficial materials		Use of modern technology would give project prestige and a unique solution.		Difficult to replace individual units, require skilled labour. Difficult access for plant to access construction of sloping face, long reach required. The hexagonal units can be slippery. The required mass of the concrete or alternative would likely mean risk of muscularskeletal injury.		May not adequately reduce the risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Likely to be little benefit over more traditional forming techniques. Condition of blocks would mean there may be more benefit to more localised repairs. Wave climate likely too high if material is light.	
D. Upper Revetment/ Stepped Beams																	
D.1	Do nothing at stepped beams	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.		No capital investment required, only costs required are for immediate health and safety concerns. Adhoc maintenance unpredictable and difficult for funding.		At stepped beams damage currently includes defects and around the water line the steps have eroded or spalled to an extreme amount. The deterioration of the structure would continue to increase in rate, exacerbated by the impacts of climate change.		If the steps were to fail in the short term, this would increase the onset of the general failure of the upper revetment and the ash dumping pits protected by the current seawall would be exposed to pollute the sea and land in flood event.		Reduced levels of flood protection in Musselburgh as structure deteriorates. Lack of action may not be seen favourably.		Would need to reduce access to structure as it deteriorates for public safety. Deteriorating structure		In the medium to long term flood protection would be provided. Similar defects will continue and worsen. In the long term failure of vertical beams causing failure of upper panels.	CONSIDER	Taken forward as required baseline option	

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D.2	Do minimum- General surface level repairs	This option would consist of reactive patch and repair maintenance works to the existing stepped beams, to prolong the life.		Patchwork repairs are low capital cost with ongoing frequent maintenance required increasing in severity as structure life continues. This element failure also depends on investment to the other aspects of the structure.		Does not address inadequate cover for the reinforcement and lack of reinforcement in the protruding step element. Patch repairing is not usually adequate to stop further deterioration in the presence of chloride attack, patched areas caused "incipient anode effect" accelerating corrosion elsewhere. Patching is not considered an appropriate stand alone option.		If the steps were to fail in the short to medium term, this would increase the onset of the general failure of the upper revetment and the ash dumping pits protected by the current seawall would be exposed to pollute the sea and land in flood event.		Minimal disruption during scheme construction period.		Structure will continue to deteriorate, unless maintenance keeps pace with deterioration.		Does not increase the standard of flood protection for flood defence.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.	
D.3	Concrete repairs	This option would consist of proactive patch and repair maintenance works to the existing stepped beam		Low capital Cost with ongoing Operation and Maintenance cost.		No technical challenges to proactive repair work but would require frequent maintenance.		The additional solution required in the medium to long term may have environmental implications. Concrete patch repair products are CE marked to BS EN 1540-3 which limits the ability to reduce the carbon footprint of the repair material.		Little disruption during construction of scheme.		Access for the repairs may be an issue due to the steep revetment slope.		Additional work required to maintain this in medium to long term. Does not increase the standard of flood protection for flood defence.	CONSIDER	Would not provide increased level of flood protection, would likely require an additional capital expenditure in the medium term	
D.4	Extensive repairs to slow deterioration and add sacrificial anodes to the structure.	This option would provide protection against chloride attack of exposed reinforcement in vertical beam using sacrificial anodes, to prolong the life.		Medium capital cost solution for longevity of the stepped beam, maintenance of the sacrificial anodes are important for the success of the option. Additional capital costs are likely in the future to achieve medium to long structure life.		May not be possible to achieve medium to long term design life. Sacrificial anodes are tied to exposed reinforcement at the boundary of each concrete repair prevents the corrosion of the reinforcement within the concrete to prevent their further deterioration. Where repairs are not yet required, half-cell potential testing is undertaken to identify critical areas for future deterioration. Cylindrical anodes are attached to the reinforcement in these areas in a grid configuration. Provides up to 15 years of protection for the repaired areas but will not slow deterioration along the length of the structure.		Safeguarding the steel currently used within the structure, preventing its replacement reduces the carbon footprint of the project. Save on increased carbon footprint which would occur from deteriorated patchwork repairs in the short term and alternative solution being required. No provision for vegetation or colonisation within the structural repair solution.		Little disruption during construction of scheme. Would be seen to be providing proactive repairs.		Installation would require the reinforcement to be exposed which may not be feasible due to access. Access is difficult due to the steep revetment slope and tides combined.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	CONSIDER	Would not provide increased level of flood protection, would likely require an additional capital expenditure in the medium term	
D.5	Replace stepped beams	Replace stepped beams, which would include the need to remove hexagonal blocks and then reform vertical and replace.		Logistically and technically difficult therefore very high capital cost.		Not possible to remove the stepped beam without impacting the stability of the sloping face, could lead to catastrophic failure.		Risk of catastrophic failure means risk of contamination by PFA and environmental disaster.		Risk of catastrophic failure for only minor longevity gain will not be favourable.		Steps can cause allurement attracting public to sit and walk on them. The steps become slippery and hazardous unless regularly cleaned		If successful medium to long term the structural breach of the structure would be low. No additional flood protection is provided. If unsuccessful flood event could occur during construction due to structural failure.	REJECT	Not feasible due to the scale of disruptions, cost and difficulty of removing entire structure.	
D.6	Encase the stepped beam in mass concrete	Provide concrete cover to existing stepped beam.		Moderate to high capital cost compared with patch and repair option.		Interface with existing stepped beam and hexagonal units would be challenging and success of option would depend on these. Option may need to consider methods of slowing deterioration of stepped beam. Encasing the structure can only increase the design life of the structure up to a limit. This creates a short to medium term solution but one which is much harder to address in the long term. A significant depth of concrete may be required.		Concrete pouring risk of contamination. Carbon cost of making concrete is high as well as the disposal of existing concrete but low carbon mixes could be considered. The disturbance to species in the area is moderate due to volume of construction noise and duration.		Would be seen to be providing proactive repairs. Areas would be needed for a site compound and reduced amenity use in the short term.		Comprehensive formwork needed to reduce health and safety risks. Site compound required. Protection from concrete alkaline burns ensuring trained workforce utilised.		If successful medium to long term the structural breach of the structure would be low. No additional flood protection is provided.	CONSIDER	Corrosion may be expected to continue until such a time that oxygen is reduced at the surface of the reinforcement. To ensure reflective cracking does not occur within the overlay concrete, a significant thickness of concrete may be required.	
D.7	Apply waterproof coating to the stepped beam after repairs	In this option whichever option is used, a waterproof coating would be applied in order to slow down the corrosion process on the repairs.		Capital cost relatively low. Ongoing maintenance required however, waterproof coating application can significantly reduce maintenance costs.		Applying a waterproof coating after repairs can help to slow down chloride attack and increase the design life of the structure.		Moderate disturbance to species. May be possible to adapt coating to not disturb species i.e. pore blocking coating. A pore blocker coating is a waterproof coating that penetrates into the concrete to seal the micropores at the surface. There are coatings that are suitable for potable water that we could propose to ensure minimal environmental effects.		Fairly low impact.		Logistically difficult due to tidal conditions and access		Reduces risk of structural breach of the structure in a storm event. Stepped beam supports provides bookends to the upper revetment, so failure of beam increases failure of upper revetment which in turn could lead to failure of headwall. This option does not increase the standard of flood protection for flood defence.	CONSIDER	Enhances the maintenance free life of the structure. Similar applications to that intended here may not be common place so would need further appraisal.	
E. Toe Beam																	
E.1	Do nothing at toe beam	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.		No capital investment required, only costs required are for immediate health and safety concerns. Adhoc maintenance unpredictable and difficult for funding.		At the toe beam damage currently includes a rounding/weathering with cracks in joints between panels. In rare cases the reinforcement is exposed. The deterioration of the structure would continue to increase in rate, exacerbated by the impacts of climate change.		No provision for vegetation or colonisation. Failure of this toe beam would lead to successive failure of the structure leading to flood risk and potential pollution into the sea from ash pits. Break up of toe beam would also lead to an increase in building waste in front of the defence.		Reduced levels of flood protection in Musselburgh as structure deteriorates. Lack of action may not be seen favourably.		Difficult to access in intertidal range.		In the short term flood protection would be provided via support to the upper revetment elements. Similar defects will continue and worsen. In the medium to long term: reduced support to upper defence elements.	CONSIDER	Taken forward as required baseline option	
E.2	Do minimum - General surface level repairs	This option would consist of reactive patch and repair maintenance works to the existing toe beam, to prolong the life.		Patchwork repairs are low capital cost with ongoing frequent maintenance required increasing in severity as structure life continues. This element failure also depends on investment to the other aspects of the structure.		Does not address inadequate cover for the reinforcement. Patch repairing is not usually adequate to stop further deterioration in the presence of chloride attack, patched areas caused "incipient anode effect" accelerating corrosion elsewhere. Patching is not considered an appropriate stand alone option.		No provision for vegetation or colonisation.		Minimal disruption during scheme construction period.		Difficult to access in intertidal range. Structure will continue to deteriorate, unless maintenance keeps pace with deterioration.		In the short term flood protection would be provided. Similar defects will continue and worsen. In the medium to long term: reduced support to upper defence elements.	REJECT	Surface level repairs are unlikely to be sufficient in the medium to long term at which point another option of damage repair will be required.	
E.3	Extensive repairs to slow deterioration and add sacrificial anodes to the structure.	This option would consist of proactive patch and repair maintenance works to the existing toe beam and provide protection against chloride attack of exposed reinforcement using sacrificial anodes, to prolong the life.		Medium capital cost solution for longevity of the toe beam, maintenance of the sacrificial anodes are important for the success of the option.		No technical challenges to proactive repair work. May not be possible to achieve medium to long term design life. Sacrificial anodes are tied to exposed reinforcement at the boundary of each concrete repair prevents the corrosion of the reinforcement within the concrete to prevent their further deterioration. Provides up to 15 years of protection.		Safeguarding the steel currently used within the structure, preventing its replacement reduces the carbon footprint of the project. Save on increased carbon footprint which would occur from deteriorated patchwork repairs in the short term and alternative solution being required. No provision for vegetation or colonisation within the structural repair solution.		Little disruption during construction of scheme. Would be seen to be providing proactive repairs and maintaining flood protection.		Difficult to access in intertidal range.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	CONSIDER	Repairs to toe beam need to ensure stability to the revetment above.	

