Lochgilphead Flood Study

Options Appraisal Report

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Quality information

Prepared by	Checked by	Approved by
Morag Hutton Senior Hydrologist	Debbie Hay-Smith Principle Engineer	Dylan Huws Associate Director

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Prepared for:

Argyll and Bute Council
Helensburgh & Lomond
Civic Centre
38 East Clyde Street
Helensburgh
G84 7PG

Prepared by:

AECOM Limited
1 Tanfield
Edinburgh EH3 5DA
United Kingdom

T: +44 131 301 8600
aecom.com

Executive summary

Project Overview

As part of this Flood Study, Argyll and Bute Council (ABC) were looking to investigate fluvial and coastal flood risk in the town of Lochgilphead as identified in the Argyll and Highland Local Flood Risk Management Plan (LFRMP). AECOM have been commissioned to undertake a Flood Study to identify current and future flood risk and identify potential flood mitigation options that may then be present to SEPA for prioritisation for centralised Scottish Government funding.

This report covers Phase 4 of the study, where significant work has been carried out to understand the flood mechanisms affecting Lochgilphead. Fluvial flooding from the Badden Burn, Cuilarstich Burn and from overflow from the Crinan Canal is seen to affect areas including the caravan park, Lorne Street and upstream of the Meadows from relatively frequent events. Coastal flooding, as a result of still water levels, was found to be the main source of flooding, affecting the Front Green, caravan park and properties along Poltalloch Street and Argyll Street from relatively frequent events. Predicted sea level rise as a result of climate change is expected to significantly increase flood risk in the future.

Once the baseline conditions were understood, a Long List of potential flood mitigation options was collated. An option screening process was undertaken on this Long List, assessing legal, environmental, cost and technical feasibility, to produce a short list of viable flood mitigation options. This process has been summarised in more detail in the previous Phase 3 report. Table 0-1 displays the short listed viable options.

Table 0-1: Short listed flood mitigation options

Measure Category	Measure
Direct defences	Fluvial measure - Increasing left bank along the caravan park
	Coastal measure - Coastal flood wall along existing coastal defences
	Coastal measure - Coastal flood wall set along Poltalloch Street
	Coastal measure - Flood embankment along existing coastal defences
	Coastal measure - Flood embankment set back within front green area
	Coastal measure - Combination of direct defences
Property flood protection	Coastal and fluvial measure - Small scale property interventions
Flood resilience	Coastal and fluvial measure - improve building resilience
Self help	Coastal and fluvial measure - improve understanding of flooding issues and how to cope better.
Land reclamation	Coastal measure - Infilling of an area of back of houses east of front green and at Police Station
Canal management	Fluvial measure - Alternative operation of canal

The purpose of this report is to develop and appraise the shortlisted flood mitigation options through concept design, costing, damages assessment and multi-criteria appraisal to consider the economic, social and environmental aspects of each option. The aim of this exercise is to comparatively evaluate the options so that the best solution can be identified for Lochgilphead.

It is proposed that the findings of this study be passed to SEPA for inclusion in the next round of SEPA FRM Strategies. The Strategies set out a prioritised list of actions for flood risk on national scale, which may then be submitted for approval and funding to the Scottish Government.

Option Development

The short listed options developed in previous phases of this Flood Study were then developed and appraised during this phase through the following:

- Public consultation – with the local community and stakeholders to get feedback on options.
- Concept design – to develop a more detailed understanding of costs and how options would be constructed and identify opportunities and constraints.
- Costing – to determine the cost of each option. This has been considered over the whole 100-year design life (25 year for PFP) of the proposed scheme to include annual and intermittent maintenance costs.
- Damage assessment – to quantify economic benefits from the option in terms of damages avoided over the 100 year life of the scheme (25 year for PFP).
- Cost benefit – to establish the economic viability of each option
- Multi-criteria appraisal – to appraise options holistically in terms of social, economic and environmental.

The appraisal has allowed AECOM to assess the options against each other so that recommendations could be made based on the appraisal of economic, social and environmental impacts, whole life costs and consideration of risk and uncertainty, both present and future.

Recommendations

Preferred option for prioritisation

Weighing the economic and environmental considerations, the appraisal has determined that there is a viable scheme for Lochgilphead that should be presented for SEPA prioritisation. If successful, this will then be put forward for centralised Scottish Government support, which could receive 80% funding.

The following option is recommended to be taken forward as a preferred scheme and presented for SEPA prioritisation:

- Property Flood Protection for coastal properties

Installing PFP was assessed as being capable of providing protection to all 33 properties affected by the 0.5% AEP coastal event. A total of 30 out of the 33 properties could be protected up to the 1%-0.5% AEP events, offering a high level of protection.

Additional recommended flood resilience options

In addition to the preferred scheme that will be presented for SEPA prioritisation, the additional categories of Self Help and Flood Resilience have also been carried forward to the recommendations. It is recommended that these options are taken forward by ABC with the aim of working towards educating the public and promoting Self Help and Flood Resilience within the community.

Another recommendation of this study is that ABC engage with Scottish Canals to establish whether any alteration to the operation of the canal could be made so that flow over Waste Weir 3 could be reduced and therefore result in less frequent flooding of the A 816.

Recommended next steps

Should a scheme be taken forward through the SEPA prioritisation process, it is recommended to further develop the preferred scheme. This would be done by the following:

- Submitting Flood Study findings for SEPA prioritisation to be considered for Scottish Government funding for the preferred option;

- Carry out further consultation with residents and local businesses, emphasising why PFP has been presented as the most viable option, and the need to reassess direct defence options in the future;
- ABC to establish a policy on how PFP could be effectivity rolled out as part of a flood scheme;
- Carry out buildings surveys to determine the exact number of properties that would see benefit from PFP installations;
- Consult with residents and businesses with regards to PFP installations;
- Educate the public on flood risks, and promote self-help and flood resilience;
- Near the end of PFP design life, a direct defence option should be reassessed. Development of reliable cost estimates and reasonable standards of protection for direct defences with a view to ascertaining if a positive benefit cost ratio can be obtained.

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1. Introduction

1.1 Purpose of the report

Argyll and Bute Council (ABC) are looking to investigate flood risk in the town of Lochgilphead and potentially identify ways in which this flood risk could be reduced. The Flood Risk Management (FRM) Act (Scotland 2009) provides the necessary statutory powers and potential funding to address this risk and also allows any measures promoted to enhance the local area. AECOM was commissioned to undertake a Flood Study (FS) for Lochgilphead. The study will propose new flood mitigation measures for coastal and fluvial flooding. This will enable ABC to make an informed decision moving forward on the most economically, environmentally and socially viable options to alleviate flooding in Lochgilphead.

At this point of the study, significant work has been carried out to understand the flood mechanisms affecting Lochgilphead and to identify constraints and opportunities with regard to potential flood mitigation options. An option screening process has been carried out to produce a short list of options which has been summarised in more detail in Section 3. The short listed options resulting from the screening process have been developed in more detail in this report.

The following Phases of this Flood Study have already been undertaken and consist of:

- Phase 1 – Data gap analysis
- Phase 2 - Baseline modelling
- Phase 3 – Options screening report

The purpose of this report, Phase 4, is to detail the development and appraisal process of the shortlisted options through hydraulic modelling, concept design, costing, damages assessment and multi-criteria appraisal to consider economic, social and environmental aspects of each option. The aim of this is to assess the options against each other so that the best solution can be identified. The scope of the report includes:

- Summarising the process to date
- Modelling of short listed mitigation options
- Costing of short list options
- Economic, Social and Environmental Appraisal of the short list options
- Prioritise list of mitigation options
- Next steps

1.2 The process

The project is being carried out in a phased approach in line with Scottish Environment Protection Agency (SEPA) and Scottish Government Guidance[1][2]. **Figure 1.1** provides a high level overview of the study development process.

[1] Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities, Scottish Government, May 2016.
[2] Local Authority flood study checklist, Version 2, SEPA, June 2017.

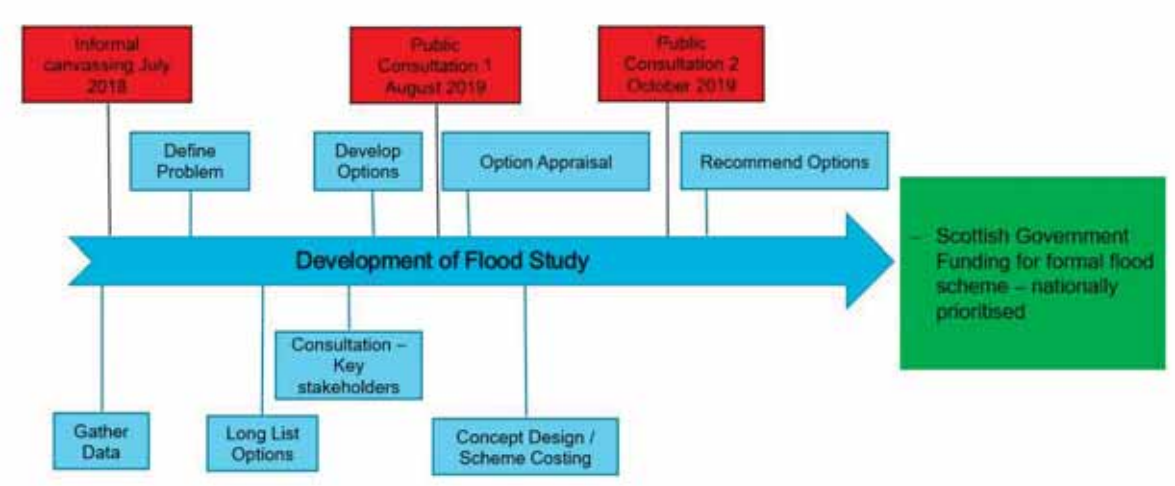

Figure 1-1 The study process

Significant work has been carried out to understand the flood sources and mechanisms affecting Lochgilphead. During Phase 1 the existing available information was collated and a gap analysis undertaken to determine the quality of the data and what additional information was needed in order to undertake the assessment of flood risk.

At the start of the flood study process, a public consultation was carried out with the residents of Lochgilphead, to understand their experience of flooding in the area and to identify hotspots. This information was then be used to sense check any modelling outputs generated. Further public consultation was held during Phase 3 to present the findings of the long list to short list process to the community, where feedback and comments were gathered on the options identified to manage the flood risk. Consultation was a key part of the Phase 3 process. As well as public consultation, statutory stakeholders such as SEPA, Scottish Canals and Scottish Water were involved through technical workshops. Phase 4, which is this phase, saw the final consultation event that presented the preferred option for Lochgilphead. The feedback is discussed later in this report.

The flood mechanisms and extents currently experienced in Lochgilphead were confirmed in Phase 2. Flooding from coastal and fluvial sources were assessed through long-term wave transformation modelling, joint probability and wave overtopping analyses. Catchment hydrology was undertaken to form the fluvial inflows to the two watercourses in the study area. In addition to this, a high-level model of the Crinan Canal was also constructed to understand how this influenced fluvial flows. These sources, fluvial, coastal and canal, were then combined in a computer model to establish an overall picture of flooding in Lochgilphead. The findings of this stage are summarised in Section 2 of this report.

The study is currently at Phase 4; where the drivers of flooding and the scale of the problem are understood and short listed options to mitigate flood risk have been proposed. The process of determining the short list in Phase 3 was informed by feasibility screening assessments, additional assessments including ecological, environmental and planning desk studies to identify constraints to and opportunities for flood alleviation options.

The Scottish Government Guidance on Options Appraisal for Flood Risk Management sets out a clear approach to identify and prioritise mitigation measures. The following steps are highlighted:

- Define the purpose of the appraisal and set objectives.
- Identify “long list” of potential flood measures
- Screen to create a “short list” of flood measures
- High level appraisal of short listed flood measures

AECOM have adopted this approach for Phase 4 of this study. A short list of the most feasible and beneficial options were determined in Phase 3 and will be further assessed during this phase of the study. The short list of options will be further developed through detailed modelling where required, outline design and cost benefit appraisal. The way forward will then be dependent on the option recommendations. If a formal scheme is determined to be the best option, the findings of this study would be passed to SEPA for inclusion in the next round of SEPA FRM Strategies. The Strategies set out a prioritised list of actions for flood risk on a national scale.

If successful, the FS will then be submitted for approval to Scottish Government and the scheme details presented to the public for comment. Following this, detailed design will commence with funding statements compiled and approved prior to tender and construction.

2. Baseline Modelling Results – Summary

Lochgilphead is located in a Potentially Vulnerable Area that has been identified as being at risk from fluvial, canal and coastal sources of flooding.

To assess these flooding interactions, a 1D/2D model was constructed, with inflows representing the coastal conditions, fluvial subcatchments and Crinan Canal. Full details of the baseline method and results can be found in the Phase 2 report.

2.1 Model inflows

Inflows from the three flood sources were established by undertaking hydraulic modelling and hydrological analysis. A summary of the assessment undertaken for each source is presented below.

2.1.1 Coastal

The main objective of the coastal modelling exercise is to establish the nearshore extreme still water levels and wave characteristics along the frontage at Lochgilphead which can then be used in the inundation modelling. In order to achieve this, AECOM has undertaken a numerical modelling study to investigate the existing and future (up to the year 2100) wave climate. The information on wave conditions and extreme sea levels was used to assess still water levels and provide wave overtopping rates which were used as inflows into a linked 1D/2D hydraulic model that included all sources of flooding.

A regional wave model was run to establish the offshore wave heights at Lochgilphead under present day conditions. The regional modelling results show that the wave climate at the entrance to Lochgilphead, at Ardrishaig, is moderate (< 3 m) although a maximum significant wave height of 3.5 m was predicted over the available 38 year hindcast period. A joint probability analysis of wave heights and water levels was undertaken for present day condition and a future (2100) epoch. The results from this extremes offshore analysis were then used as boundary conditions for a local high resolution coastal model of Loch Gilp.

The findings from the local model for the present day scenario show that wave conditions within Lochgilphead are small, with a 1% AEP event producing wave heights in the region of 0.8 m. The small waves can be attributed to the extensive shallow bathymetry within Loch Gilp.

Due to the small wave heights, and upward sloping topography of the frontage at Lochgilphead, wave overtopping is not considered a significant issue. Increases in still water levels, as predicted in climate change scenarios, represent the greatest source of flooding to the lower lying areas of the town.

The extreme sea level established in this coastal modelling exercise was applied as the tidal boundary to the 1D/2D linked model.

2.1.2 Crinan Canal

The Crinan Canal discharges into the Badden Burn catchment via Waste Weir 3 in between Cairnbaan and Lochgilphead. There is also the potential for the canal to overtop its embankment should levels build sufficiently. Both sources will contribute to flood risk in and around Lochgilphead and require to be added into the 1D/2D model.

A simplified 1D model of the Crinan Canal, including sluice gates, waste weirs and controlled and uncontrolled feeders was constructed to establish likely flows from the canal into the Badden Burn catchment. These flows were applied to the 1D/2D model. Assumptions were made in relation to operation and these are fully discussed within the Phase 2 report.

It was found that Waste Weir 3, downstream of Cairnbaan, discharged into the Badden Burn from the 50% AEP event, and spill over the canal embankment occurred from the 20% AEP event. These flows contributed to the total flows in the Badden Burn and were applied to the linked 1D/2D model as point inflows.

2.1.3 Fluvial

The watercourses that run through Lochgilphead are made up of numerous subcatchments. These subcatchments were represented in the 1D element of the model separately at their inflow location to best replicate timings and flood volumes throughout the reach.

However, there are inherent issues with small catchment hydrology, and for this reason, peak flow for the total larger catchment at the tidal limit of the watercourse was calculated so that the subcatchment flow could be reconciled to a flow estimate that held more confidence.

Each subcatchment was delineated using FEH Web Service information where available. Given the difference in catchment size, critical storm durations were found to vary. To establish one critical duration for the entire catchment, a range of durations were run through the 1D/2D model to establish the duration that produced the greatest flooding at key receptors.

To establish the peak flow estimates for the catchment to the tidal extent, catchment descriptors for the total catchment were downloaded from the FEH Web Service and amended where appropriate. These descriptors were then used to undertake Statistical and ReFH2 analyses at the downstream end for comparison before selecting the preferred method. The Statistical method was deemed to be the most appropriate method when considering the catchment descriptors and also produced the largest flows. These flow estimates were taken forward as the downstream peak flows to which subcatchment inflows were to be scaled to.

When undertaking the reconciliation, it was found that the uplift factors of the subcatchments would have to be very high to achieve a match with the Statistically derived flows at the downstream boundary. Sensitivity checks were undertaken to establish whether these uplifts were realistic and if the downloaded catchment descriptors were correct. It was found that the catchment descriptors were accurate, but the uplifts were unrealistic due to floodplain functioning around the Meadows area. Flows were not reconciled to the Statistic peaks for this reason.

As the subcatchments were represented by ReFH2 units, all subcatchment inflows were uplifted by the difference between the ReFH2 downstream peaks and the Statistical downstream peaks. This equated to uplifts on all subcatchment peaks of between 1.18 and 1.24, based on the ratio of the downstream Statistical Analysis flows to the ReFh2 peak flow estimates. Full details of this analysis can be found in the Phase 2 report.

Climate change uplifts used within this study were based on the SEPA commissioned CEH report which utilised UKCP09 data. The medium emission scenario, 50th percentile uplift of 37% was applied, with the medium emission, 90th percentile of 60% assessed as a sensitivity test.

These inflows, with the standardised critical storm duration and flow reconciliation uplift were applied to the 1D inflows into the 1D/2D model.

2.1.4 Joint probability

Once the coastal and fluvial conditions had been established, a joint probability assessment was undertaken to establish the likelihood of fluvial and coastal interactions.

There is no gauged data from the surrounding areas that could be used to establish joint probability likelihood. Therefore, the most appropriate way to determine joint probability is through sensitivity testing within the modelling.

The sensitivity testing involved running a high fluvial event with a range of coastal levels to identify if there were any key areas where flooding increased during a combined event (i.e. medium tidal and coastal event - $Q_{05\%}$ $T_{10\%}$) than from a single source event (i.e. high fluvial, minimal tidal - $Q_{0.5\%}$ T_{MHWS}). The same combinations were run for a tidal event, with a high tide of 0.5% AEP with a range of fluvial flows. This analysis was also undertaken for climate change scenarios. For the single source simulations, a tide level of the Mean High Water Spring (MHWS) level was applied to the high fluvial flows, and a flow equating to QMED / 2 was applied to the high tidal levels.

It was found that the two sources of flooding were largely independent of each other, with fluvial sources causing the greatest flood risk to areas upstream of Bishopton Road and tidal sources causing the greatest flood risk to areas downstream of Bishopton Road.

Given the independence of flood sources, a set of fluvial runs, with a MHWS boundary, and a set of tidal runs, with a QMED / 2 fluvial flow were undertaken.

2.2 Flood risk

Given the mechanisms found in the joint probability analysis, where some areas were tidally dominated and some were fluvial dominated, a full suite of fluvial simulations and a full suite of tidal simulations were undertaken to establish the maximum flood depths and extents at all locations across the study area.

2.2.1 Fluvial

Figure 2-1 displays the sequence of when flooding occurs in a 0.5% AEP event.

During the 0.5% AEP fluvial event, which includes any flow from the canal, flooding first occurs from overflow Weir 3 on the canal and from overtopping of the culvert near Cairnbaan on the Badden Burn (location 1). Out of bank spill then occurs upstream of the Meadows area into the rural land on either side of the watercourse (location 2). Flooding from these spill locations combines with spill from the canal and causes much of the land and the A816 between Lochgilphead and Cairnbaan to become inundated. Whilst flooding continues to spread upstream of Lochgilphead, out of bank flow is first noted at the confluence of the Badden Burn and Cuilarstich Burn (location 3) and at the caravan park (location 4). Flood waters build in the caravan site before flowing over the A83 and out to sea. Later in the event, an additional area of flooding is observed around the junction of Bishopton Road and the A816 around the ABC plant yard (location 5).

The joint probability analysis showed that during a fluvial event, it was likely there would be a low tide. No flooding is observed during a fluvial event as a result of a MHWS sea level as the tide levels do not reach the top of the coastal defences along the Front Green.

The 0.5% AEP event plus climate change follows the same flood mechanism as the 0.5% AEP present day event, albeit with an increase in flood depths. Additional areas of flooding on both banks originates from the Cuilarstich Burn at the Bishopton Road crossing (location 6) which occurs slightly later in the event than spill into the caravan park.

The joint probability analysis showed that during a fluvial event, it was likely there would be a low tide. No flooding is observed during a fluvial event as a result of a MHWS sea level as the tide levels do not reach the top of the coastal defences along the Front Green.

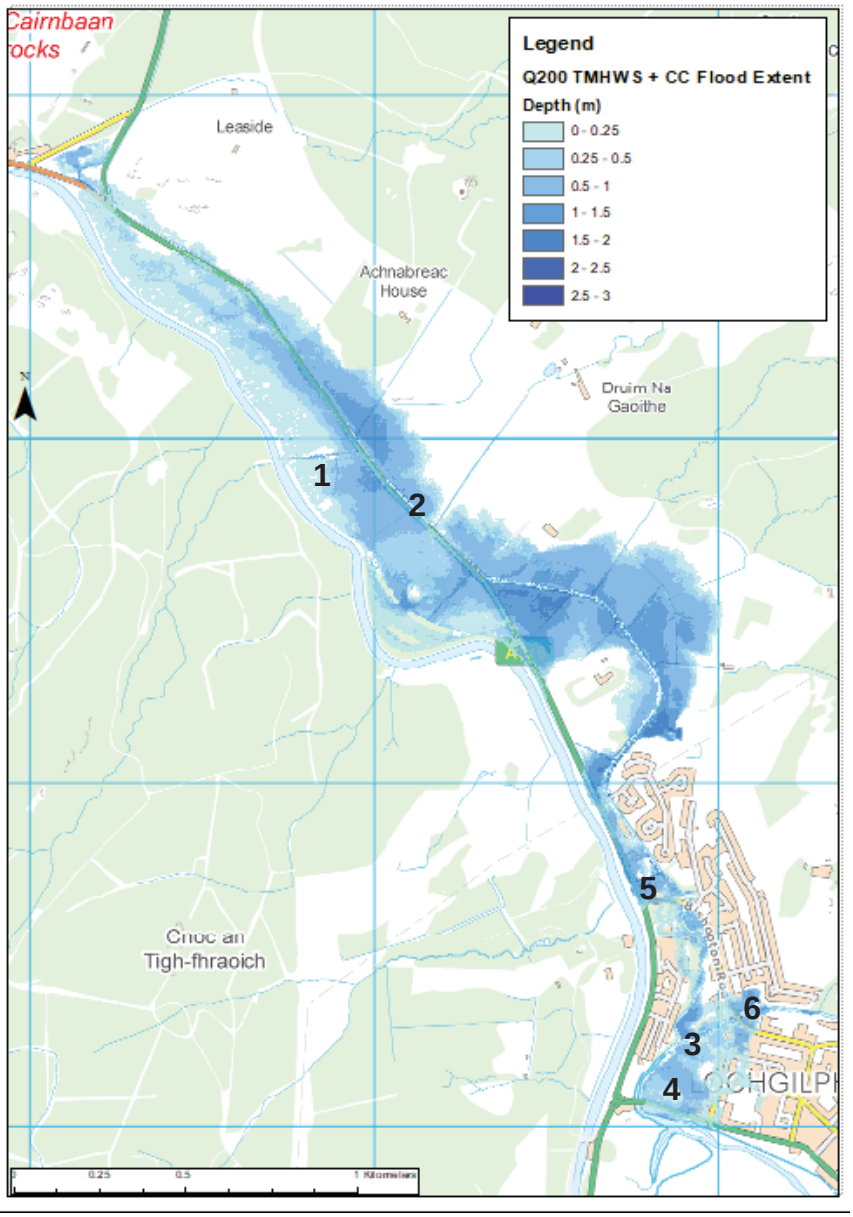

Figure 2-1: Fluvial flooding $Q_{0.5}$ T_{MHWS} + CC

During higher frequency events, flooding first occurs on the floodplain surrounding the A816 and at the confluence of the Badden Burn and Cuilarstich Burn from the 50% AEP event. More notable flooding is experienced upstream of the Meadows area from the 10% AEP event. By the 2% AEP event, a large portion of the floodplain upstream of the Meadows is inundated, and spill into the caravan park from the Badden Burn commences. By the 1% AEP event, a large percentage of the caravan park is inundated.

2.2.2 Tidal

During the 0.5% AEP tidal event, with a low fluvial flow, flooding first occurs around the confluence of the Badden and Cuilarstich Burn due to tidal levels backing up in the channel. The entire Front Green up to Poltalloch Street becomes flooded before the peak tide where tidal waters are also seen to spill over the A83 and over the left bank of the watercourse into the caravan park. Tidal floodwaters begin to encroach onto properties along the A83, before spreading up Argyll Street.

The joint probability analysis showed that during a tidal event, it was likely there would be a low flow in the watercourses and from the Crinan Canal. Some minor flooding is noted on the A816 from the canal overflow weir and from overtopping of the culvert at Cairnbaan during a tidal event. Average depths are in the region of 100mm.

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The 0.5% AEP event plus climate change follows the same flood mechanism as the 0.5% AEP present day event, albeit with an increase in flood depths in the caravan site and on the Front Green. A larger portion of the urban area of Lochgilphead is affected in the climate change scenario, with floodwaters reaching Lorne Street and Union Street, again producing greater flood depths.

The joint probability analysis showed that during a tidal event, it was likely there would be a low flow in the watercourses and from the Crinan Canal. Some minor flooding is noted on the A816 from the canal overflow weir and from overtopping of the culvert at Cairnbaan during a tidal event. Average depths are in the region of 200mm.

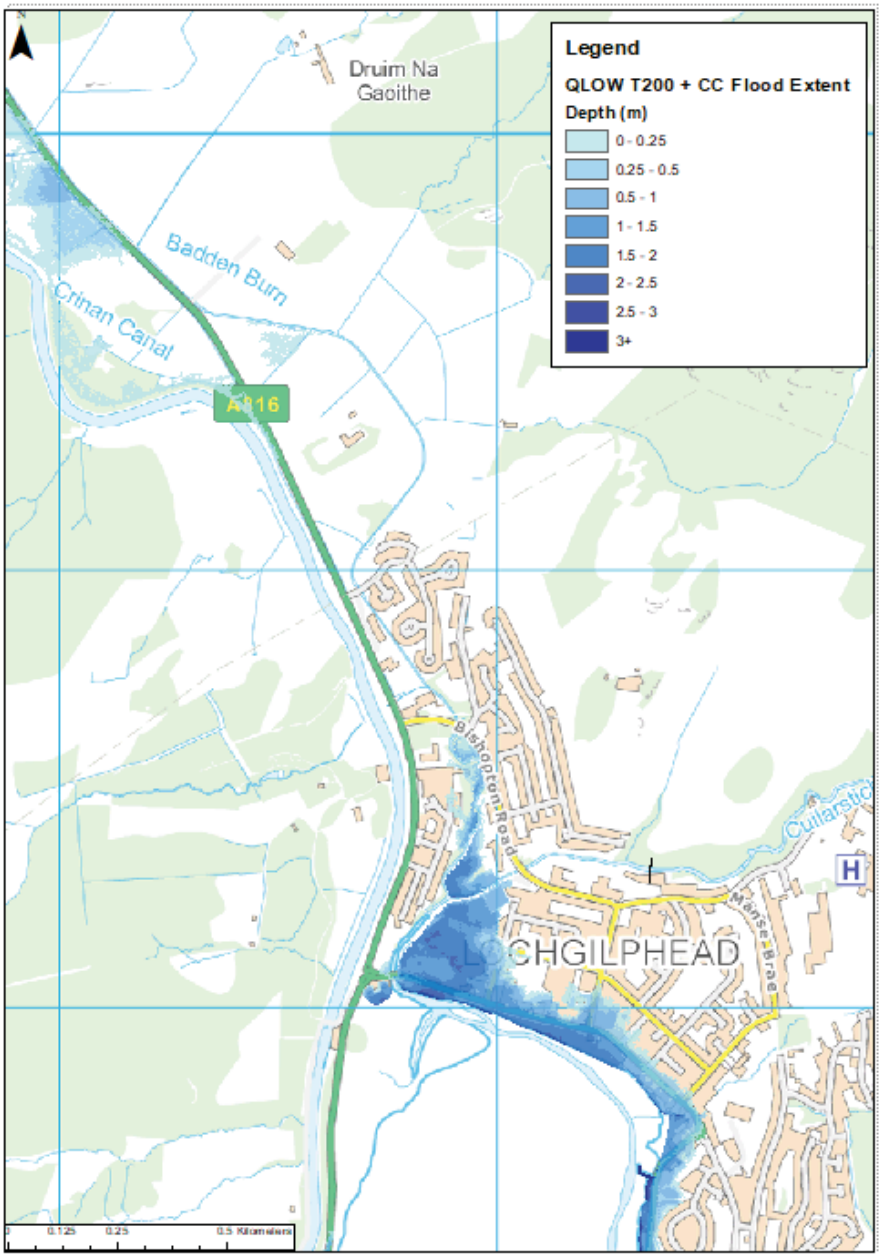

Figure 2-2: Tidal flooding Q_{LOW} $T_{0.5\%}$ + CC

During higher frequency events, flooding occurs on sections of the Front Green from the 50% AEP event. By the 20% AEP event, the whole Front Green is inundated, and tidal levels have exceeded the levels on Poltalloch Street and overflowed into the caravan park, causing inundation across approximately 60% of the site. Properties along Poltalloch Street are seen to be affected from the 10% AEP onwards, with flooding becoming more widespread through Lochgilphead by the 2% AEP event.

3. Short Listing Process

Following baseline modelling, option screening was carried out based on guidance in the Flood Risk Management (Scotland) Act 2009. An initial long list of all possible flood protection options was developed through an internal workshop with ABC. This long list included a wide range of options from NFM to traditional direct defences. A screening exercise was then undertaken to identify the feasible options from a flood risk performance, constructability and economic perspective which would then form the short list of options, meaning further assessment could be focused around viable options.

The full Long List to Short List screening process is detailed in 'The Lochgilphead Flood Study Options Screening Report' (Phase 3). The report outlines our initial long list of flood mitigation options and summarises the short list process which was informed by the following inputs:

- External workshops with ABC and statutory stakeholders such as SEPA and Scottish Canals to integrate their feedback to shortlisting process
- Public consultation event to gain feedback on options and factor this into appraisal
- Ecological Preliminary Appraisal Study and Planning and Environmental Constraints Study to identify constraints to further inform appraisal

These inputs were layered up and the assessment either included or discounted options based on their feasibility. The result of this assessment was production of the short list, which is set out in Table 3-1. The majority of options taken forward were focused around protection from coastal sources as this source poses the greatest flood risk and concentration of properties in Lochgilphead.

Table 3-1 Short list of options

Measure Category	Measure	ID
Direct defences	Fluvial measure - Increasing left bank along the caravan park	3.2
	Coastal measure - Coastal flood wall along existing coastal defences	3.3
	Coastal measure - Coastal flood wall set along Poltalloch Street	3.4
	Coastal measure - Flood embankment along existing coastal defences	3.5
	Coastal measure - Flood embankment set back within front green area	3.6
	Coastal measure - Combination of direct defences	3.8
Property flood protection	Coastal and fluvial measure - Small scale property interventions	4.1
Flood resilience	Coastal and fluvial measure - improve building resilience	5.1
Self help	Coastal and fluvial measure - improve understanding of flooding issues and how to cope better.	9.1
Land reclamation	Coastal measure - Infilling of an area of back of houses east of front green and at Police Station	11.2
Canal management	Fluvial measure - Alternative operation of canal	12.1

4. Refining options

The shortlisted options provided an overview of the type of option and its indicative location. The next stage was to refine these measures to specific locations and details based on the baseline modelling results.

The shortlist of flood protection measures were all focused on cell 1 (Figure 6-3) which extends along the front section of Lochgilphead. Splitting flood areas into cells allows defence lengths and heights to be optimised and prioritisation of where the greatest benefits are.

The final list of flood protection options that are assessed in detail in this phase is shown in Table 4-1.

The additional categories of Self Help and Flood Resilience will also be carried forward to the scheme recommendations. These options will not form part of a formal scheme but will provide general recommendations that can be undertaken in combination with the preferred scheme design to further increase resilience and awareness.

Table 4-1 Options and associated measures

Option No.	Description	Flood cell	Description of Measures
1	Direct defences: Increasing flood embankment around caravan park	1	Flood embankment along the western edge of the caravan park on the banks of the Badden Burn
2	Direct defences: Existing defence line - wall	1	Flood wall along the existing defence line at the Front Green. This is likely to be set back slightly to ease construction and reduce issues relating to the structural stability of the existing wall. Flood embankment along the western edge of the caravan park on the banks of the Badden Burn. Coastal flood wall behind the properties at Lochnell Street and A83. Vehicle access flood gate across the A83 and several smaller gates for access to the shore.
3	Direct defences: Existing defence line - embankment	1	Flood embankment along the existing defence line at the Front Green. This set back slightly to ease construction and reduce issues relating to the structural stability of the existing wall. There are sections where it may be necessary to install a flood wall where there are space constraints. Flood embankment along the western edge of the caravan park on the banks of the Badden Burn. Coastal flood wall behind the properties at Lochnell Street and A83. Vehicle access flood gate across the A83 and several smaller gates for access to the shore.
4	Direct defences: Set back wall	1	Flood wall set back along Poltalloch Street. This may be either directly at the pavement or set back slightly if this eases construction. Flood embankment along the western edge of the caravan park on the banks of the Badden Burn. Coastal flood wall behind the properties at Lochnell Street and A83. Vehicle access flood gate across the A83 and several smaller

Option No.	Description	Flood cell	Description of Measures
			gates for access to the Front Green.
5	Direct defences: Set back embankment	1	Flood embankment set back within the Front Green. There are sections where it may be necessary to utilise a flood wall where there are space constraints. Flood embankment along the western edge of the caravan park on the banks of the Badden Burn. Coastal flood wall behind the properties at Lochnell Street and A83. Vehicle access flood gate across the A83 and several smaller gates for access to the Front Green.
6	Direct defences: Combination of defences	1	Combination of direct defences best suited to the location and requirements. This could entail a wall, embankment, copping stone, flip-up/demountable barriers etc. This combination approach would extend along the Front Green and behind Lochnell Street. Flood embankment along the western edge of the caravan park on the banks of the Badden Burn. Vehicle access flood gate across the A83 and potential for several smaller gates for access to the Front Green depending on use of demountables.
7	Land reclamation and combination of defences	1	Combination of direct defences best suited to the location and requirements. This could entail a wall, embankment, copping stone, flip-up/demountable barriers etc. This combination approach would extend along the Front Green, and behind Lochnell Street. Small scale land reclamation behind the properties on Lochnell Street to provide additional space to aid construction and provide a continuous footpath. Flood embankment along the western edge of the caravan park on the banks of the Badden Burn. Vehicle access flood gate across the A83 and potential for several smaller gates for access to the Front Green depending on use of demountables.
8	Direct defences: shorter section of lower wall	1	Flood wall set along Poltalloch Street from wall at police station to junction with Lorne street. Flood wall up Lorne street to tie in to high ground Vehicle access flood gate across Poltalloch Street and several smaller gates for access to the Front Green.
9	PFP	1	Property flood protection to be provided to coastally affected properties. Measures would be passive or automated if possible. Affected properties are primarily along Poltalloch Street and Lochnell Street. This would include measures such as flood doors and flood-proof airbricks. Appropriate for flood levels up to 0.6m in depth. PFP could be done in combination with other resilience measures such as waterproof paint and raising sockets to further minimise damage from flooding.

5. Modelling and Development of Short-Listed Options

5.1 Modelling of mitigation options

Hydraulic modelling of the coastal shortlisted options has not been undertaken because the outline design of the coastal defences is simply set against the predicted tide and wave level. Wave overtopping from flood events below the design level is taken to be negligible because of the small wave heights, and flood events in excess of the design event are assumed to fully inundate the area behind the defence line up to the predicted flood level.