Appendix A - Musselburgh Flood Protection Scheme - Ash Lagoons Seawall Options Study - Long List RAG Analysis

REF	OPTION	Description	GRADI	ECONOMIC COMMENTS	GRADI	TECHNICAL COMMENTS	GRADI	ENVIRONMENT / ECOLOGY COMMENTS	GRADI	SOCIAL & STAKEHOLDER COMMENTS	GRADI	HEALTH & SAFETY COMMENTS	FLOODING GRADING	FLOODING COMMENTS	PROPOSAL	COMMENTS	OPPORTUNITY / MULTIPLE BENEFIT
E.4	Replace toe beam with Rock Toe	In this option the existing toe beam would be removed and replaced with a rock toe, where the armour is sized to stabilise the upper slope and against hydraulic action.		Medium capital cost option, additional rock and fill refurbishment of lower revetment (dependent on rock availability). Periodic maintenance required. Minimum ongoing intervention expected		Would likely require the full refurbishment of the lower revetment to design standards. Existing revetment facing would be at risk of sliding/failure on removal of the toe beam as it is designed to be supported by the toe beam. May need to remove and replace concrete revetment to ensure good placement.		Moderate disturbance to species. Rock can provide habitat but already in place so no additional benefit from this.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Placement of rock is generally straightforward but in this case there may be challenged with the upper revetment. Suitable plant would be required. Demolition of the toe beam could cause failure of other structural elements including collapse of upper revetment.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Extensive temporary works required to support hexagonal units, H&S issues with structural integrity of the remaining structure while works ongoing.	
E.5	Replace toe beam with gabion mattress	In this option the existing toe beam would be removed and replaced with a gabion mattress, with the function to stabilise the upper slope against hydraulic action.		Overall low to medium capital cost option. Periodic maintenance required.		A cage or box filled with rocks or concrete. Used as erosion protection in low to moderate wave environments and as retaining walls. Limited design life, not feasible in high wave energy environments Gabions are permeable due to the voids between the rock fill and may require suitable geotextile to retain and prevent washout of material beneath and behind which could be prone to puncture on placement. Interlock with revetment facing blocks and lower rock revetment could be an issue.		Moderate disturbance to species. Gabions can provide habitat but no additional benefit due to rock already in place.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Placement of gabions are straightforward, suitable plant would be required. Demolition of the toe beam could cause failure of other structural elements including collapse of upper revetment. Placement of gabions would be difficult as they normally require some kind of manual input to place rock, lace baskets together etc, which may be difficult in the intertidal zone due to time constraints.		Reduces risk of structural breach of the structure in a storm event. Toe beam supports the upper revetment, so failure of toe beam increases failure of upper revetment which in turn could lead to failure of headwall. This option does not increase the standard of flood protection for flood defence.	REJECT	Extensive temporary works required to support hexagonal units, H&S issues with structural integrity of the remaining structure while works ongoing. Design life of gabions may not achieve scheme objectives.	
E.6	Replace Toe Beam with Grouted Rock Toe	In this option the existing toe beam would be removed and replaced with a grouted rock toe, with the function stabilise the upper slope and against hydraulic action.		Overall low capital cost option. Where the availability of rock is low, and therefore expensive, its more economical to use a grouted rock toe where the size of material needed is lower. Periodic maintenance required.		The stability of loose granular materials (gravel or crushed stone) or open blockwork elements in new or existing rock structures can be improved by grouting. The grouting binds smaller grains, stones and elements together. Stone or element sizes may therefore be reduced, making more economic use of available granular materials. This option can be applied to withstand large hydraulic loadings in situations where the vertical construction space is too small for placing larger armourstone or in situations where armourstone or rip-rap of the mass required for stability is not available. Due to voids in the existing rock and gravity a significant quantity of grout may be required before it will set around toe beam area.		No provision for vegetation or colonisation. Moderate disturbance to species. Risk of contamination when pouring grout or bitumen		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Careful control procedures are needed during construction.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Extensive temporary works required to support hexagonal units, H&S issues with structural integrity of the remaining structure while works ongoing.	
E.7	Apply waterproof coating to the toe beam after repairs	In this option whichever option is used, a waterproof coating would be applied in order to slow down the corrosion process on the repairs.		Capital cost relatively low. Ongoing maintenance required however, waterproof coating application can significantly reduce maintenance costs.		Applying a waterproof coating after repairs can help to slow down chloride attack and increase the design life of the structure.		Moderate disturbance to species. May be possible to adapt coating to not disturb species i.e. pore blocking coating. A pore blocker coating is a waterproof coating that penetrates into the concrete to seal the micropores at the surface. There are coatings that are suitable for potable water that we could propose to ensure minimal environmental effects.		Fairly low impact.		Logistically difficult due to tidal conditions and access		Reduces risk of structural breach of the structure in a storm event. Toe beam supports the upper revetment, so failure of toe beam increases failure of upper revetment which in turn could lead to failure of headwall. This option does not increase the standard of flood protection for flood defence.	CONSIDER	Enhances the maintenance free life of the structure. Similar applications to that intended here may not be common place so would need further appraisal.	
E.8	Overlay the existing toe beam with mass concrete	In this option, the toe beam is covered with mass concrete and the existing toe beam is encased		Low capital cost option with limited design life. Periodic but complex maintenance may be required.		Encasing the structure can only increase the design life of the structure up to a limit. This creates a short to medium term solution but one which is much harder to address in the long term.		Concrete pouring risk of contamination. Carbon cost of making concrete is high as well as the disposal of existing concrete. The disturbance to species in the are is low.		Visually may not look uniform and draw criticism.		Logistically difficult due to tidal conditions and access		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for flood defence.	REJECT	Access issues and ongoing complicated maintenance.	
F. Rock Armour/ Lower Revetment																	
F.1	Do nothing at lower revetment rock armour	No repairs or maintenance will be undertaken. Only immediate health and safety critical works.		No capital investment required, only costs required are for immediate health and safety concerns. Adhoc maintenance unpredictable and difficult for funding.		The deterioration of the structure would continue to increase in rate, exacerbated by the impacts of climate change. At the lower revetment damage currently includes large stones missing from gradings and toe beam exposed. The condition is generally poor, and patchwork repairs are evident already with concrete having been used to stabilise the rock with limited success.		Rock has some environmental benefits and can provide habitat for species and would could continue to do so even with no active intervention. Failure of this rock armour would lead to successive failure of the toe beam and subsequent structure leading to flood risk and potential contamination from ash pits.		Support for the upper elements would continue in the short term but further loss of the rock revetment will lead to reduced stability for the upper revetment sections. Therefore, lack of action may not be seen favourably.		Would need to reduce access to structure as deteriorates for public safety.		In the short term, the toe beam has significantly reduced support- risking localised collapse. Similar defects will continue and worsen, accelerating with scour of further material. In the medium term: acceleration of damage due to increase in storminess/climate change. Failure of the lower revetment could lead to failure of the undermined toe beam and therefore failure of the upper revetment and headwall. It is the failure of this lower revetment, causing failure of elements above that risks the flood protection.	CONSIDER	Taken forward as required baseline option	
F.2	Do minimum- reactive maintenance, moving the rock armour back to the toe beam.	This option would consist of reactive patch and repair maintenance works to the existing lower revetment armour, to prolong the life of the toe beam from scour.		Low capital cost re-using existing materials. High cost of maintenance work from mobilised rock and repetition of this solution.		Maintenance of the structure will need to keep up with deterioration otherwise approach ineffective. It is likely that the structure lower revetment will fail in the same way again as the rock sizing does not seem adequate for stability in the wave conditions. May not be adequate quantities of rock on site to rebuild lower revetment.		Rock can provide habitat to species but no improvement to the existing provisions. Minimal disruption to species in construction. Low carbon footprint.		Little disruption during construction of scheme.		Placement of rock is straightforward, suitable plant would be required.		No additional flood protection to Musselburgh. Short term structural breach risk removed. Only delays onset of 'Do nothing'.	REJECT	With no import of material there is no benefit in moving material. Will not halt ongoing undercutting.	