At extreme fluvial events, only a limited number of permanent properties, and the static caravans in the caravan park are at risk of flooding. It should be noted that non-permanent properties such as caravans, do not hold any significant damage value in the economic assessment.Therefore, only one fluvial defence option has been considered, which has been adapted so it can also be included in the coastal options. The outline design of the fluvial option was modelled by incorporating the increased embankment height into the baseline model. This helped to establish length and height of defence.

Figure 5-1 displays a schematisation of the shortlisted options. All options are detailed more fully in the following sections and within the drawings in Appendix A.

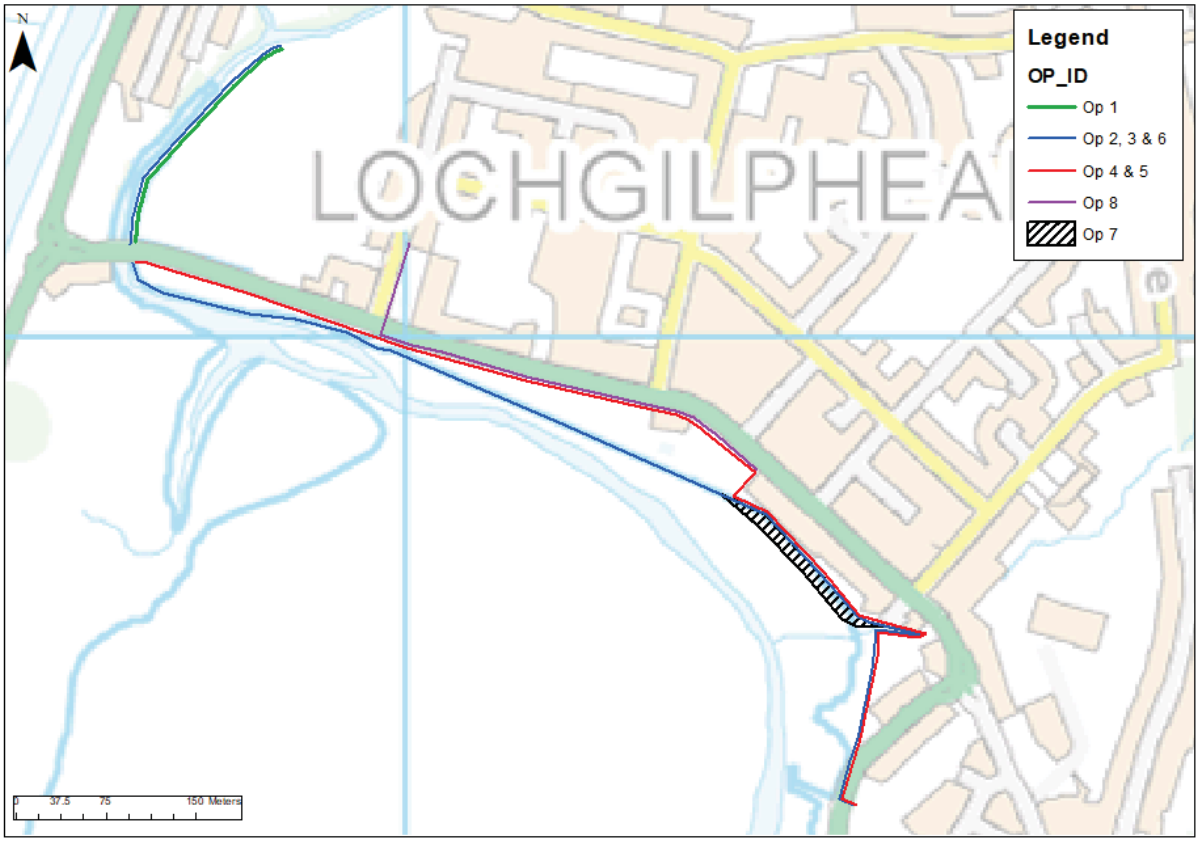

Figure 5-1: Schematisation of shortlisted options

5.2 Design defence level and standard of protection

The main purpose of the coastal flooding defence is to protect properties within the town, both residential and commercial from direct tidal inundation. Flood defence crest heights are made up of two elements; the design flood level (in this case extreme sea level) and a freeboard allowance. Freeboard is applied to accommodate waves and a factor of safety against general uncertainties in the determination of the design flood level.

Because Lochgilphead, Loch Gilp and Loch Fyne are very sheltered from the open sea, and nearshore modelling established that wave heights concurrent with extreme tides are very low, it is expected that wave overtopping of any sea defence will be small to negligible. For the purpose of this

flood study, the flood defences heights are based on applying a freeboard allowance of 0.6m on top of the maximum still-water flood level; this has been applied for simplicity and does not materially influence the appraisal of the options. Should an option be viable, the actual freeboard applied to the final defence design could be chosen specifically for the wall type and location against a determination of tolerable wave overtopping.

After an assessment of still water levels, existing ground levels and number of affected properties, the 0.5% AEP/ 10% AEP+ climate change event was taken as the general Standard of Protection (SoP) that defences would aim to protect up to. It should be noted that any defence foundations would be designed so that defences could be raised in the future if required. It will be stated if this is not the SoP achieved by an option. Protecting to this event meant that a good standard of protection would be provided but held lesser visual and cost implications of providing protection for high climate change events. See Section 5.12 for discussion around sensitivity testing of SoP and BCR. Direct defences, ranging from 1.3 - 2m high (depending on location) would be required to protect Lochgilphead and all properties along Poltalloch Street and the A83 to a 0.5% AEP (1 in 200 year) current day event. These heights include a freeboard allowance. The highest defences are required along (or just set back from) the existing defence line in the middle of the front green, just west of the Poltalloch Street/Argyll Street junction.

Direct defences to a 0.5% AEP current day standard could provide protection for up to 83 properties. But it should be noted that only 52 of these properties are classed as permanent, with the remainder being static caravans.

Indicative sections of the defences were drawn against the 0.5% AEP (1 in 200 year) event and the different extreme flood levels shown alongside to gain an understanding of the SoP that varying defence heights could provide to the properties at risk. These sections are shown in Appendix A.

5.3 Option 1 - direct defences: increasing flood embankment along caravan park

Direct defences would require raising the existing fluvial embankment along the caravan park, from Polltaloch street to the confluence of the Cuilarstich and Badden burns.

To assess the required height and extent of this option, the bank lines were raised in the baseline model and run for a range of AEP events. It was found that it was possible to eliminate flooding to the caravan park up to and including the 1% AEP event. Events exceeding this would require a much greater length of embankment as flow travels overland from the Cuilarstich Burn.

The average water level in the burn at the caravan park with the raised embankment in place was 3.55mAOD, to which a freeboard allowance of 600mm was added. The total length of embankment was approximately 220m.

An indicative section was drawn to show the defence height and width required to offer a 1% AEP (1 in 100yr) fluvial SoP. The location of the embankment can be seen in **Figure 5-2**. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP1-A'** in Appendix A.

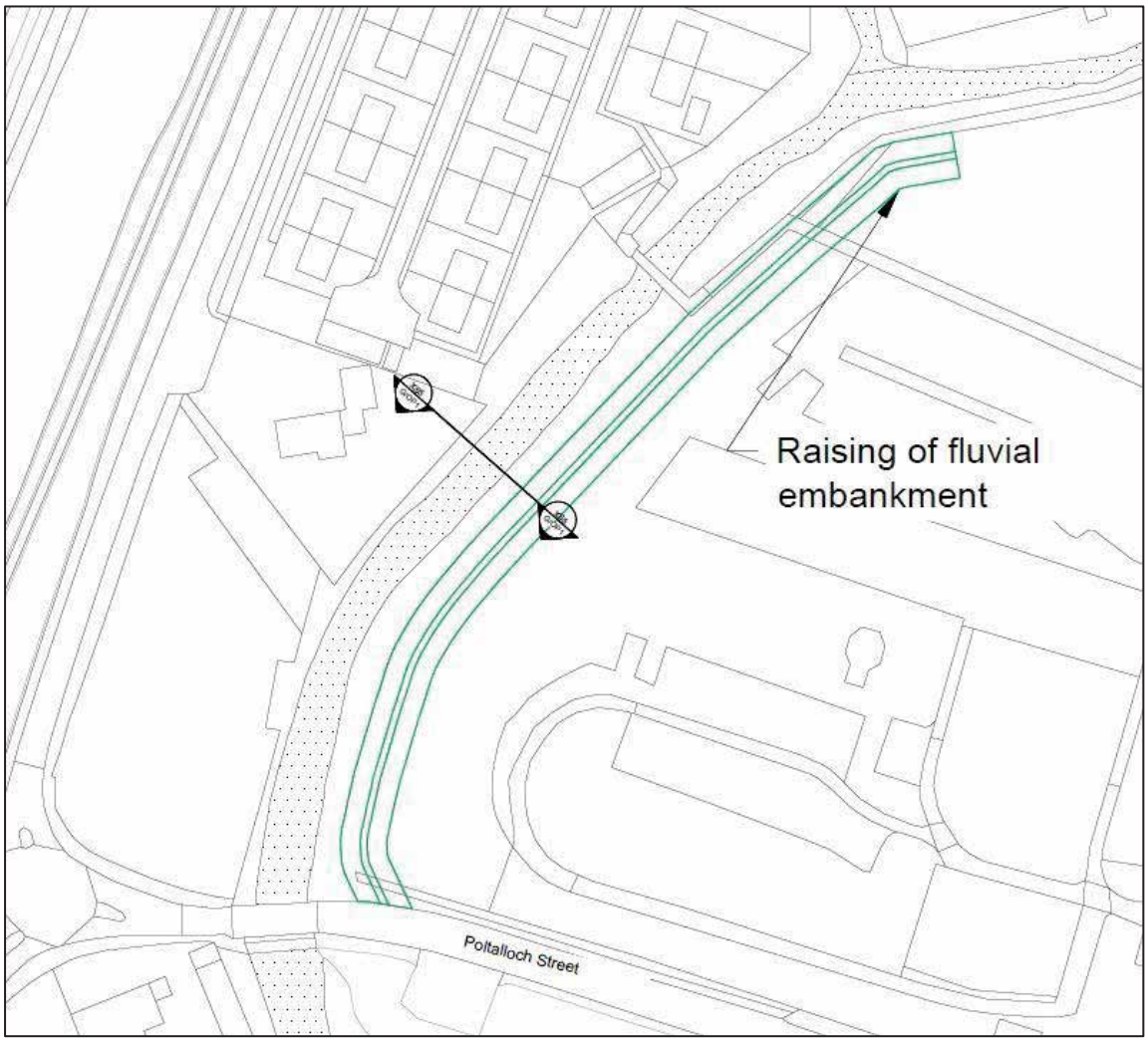

Figure 5-2 Option 1: Raising of direct defence embankment along caravan park

The defence height required would have significant influence on the appearance of the caravan park and may cause adverse visual impact. However, the bank of the burn is currently heavily vegetated and the visual disruption of this option could be minimised.

Direct defences could provide protection for up to two permanent commercial properties. Up to 28 non-permanent (static caravans) could also be protected by the defence. It should be noted that the total number of non-permanent properties is likely to vary over time.

5.4 Option 2 - direct defences: existing defence line wall

Direct defences on the existing defence line at the Front Green would require to extend along the existing coastal wall parallel to Poltalloch Street from the Poltalloch Street road bridge and along the existing defence to the wall behind the police station on Lochnell Street. The proposed coastal defence would then extend behind the properties on Lochnell Street and the A83 before linking with a floodgate across the A83 that ties into higher ground. This adds up to approximately 920m of direct defence flood-wall. The average height of defences for this option is 1.8m above existing ground levels. This includes a freeboard allowance.

The fluvial embankment presented in **Section 5.3** can be adapted to increase the SoP to the 0.5% AEP event. This would account for 220m of direct-defence flood embankment of approximately 1.75m in height. This includes a freeboard allowance.

It is estimated that 3 flood gates, approximately 18m in length, would be required to provide access to the front green and across the A83. The location of flood wall and gates can be seen in Figure 5-3. An indicative section was drawn to show the defence height and width required to offer a 0.5% AEP (1 in

200yr) tidal SoP. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP2-A'** in Appendix A.

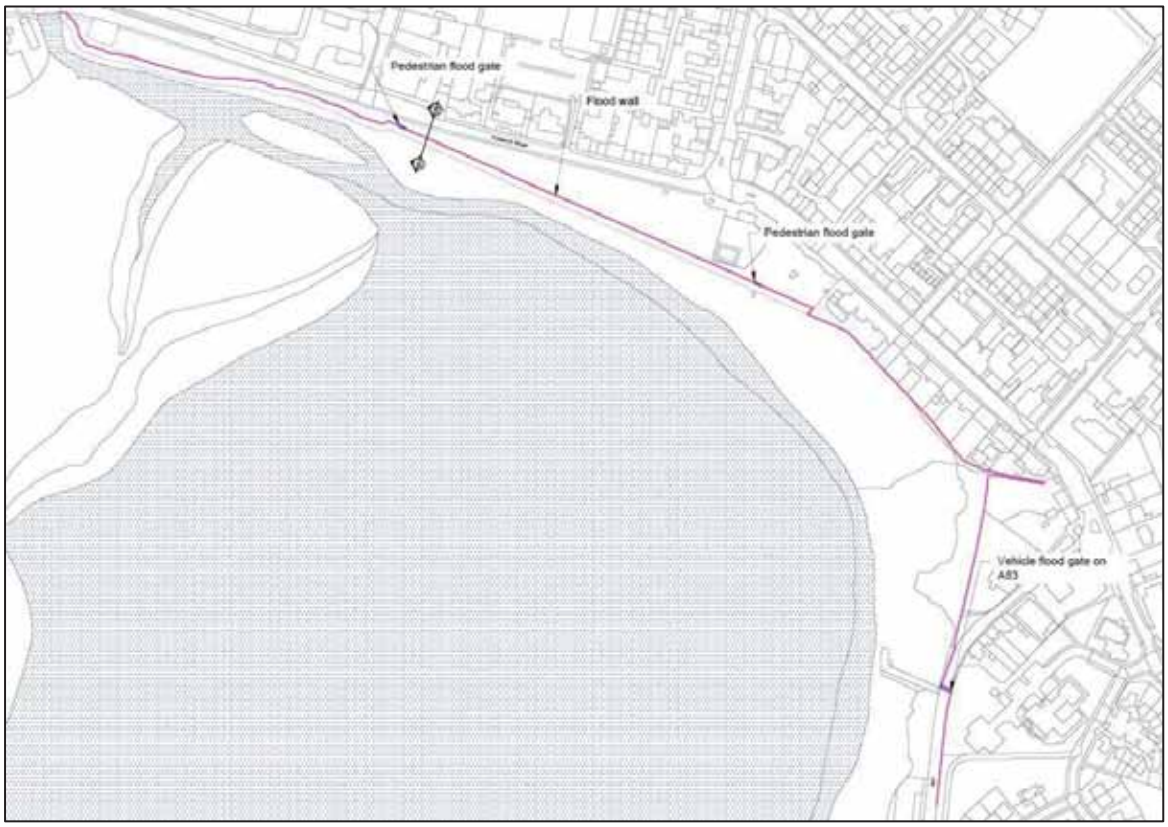

Figure 5-3 Option 2: Direct defences along existing coastal wall

The proposed defence is shown to be set back 5m from the existing wall on the Front Green. This is due to the condition of the existing wall being unknown and therefore to reduce any loading on the structure, and for sufficient construction space to be provided. This area would be used to allow access for maintenance on the seaward side of the defence and could be landscaped. The defence height required would have significant influence on the character of the area, reduced connectivity with the sea and may cause extremely adverse visual impact.

Direct defences could provide protection for up to 64 permanent properties, residential and commercial.

5.5 Option 3 - direct defences: existing defence line embankment

Direct defences on the existing defence line at the Front Green would require constructing an embankment along the existing coastal wall parallel to Poltalloch Street from the Poltalloch Street road bridge and extending along the existing defence to the wall behind the police station on Lochnell Street. Where the space does not allow for the embankment footprint (2m height, 1:3 sloping sides with 3m crest can be up to 15m wide in places) a flood wall would require to be installed. This would account for 365m of direct-defence flood embankment. The average height of embankment is 1.9m above existing ground levels. This includes a freeboard allowance.

The proposed defence would then extend as a coastal flood wall behind the properties on Lochnell Street and A83 before linking with a floodgate across the A83 that ties into higher ground (as shown in **Figure 5-3**). This (along with flood wall utilised where space does not permit an embankment) adds up to approximately 565m of direct defence flood-wall.

The fluvial embankment presented in **Section 5.3** can be adapted to increase the SoP to the 0.5% AEP event. This would account for 240m of direct-defence flood embankment of approximately 1.75m in height. This includes a freeboard allowance.

The total embankment length for this option would be 605m.

It is estimated that 3 flood gates. approximately 18m in length, would be required to provide access to the front green and across the A83. The location of the embankment, flood wall and gates along the front green can be seen in **Figure 5-4**. An indicative section was drawn to show the defence height and width required to offer a 0.5% AEP (1 in 200yr) tidal SoP. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP3-A'** in Appendix A.