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F.3	Patch and repair works utilising suitably sized rock armour where required	This option would consist of proactive patch and repair maintenance works to the lower revetment utilising appropriate rock sizing for stability within the design life.		Moderately high capital cost compared to utilising existing rock due to source and transport of new materials. Likely ongoing maintenance cost as further deterioration of the rock continues.		Larger rock grading and thickness may be implemented for the structure design life. Unrepaired or replaced rock would likely not achieve scheme design life/standard of protection.		Rock can provide habitat to species but no improvement to the existing provisions. Minimal disruption to species in construction. Low carbon footprint.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Site compound required to store rock. Can be installed relatively easily. Placement of rock is straightforward, suitable plant would be required.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	CONSIDER	Broadly in keeping with what is there already.	
F.4	Patch and repair by concrete cover to stabilise rock armour	This option consists of moving rock which had moved from the toe beam and then applying concrete to secure all rock armour.		Patchwork repairs are low capital cost with ongoing frequent maintenance required increasing in severity as structure life continues. This element failure also depends on investment to the other aspects of the structure.		Repairs are unlikely to last into the medium term. Potential for greater displacement if undermining continues as failure would be in a block rather than individual rock displacements.		The disturbance to existing species within the vicinity is relatively low and of moderate duration. Concrete has a high carbon footprint cost. Where rock is secured with concrete some biodiversity may be lost.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound. Visually obtrusive.		Straightforward installation. Protection from concrete alkaline burns ensuring trained workforce utilised.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	REJECT	Unfeasible due to technical and environmental reasoning	
F.5	Enhance rock armour to suitable size and form to protect from further scour and support toe beam	This option involves enhancing the current armour, filling any voids and sizing and sourcing (or reusing) rock armour of a suitable size for its stability at the toe beam.		Moderate to high capital cost depending on rock source but cheaper than full revetment, periodic maintenance thereafter.		Reinstating rock at the toe of the structure of suitable sizing for a defined design period, extends the longevity of the structure. Try to reuse rock where possible within the grading or as underlayer. Rock revetment could move seaward of existing defence line and provide additional protection to toe beam. Could be adapted in future to whole structure rock revetment.		The disturbance to existing species within the vicinity is relatively low and of moderate duration. Rock has some environmental benefits and can provide habitat for species but this is not additional to the existing rock.		Would be seen to be providing proactive repairs and flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Site compound required to store rock. Placement of rock is generally straightforward but ensuring voids are filled may be challenging; suitable plant would be required. May be difficult to ensure good interlock with new rock and existing toe beam reducing stability and risk of rocks moving or becoming displaced.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	CONSIDER	Rock could be sized to achieve the scheme design life and standard of protection. Rock is a sustainable material that could be reused as part of a future solution or could be adapted or added to form a whole structure rock revetment. Ensuring existing voids are filled may be difficult.	
F.6	Remove and replace rock armour, the new lower slope revetment could consist of OSA/concrete lower revetment.	This option involves removing any remaining armour and then, sizing and sourcing OSA or concrete of a suitable size for its stability at the toe beam		Moderate capital cost depending on source of materials, periodic maintenance thereafter.		No support to the toe beam during construction and may not provide support to upper revetment. The existing revetment toe is below MLWS which would make pouring of OSA difficult and perhaps not feasible.		The disturbance to existing species within the vicinity is moderate with moderate duration. Any species that have colonised lower rock would be effected.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Technically challenging to retrofit revetment below toe beam. Could risk collapse of upper elements. Parts of structure are submerged at low water and may make installation of OSA challenging in intertidal zone increasing risk to operatives.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	REJECT	OSA only suitable in low to moderate wave climates and difficult to justify scheme design life. Difficult to remove the rock armour and replace lower revetment with OSA or concrete. Would likely need to be a whole structure solution to adopt these materials.	
F.7	Replacement with vertical toe (sheet piles)	This option involves removing any remaining armour or piling through armour and core and then sheet piling a toe		Capital cost of sheet piling can be expensive, depends on source of materials, periodic maintenance thereafter.		Difficult to pile through rock. The toe beam is higher than the ground level, in order to install the sheet piles the rock would likely need to be removed which will be difficult due to embedment as well as part of the core which will impact whole structure stability. An anchored sheet pile requires half of the length of the pile below existing ground level which is considerably large making the structure expensive.		The disturbance to existing species within the vicinity is moderate from construction noise and duration.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound.		Difficult installation due to lower rock revetment and length of sheet piling required.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	REJECT	Unfeasible due to the difficulties in access, noise and increase in the potential scouring processes against a vertical toe.	
F.8	Create Beach fronting existing structure	Create a new beach in front of the existing seawall along with the associated beach control structures		Very high capital costs. There would be a significant volume of sand. This would either need to be replaced frequently or held in place with groyne structures which could be made from rock or timber.		It would be possible to create a stable beach if the correct size and number of groynes are also installed. Beach maintenance will still likely be required periodically. A significant number of studies would be required to first model the hydrodynamic processes and then to design stable beaches. Also the risk of downdrift effects would need to be fully understood or it could impact the feed of material to the adjacent coastline (Fisherrow frontage). Beach may draw down significantly after storm meaning structure is again exposed. This beach can be corrected with maintenance recycling or nourishment regime. However, it would not fix areas were toe has started to be undermined and because of this some remedial works to the existing structure would still be advised		Difficult to source, covering a bigger footprint than structure impacting the intertidal habitat. Source of material issues/ large footprint may smoother existing marine biodiversity. Knock on effects to wider frontage would need to be understood.		Would be seen to be providing proactive repairs and maintaining flood protection. Longer construction period would mean reduced access to seawall. Areas would be needed for a site compound, to store material and a logistical plan of beach nourishment deliveries. Beach may provide amenity benefits (assuming access is created) which would be good for the local community.		If beach is provided public would likely try to access the beach and therefore adequate access would be required. If beach is drawn down during storm structure may be at risk of failure.		Reduces risk of structural breach of the structure in a storm event. Does not increase the standard of flood protection for Musselburgh.	REJECT	It may smother existing biodiversity. Would be difficult to maintain sufficient beach levels to ensure structure remains covered therefore impacting stability without providing significant beach control structures. Introduction of new beach control structures likely to impact adjacent frontages, interrupt sediment supply.	There would be opportunities for increased amenity use of the foreshore area.

S4 Timeline of Outline Design

Appendix D

Musselburgh Flood Protection

Evolve design in consultation

Evolve design in consultation

Jacobs evolve the Outline Design as per their contract under Project Board Authority. The final decision on the Outline Design will be taken by Council at a later date.

2022

Summer 2021
Post Covid Consultation Restart

Following a break caused by covid restrictions, public consultations restart as locals are consulted on opportunities and risks, shown various types of flood defences and asked to provide their priorities for the design and preferences for bridge replacements.

August 2022
Full Council Meeting

The Project Team presents their report on the previous consultations and seeks approval to incorporate the Sea Wall into the Preferred Scheme and revise the Scheme's model. The team commits to returning with an updated estimate, a public timeline and a plan for consultation and communication during Stage 4.

October 2022
Full Council Meeting

The Project Team presents on the flood risk to Musselburgh, the options for flood protection at the Sea Wall as well as the communications and consultation plan for Stage 4. A new Scheme estimate is presented and permission to proceed is sought.

2023

June 2023
Public Exhibition

A major public consultation event is held to present the initial Outline Design to a wide audience and gather their feedback. The Project Team collects these inputs and compiles a report, work begins to revise the Outline Design based on the feedback collected.

Consultation
The specific approach to consultation is set out in our Stage 4 Consultation Plan which will be available via our website following Council approval.

2024

January 2024
Full Council Meeting

The Project Team presents the finalised Outline Design to Council and seeks approval to advance to Stage 5 when the Proposed Scheme will be published.