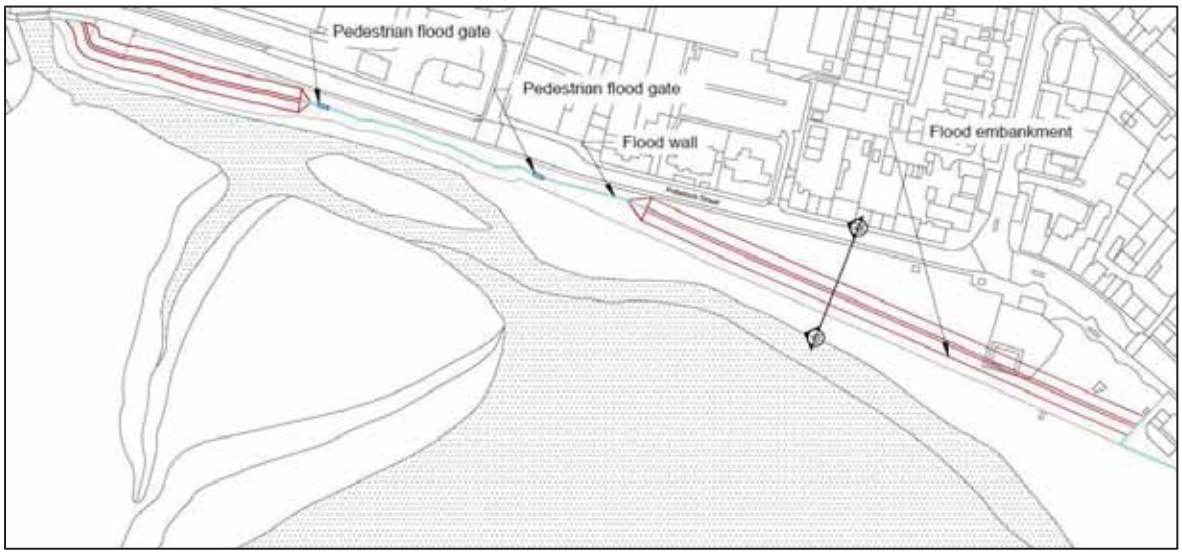

Figure 5-4 Option 3: Direct defence flood embankment along existing coastal wall at front green

The proposed defence is shown to be set back 5m from the existing wall on the Front Green. This is due to the condition of the existing wall being unknown and therefore to reduce any loading on the structure, and for sufficient construction space to be provided. This area would be used to allow access for maintenance on the seaward side of the defence and could be landscaped. The defence height required would have significant influence on the character of the area, reduced connectivity with the sea and may cause extremely adverse visual impact. This could be somewhat mitigated through landscaping.

Direct defences could provide protection for up to 64 permanent properties, residential and commercial

5.6 Option 4 - direct defences: set back wall

Direct defences set back from the existing defence line at the Front Green would run close to Poltalloch Street, tying into high ground at Poltalloch Street road bridge and extending along to the wall to the police station on Lochnell street. The proposed coastal defence would then extend behind the properties on Lochnell Street and A83, before feeding into a floodgate across the A83 that tied into higher ground (as shown in **Figure 5-3**). This adds up to approximately 940m of direct defence flood-wall. The average height of embankment is 1.25m above existing ground levels. This includes a freeboard allowance.

The fluvial embankment presented in **Section 5.3** can be adapted to increase the SoP to the 0.5% AEP event. This would account for 240m of direct-defence flood embankment of approximately 1.75m in height. This includes a freeboard allowance.

It is estimated that 3 flood gates, approximately 18m in length, would be required to provide access to the front green and across the A83. The location of wall and gates on the front green can be seen in **Figure 5-5**. An indicative section was drawn to show the defence height and width required to offer a 0.5% AEP (1 in 200yr) tidal SoP. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP4-A'** in Appendix A.

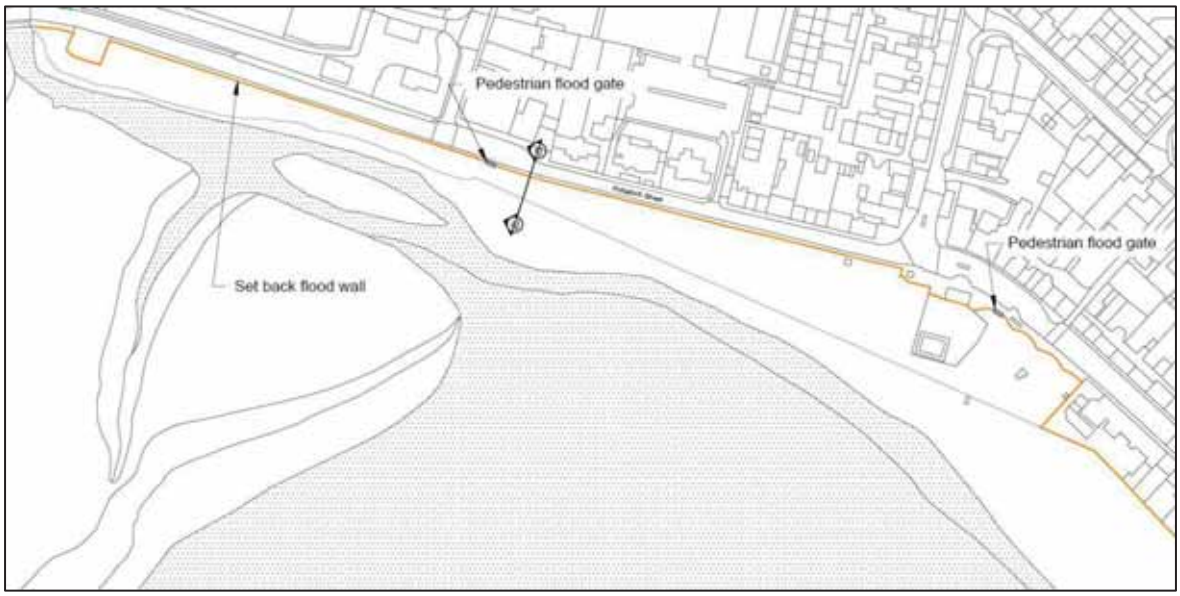

Figure 5-5 Option 4: Direct defence set back from existing coastal wall at front green

The proposed defence is shown to follow the kerb line along the south side of the pavement on Poltalloch street. This could be set back marginally if this were to ease construction and reduce the number of trees lost. The defence height required would have significant influence on the character of the area, reduced connectivity with the sea and may cause extremely adverse visual impact. This could be somewhat mitigated through landscaping.

Direct defences could provide protection for up to 64 permanent properties, residential and commercial

5.7 Option 5 - direct defences: set back embankment

Direct defences set back from the existing defence line at the Front Green would require constructing an embankment along the northern edge of the Front Green, from the Poltalloch Street road bridge to the wall at the police station on Lochnell Street. Where the space does not allow for the embankment footprint (2m height, 1:3 sloping sides with 3m crest, can be up to 15m wide in places) a flood wall has been utilised. This would account for 365m of direct-defence flood embankment. The average height of embankment is 1.9m above existing ground levels. This includes a freeboard allowance.

The proposed coastal defence would then extend as a flood wall behind the properties on Lochnell Street and A83. The wall would then cross the A83, before linking to a floodgate across the A83 that ties into higher ground (as shown in **Figure 5-3**). This (along with flood wall utilised where space does not permit an embankment) adds up to approximately 565m of direct defence flood-wall.

The fluvial embankment presented in **Section 5.3** can be adapted to increase the SoP to the 0.5% AEP event. This would account for 240m of direct-defence flood embankment to approximately 1.75m in height. This includes a freeboard allowance.

The total embankment length for this option would be 605m.

It is estimated that 3 flood gates, approximately 18m in length, would be required to provide access to the front green and across the A83. The location of the embankment, flood wall and gates along the front green can be seen in **Figure 5-6**. An indicative section was drawn to show the defence height and width required to offer a 0.5% AEP (1 in 200yr) tidal SoP. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP5-A'** in Appendix A.

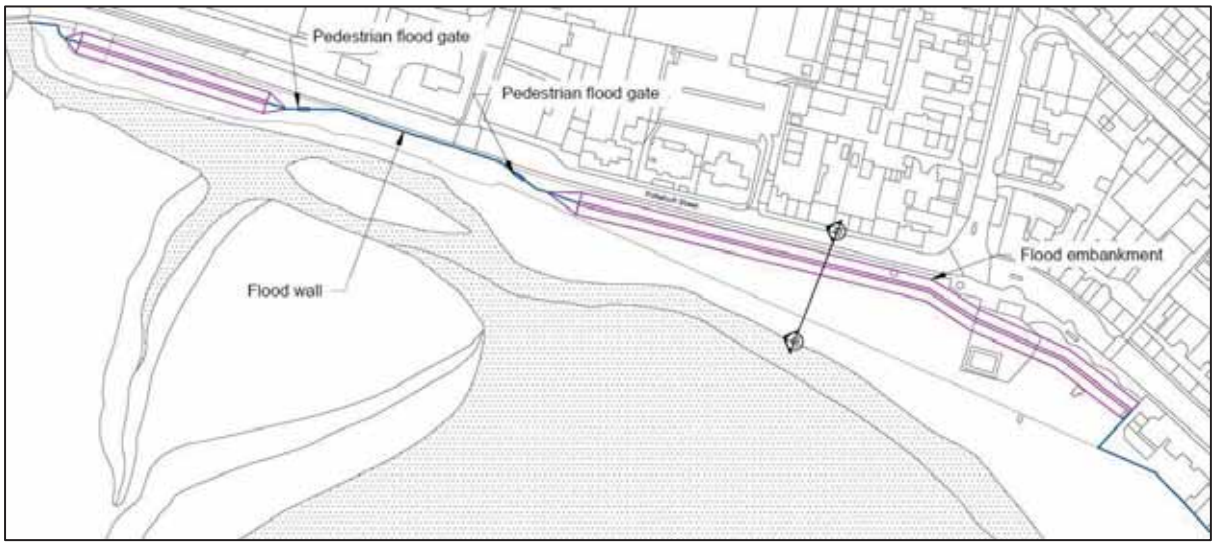

Figure 5-6 Option 5: Direct defence flood embankment set back from coastal wall at front green

The proposed embankment is shown to be set back from the kerb line along the south side of the pavement on Poltalloch Street. This is due to the presence of trees along the kerb line. The defence height required would have significant influence on the character of the area, reduced connectivity with the sea and may cause extremely adverse visual impact. This could be somewhat mitigated through landscaping.

Direct defences could provide protection for up to 64 permanent properties, residential and commercial

5.8 Option 6 - direct defences: combination of defences

Option 6 presents a combination of various options that are best suited to their location. This includes the construct of an embankment along the existing coastal wall parallel to Poltalloch Street from the Poltalloch Street road bridge and extending to just west of the Lorne Street junction. The defence would then extend as a flood wall along the existing coastal wall to the police station on Lochnell Street. A stretch of demountable defence will be included in this section of wall, to allow open views of Loch Gilp down Argyll street. The demountable defences considered in this option are simple frame and barrier structures, similar in concept to a series of stoplogs, which are manually mounted and demounted from permanent footings. The proposed defence would then extend as a flood wall behind the properties on Lochnell Street and A83, before linking to a floodgate across the A83 that ties into higher ground (as shown in **Figure 5-3**). This adds up to approximately 815m of flood-wall (including 50m of demountable wall) and 115m of flood embankment. The average height of defence is 1.9m above existing ground levels. This includes a freeboard allowance.

The fluvial embankment presented in **Section 5.3** can be adapted to increase the SoP to the 0.5% AEP event. This would account for 240m of direct-defence flood embankment to approximately 1.75m in height. This includes a freeboard allowance.

It is estimated that 1 flood gates, approximately 8m in length, would be required to provide vehicle access across the A83, the demountable barrier would provide further access. The location of the embankment, flood wall and demountable wall on the front green can be seen in **Figure 5-7**. An indicative section was drawn to show the defence height and width required to offer a 0.5% AEP (1 in 200yr) tidal SoP. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP6-A'** in Appendix A.

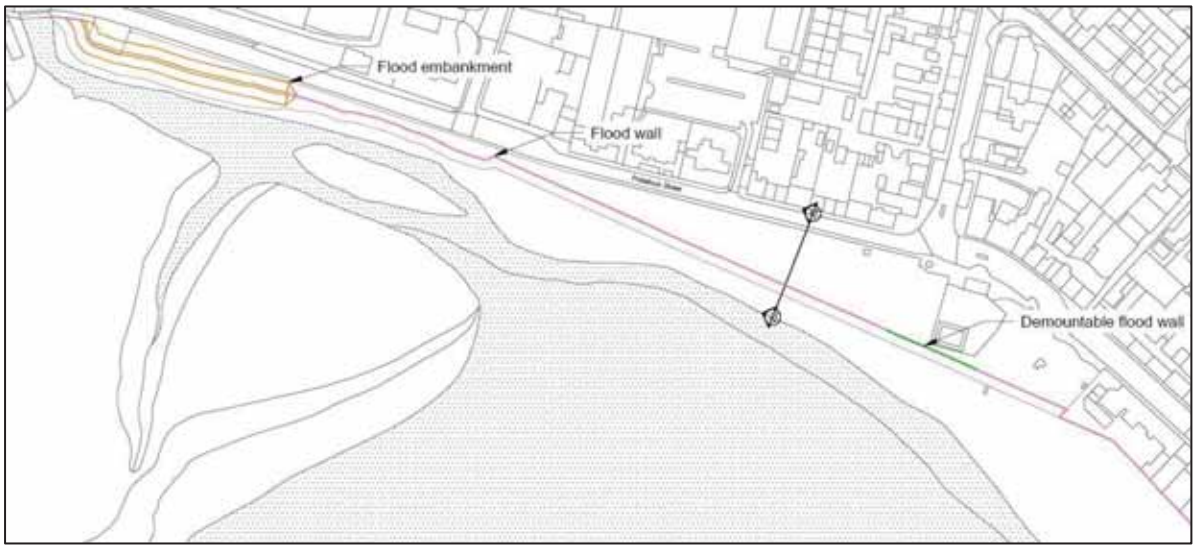

Figure 5-7 Option 6: Combination of direct defence measures to best suit their location on the front green

The proposed defence is shown to be set back 5m from the existing wall on the Front Green. This is due to the condition of the existing wall being unknown and therefore to reduce any loading on the structure, and for sufficient construction space to be provided. This area would be used to allow access for maintenance on the seaward side of the defence and could be landscaped. The defence height required would have significant influence on the character of the area, reduced connectivity with the sea and may cause extremely adverse visual impact. This could be somewhat mitigated through landscaping and option choice. Elements such as the demountable allow for a more flexible approach to flood risk.

Direct defences could provide protection for up to 64 permanent properties, residential and commercial.

5.9 Option 7 - land reclamation and combination of defences

Option 7 consists of small scale land raising and a combination of direct defences. It is proposed that the area behind Lochnell Street and the A83 is reclaimed (approximately 2500m^3 of fill) which would provide additional space for construction and provide a continuation for a footpath along the frontage. Variations of direct defences would then be installed along the existing defence line.

An embankment/flood wall/ demountable arrangement would sit along the existing coastal wall from the Poltalloch Street road bridge to the police station as shown in Option 3, Section 5.5. This adds up to approximately 185m of flood-wall and 365m of flood embankment. The average height of defence is 1.9m above existing ground levels. This includes a freeboard allowance.

The proposed defence would then extend as a flood wall along the existing boundary walls behind the properties on Lochnell Street, before linking to a floodgate across the A83 that ties into higher ground (as shown in **Figure 5-3**). The reclaimed land would be supported by a coastal revetment retaining wall, with the land providing a continuous footpath along the shore. This section of coastal flood wall behind Lochnell Street extends a total of 380m and is approximately 1.3m above the elevation of the existing land and therefore also the reclaimed land.

The fluvial embankment presented in **Section 5.3** can be adapted to increase the SoP to the 0.5% AEP event. This would account for 240m of direct-defence flood embankment to approximately 1.75m in height. This includes a freeboard allowance.

It is estimated that 3 flood gates, approximately 18m in length, would be required to provide vehicle access across the A83. The location of the flood wall along the reclaimed land can be seen in **Figure 5-8**. An indicative section was drawn to show the defence height and width required to offer a 0.5% AEP (1 in 200yr) tidal SoP. For full detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP7-A'** in Appendix A.

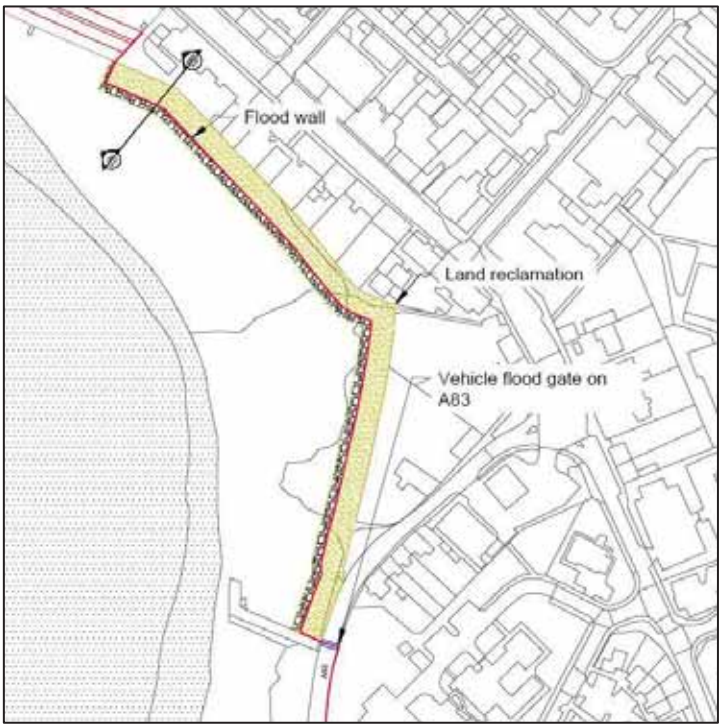

Figure 5-8 Option 7: Land reclamation and direct defence. Defence runs along coastal side of reclaimed land.

The proposed defence is shown to be set back 5m from the existing wall on the Front Green. This is due to the condition of the existing wall being unknown and therefore to reduce any loading on the structure, and for sufficient construction space to be provided. . This area would be used to allow access for maintenance on the seaward side of the defence and could be landscaped. The defence height required would have significant influence on the character of the area, reduced connectivity with the sea and may cause extremely adverse visual impact. This could be somewhat mitigated through landscaping and option choice. Elements such as the demountable allow for a more flexible approach to flood risk than some of the fixed options such as Option 3.

Direct defences could provide protection for up to 64 permanent properties, residential and commercial.

5.10 Option 8 - direct defences: shorter wall

Shorter direct defences were investigated to establish if a reduced length option could be more cost beneficial than a scheme along the entire front. The defence would be set back along Poltalloch Street and would require to be tied into the wall at the police station and continue up Lorne Street to reach higher ground. It should be noted that protection is only viable up to the 1% AEP event, as after that, floodwaters can travel along the A83 and Lochnell Street and inundate areas behind the defences. The wall would extend approximately 380m and be approximately 0.8- 1.2m above existing ground levels. This includes a freeboard allowance.

It is estimated that 3 flood gates, approximately 13m in length, would be required to provide access to the Front Green and across Poltalloch Street at the Lorne Street junction. The location of the proposed wall and gates can be seen in **Figure 5-9**. An indicative section was drawn to show the defence height and width required to offer a 1% AEP (1 in 100yr) tidal SoP. For detailed plan and indicative section, refer to sheet number '**60578815_SHT_20_G_OP8-A'** in Appendix A.

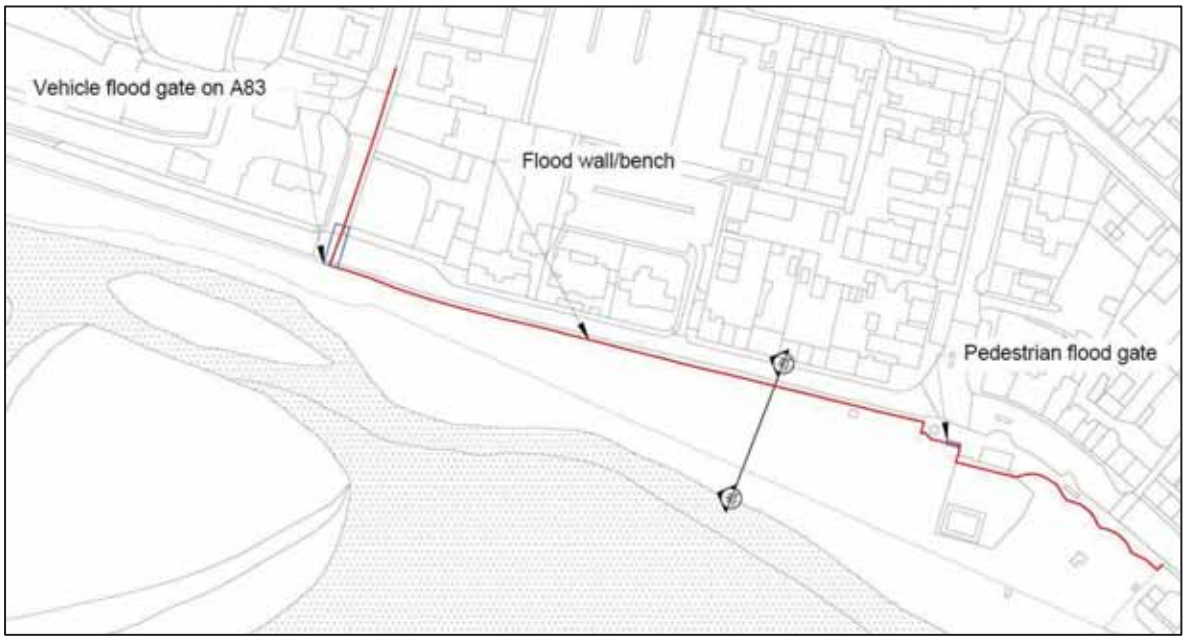

Figure 5-9 Option 8: Shorter direct defence along Poltalloch Street.

The proposed defence is shown to follow the kerb line along the south side of the pavement on Poltalloch street. This could be set back marginally if this were to ease construction and reduce the number of trees that would require to be felled. The defence height would be significantly reduced from other options outlined above and would therefore have less impact on the character of the area and connectivity with the sea.

Direct defences could provide protection for up to 20 permanent properties, residential and commercial.

5.11 Option 9 - property flood protection (PFP)

Property Flood Protection (PFP) are measures for protecting individual properties from flooding, focusing on blocking flow entry routes through things like air bricks, doorways, drainage pipes, defects in building fabric and building foundations / subsoil. In cases where a formal flood protection scheme may not be viable a strategy of resilience to targeted properties affected by flood depths which are optimal for PFP measures may offer more benefit in comparison to a capital scheme.

This measure has not been modelled but has been considered in the economic damages assessment by removing damages up to an assessed level.

Property Flood Protection includes measures such as:

- Airbrick covers, flood-proof doors and door screens;
- Flexible waterproof sealant around cables / pipes to seal holes created for pipes and cables entering the building;
- Automatic non-return valves on drainage pipes and boiler release pipes;
- Facade repairs and render crack sealing to minimise water ingress through defects;
- Over-render - new layer of external render over full property facade;
- Sump pump to drain the solum should water enter.

Depths of flooding below 0.6m is generally considered to be the limit of operation for PFP. Above this depth, seepage is likely to occur and above 1m it is generally accepted that the structural integrity of buildings can be affected, and it is thereafter better to allow inundation of the property to allow water levels to equalise.

To begin with, all properties affected by coastal flooding were assessed, with properties only flooding from a 0.1% AEP and greater being discounted. It was deemed appropriate to remove these

properties as this is an extremely rare event and would unlikely to pay for itself over the 25-30 year lifespan of the product. The onset of flooding and flood depth for the remaining 33 properties was then assessed and it was found that 30 permanent properties could be protected from internal flooding to a 1% AEP - 0.5% AEP (1 in 100 year - 1 in 200 year event). The remaining 3 properties could be protected at a reduced SoP, between the 5%- 50% AEP events. This was due to the overall flood depths being too high for PFP at these 3 properties during large events. The 33 potential candidate properties are shown in **Figure 5-10**.

Given that flood risk to Lochgilphead is predominantly coastal, and flood warning is expected in advance of such events it could be considered that standard flood resistance can be achieved through demountable features such as door guards, airbrick covers, etc. These are lower cost than passive automated systems. However, manual PFP holds greater risk as it relies on individual deployment. For this reason, it is recommended that passive or automated PFP be installed if possible.

The impact of this measure has been assessed by removing damages associated with flooding up to and including the 0.5% AEP event. Where the 0.5% AEP event depth is greater than 0.6m, the damage would remain as PFP would not be able to protect against that flood depth. This simple assessment assumes that if floodwater cannot enter property there will be no damages associated. It should be noted that additional work would be required to specify PFP for each property including property surveys as it is likely a bespoke approach will be required for each property.

The benefit of PFP is measured over a 25-year period; the expected lifespan of the installed products. It must be noted that manufacturers' stated service lives for protection measures is typically of the order of 20-30 years, however poor maintenance and inappropriate storage can significantly reduce these timescales; therefore, education is essential to achieve optimal performance from PFP. On this basis PFP has only been considered over a 25-year design life. Another challenge to this measure is how this is implemented from a legal standpoint in terms of ownership, purchase, and maintenance of the equipment. This measure would require significant community engagement and communication. Argyll and Bute Council's current view is that a PFP scheme would be implemented on a grant bases with homeowner maintenance obligations. It remains to be seen on what basis any Scottish Government funding would be provided.

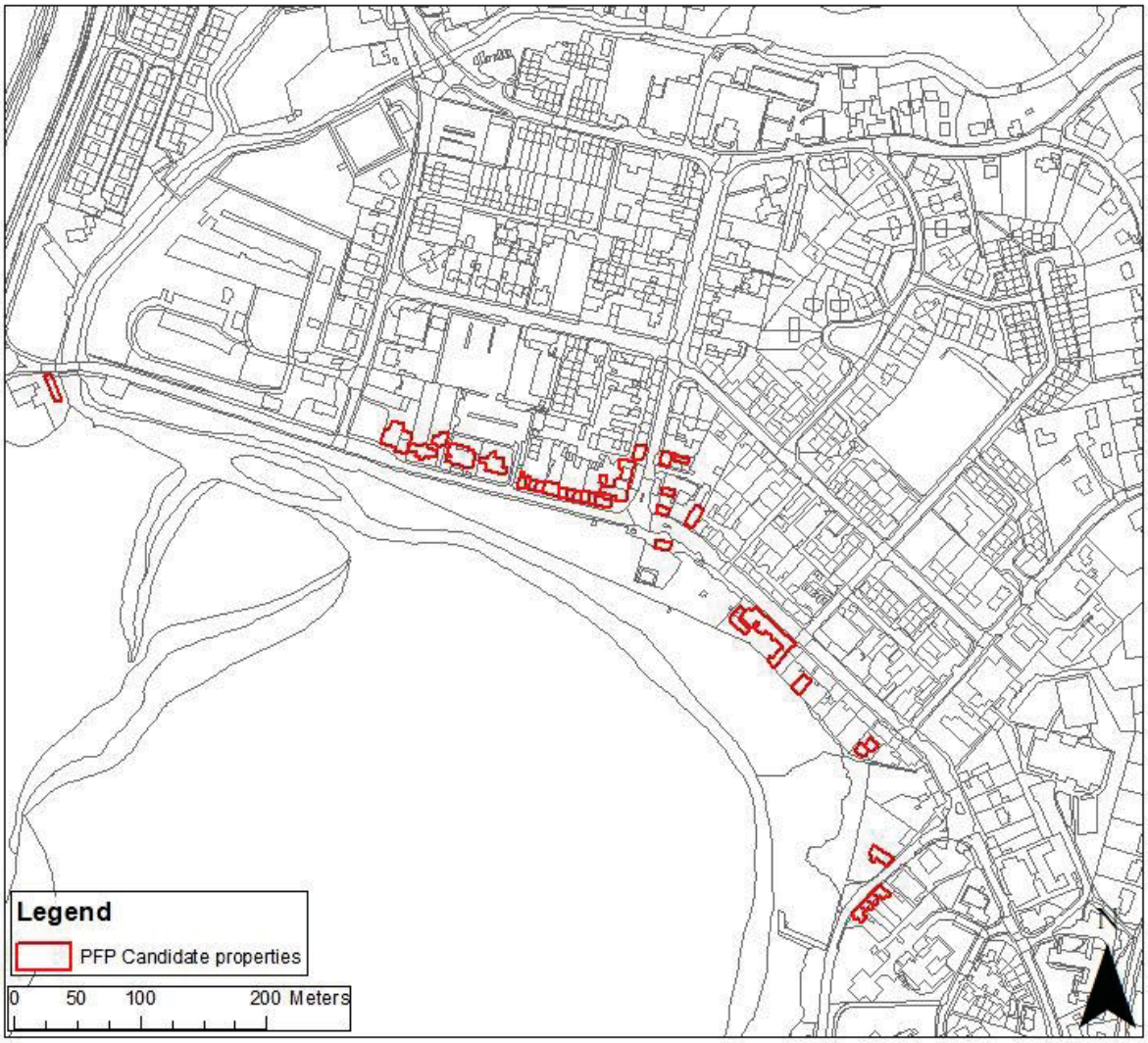

Figure 5-10 Option 9: PFP potential candidate locations. 33 properties protected to a 1 in 200-year event

It should be noted that for this stage of the options appraisal, PFP is considered appropriate and effective for all properties. Understandably this assumption may not prove correct, especially when considering the types of properties in Lochgilphead. Further surveys would be required to determine property suitability. A positive cost benefit ratio would be expected for PFP due to the relatively low costs and early onset of flooding.

Based on the economics this option could offer a significant improvement in flood damages in Lochgilphead with significantly less disruption and reduced visual impacts than the majority of options discussed above. After the 25 year period, the impacts of climate change could be reassessed and a longer term protection scheme may be cost beneficial.

5.12 SoP variation

To understand the impact of varying the SoP, and therefore whether an option may be viable at an alternative SoP the residual damages for the 2% and 0.5% + CC AEP events were established for Cell 1 where all options have been focused.

Table 5-1 displays the findings of this assessment.

Table 5-1: Variation in SoP

Standard of protection (SoP)	Coastal baseline damages in cell 1	Residual damages	Benefit
2% AEP event	£3,802,255.88	£3,217,577.44	£584,678.44
0.5%+CC AEP event	£3,802,255.88	£216,782.33	£3,585,473.55

It can be seen that by providing a direct defence along the length of the coastal extent to the 2% AEP event leaves very high residual damages. A defence to the 0.5% AEP + CC however, results in very minimal residual damages. The benefit of each SoP should be more than the estimated cost if an option is to achieve a positive cost benefit.

A change in the design flood and defence height (standard of protection or freeboard allowance) would be expected to give a relatively small change in the cost of the defence given a significant proportion of the cost is associated with the foundations and ground works rather than the height of the wall. Additionally, defence height and alignment are also not found to vary significantly between events due to the nature of coastal flooding extents and levels. For these reasons, the construction costs presented in Table 6-2 are still applicable for varying standard of protections.

For full protection along the entirety of the frontage, this equates to costs between £5.5 – 7.5m, equating to a BCR of between 0.5 and 0.65. Even if residual damages were eliminated completely, a positive cost benefit ratio cannot be achieved for the whole Lochgilphead frontage.

Further assessment of the BCRs after a single life cycle of PFP in 20-30years will likely incur a higher levels of Annual Average Damages, due to sea level rise, and a cost beneficial solution may be possible.

6. Economic Appraisal

An economic appraisal has been used to assess the monetised benefits of each option, with regards to the final damages avoided. In addition to a purely economic appraisal, the social and environmental benefits for each option will also be assessed on a qualitative basis. The economic appraisal has been carried out over a 100 year period for formal schemes and 25years for PFP. This reflects the standard physical life (with maintenance) of a conventional flood scheme and allows benefits to be assessed over the lifetime of the scheme.

6.1 Baseline Damages Summary

The baseline economic impacts (flood damages), used in this economic appraisal are presented under separate cover: reference should be made to *'Baseline Economic, Social and Environmental Impact Assessment- Technical Report*[3]*'.*

6.2 Benefits of Options

It should be noted that it is not possible to completely prevent flooding from happening; not all of the above damages can therefore be mitigated using a flood scheme, since there will always be some residual risk associated with more extreme events. This is demonstrated in **Figure 6-1** below. The shaded area in the graph shows the theoretical residual damages expected in a 1 in 100yr (1% Annual Exceedance Probability) flood scheme.

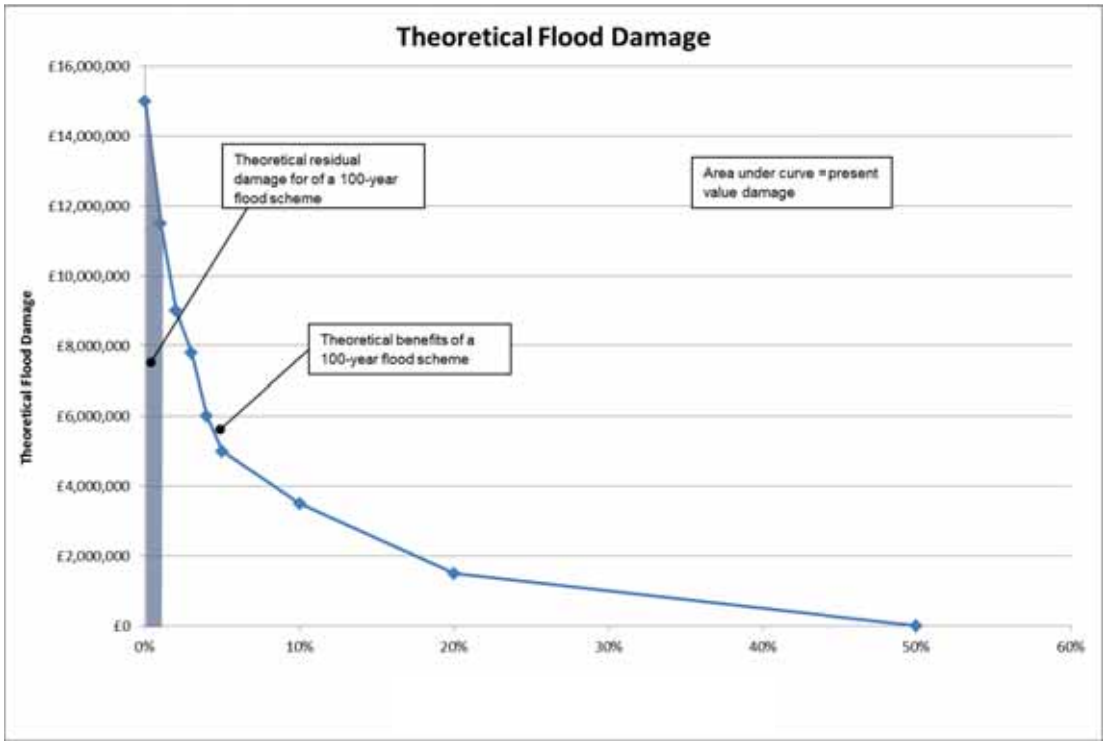

Figure 6-1 Theoretical representation of simplified residual damages[4]

For example, for direct defence schemes, residual damages are dependent on flood characteristics during an exceedance event. Once exceedance occurs, damages quickly return to, or in some cases surpass, the pre-scheme damages. Storage schemes, on the other hand, provide some benefit even to events which exceed the top water level of the storage area.

Residual damages and benefits for each of the scheme options are shown in **Table 6-1**: below. Option 2- 7 provide a 0.5% AEP present day standard of protection which is directly comparable to the 10% AEP + CC event.

[3] Lochgilphead Flood Study Baseline Economic, Social and Environmental Impact Assessment- Technical Report, AECOM, April

[4] The annual exceedance probability is the inverse of the return period e.g. a 100 year return period is equivalent to an annual exceedance probability of 1/100 = 1%.

It should be noted that a reduction factor has been applied to the benefits of PFP option to account for reduced reliability and failure. This is in line with EA guidance. Full details of the economic assessment can be found in the Economic, Social and Environmental Impact Assessment in the Phase 3 appendices.