Projection based on best information - October 2022

East Lothian Council | CPE Consultancy | Jacobs | Turner & Townsend

October 2022

Report

Strategic Communications Plan

Musselburgh Flood Protection Scheme

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Musselburgh
Flood Protection

Contents

1 Document Information

1.1 Preparation

ACTION	NAME	DATE
Prepared By	Gregor Moodie	05/10/2022
Reviewed By	Rachael Warrington	11/10/2022
Reviewed By	Conor Price	14/10/2022

1.2 Configuration Management

ISSUE STATUS	REVISION	DATE
Draft	Revs 0.1 – 0.6	05/10/2022 – 14/10/2022
For Issue	Rev 1.0	14/10/2022

2 Introduction

2.1 General

The Musselburgh Flood Protection Scheme (the Scheme) is being progressed by East Lothian Council to reduce the very significant levels of flood risk to the town of Musselburgh.

This project is being managed under the PRINCE2 Project Management System. This report is therefore further to the detail provided on the project's approach to communications in the Project Brief. This document is a separate, stand-alone, report and supersedes that reports: the detail contained within this report defines the project approach to communications for the Scheme.

The following text from the Project Brief is reproduced for ease of reference only:

The project will be required to interface with many external individuals and organisations through its whole life-cycle. The main criteria for interface will be:

1. *Scheme establishment and collection of available external information;*
2. *Consultation on the Scheme design;*
3. *Consultation on the Statutory Approvals Processes; and*
4. *Consultation on Scheme delivery (i.e. construction).*

These interfaces will require to be considered alongside the requirements to engage with the Project Users (as highlighted in Section 7 of this report) and in some instances there will be an overlap. There will however be many more consultation interfaces compared with Project Users.

The following interfaces are listed such that they can be further considered within the Business Case, Stakeholder Management Plan and Communications Plan:

1. *The Scottish Government – Flood Protection and Planning Teams;*
2. *SEPA (Scottish Environment Protection Agency) – many sections;*
3. *SNH (Scottish Natural Heritage);*
4. *Historic Environment Scotland;*
5. *Transport Scotland;*
6. *All appropriate locally elected officials from Musselburgh and East Lothian Council;*
7. *The appropriate Musselburgh area Community Councils and the Local Area Partnership;*
8. *The appropriate Housing Associations in the Musselburgh area;*
9. *All relevant public utility providers (i.e. Scottish Water (Water and Wastewater), Scottish Gas Networks (SGN), Scottish Power and Energy Services (SPEN), British Telecom (BT), ELC Street Lighting, cable providers etc.);*
10. *All appropriate ELC Sections and Officers to ensure ELC discharges all of its statutory responsibilities e.g. Planning, Tree Protection, Environmental Protection, Adopted Road Network, Core Path Network etc.*
11. *The Musselburgh business community in general and many businesses individually;*
12. *Many organisations in Musselburgh;*
13. *The schools in Musselburgh;*
14. *The people of Musselburgh.*

The Project Team have so far been developing the Scheme through a consultative framework, and over the years since the project's inception have met with many individuals to get their views on what is important for the Scheme. These individuals include local residents, statutory stakeholders, landowners, and business owners. This engagement has been invaluable in helping to shape the Scheme thus far and the Project Team are eager to continue building upon the relationships established and the momentum within the town as the Scheme develops.

The Project Team have been advancing their approach to communications under the oversight and direction of the Project Board since 2016. In spring 2021 the Project Board recognised the changed external landscape (relating to ability to consult) in existence at that point in time due to the COVID-19 Pandemic, and requested that the Project Team develop a Strategic Communications Plan. The Strategic Communications Plan that emerged from this instruction has developed into this plan. At the highest levels it is worth noting that this involved the acceleration of intended major communication activities from their use at the construction stages of this project, to this earlier design stage. This resulted in a significant increase in the workload obligations of the Project Team within Project Stage 4 (the Outline Design) with the resultant increases in stage cost and project team resource requirement. The Strategic Communications Plan was primarily intended to establish the architecture for a communications plan that was reactive and capable to continuing to evolve as appropriate within the context of the pandemic and desire from the community. It was to coordinate between other plans such at the Stakeholder Management Plan and also the many communication tools that were already being used, to some extent, by the team.

The key Communication tools are:

1. The development of a Scheme Logo and Brand;
2. A stand-alone Scheme Website;
3. A Scheme Newsletter;
4. The establishment of Local Area Consultation Groups;
5. A process for holding digital public meetings;
6. Public Information Boards across the town;
7. A Stakeholder Email database for update emails;
8. Processes for the publication of information to the local papers; and
9. The design of Scheme ‘Infographics’ for capturing the essence of key aspects of the project.

This list is not considered to be exhaustive, and it is assumed that new communication tools will be identified and developed as the project advances.

This Strategic Communication Plan is to be regarded as a ‘live’ document and as such will be updated as necessary at appropriate points during the project duration.

2.2 Definitions

Communication means the exchange of all project information, both formal and informal and may include (but is not restricted to) letters, e-mails, press releases, telephone / conference calls, or face-to-face meeting, use of social media, public exhibitions, etc.

2.3 Objectives

The objectives of this plan are:

- To define the project's approach to communication;
- To manage the individual communication plans for individual communication tools of the Strategic Communications Plan;
- To provide an overarching strategic approach to management of all aspects of the Scheme's approach to communication;
- To provide connectivity between the different Scheme requirements of communication, consultation and stakeholder management;
- To facilitate engagement with stakeholders at all levels throughout the project lifecycle;
- To aspire to achieving appropriate transfer of information to those who need to know - to keep them up to date with project progress; and
- To establish processes for receipt of communications from the public, including the processes of response.

2.4 Target Audience

The Scheme is being advanced to deliver flood risk reduction to the town of Musselburgh from flood events that could derive from the Firth of Forth (i.e. the sea), the River Esk or the Pinkie Burn. It is currently estimated that there are in the order of 2,900 properties at risk of flooding in Musselburgh. This includes almost the whole of the town centre, all of the Eskmills Business Park area, and many critical infrastructural assets including all road bridges in the town and the wastewater and gas distribution networks.

It may therefore be reasonably identified that flood risk affects the whole of Musselburgh, either directly or indirectly. The Scheme is therefore likely to be of interest to everyone in the town, including both those who reside there and those who use the town for business, shopping or school etc.

The Scheme is being advanced under the Flood Risk Management (Scotland) Act 2009, and it must also take into consideration many other pieces of legislation. The Scheme will require an Environmental Impact Assessment. The Scheme is therefore to be of interest to many regulatory organisations.

Any construction project that delivers new flood defences in the town of Musselburgh is likely to interface with the existing built environment of what is a historic town. This will include the existing road and foot bridges, the road network itself, the street-lights, the public utilities such as water, sewer, telecoms, power etc. The Scheme is therefore to be of interest to those who manage these public assets on behalf of the state.

The following key categories of interested parties are identified to broadly group the possible interested parties:

1. The Elected Representatives for the area;
2. The town's Community Council;
3. The Statutory / Regulatory Organisations;

4. The many officers within East Lothian Council who hold have responsibilities for the management of assets and services in Musselburgh (e.g. Education, Housing, Planning, Roads, Waste, Street-Lighting, Flood Protection etc.);

5. Local businesses and users of those businesses;

6. The schools and the pupils at those schools;

7. Community groups;

8. The owners and residents of property in Musselburgh;

9. Those who use the town's services, and / or its environment;

10. Members of the general pub with an interest in flood protection, including those in proximity to Musselburgh who rely on the critical infrastructure in Musselburgh (or which passes through).

2.5 Project Governance

This project is being advanced under the PRINCE2 Project Management System so that East Lothian Council can apply a clear, logical, step-by-step process for advancing the project.

The project sits under the authority of a Project Board made up of senior representatives from across East Lothian Council with delegated decision-making authority from Council.

The specific management of communication activities is to be managed by a project 'Communications Working Group' further to instruction from the Scheme's Project Board.

3 Context

This document is one of a suite that define: the overall approach to communications in the project (Communications Plan); a matrix of stakeholders and communications methods to be used (Strategic Communications Matrix); an analysis of Stakeholders (Stakeholder Management Plan); and the approach to consultation in Stage 4 Outline Design (Stage 4 Outline Design Consultation Plan).

This document should be read and understood in conjunction with these other productions which can be provided to you by the Project Management Team.

4 The Strategic Communications Tools

4.1 Scheme Logo and Brand

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a unique project logo and brand. This logo will then be available for use thereafter for the rest of the project duration, and the use of the brand will allow for consistency of presentation.

4.2 Scheme Website

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops, and thereafter manages a Scheme Website.

This Scheme Website is to be a stand-alone Project Website with its own url for ease of control and management. This website will act as a depository for information relating to the Scheme, including background information and latest news update. It will also act as a public store for reports, technical notes, drawings etc. from current and previous stages. The website will be open to all and be capable of having a global reach.

4.3 Scheme Newsletter

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a Scheme Newsletter and thereafter manages a system of production for its periodic issue. It is assumed that such a newsletter will be issued on a quarterly basis, however it is understood that this may be too frequent or indeed infrequent depending on the volume of work and thus information requiring to be communicated – the Project Board shall be the ultimate overseer of the issue dates.