Table 6-1: Residual Damages

Option No.	Option	Baseline	SoP (%AEP)	Residual	Total benefit	Additional economic benefits
1	Direct defences: Flood embankment along caravan park	£352,232.57	1% (fluvial)	£321,771.98	£30,460.59	N/A
2	Direct defences: Existing defence line wall	£3,802,255.88	0.5%/10%+cc (tidal)	£2,270,193.08	£1,532,062.80	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
3	Direct defences: Existing defence line embankment	£3,802,255.88	0.5%/10%+cc (tidal)	£2,270,193.08	£1,532,062.80	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
4	Direct defences: Set back wall	£3,802,255.88	0.5%/10%+cc (tidal)	£2,270,193.08	£1,532,062.80	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
5	Direct defences: Set back embankment	£3,802,255.88	0.5%/10%+cc (tidal)	£2,270,193.08	£1,532,062.80	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
6	Direct defences: Combination of defences	£3,802,255.88	0.5%/10%+cc (tidal)	£2,270,193.08	£1,532,062.80	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
7	Land reclamation and combination of defences	£3,802,255.88	0.5%/10%+cc (tidal)	£2,270,193.08	£1,532,062.80	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
8	Direct defences: shorter wall	£3,802,255.88	1% (tidal)	£3,485,263.19	£316,992.69	Reduced flood depth and velocity on A83, Poltaloch Street, and side streets.
9	PFP	£1,339,650.46*	5%-0.5% (tidal)	£623,562.73	£594,352.82*	N/A

**Note baseline differs for PFP properties where appraisal period is 25 year rather than 100 year*
**It should be noted that a reduction factor has been applied to the benefits of PFP option to account for reduced reliability and failure. This is in line with EA guidance.*

6.3 Option Costs

This cost build up provided is an indicative cost only, to help compare the conceptual options and appraise the options against the benefits from the flood damages avoided. These options have been developed to feasibility design stage, so there is significant uncertainty in the costs, which has been factored into the overall quoted estimates in this report by way of an optimisation bias uplift. Option costs should be reviewed in tandem with the social and environmental options appraisals to help appraise and recommend options to manage flood risk in Lochgilphead.

A number of sources were used to guide the costing of options. These include:

- Cost estimation for fluvial defences – summary of evidence Report –SC080039/R2, Environment Agency, March 2015
- Cost estimation for coastal protection - summary of evidence – SC080039/R7, Environment Agency, March 2015
- Cost estimation for temporary and demountable defences – summary of evidence, Report – SC080039/R10, Environment Agency, March 2015
- Cost estimation for household flood resistance and resilience measures – summary of evidence, SC080039/R11, Environment Agency, March 2015
- Flood Prevention Schemes - Guidance for Local Authorities, Scottish Government

6.3.1 Capital Cost

6.3.1.1 Traditional engineering works - unit rates

Only the core elements of the flood protection measures (and necessary ancillary works) have been included in the cost build up. Traditional engineering solutions such as flood defences have been costed using rates extracted the various Environment Agency (EA) Guidance Documents for Costing Flood Risk Management Elements as listed above.

The EA unit rates have been determined using actual construction costs from flood risk management projects across the UK from 1985 – 2015. The guidance has taken this data and attempted to standardise unit rates based on the kind of element being implemented e.g. flood embankment, defences, culverts etc. This unit rate can then be scaled based on the size of the proposed measure. Each rate is specific to the type of element employed and are graded in terms of the geometry and length of the element. All cost rates have been uplifted to current price based on the Building Construction Index.

For example, in the case of a floodwall, a wall of height 1.2-2.1m over a length of 50-100m would generate a unit rate of £2,905 per m length of wall. In the case of a direct defence wall of 1.5m high over 50m this would generate a capital cost of 2,905 x 50 = £145K. Each unit rate factors in total construction cost of each feature including temporary and associated works.

These benchmarked or unit cost estimates are broadly typical or representative of the type of works. However, for civil engineering works, the tremendous variety of project conditions and complexities make the straightforward use of these rates less reliable. The prices given can only be taken as a guide to actual cost. The various EA guidance documents state that the rates are suitable for initial appraisal of options which is the purpose of this study. Given that the level of design is at the stage of feasibility assessment at present, these benchmarked costs provide broad estimates to compare options to aid the selection of preferred options which could then be designed in full to outline and detail stages.

For construction costs it is necessary to be mindful of the chosen method of executing the work, drawing up a detailed programme and then costing the resources needed. Scale, site difficulties, locale, tender climate are all factors in the actual sum tendered. For this reason, more detailed cost estimation carried out using unit rates from industry guidance which are broken down to material, plant and labour rates for each item of construction was not deemed to be appropriate at this stage as the construction details of the options are not known at this time.

6.3.1.2 PFP Measures

If PFP is taken forward as an option, property surveys by a manufacturer, Scottish Flood Forum or qualified staff will be required at individual properties to determine a bespoke flood protection strategy. As PFP will be tailored to individual properties based on flood entry routes, a simplistic assumption has been made for costing. In line with EA costing guidance, measures which offer a "premium" standard of protection have been assumed for residential properties as these are the most vulnerable receptors. The high estimate has been used for the costing. This includes two flood-proof doors, two airbrick covers and external wall render/bricks (20 m). For non- residential properties a standard protection was deemed suitable so measures would not impact operational of business as they are demountable. Again, the high end of the cost estimate has been used. This includes two demountable door guards and multiple airbrick covers.

6.3.2 Acquisition or enabling costs (pre-construction)

EA guidance is unclear as to what costs such as construction preliminaries and accommodation works are included in the core capital cost data on which the unit rates are based. Guidance is included for enabling costs: scheme development, design, planning, and project management etc. Enabling costs are very variable and for complex projects are clearly higher.

In the absence of any additional data the values recommended for use in the EA guidance are used. For local authority projects of >£1m an allowance of 10% of the capital costs is recommended estimate for the enabling cost. For projects between £200k and £1m, an allowance of 15% the capital cost is recommended and 21% of the capital cost is recommended for projects less than £200k. For PFP, 5% of the capital cost is assumed.

6.3.3 Optimism Bias

Optimism Bias relates to the unavoidable tendency for project appraisal cost estimates to be overly optimistic; this is inherent in early stage cost estimates because major project risks are not quantifiable at this stage. Optimism Bias is intended to account for uncertainty over project costs and the likely increase between the current project stage, i.e. capital expenditure review, and completion. Through a review of the current stage inputs, assumptions and risks, these can be factored into an overall uncertainty for Optimism Bias.

For most flood studies the options considered are similar in terms of their construction requirement and therefore associated risks. The options for Lochgilphead fall into two distinct categories including:

- Direct Defences – large scale engineering measures
- PFP – local resilience intervention

The Scottish Government's Project Appraisal Guidance[5] gives advice on the application of optimism bias to flood protection costs at the Strategic and Scheme level and this has been applied to this study.

This flood study presents an appraisal of potential flood protection costs at a strategic level. The appraisal guidance recommends 60% optimism bias is taken as a starter point for this level of assessment. An assessment is then made as to whether the valuations of different risk components contributing to the overall optimisation bias can be reduced based on the information available or through demonstratable actions that would minimise the risk. The risk components include; project specific risks, client risks, environmental issues and external influence risk. In line with the appraisal guidance, different optimism bias has been calculated for each option category to provide a more realistic quantification of uncertainty.

Risks were reviewed for the two categories of options. For direct defences there was no strong case to reduce any of the risk items therefore optimisation bias of 60% is applied. For PFP a reduction could be made because external influence risks generally associated with large scale construction such as ground investigation, construction materials and plant are less relevant and an optimism bias of 40% is considered appropriate. These biases were applied to the Whole Life cost of options in line with Scottish Government Guidance.

[5] Flood protection schemes - assessment of economic, environmental and social impacts: guidance, Scottish Government, February 2012

6.3.4 Uncertainty

There are several uncertainties identified within the current costing. These include:

- Costs have been based on conceptual design sizing.
- Costs are based on standardised unit rates and research.
- No significant geotechnical design requirements will be required as GI investigation is unavailable at this stage e.g. contamination, groundwater issues, seepage etc.
- Land purchase costs have not been considered as these costs are highly uncertain. This is difficult to quantify as it will require individual landowners and organisations working together in partnership to deliver a joint vision. This uncertainty can skew the benefit cost assessment of options significantly which should not be the case at options appraisal stage.

There are further limitations of the EA costing guidance in particular for coastal defences. The data on which the costs of coastal defences have been derived is based on a small number of examples.

In the EA guidance, coastal defence costs are also not linked to defence height in the same way as fluvial defences are for example. This means that it is not possible to derive different costs representing variations in standard of protection. For the purpose of this flood study a single cost has been derived for each defence option which is considered to be representative of the defence option irrespective of standard of protection provided.

6.3.5 Operation and Maintenance Costs

Flood risk management measures require ongoing maintenance to ensure the system remains in good working order and the design life of the system is extended as long as possible. Operation and maintenance activities will include the following:

- Monitoring and post-construction inspection;
- Monitoring and inspection post event;
- Regular, planned maintenance (annual or more frequent); and,
- Intermittent, refurbishment, repair/remedial maintenance.

It is recommended that these long terms costs are considered as part of the initial benefit cost assessment so a full “whole life” cost of an option is considered to allow transparent appraisal of options and budget accordingly.

Environment Agency guidance has been used to determine the likely maintenance and operational activities associated with the different elements of the scheme, the frequency of these activities and cost per metre of a feature, cost per visit or % of capital cost has been used to determine annual maintenance costs. Generally, items such as floodwalls and embankment have a cost per m length depending on the environment and access and floodgates and demountables carry a maintenance cost as a percentage of the total cost ranging from around 5-10%. These are included in the whole life cost build ups.

Generally, flood defence maintenance will come under the remit of ABC, which will include vegetation clearance and inspection of flood walls. This would be considered as a minimum.

PFP measures will require a degree of maintenance costs to minimise the risk of operational failure during a flood. The degree of maintenance required will depend on the type of measure implemented but may require intermittent or annual inspections and maintenance by qualified personnel to ensure that all elements are in good working order. Costs for this work should be defined through discussions with the manufacturer, however EA guidance recommends a typical cost for this to be around 1% of the purchase cost of the measures; this cost is not included in the overall whole life cost because it is envisaged that maintenance of PFP measures would be handed over to property owners and it would be their responsibility to use and maintain these assets.

6.3.6 Whole Life Cost

Whole life costing is defined as 'the systematic consideration of all relevant costs associated with the acquisition and ownership of an asset'. A schematic of whole life costs is shown in Figure 6-2 below.

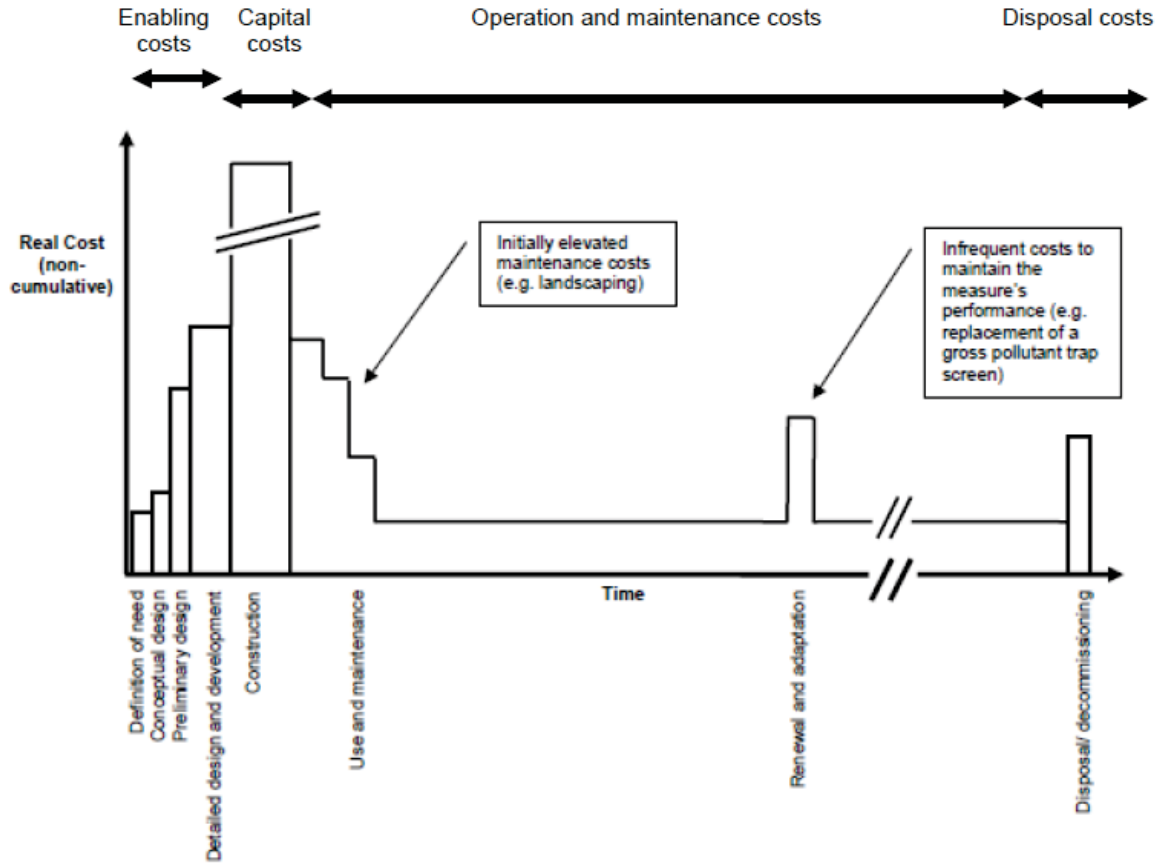

Figure 6-2 Conceptual schematic of whole life costs[6]

Each option has been considered for its whole life cost. This requires the whole life cost of the option to be expressed in terms of present value (PV). Present value is a single figure representing all the future costs and incomes at their equivalent present value.

Discounting is an important part of the present value calculation as it offers a way to compare value of costs and benefits over different time periods relative to their present values. This allows the depreciation of money in the future to be accounted for and to factor in its reduced capacity for generating a return through interest because of inflation. Discounting is a means of assessing how much less an amount is worth in the future than it is now.

Whole life costs of each option over the life of the scheme are brought to a present value (PV), using 2018 as the base year. This allows a direct comparison with flood damages which are also priced to 2018. The current discount rates specified in the HM Treasury Green Book; Appraisal and Evaluation in Central Government, Treasury Guidance have been adopted. An appraisal period of 100 years has been used, as recommended by Scottish Government for Flood Prevention works, therefore the Green Book recommended discount rate of 3.5% reducing to 2.5% over the appraisal period is adopted.

The economic appraisal has assessed PFP over a 25 year design life. This is due to the complexities regarding ownership and liability of these elements. Current ABC policy is that ABC can provide advice and potentially purchase and facilitate initial installation of these measures as part of a grant scheme funded by Scottish Government, but PFP would then become the property owner's

[6] reproduced from: *Cost estimation for fluvial defences – summary of evidence, Report –SC080039/R2*, Environment Agency, March 2015

responsibility over which ABC would have no control. It is likely a PFP scheme would be re-evaluated again in 25 years to determine its viability as a scheme.

6.3.7 Summary of Cost

Table 6-2 displays the capital, maintenance and whole life costs for each option.

Table 6-2 Summary of Costs

Option No.	Description	Items costed	Capital Cost	Operation and Maintenance Cost[7] (100 years)	Whole Life Cost (Present Value)	Whole life with Opt Bias 60% (40% for PFP)
1	Direct defences: Flood embankment along caravan park	• 220m of flood embankment	£235,669.28	£598.18	£253,507.74	£405,612.38
2	Direct defences: Existing defence line wall	• 240m of flood embankment • 920m of flood wall (1.2m- 2,1m tall) • 1 vehicle access and 2 pedestrian flood gates	£4,381,492.98	£2,709.54	£4,462,294.78	£7,139,671.66
3	Direct defences: Existing defence line embankment	• 605m of flood embankment • 565m of flood wall (1.2m- 2,1m tall) • 1 vehicle access and 2 pedestrian flood gates	£3,356,502.88	£3,622.46	£3,464,528.93	£5,543,246.28
4	Direct defences: Set back wall	• 240m of flood embankment • 940m of flood wall (1.2m- 2,1m tall) • 1 vehicle access and 2 pedestrian flood gates	£4,457,162.42	£8,642.02	£4,714,878.04	£7,543,804.87
5	Direct defences: Set back embankment	• 605m of flood embankment • 565m of flood wall (1.2m- 2,1m tall) • 1 vehicle access and 1 pedestrian flood gates	£3,356,502.88	£3,622.46	£3,464,528.93	£5,543,246.28
6	Direct defences: Combination of defences	• 355m of flood embankment • 815m of flood wall (50m demountable) between 1.2 and 2.1m • 1 vehicle access flood gate	£4,011,652.06	£8,184.81	£4,255,732.96	£6,809,172.74
7	Land reclamation and combination of defences	• 605m of flood embankment • 725m of flood wall (1.2m- 2,1m tall) • 2500m^3 of fill • 1 vehicle access and 2 pedestrian flood gates	£3,788,274.53	£3,386.40	£3,889,260.98	£6,222,817.56
8	Direct defences: shorter wall	• 170m flood wall (0m- 1.2m tall) • 210m flood between (1.2m- 2,1m tall) • 1 vehicle access and 2 pedestrian flood gates	£1,152,463.08	£1,885.08	£1,208,678.36	£1,933,885.37
9	PFP	• 20 residential properties • 13 non-res properties	£184,118.46	£0.00	£184,118.46	£257,765.84

[7] Note this figure represents typical average annual maintenance cost for option though for some options more intermittent recommended maintenance has been included in the Whole Life Cost e.g. removal of sediment from wetlands at 10 year intervals.

6.4 Benefit-Cost Ratio

The benefit cost ratio for each option has been summarised in **Table 6-3** below. This is a useful parameter which feeds into the appraisal process but should be considered alongside the non-monetised benefits and limitations as part of the overall economic, social and environmental appraisal. A figure illustrated flood cells is shown in **Figure 6-3**.

See section 5.12 for additional discussion on SoP.

Table 6-3: Benefit Cost Ratio

Option No.	Description	Costs	Main Flood Cells Affected	SoP (%AEP)	Damages Avoided (present value)	Number of properties with reduced flood risk	Benefit-Cost Ratio	BCR Rank
1	Direct defences: Flood embankment along caravan park	£405,612.38	1	1% (fluvial)	£30,460.59	2 permanent properties, 28 non-permanent	0.08	9
2	Direct defences: Existing defence line wall	£7,139,671.66	1	0.5%/10%+CC (tidal)	£1,532,062.80	64 permanent properties	0.21	6
3	Direct defences: Existing defence line embankment	£5,543,246.28	1	0.5%/10%+CC (tidal)	£1,532,062.80	64 permanent properties	0.28	3
4	Direct defences: Set back wall	£7,543,804.87	1	0.5%/10%+CC (tidal)	£1,532,062.80	64 permanent properties	0.20	7
5	Direct defences: Set back embankment	£5,543,246.28	1	0.5%/10%+CC (tidal)	£1,532,062.80	64 permanent properties	0.28	2
6	Direct defences: Combination of defences	£6,809,172.74	1	0.5%/10%+CC (tidal)	£1,532,062.80	64 permanent properties	0.22	5
7	Land reclamation and combination of defences	£6,222,817.56	1	0.5%/10%+CC (tidal)	£1,532,062.80	64 permanent properties	0.25	4
8	Direct defences: shorter wall	£1,933,885.37	1	1% (tidal)	£316,992.69	20 permanent properties	0.16	8
9	PFP	£257,765.84	1	2%-0.5% (tidal)	£594,352.82	33 permanent properties	**2.31**	**1**

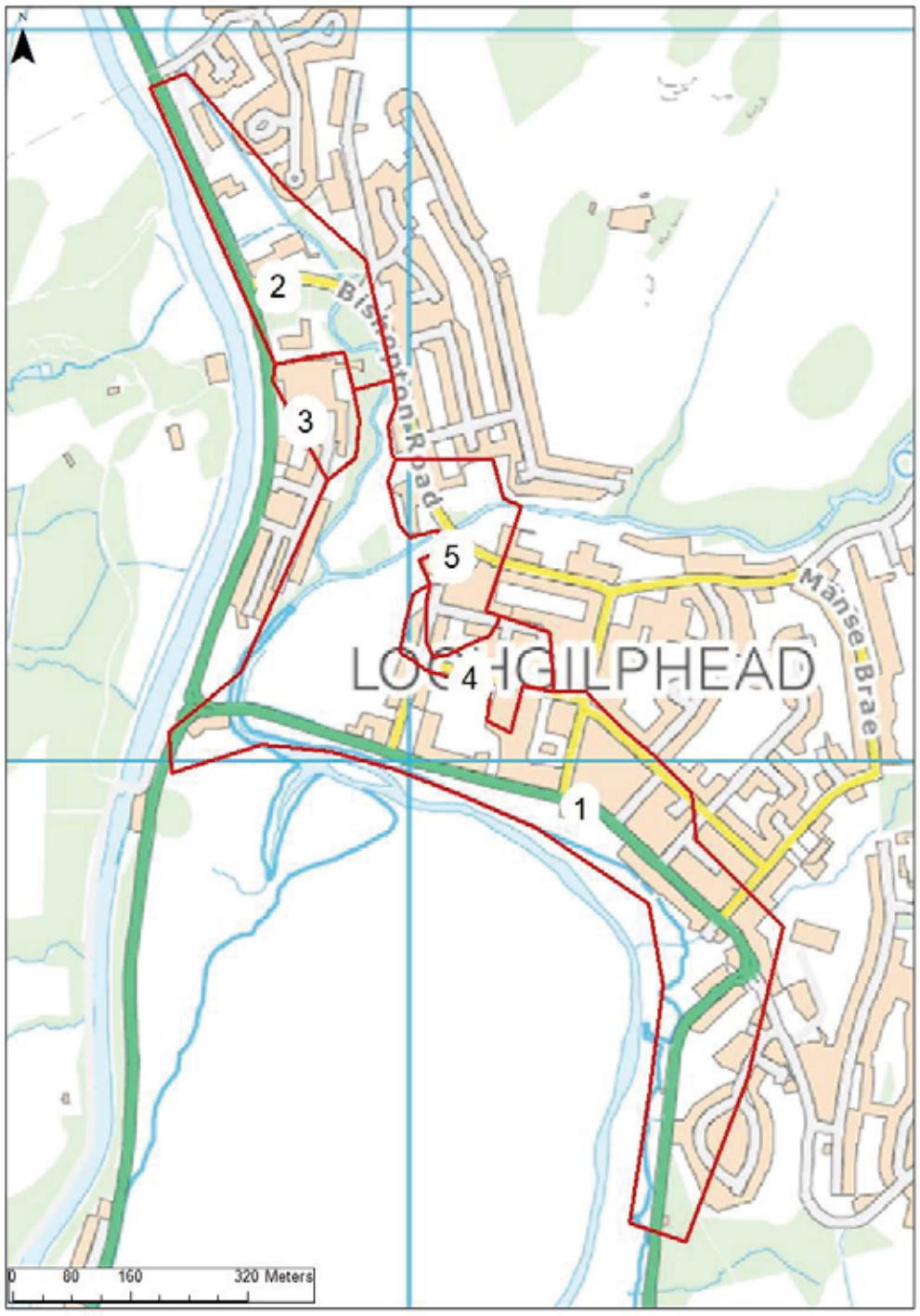

Figure 6-3 Lochgilphead Flood Cells

7. Environmental and Social Appraisal

Historically, appraisals of flood protection options were often focussed on cost-benefit analysis. The cost benefit ratio is a useful metric to compare the monetised benefits and impacts of options. To ensure focus is not solely placed on those parameters which have been monetised, an environmental and social appraisal has been carried out for this study.

The baseline assessment is included in the *'Lochgilphead Baseline Economic, Social and Environmental Impact Assessment – Technical Report'.*

Options involve four categories: Land Reclamation; Flood Embankments; Flood Walls; and Property Flood Protection.

7.1 Overview

7.1.1 Environmental

The environmental impacts of the baseline have been assessed over the 100 year appraisal period. It is understood that at present there are no pressing environmental issues associated with flooding. However, over 100 years, under the influence of climate change, environmental pressures may arise. Impacts included in this assessment are:

- Water environment
- Biodiversity, flora and fauna
- Air and soil
- Climatic factors
- Landscape
- Cultural heritage

The primary requirements for environmental appraisal are to identify opportunities for environmental enhancement and assess environmental impacts associated with any flood mitigation options (thus allowing for impacts to be mitigated). For this appraisal, the environmental impacts are described; this is considered adequate for this appraisal unless there is an indication that impacts will be significant, in which case a formal Environmental Impact Assessment may be required.

7.1.2 Social

Flooding and flood risk has a significant impact on society before, during and after a flood event has occurred. Werrity et al.[8] carried out a study into the social impact of flooding and flood risk in Scotland. The feedback from surveys carried out as part of the study highlight that the intangible impacts of flooding are significant, and it is therefore important to consider such impacts. Impacts included in this assessment are:

- Risk to life
- Health
- Social vulnerability
- Recreation, community and way of life

It should be noted that social impacts are often interlinked; for example, a heritage feature could be a source of recreation which in turn could have benefits in terms of well-being.

There are a number of stakeholders and groups in Lochgilphead. Stakeholders such as SEPA[8] and Scottish Water have been consulted during the shortlisting process and two public consultations have been held.

[8] Werritty et al, *Exploring the Social Impacts of flood Risk and Flooding in Scotland*, Scottish Executive Social Research, Edinburgh, 2007

7.2 Results

Table 7-1 displays the results the qualitative social and environmental appraisal which should be considered along with the CBR established in the economic appraisal.

Table 7-1: Results of the social and environmental appraisal

Project name		**Lochgilphead Flood Study**				
Element		**Baseline**	**Land Reclamation - Direct Defences**	**Flood Embankment - Direct Defences**	**Flood Walls – Direct Defences**	**Property Flood Protection**
Element Description		Do-nothing - No intervention	Approximately 4500 m^3 of fill behind Lochnell Street, and approximately 300m of floodwall.	Up to 620 of flood embankments ranging 1.2-2.25m high for different combination of options.	Up to 940m of flood walls ranging from 0.7-2.1m high for different combination of options.	PFP installed at 13 res properties and 20 NRP. Mix of passive and demountable features.
Approaches to adaption		None	One-off intervention	One-off intervention	One-off intervention	One-off intervention
Category		**Description and quantification of impacts**	**Description and quantification of impacts**	**Description and quantification of impacts**	**Description and quantification of impacts**	**Description and quantification of impacts**
Social	Risk to life	Low to moderate hazard, with flood hazard increasing for the more severe floods	Reduction of flooding leads to reduced risk to life	Reduction of flooding leads to reduced risk to life	Reduction of flooding leads to reduced risk to life	Higher residual risk to life as flooding is only reduced within properties.
	Health and well-being	Anxiety associated with flooding, physical health effects due to contact with flood water, worry about future flooding. It should be noted there is uncertainty in this developing area of research.	Direct defences may provide more visual reassurance during flood event Reduction of flooding leads to reduced expected health impacts. However residual impacts will remain.	Direct defences may provide more visual reassurance during flood event Reduction of flooding leads to reduced expected health impacts. However residual impacts will remain.	Direct defences may provide more visual reassurance during flood event Reduction of flooding leads to reduced expected health impacts. However residual impacts will remain.	High residual health and well-being impacts as flooding is only reduced within properties.
	Social vulnerability	Local assets at risk of flooding increasing flood disadvantage	Reduction of flooding would reduce social disadvantage	Reduction of flooding would reduce social disadvantage	Reduction of flooding would reduce social disadvantage	High residual social vulnerability as local assets may not be protected.
	Recreation, community and way of life	Community features are at risk of flooding include local businesses. Flooding impacts the village centre, Flooding would seriously impact the recreation, community and way of life for residents.	Reduction of flooding would increase access to the village, therefore improving way of life. This not only affects the people of Lochgilphead, but people in the wider community who rely on the services and businesses	Reduction of flooding would increase access to the village, therefore improving way of life. This not only affects the people of Lochgilphead, but people in the wider community who rely on the services and businesses	Reduction of flooding would increase access to the village, therefore improving way of life. This not only affects the people of Lochgilphead, but people in the wider community who rely on the services and businesses	High residual impacts as local amenity and transport (roads) may not be protected. Could enhance community and way of life through development of a local partnership group to manage proposed measures

Environmental	Water	Pollution of watercourses during a flood event from contact with backed-up sewers and flood debris. Loch Fyne outer basin has an overall water status of 'Good' from 2007 to 2017.	General reduction of flooding reduces the risk of contaminants. Watercourse discharges to Loch Gilp at this location and would need to be culverted.	General reduction of flooding reduces the risk of contaminants.	General reduction of flooding reduces the risk of contaminants.	No reduction of flooding therefore risk of contaminants is not reduced
	Flora and fauna (biodiversity including fisheries)	Not considered to be significantly affected by current flood risk	Reclaiming land may have some adverse impact by altering habitat.	Some embankments may require small scale tree felling.	No significant impacts expected.	No significant impacts expected.
	Air and soil	Not considered to be significantly affected by current flood risk	No significant impacts expected.	No significant impacts expected.	No significant impacts expected.	No significant impacts expected.
	Climatic Factors	Greenhouse gas emissions associated with flood response and post-flood recovery	Emissions reduced through reduction of flooding. Works will have greater climatic costs due to imported fill.	Emissions reduced through reduction of flooding. Works will have climatic costs.	Emissions reduced through reduction of flooding. Works will have climatic costs.	Emissions reduced through reduced flood recovery. Works will have small climactic costs.
	Cultural heritage	Flooding of Lochgilphead conservation area and listed buildings. Possibility that flood risk is discouraging investment in maintaining the area.	Reduced risk of flooding to listed buildings. Walls will change character of area by impeding connection to Loch Gilp as well as its footprint.	Reduced risk of flooding to listed buildings. Embankments will change character of area by impeding connection to Loch Gilp. Can be landscaped to provide amenity.	Reduced risk of flooding to listed buildings. Walls will change character of area by impeding connection to Loch Gilp (unless demountable).	Locally no loss of heritage.
	Landscape	Not considered to be significantly affected by current flood risk.	Walls will change character of area by impeding connection to Loch Gilp and changing the landscape of the seafront.	Visual impact, which can be minimized by sensitive design, however size and height will be at least 1m in most places which may be considered intrusive and not in keeping with the local landscape.	Visual impact, which can be minimized by sensitive design, however size and height will be at least 1m in most places which may be considered intrusive and not in keeping with the local landscape.	No significant impacts expected.

7.3 Summary

7.3.1 Environmental

In general, Lochgilphead would experience environmental benefit through the reduction of flood risk from each option. Different options however have different wider benefits and disadvantages associated which add or detract from their value.

Direct defences and land reclamation have the most negative environmental impact. Walls/embankments would have a negative visual impact and cut off community connection to Loch Gilp. These impacts can be reduced through sensitive design to the existing landscape using materials which are similar to locally used materials. Small scale felling of trees may be required for embankments set back within the front green (Option 5) which may cause small scale habitat loss.

PFP offers no significant environmental benefit or loss, out with those gained by reducing flood risk.

Baseline flood scenarios have carbon emissions associated with flood response and post-flood recovery. Flood defence options reduce these emissions to varying degrees, for example direct defences around specific properties or PFP still require some clear up and flood response. All works have associated climatic costs however these vary in magnitude. Direct defences would require more fuel and imported materials, increasing climate costs.

7.3.2 Social

In general, the options assessed provide social benefits associated with their impact on flood risk. The reduced flood risk offered by direct defence options increases access to the village during floods which enhances community way of life. This not only allows residents of Lochgilphead access to the village, but also those living in the wider community. Lochgilphead is a hub for a number of more isolated communities in the surrounding area, who rely on the services and businesses within the town. Properties effected by flooding include banks, shops, hotels and the police station. Protecting these properties will benefit Lochgilphead and the surrounding area. Additional benefits and disadvantages are also specific to each option. Some types of local flood defences, demountable and PFP, could enhance community and way of life through the development of a local partnership group to manage and install to proposed measures. Moreover, these types of defences limit visual intrusion, which would be hard to avoid using more traditional direct defences.

Direct defences are usually considered to offer the greatest social benefit, through stress and anxiety reduction, by providing the best standard of protection to properties. Landscaped embankments and benches incorporated into flood walls can provide additional amenity to the area.

8. Public Consultation Event

A public consultation event was held in Lochgilphead Community Education Centre on the 29th of August 2019 after the Phase 3 report had been issued. This event detailed the Long List to Short List process and identifies some of the potential options. A further consultation event was held in the same location on the 22nd of October to outline the preferred option we had identified after completing the work within this report.

The event had varying levels off attendance. The 22nd of October events was well attended and those attending gave insight into flood events and flood risk in Lochgilphead and provided feedback on the identified options.

8.1 Comments in relation to flooding

In general, there was agreement that coastal flooding does currently affect properties and fluvial flooding frequently affects the A816 between the Meadows and Cairnbaan. There was also general agreement that this was likely to get worse in the future. The following accounts of flooding were recorded:

- Water levels inundate the Front Green and reach Poltalloch Street approximately every year;
- Flooding sometimes encroaches on to Poltalloch Street;
- Sea weed being carried onto the Front Green is a frequent problem;
- Several comments made about fluvial flooding and this being attributed to lack of drain and ditch clearance;
- Confirmation that waves are not a significant issue. Flooding is caused by a combination of high tides and surge up Loch Fyne.
- Tidal flooding generally recognised as an issue and understood that flooding would become more severe and frequent in the future.

8.2 Feedback on shortlisted options

The following feedback was provided regarding options that had been considered for Lochgilphead:

- Concern about how any defences would work together with the Front Green redevelopment and how they would affect the character and views of the area;
- Generally good feedback on defence options as the flooding problem is appreciated, this however becomes less palatable when overall defence heights are discussed;
- Using material from the build-up land in Loch Gilp was suggested as a means of reducing the cost of building embankments. It was noted that there would likely be contamination and material suitability issues with this;
- Preference of walls over embankments due to space constraints on the Front Green;
- A tidal barrage was considered by most as an unlikely and undesirable solution although there were a couple of people that thought it would be reasonable;
- PFP was outlined as the preferred option for Lochgilphead and this was generally well received. Several of the identified properties would be very keen to see if a Council grant scheme could be put in place if funding was made available.

8.3 Resident canvassing

As part of the last consultation event in October, canvassing was undertaken at several of the properties that had been identified in the PFP assessment. The following comments were gathered:

- Several comments that owners had previously investigated PFP and would be very interested in this as an option;
- Some concerns relating to maintenance of PFP;
- General positive feedback to the more passive or automated options that would reduce human error.

9. Option Recommendations

The options have been assessed in a holistic manner to include social, environmental and economic factors together to ensure the option selection process is not unfairly weighted towards economics.

9.1 Appraisal Summary

The benefit cost assessment has enabled clear decision making for all options. It is generally considered reasonable to reject an option with a BCR significantly under unity. When a solution's costs significantly outweigh the monetised benefits to such a degree that additional benefits which have not been monetised such as environmental gains for water quality, ecology etc. would be highly unlikely to provide enough additional benefit to achieve unity in the BCR. This applies to all options which include direct defences (Option 1-8). Although a high standard of flood protection could be provided with these options, the high capital costs of flood wall construction vastly outweighs the economic return. Furthermore, direct defence options were found to have the most negative environmental impacts, due to the significant engineering works required. Although these options presented some social benefit, it is not considered enough to outweigh the economic and environmental costs. On this basis these options are not viable.

PFP to provide protection to properties that are affected up to the 0.5% AEP event is shown to be the most viable option. It is the only option considered with a BCR greater than 1. There are no real wider environmental benefits. Some social disadvantages remain with PFP, as the flooding is not addressed at source, and although properties will be protected, infrastructure around the town will still experience flooding. However, PFP could enhance community resilience due to a reduction in stress relating to flood risk and maintain way of life by maintaining access to amenities. Development of a strategy to manage and install the proposed measures should be undertaken. **Table 9-1** below presents the recommended option, and associated BCR.

Table 9-1 Summary of Recommendations

Description	Costs	Damages Avoided (present value)	SoP (%AEP)	Number of properties with reduced flood risk	BCR
PFP	£257,765.84	£594,352.82	2%-0.5% (tidal)	33 permanent properties	2.31

Option 9, the provision of PFP to individual properties, shows a positive return and is therefore recommended as the preferred flood scheme option for Lochgilphead. As PFP has a limited design life, estimated to be between 20 and 30 years, the impacts of climate change and in particular the increase of extreme sea level should be regularly re-evaluated. It is therefore recommended that review of a formal scheme is undertaken within 20 years of any PFP being installed.