The Scheme Newsletter will be issued to all postcodes in the EH21 Postcode area. It will be delivered by the Royal Mail Door-to-Door Delivery service.

The newsletters content will be determined, and its design and production managed by the Communications Working Group.

At the time of writing, the Project Team are working to a first issue being received by the public in November 2022.

4.4 Public Notice Boards

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project installs and thereafter maintains a network of public notice boards throughout Musselburgh.

These Public Notice Boards will be located in key pedestrian footfall locations to provide information and notify of events.

The Scheme currently has seven public notice boards located throughout Musselburgh, three along the coast and four along the urban length of the river. At the time of writing, two more boards are being organised at both ends of the Sea Wall path to bring the total to nine.

The Public Notice Boards are A1 information boards which are designed in-house by the Project Team and provide concise, simple, and artistically engaging updates about the Scheme's progress. The boards reach local residents who may not use the internet or have registered for updates, whilst also being relevant to visitors. For those that do use the internet, the boards also feature a QR code to link people onwards to the website where they can access more detailed information.

4.5 East Lothian Council Press Releases

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a process for issuing Press Releases.

The Scheme is a major project and has a Project Team, however it is a project by East Lothian Council, and therefore all press communications travel through East Lothian Council's communications team.

The Project Team have developed a schedule of intended Press Releases through the Communications Working Group, however in the event of an AD-HOC requirement of a press release this will be confirmed through a meeting of the Communications Working Group.

All Press Releases are generated by the East Lothian Council's Communications Team, working in partnership with the Project Team.

4.6 Newspaper Advertisement

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a process for periodically placing key Scheme information into the local papers via a paid newspaper AD.

Throughout the project duration the Project Team will make use the Musselburgh Courier, a locally circulated newspaper. When East Lothian Council issue a Press Release the Project Team do not have control over the newspapers use of text and / or images. There are however occasions when the Project Team will require a specific message or image to be presented to the public through the newspaper – on such occasions it is appropriate to use a paid AD to place the required content.

4.7 Letter Management

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a process for management of formal letters – both letters received and letters issued.

The Scheme will on occasion receive a letter. The use of letters as a means of communications is less frequent in this era of emails and digital communication, however it is still in existence. Such letters require to be logged and filed, and as appropriate, responded to.

The Project Team require to issue letters on occasions. Through the period of the design this will most likely be to issue invitation to an event being organised by the Project Team. During the project's Stage 5 (the Approvals Processes) it will be required to issue formal letters of notification of the Scheme's Publication as required by the Flood Risk Management (Scotland) Act 2009.

4.8 Public Meetings

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops an approach to holding and managing public meetings.

During the COVID-19 Pandemic it was assumed that this would be required to be through online digital meetings, and through the autumn of 2021 the Project Team undertook initial Local Area Consultation Meetings through (online) MS Teams meetings to develop and establish such a process.

Since spring 2022 with the return to normal in the post-COVID-19 period, the Project Team are again using in-person public meetings. This is the preferred approach to engagement with the public, however the Project Team now have the capacity to undertake either in-person or digital meetings and will make a judgement call on which is the most appropriate to use for all meetings moving forward.

4.9 Public Exhibitions

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops an approach to hosting Public Exhibitions at key points in the Scheme's development to formally present update on the Scheme.

The use of Public Exhibitions by projects is not unique to this project. Indeed it is an approach common to almost all flood protection schemes. This project has always planned to use Public Exhibitions, and the verification of this within this Strategic Communications Plan is considered only a formality of record.

4.10 Stakeholder Management

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a Stakeholder Management Plan to define and manage to overall coordination of project stakeholders.

The Stakeholder Email Register and update emails as defined in Section 4.11 of this report is one part of that management process, however given its importance under data protection and in relation to communication in general it is given its own section in this report.

4.11 Stakeholder Email Register & Update Emails

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a register of all stakeholder emails and a process for updating those emails via a periodic update email.

The Stakeholder Email Register is to be fully compliant with GDPR and all relevant data management regulations.

It is recognised that whilst some use email as their primary form of communication there are others that may not have access to email at all. The use of this process is therefore within the context of that understanding and thus the Project Team are to use both digital and non-digital means of communication together.

4.12 Consultation

The Scheme's development is being advance through a consultative design approach. This was first formally recorded through the report to Cabinet in January 2020, however it was ongoing prior to that point in time and has been ongoing since. It is considered that this approach offers the greatest likelihood of evolving a bespoke flood protection scheme for the town of Musselburgh that the people of the town will accept.

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a specific consultation plan for the rest of Project Stage 4 (the Outline Design). This requirement is further to the recommendation of Council at its meeting in August 2022.

For further details on the Outline Design Consultation Plan please reference the individual report that defines that plan – which is Appendix L.

Appendix F

October 2022

Report

Consultation Plan for the Outline Design

Musselburgh Flood Protection Scheme

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Musselburgh
Flood Protection

Contents

1 Document Information

1.1 Preparation

ACTION	NAME	DATE
Prepared By	Gregor Moodie	29/09/2022
Reviewed By	Conor Price	14/10/2022

1.2 Configuration Management

ISSUE STATUS	REVISION	DATE
Draft	Revs 0.1 – 0.4	29/09/2022 - 14/10/2022
For Issue	Rev 1.0	14/10/2022

2 Introduction

The Musselburgh Flood Protection Scheme (the Scheme) is being progressed by East Lothian Council to reduce the very significant levels of flood risk to the town of Musselburgh.

This project is being managed under the PRINCE2 Project Management System. This report is therefore further to the detail provided on consultation in the project's Strategic Communications Plan. This document is a separate, stand-alone, report and supersedes that report: the detail contained within this report defines the project approach to consultation for the Outline Design stage of the Scheme.

The following text from the Strategic Communications Plan is reproduced for ease of reference only:

The Scheme's development is being advance through a consultative design approach. This was first formally recorded through the report to Cabinet in January 2020, however it was ongoing prior to that point in time and has been ongoing since. It is considered that this approach offers the greatest lightly hood of evolving a bespoke flood protection scheme for the town of Musselburgh that the people of the town will accept.

It is required of this Strategic Communications Plan, further to direct instruction from the Scheme's Project Board, that the project develops a specific consultation plan for the rest of Project Stage 4 (the Outline Design). This requirement is further to the recommendation of Council at its meeting in August 2022.

For further details on the Outline Design Consultation Plan please reference the individual report that defines that plan – which is Appendix L.

The Project Team have so far been developing the Scheme through a consultative framework, and over the years since the project's inception have met with many individuals to get their views on what is important for the Scheme. These individuals include local residents, statutory stakeholders, landowners, and business owners. This engagement has been invaluable in helping to shape the Scheme thus far and the Project Team are eager to continue building upon the relationships established and the momentum within the town as the Scheme develops.

The purpose of this report is to set out the approach to consultation for the rest of the Outline Design (i.e. the rest of the time during Project Stage 4 (the Outline Design)).

It is considered that the processes identified in this plan were the intention of the Scheme, through its commitment to continue with its design consultation approach as defined in the Strategic Communications Plan, however at this point in time this plan is also, specifically, in response to a recommendation from Council in August 2022. This amendment to the Council recommendations is provided here for ease of reference:

Instructs that the consultation process throughout the outline design must allow for public participation into a discussion of what form/s of defence are deemed acceptable; must present indicative options to show how altering the height of defences might change the standard of protection; and must gather feedback on public preference between these options. Council further instructs the Project Team to present their proposals in relation to this instruction to the October 2022 meeting of Council. This will ensure that Councillors are better informed about the wishes of their constituents before progressing to the approvals process as defined in the Flood Risk Management Act (2009).

3 Consultation and Communication

3.1 Definitions

The Project Team understand consultation and communication to be two distinct methods of community engagement. It is understood that various definitions of these two terms exist, and the extent to which communication can be considered consultation is a matter for debate. For clarity and ease of understanding, for the purposes of the Scheme the following definitions are used by the Scheme:

1. 'Communication' is to be thought of as a one-way process in which information about the Scheme, such as updates on key milestones, are communicated out. Although unsolicited, individuals may respond to communications with thoughts, opinions, or concerns and these will always be noted by the Project Team, and if appropriate will be considered within the approach taken by 'consultation'.

2. 'Consultation' entails a direct form of engagement with individuals or groups (whether public, statutory, business etc.) whereby information is provided on one or multiple aspects of the Scheme and an opportunity is provided to give thoughts, opinions, concerns etc. (collectively, 'inputs') on those aspects. Consultation is therefore a two-way process, however it is clearly highlighted that 'consultation' does not empower the external parties with decision-making powers or rights. Their thoughts are being collected by the Project Team so the Project Team is better informed in determining the form of the Scheme under the contractual obligations that exist for the Project Team. Ultimately the decision-making will be made by the parties empowered through the Project Governance structure and the final decisions will be made by East Lothian Council as defined by the Flood Risk Management (Scotland) Act 2009.

The key difference therefore lies in the objective, where the objective of consultation is to collect inputs on one or more aspects of the Scheme, and the objective of communication is to provide information.

3.2 Why differentiate between the two?

The development of the Scheme will involve many individuals, however not everyone will need to be involved to the same extent. Likewise, involvement by a group or individual might by necessity be much greater at one stage than another. Consultation must be targeted appropriately to make efficient use of the Project Team's time and resources. For example, someone who occasionally visits Musselburgh for a daytrip is unlikely to be as invested in the development of the Scheme as someone who lives beside the River Esk or on the Coastal Foreshore and has a flood risk. In this instance, it would not be appropriate or a good use of resources to treat the two the same.

By communicating widely through our communication tools (e.g. the stakeholder email, our website, our public notice boards and newsletters etc.) we aim to empower individuals to make their own decision on the extent to which they want to be involved in consultation.

4 Objectives and limitations of consultation

4.1 What is the objective of consultation for the Scheme?

There are several reasons why consultation is important to the Scheme. Firstly, consultation with statutory and regulatory bodies is essential to ensure that the Scheme is aware of any laws and regulations that it will interact with or need to abide by. Consultation with the public and organisations allows the Project Team to shape a Scheme that works for local people. Local residents are the ones who are at risk from flooding, but are also the ones who use the spatial environment of Musselburgh on a daily basis. Therefore, they are best placed to offer thoughts on how the Scheme's design can be evolved to minimise negative impacts and improve the local area.

As well as with the public, consultation with businesses, organisations, and local interest groups can be helpful in identifying local issues that may not relate to flooding but through the vehicle of the Scheme could be directly or indirectly improved. In certain cases, these are significant enough to become defined multiple-benefit opportunities, such as the provision of Active Travel and restoration of the river environment.

4.2 Form of Defence Determination during the Outline Design (Project Stage 4)

Within the Outline Design stage of the Scheme, the primary objective of consultation is to allow the Design Consultant, Jacobs, become sufficiently informed such that they can determine the proposed 'Form of Defences' to be used throughout the town and their alignment. A high-level overview of the pathway to determining the Form of Defences is set out in Figure 1 below.

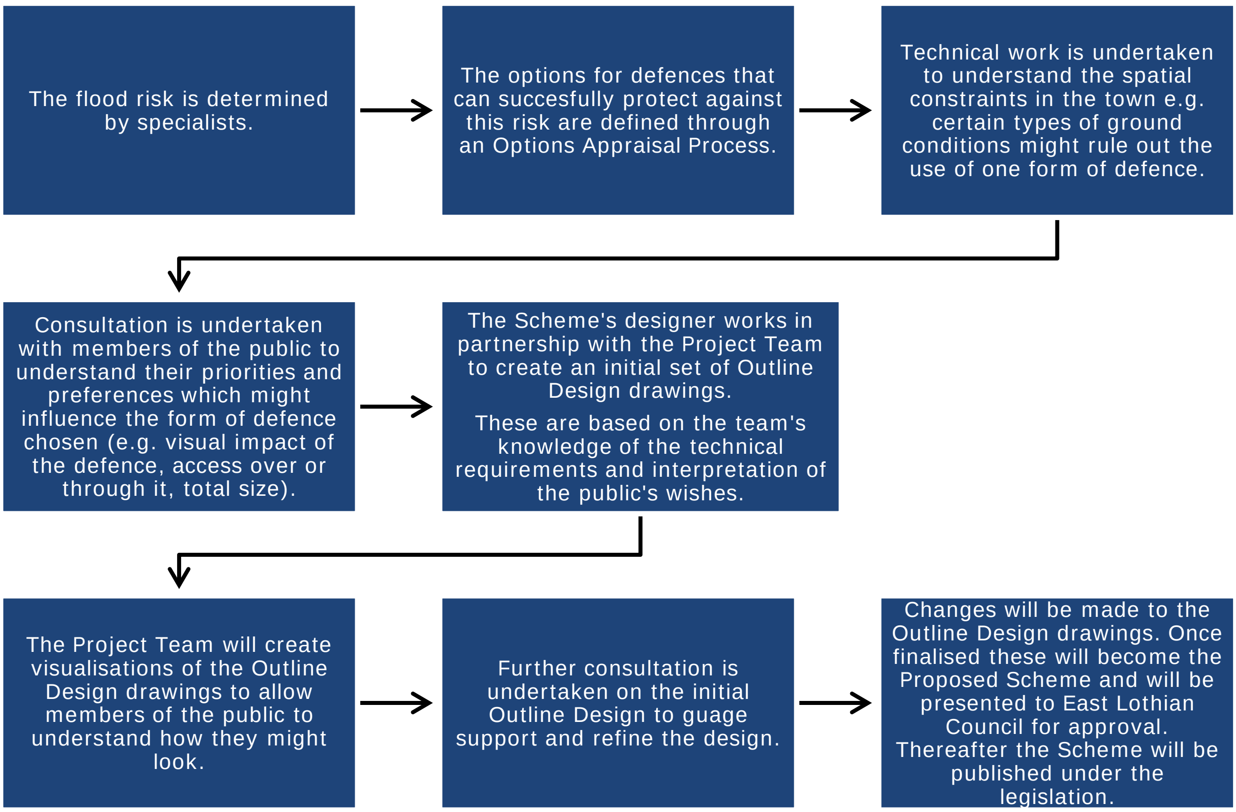

Figure 1: High-level overview of the pathway for the Form of Defence Determination

Whilst Figure 1 provides a generalised overview for the purposes of simplicity, it does not fully capture the nuanced approach to determining the Form of Defences throughout the entire flood scheme. There are two reasons for this: firstly, the length of the defences will be such that they will cross through areas of different ownership (e.g. on public land or on private land), and secondly, the pursuit of multiple-benefits means that some sections may be subject to additional decision making inputs, such as those of the Musselburgh Active Toun (MAT) project or Historic Environment Scotland.

In areas where the defences sit entirely on private land, it is fair and reasonable that the first consultation is with the private land owner and / or occupier. Only thereafter is it appropriate for the proposed defences at this location to be considered by the wider public consultation.

Similarly, where two different design logics exist for a single section (e.g. that of the Flood Protection Scheme and the Active Travel Network) it is important that the Project Team establish who should be involved in the decision-making and which, if any, logic must take precedence. A specific example of this scenario is as follows: both projects are proposing to replace the Shorthope Street Footbridge – the Scheme to remove its in-stream piers and to raise it further above river level: the Active Toun project to widen it make it more usable for pedestrians and cyclists etc.

To achieve this, the Project Board have established a process under their authority and management that defines the approach to the Form of Defence Determination. This was approved by Project Board in early October 2022. This process subdivides the entire flood protection scheme into ‘Design Sections’ to allow more accurate and detailed discussion, and logs the decision making parties involved in each section. Inputs to the design thinking are captured within a tracker maintained by the Project Team, a snippet of which is provided as an example in Appendix A.

4.3 Limitations of Consultation

As with any process there are limitations, and for clarity the limitations to Outline Design Consultation that will be undertaken by this project are defined in this section.

1. It is not possible for the Project Team to engage with everyone in Musselburgh, the time and resources required would make this a disproportionate use of public money. Simultaneously there are members of the public who simply do not want to engage / be consulted. The Scheme’s mass communication effort, as defined in the Strategic Communications Plan, ensure that those who do want to engage have every opportunity to do so, and those that do not are nonetheless kept informed.

2. Consultation can also be limited in terms of who it reaches, for example younger people and those who have additional needs are generally underrepresented in public consultations on most subjects. Through discussion with East Lothian Council’s equalities officer, the Project Team have taken appropriate steps to ensure that our consultations are accessible, and will continue to work with Council partners to reach more young people as a matter of priority. The approach to consulting with young people is outlined further in Section 5.3 of this report.

3. The outcome of the consultation is another major limitation where it results in the ‘consultee’ determining that they have not been listened to and / or that the Scheme has done its own thing and ‘ignored’ their representation. This is a huge risk for the Scheme, as ultimately such a disenfranchised consultee may become a Scheme Objector under the legislation. The project team are aware of this risk and working to mitigating this risk by, for example, producing reports after key public meetings including sections focused on highlighting the concept ‘You Said – We Did’. The major limitation here however is that some consultees may not like the action that is taken in response to their representation, but this is not a consultation risk – it is a different risk and the Project Team cannot be held responsible for those who choose to ‘Object’ to the Scheme – that is their right under the legislation.

5 Consultees

5.1 Who is being consulted?

The Project Team are consulting widely on the Scheme with various different categories of stakeholders. These include the following categories (as defined by the Scheme):

1. Regulatory Stakeholders (i.e. those who have to make a decision-making input in relation to the Scheme relative to their regulatory / legislative working responsibilities);

2. Key Stakeholders (i.e. Scottish Water relating to the proposed use of their reservoirs in Mid-Lothian, and Buccleuch Estates / Dalkeith County Park relating to the proposed Upstream Debris Trap by Whitecraig);

3. The Multiple-Benefit partners (i.e. Fisherrow Harbour & Seafront Association, Scottish Power, ELC re the Musselburgh Traffic Management Plan, the Musselburgh Active Toun project, and organisations not yet determined re the emerging Musselburgh River Restoration project);

4. Public Stakeholders (i.e. businesses, the general public, local interest groups etc.),

5. Private Land Owners and Occupiers on whose land the proposed new flood defences may be located and / or on which the construction works may need temporary access.

For reference, each of these categories is broken down below.

5.1.1 Regulatory Stakeholders

CATEGORY	FORUM	SUB-DIVISION	MEMBERSHIP	FREQUENCY
REGULATORY	Scheme Working Groups	Roads, Structures & Access Working Group	• ELC Access & Pathways • ELC Amenity & Countryside • ELC Archaeology • ELC Flooding • ELC Green Networks • ELC Planning • ELC Roads Services • ELC Structures • ELC Transport Planning • Jacobs Engineering • Jacobs Landscape Architecture	This group meets as required for a length of time determined by the complexity of the subject(s) under discussion.
		Watercourse & Coastal Impact Working Group	• ELC Amenity & Countryside • ELC Biodiversity • ELC Rangers Service • ELC Flooding • Fisherrow Harbour Harbourmaster • Forth District Salmon Fisheries Board • Jacobs Engineering • Jacobs Ecology • Jacobs Landscape Architecture • Marine Scotland • NatureScot • SEPA	This group meets as required for a length of time determined by the complexity of the subject(s) under discussion.
		Planning, Heritage & Landscape Working Group	• ELC Planning • ELC Heritage • ELC Archaeology • ELC Amenity & Countryside • ELC Biodiversity • NatureScot	This group meets as required for a length of time determined by the complexity of the subject(s) under discussion.

			• ELC Flooding • Historic Environment Scotland • ELC Green Networks	• Jacobs Engineering • Jacobs Ecology • Jacobs Landscape Architecture	
		Land & Legal Working Group	• ELC Legal • ELC Assets	• ELC Estates • ELC Flooding	This group meets as required for a length of time determined by the complexity of the subject(s) under discussion.
		Financial Working Group	• ELC Finance		This group meets monthly to review project finances and provide financial assurance and oversight. This group also meets on an additional ad-hoc basis as required.
		Environmental Consenting Working Group	• ELC Planning • ELC Environmental Protection • ELC Archaeology • SEPA • NatureScot • Forth Rivers Trust • Jacobs Engineering • Jacobs Ecology	• ELC Heritage • ELC Biodiversity • ELC Amenity & Countryside • Historic Environment Scotland • Forth District Salmon Fisheries Board	This group meets as required for a length of time determined by the complexity of the subject(s) under discussion.

5.1.2 Key Stakeholders

CATEGORY	ENTITY	FORUM	FREQUENCY	SIGNIFICANCE
KEY STAKEHOLDERS	Buccleuch Estates / Dalkeith Country Park	Direct Consultation	Ad Hoc	Substantial land holdings in the catchment and the Preferred Scheme proposes a Debris Trap intervention within the river as it passes through Dalkeith Country Park.
	Scottish Power	Direct Consultation	Ad Hoc	Scottish Power owns significant assets within Musselburgh that will be integral to the Scheme's development.

5.1.3 Multiple-Benefit Partners

CATEGORY	ENTITY / PROJECT	FORUM	FREQUENCY	SIGNIFICANCE
MULTIPLE-BENEFIT PARTNERS	Fisherrow Harbour & Seafront Association	Direct Consultation	Ad Hoc	FH&SA hold a management agreement with ELC to manage the historic Fisherrow Harbour. The association is an umbrella group for harbour users and is represented in consultation by elected trustees.
	Musselburgh Active Toun Project (ELC Roads)	Direct Consultation	Ad Hoc	ELC is in parallel delivering a project to introduce Active Travel Networks and placemaking to Musselburgh. Significant sections of this will sit within the Scheme's footprint and therefore co-design and delivery is essential to achieve an acceptable product, maximum benefit and overall capital investment savings.

	Musselburgh Traffic Management (ELC Roads)	Direct Consultation	Ad Hoc	ELC has ambitions to improve the efficient flow of traffic within Musselburgh to create a safer environment for pedestrians and road users and to reduce congestion and associated pollution. As the Scheme will interface with key roads and reshape the spatial environment it is appropriate to consult on opportunities to achieve multiple-benefits.
	Musselburgh River Restoration	TBC	TBC	This is an emerging multiple-benefit based on feedback from public consultation which strongly advocated for river restoration to improve habitats and reduce localised flood risk. In addition, the Project Team feel that there are wider opportunities to work with NatureScot, SEPA and FDSFB to achieve wider benefits in the urban river environment and upstream.
	Invasive and Non-Native Species Steering Group	Working Group	Biannual	This steering group, instigated by the MFPS Project Team, brings together local authorities, volunteer groups, and landowners to take a joined up approach to managing INNS (notably Giant Hogweed and Japanese Knotweed) in the town and catchment.

5.1.4 Public Stakeholders

CATEGORY	SUB-DIVISION	FORUM	MEMBERSHIP	FREQUENCY
PUBLIC STAKEHOLDERS	Local Businesses	Direct Consultation	• More than 100 local businesses	This group meets as required for a length of time determined by the complexity of the subject(s) under discussion.
	General Public	Major Public Events (e.g. The Musselburgh Area Consultation / Public Exhibitions 1 and 2) & via Local Area Consultation (LAC) Groups	• Local residents • Non-locals with an interest in the Scheme	The Scheme hosts major public events at key points in the project. Three major events (i.e. those open to the whole town) have been held since the Scheme's initiation. A cycle of LAC Group consultations were held from September 2021 to February 2022. The Scheme also meets with individual groups or defined residents if their area or property requires special attention or further consideration.
	Organisations / Local Interest Groups	Direct Consultation	• Various throughout the town and catchment	Ad Hoc / By Invitation

5.1.5 Local Area Consultation Groups

CATEGORY	LOCAL AREA	FORUM	MEMBERSHIP	FREQUENCY
LOCAL AREA CONSULTATION GROUPS	Edinburgh Road	Direct Consultation	Local residents and business owners of the Edinburgh Road Area	Ad Hoc
	Fisherrow	Direct Consultation	Local residents and business owners of the Fisherrow Area	Ad Hoc
	Mountjoy	Direct Consultation	Local residents and business owners of the Mountjoy Area	Ad Hoc
	Goosegreen	Direct Consultation	Local residents and business owners of the Goosegreen Area	Ad Hoc
	Esksides	Direct Consultation	Local residents and business owners of the Esksides Area	Ad Hoc
	Eskmills	Direct Consultation	Local residents and business owners of the Eskmills Area	Ad Hoc
	Inveresk	Direct Consultation	Local residents and business owners of the Inveresk Area	Ad Hoc

5.1.6 Landowners & Occupiers

CATEGORY	SUB-DIVISION	FORUM	FREQUENCY	SIGNIFICANCE
LANDOWNERS & OCCUPIERS	Landowners	Direct Consultation	Ad Hoc	Individuals who privately own land over or upon which operations will need to take place to construct the Scheme OR that will be the location of elements of the Scheme.
	Occupiers	Direct Consultation	Ad Hoc	Those who hold a lease agreement for land over or upon which operations will need to take place to construct the Scheme OR that will be the location of elements of the Scheme.

6 Consultation during the Outline Design

6.1 When will the Outline Design take place?

The Project Team have developed a Timeline that defines the duration of the Outline Design and highlights the key dates within this time. The Outline Design is intended to start after the Council's October 2022 meeting and to conclude when the Scheme presents a report back to Council in January 2024. The Timeline for the Outline Design is being presented to Council in October 2022, and will be published on the Scheme Website during that week.

6.2 What are the specific timings for the consultation?

At the time of writing this report the specific timings for each of the consultations that are required of this Consultation Plan, and within the timescales defined by the Timeline for the Outline Design, have not yet been determined. It is considered appropriate for Council to approve this proposed Consultation Plan and the proposed Timeline, before the Project Team undertake the significant activity of programme all works activities for the stage, including the individual consultations, under the contractual process for revising the contract programmes.

6.3 Public Exhibition Number Two (PE No. 2)

The largest and most significant consultation activity is a public exhibition. One will definitely take place within the Outline Design, and this will be known as Public Exhibition No. 2.

So far the Scheme has held three major consultation events that were open to the whole of Musselburgh: the Public Open Day & Call for Information in February 2019; Public Exhibition No. 1 in July 2019; and the Musselburgh Area Consultation in March 2022.

The specifics for this event are not yet confirmed, however the preliminary expectations are that: it will be held in Summer 2023 to allow time for the Outline Design to be developed; it will be held at The Brunton Theatre which is local, fully accessible, and capable of holding a large volume of people; it will be held over several days to allow as many people as possible to attend. These expectations are all subject to change and are the Project Team's assumptions only at this stage.

Full details of the event will be shared via the Scheme's communications tools well in advance to enable as many interested members of the public to be involved as possible.

6.4 Who will be consulted?

As detailed in earlier sections of this report, there are many consultees for the Scheme. As detailed in Section 6.2 of this Report the specific timetables / programme for those consultations still needs to be developed. It is expected that all identified consultees will be consulted within this process. The scale of the consultation required for each consultee will be a function of the design challenges at any given location – however please note that at all points in time the Project Team will be working to achieve the objectives, and within an understanding of the limitations, as defined in Section 4 of this Report.

6.5 Highlighting some key consultations

There is no hierarchy to the consultation process, however it is felt appropriate to acknowledge that the design of a Form of Defence will be more challenging in some locations compared with others. The following consultations are highlighted, as examples of specific consultations that present challenges,

6.5.1 Young People

Younger people have so far been underrepresented in our consultations that have been ongoing since 2018. This applies especially to the 16 to 25 age bracket and perhaps the whole age group below 35. Not only do we recognise this but during our public consultations in February and March 2022 this has been raised by members of the public as well. The Project Team feel that as this age group will be the ones to eventually 'inherit' the town and its flood scheme, that it is important we also collect their views on the Scheme.

Over the past five years the Project Team have on several occasions tried to engage with the town's schools. We achieved significant connection to Pinkie Primary School in 2019. We have had a number of discussions with Musselburgh Grammar about both contractual Community Benefits being delivered through the school and consultation with the school's public, perhaps linked to the Curriculum for Excellence. All of this has, however, not evolved into a continuous and / or meaningful connectivity that would be preferable.

Under the Scheme's contracts, the Scheme's designer Jacobs have an obligation for delivering Community Benefits, including school consultations and work experience placements. Community Benefits will also be a significant part of any works contracts in the Scheme's latter stages. We assume that these obligations can be linked to existing frameworks for engagement such as the Developing the Young Workforce (DYW) programme.

The Scheme is a generational investment, and will reshape Musselburgh. The Project Team feel strongly that the Scheme would benefit from the input of young people whilst simultaneously the young people and schools could benefit from their proximity to such a major project and all of the learning potential and life experience that it offers to them in their town, as well as sparking a passion for engagement with the process of local governance.

Within the Scheme there is now an emerging approach to engaging with school children and Young People. This is being achieved through connectivity with East Lothian Council's education and children's services directorate as well as other bodies. Specific details are not available at this early stage, however these will be developed as the project progresses and this consultation route will be managed under the authority of the Scheme's Project Board.

6.5.2 Landowners

Interventions upstream of the town will primarily occur on private land. The Project Team have already begun building working relationships with the various landowners upon whose land the Scheme might undertake operations. Throughout the Outline Design, this direct consultation will continue to allow the outline design to be developed as appropriate in line with the landowners' inputs.

6.5.3 Local Businesses

Local businesses are key drivers of a local economy and contribute towards employment, tourism, and sustainability by providing access to services and amenities within walking/cycling distance. The impact of reducing the significant flood risk to Musselburgh that will result from the Scheme delivering its proposed flood risk management interventions could be significant in encouraging investment and business confidence. It is likely to also substantially reduce insurance premiums which can boost growth and confidence.

The needs of local businesses will be distinct to those of local residents and priorities are also expected to be different. Through the Musselburgh & Inveresk Community Council and the Musselburgh Business Partnership as well as directly the Project Team have already begun to connect to local businesses to gather their inputs. As of summer 2022, hundreds of local businesses have been issued questionnaires to help identify their knowledge of flooding, the flood scheme, and what their priorities are for the future. Throughout the Outline Design, the Project Team will be looking to expand this engagement and build a clearer picture about what is most important for local businesses with regards to the Scheme.

6.5.4 Residents of the Inveresk Estate

Residents of the Inveresk Estate were first approached by the Scheme with regards to their flood risk in 2021. This was because prior to this, the Scheme's modelling showed that interventions in the catchment would be sufficient to ensure they obtained the same levels of flood risk reduction as that intended for the rest of the town of Musselburgh. Because of this it was not considered necessary to provide direct defences at this location when the Preferred Scheme was presented to Cabinet in January 2020. However, updates to the hydraulic model (within 'Model B' and now in 'Model C') confirm greater river flows due to Climate Change, and thus food risk, at this location. The intended interventions in the catchment are no longer sufficient to completely neutralise the flood risk at this location.

The Project Team have met with the appropriate residents at this location and explained this changed flood risk situation. A residents' meeting was held and residents' requested that they be provided with equivalent flood protection to that provided to others in Musselburgh.

A formal decision on whether to incorporate the Inveresk Estate into the Scheme remains to be taken by the Project Board under the authority of Council. The Project Team intends to keep the channels of consultation with residents open, and if they are formally included within the Scheme, they will be consulted as a group, of private Land Owners, to determine their preferences for providing flood protection at this location.

6.5.5 Fisherrow Harbour & Seafront Association

Fisherrow Harbour & Seafront Association is a multiple-benefit partner and a strategic partner of East Lothian Council. Consultation with this organisation has been ongoing since the Scheme's early stages.

The harbour is one of the most challenging environments in which to determine a Form of Defence. The Project Team must consider the operational requirements of the harbour itself, the historic and listed nature of the structure, the buried utilities, as well as the SPA designation of part of the beach and the whole Forth estuary. In addition to this, we must consider how the Musselburgh Active Toun project can incorporate an active travel network in proximity to the defences / harbour. Despite these challenges, there is significant opportunity to develop a solution that revitalises the harbour and creates a thriving destination for locals and visitors.

The Project Team will continue to consult with the FH&SA throughout the Outline to determine the best way to proceed, with

6.5.6 The Local Area Consultation Groups

During the consultation process undertaken between summer 2021 and spring 2022 the Project Team set-up a number of local area consultation groups. The use of these groups – which are formed in the areas that it is assumed will be in closest proximity to any defences proposed for the town – is considered essential to the Project Team evolving an Outline Design.

The following are considered to be the key areas where this process will be required:

1. The coastal foreshore – from Fisherrow Harbour to the mouth of the River Esk; and

2. The River Esk corridor – from the Station Road Bridge to the Goosegreen Footbridge.

It is assumed that the next meetings with these groups will take place in late November and notice of such events will be provided as soon as possible after the Council Meeting in October 2022.

7 Strategic Communications Plan

7.1 Signposting

The Project Team have developed a suite of communications tools to effectively reach a wide audience and deliver information severally and in a targeted way. These tools are detailed in the Scheme's Strategic Communications Plan, which is a standalone document available separately.

Appendix A – Form of Defence Determination – Design Section Tracker Example

MUSSELBURGH FLOOD PROTECTION SCHEME

PROJECT STAGE 4 - OUTLINE DESIGN

DESIGN SECTION TRACKER - FoD DETERMINATION

Revision No.	Revision 1.0
Revision Date:	15/09/2022
Author:	Conor Price

			SUMMARY OF FORM OF DEFENCE				DECISION MAKING CONTRACTUAL INPUTS						OTHER				
Count	Design Section - Information		Provisional Form of Defence				Scheme		MAT		Combined Decision		Land Owner		Roman Bridge		FHa
5	Number	Name of Section	Y/P/N	Type	Date	Details	Y/N	Taken	Y/N	Taken	Y/N	Taken	Y/N	Taken	Y/N	Taken	Y/N
1	DS-CF-02	Edinburgh Road - Along Road to SW PS	N	TBC	TBC	TBC	Y	N	N	N/A	N	N/A	Y	N	N	N/A	N
1	DS-CF-03	Edinburgh Road - SW PS Road to Green	N	TBC	TBC	TBC	Y	N	N	N/A	N	N/A	Y	N	N	N/A	N
1	DS-CF-04	Edinburgh Road - Murdoch's Green	N	TBC	TBC	TBC	Y	N	Y	N	Y	N	N	N/A	N	N/A	N
1	DS-CF-05	Edinburgh Road - Green to Beach	N	TBC	TBC	TBC	Y	N	Y	N	Y	N	Y	N	N	N/A	N
1	DS-CF-06	The Backsands Public Beach	N	TBC	TBC	TBC	Y	N	Y	N	Y	N	N	N/A	N	N/A	Y