A high-level review has been undertaken to indicate the viability of a direct defence scheme being installed in the future, following on from the recommended PFP scheme in the short term. It is considered likely that a formal scheme may be viable in the future, due to the increased frequency of coastal flooding, and therefore increased damages. This is a highly sensitive review and should not replace a full assessment in the future.

10. Conclusions and Next Steps

This report details the Option Appraisal process carried out on short-listed options to manage flood risk in Lochgilphead. A preferred solution has been identified and the process and main conclusions have been outlined below.

10.1 Summary of findings

10.1.1 Summary of phase 4 process

A long list of options was developed and then short listed by assessing the feasibility of options from a technical, legal and financial perspective with input from statutory stakeholders and local residents during phase 3.

For phase 4, the short listed options were then developed and appraised through the following:

- Public consultation – with the local community to get feedback on options
- Concept design – to develop a better understanding of costs and how options would be constructed and identify opportunities and constraints.
- Costing – to determine the cost of each option. This has been considered over the whole 100-year design life (25 year for PFP) of the proposed scheme to include annual and intermittent maintenance costs.
- Damage assessment – to quantify economic benefits from the option in terms of damages avoided over the 100-year life of the scheme (25 year for PFP).
- Cost benefit – to establish the economic viability of each option
- Multi-criteria appraisal – to appraise options holistically in terms of social, economic and environmental

The appraisal has allowed ABC and AECOM to assess the options against each other so that recommendations could be made based on the appraisal of economic, social and environmental impacts, whole life costs and consideration of risk and uncertainty, both present and future.

10.1.2 Flood risk

Coastal flood risk in Lochgilphead is overwhelmingly tidal. Fluvial flood risk is present from the Badden and Cuilarstich Burns, however, a very limited number of permanent properties are at risk during extreme events.

Wave modelling of Loch Gilp and East Loch Fyne shows that wave action is small.

Freeboard allowance used in this options appraisal is 0.6m, which is based on industry standard guidance.

10.1.3 Climate change

An uplift to account for predicted sea levels in 2100 due to climate change has been applied in this study and should be applied to any future study for direct defences. In the climate change scenario, flood extents are not seen to change significantly from the present day conditions due to the topography of the village. The events that cause flooding will however become more frequent.

Due to the predicted increase in sea levels of approximately 600mm by the year 2100 the current day 0.5% AEP event (a rare event) is seen to correspond to a 10% AEP event in 2100. This means that the frequency of disruptive flooding will increase considerably in the future which in turn will reduce the standard of protection that a defence provides over its life. It is not proposed that any direct defences would be economically viable for Lochgilphead until the end of the PFP design life (20-30 years).

10.1.4 Benefit Cost ratio

A PFP arrangement often comes out with a very high benefit cost ratio, higher than all others. PFP costs are very low compared to formal schemes and the damages avoided are relatively high because capping and write-offs limit the build-up of damages over longer appraisal periods.

At a future date it is expected that contemporary data will shed more light on the influence of climate change and the proposed demountable defences (or other adaption) could be re-evaluated.

The EA costing guidance does not give any means of adjusting the cost of sea defences based on defence height, and only splits flood walls into 3 height categories. Because of this, and the relatively limited difference in cost expected from small changes in defence heights, it is considered appropriate to use a single option cost to compare against the residual damages of different SoP.

10.1.5 Defence options and standard of protection

The 0.5% annual exceedance probability (1 in 200 year) present day still water level is approximately 4.05mAOD. The top of the existing defence wall ranges from 2.55 mAOD (middle) to 2.93mAOD (eastern) along the Front Green. With freeboard added, this would equate to defences up to 2.1m from existing ground level. Permanent flood protection to this level is unlikely to be a favourable option for the people of Lochgilphead because the flood defences will block the view and cut the town off from Loch Gilp.

It is recommended that during any future study regarding permanent defences, investigation into public option as to the size of permanent flood defences that would be acceptable should be carried out. The design flood level and standard of protection could then be established through collaborative discussions with the affected parties.

10.1.6 PFP standard of protection (SoP)

For PFP installations in Lochgilphead, we would envisage that all 33 permanent properties affected by coastal flooding up to the 0.5% AEP event could be protected. 30 of these properties could be protected to the 1%-0.5% AEP event, with the remaining 3 properties protected at a reduced SoP, between the 5%- 50% AEP events. This reduction in SoP was due to the overall flood depths being too high for PFP at these 3 properties during large events.

Although our assessment accounts for finished floor levels, it must be noted that PFP installation will vary from property to property. A detailed buildings survey is required to determine the exact number of properties, and the type of installation.

10.1.7 Environmental and social

The area of flood risk within Lochgilphead is a conservation area which also contains a number of listed structures. There are recognisable benefits of providing flood protection to such social heritage. However, direct defences risk adversely altering the connection with Loch Gilp; these negative effects could outweigh the positive.

PFP stands out from other options because they are considered to be far less visually intrusive than more traditional direct defences.

10.2 Preferred scheme recommendations

10.2.1 Preferred option for prioritisation

Weighing the economic and environmental considerations, the appraisal has determined that there is a viable scheme for Lochgilphead that should be presented for SEPA prioritisation. If successful, this will then be put forward for centralised Scottish Government support, which could receive 80% funding.

The following options are recommended to be taken forward as a preferred scheme and presented for SEPA prioritisation:

- Option 9 - Property Flood Protection

Installing PFP was assessed as being capable of providing protection to all 33 properties affected by the 0.5% AEP coastal event. A total of 30 out of the 33 properties could be protected up to the 1%-0.5% AEP events, offering a high level of protection.

10.2.2 Additional recommended flood resilience options

In addition to PFP being recommended as the coastal flood solution in Lochgilphead, the following recommendations are also made to improve Lochgilphead's resilience to flooding now and in the future.

- Self Help and Flood Resilience

It is recommended that ABC work towards educating the public and promoting Self Help and Flood Resilience within the community to improve resilience and reduce the damages as a result of flooding.

- Crinan Canal operations

Another recommendation of this study is that ABC engage with Scottish Canals to establish whether any alteration to the operation of the canal could be made so that flow over Waste Weir 3 could be reduced and therefore result in less frequent flooding of the A 816. Whilst there may not be an economic case for this option, it has the potential to reduce the inconvenient of route closure for the wider community.

- Formal defence scheme

It is also recommended that the viability of a direct defence scheme be investigated in the future towards the end of the design life for PFP as a high level assessment within this report has indicated it may be feasible. Further assessment of the BCRs after a single life cycle of PFP in 20-30 years will likely incur a higher levels of Annual Average Damages and a cost beneficial solution may be possible.

10.3 Recommendations for next steps

It is recommended to further develop flood protection options centred on the choice of PFP now, and to reassess a formal direct defence option in the future. This could be done by the following:

- Submitting Flood Study findings for SEPA prioritisation to be considered for Scottish Government funding for the preferred option;
- Carry out further consultation with residents and local businesses, emphasising why PFP has been presented as the most viable option, and the need to reassess direct defence options in the future;
- ABC to establish a policy on how PFP could be effectivity rolled out as part of a flood scheme;
- Carry out buildings surveys to determine the exact number of properties that would see benefit from PFP installations;
- Consult with residents and businesses with regards to PFP installations;
- Educate the public on flood risks, and promote self-help and flood resilience;
- Near the end of PFP design life, a direct defence option should be reassessed. Development of reliable cost estimates and reasonable standards of protection for direct defences with a view to ascertaining if a positive benefit cost ratio can be obtained.

Appendix A - Option Plans and Indicative Sections

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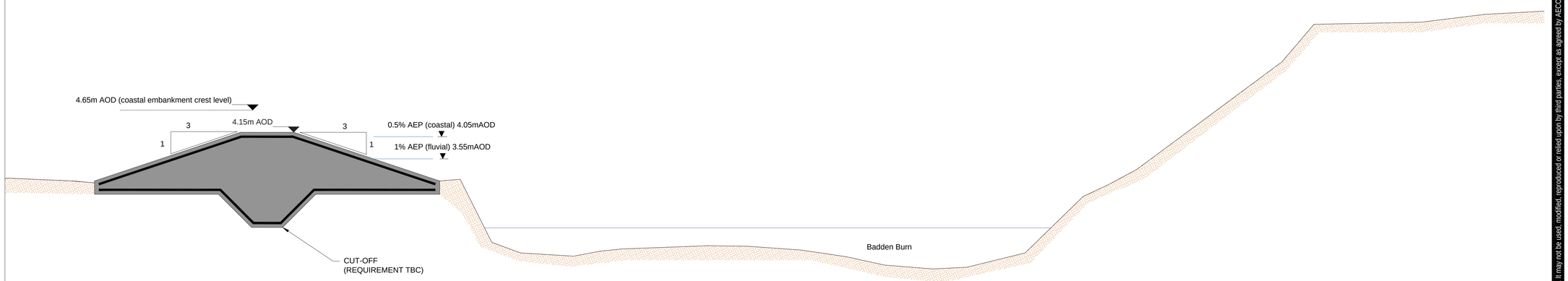

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AECOM

PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

CLIENT

ARGYLL AND BUTE COUNCIL

CONSULTANT

AECOM Limited
1 Tanfield
Edinburgh EH3 5DA
0131 301 8600 tel 0131 301 8699 fax
www.aecom.com

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LEGEND

Option 1 Raised embankment at caravan park

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I/R	DATE	DESCRIPTION
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 1
Raised embankmnet level at caravan park

SHEET NUMBER

60578115/SHT/20/G/OP1-A

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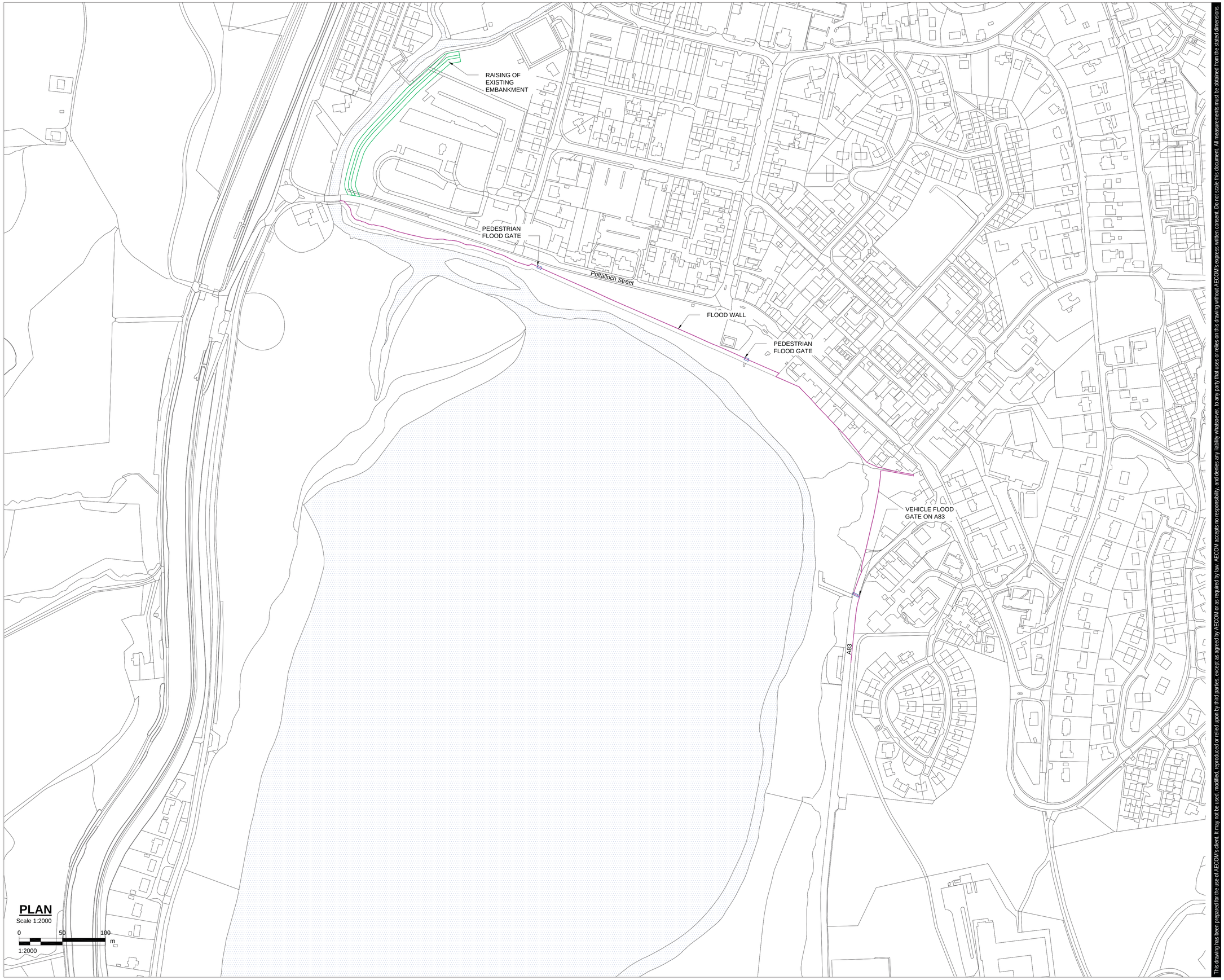

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Edinburgh EH3 5DA
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www.aecom.com

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LEGEND

- Option 2: Existing defence line wall
- Option 2: Raising of existing embankment
- Option 2: Flood Gate

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SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 2
Existing defence line wall

SHEET NUMBER

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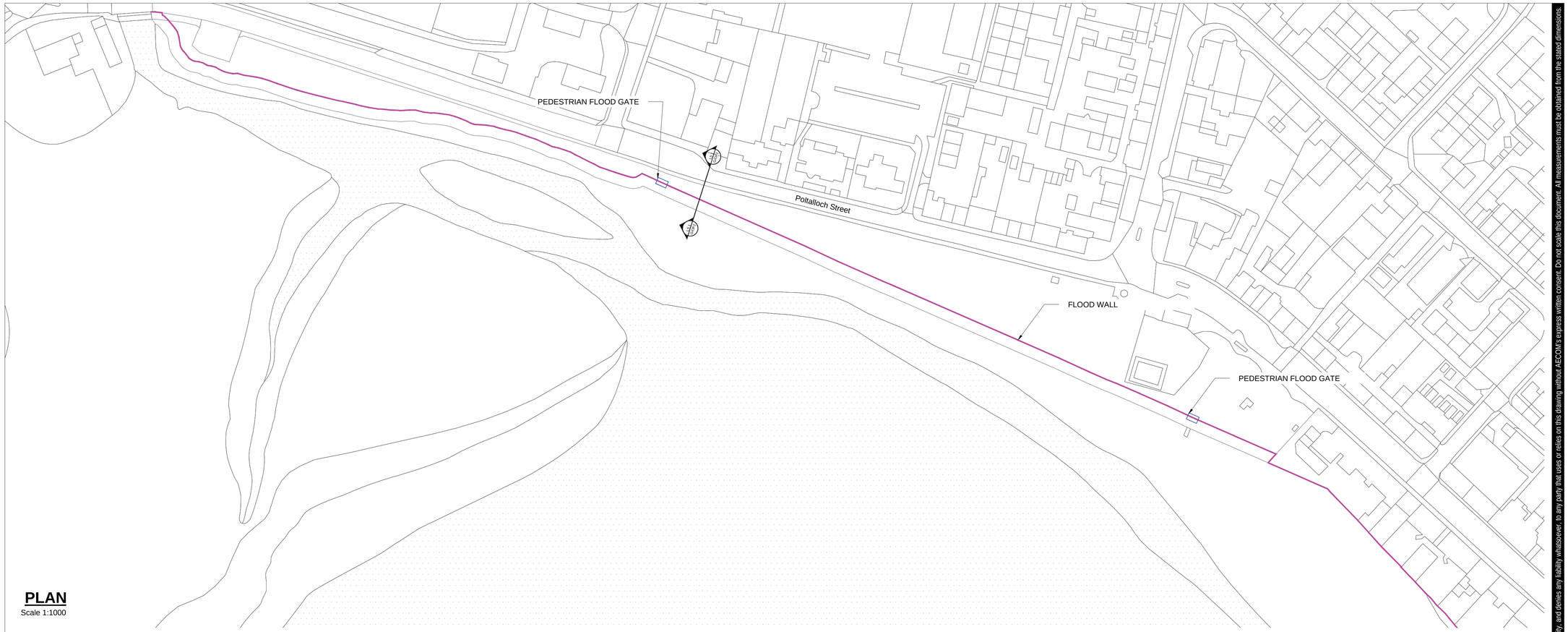

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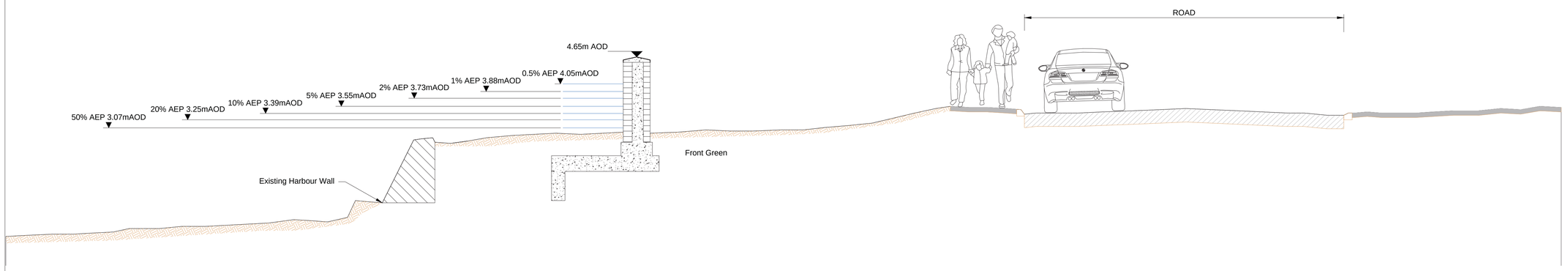

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LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

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LEGEND

Option 2 Existing defence line wall

Option 2 Flood Gate

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SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 2
Existing defence line wall

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

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LEGEND

- Option 3 Existing defence line embankmnet
- Option 3 Raising of existing embankment
- Option 3 Flood Wall
- Option 3 Flood Gate

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KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 3
Existing defence line embankmnet

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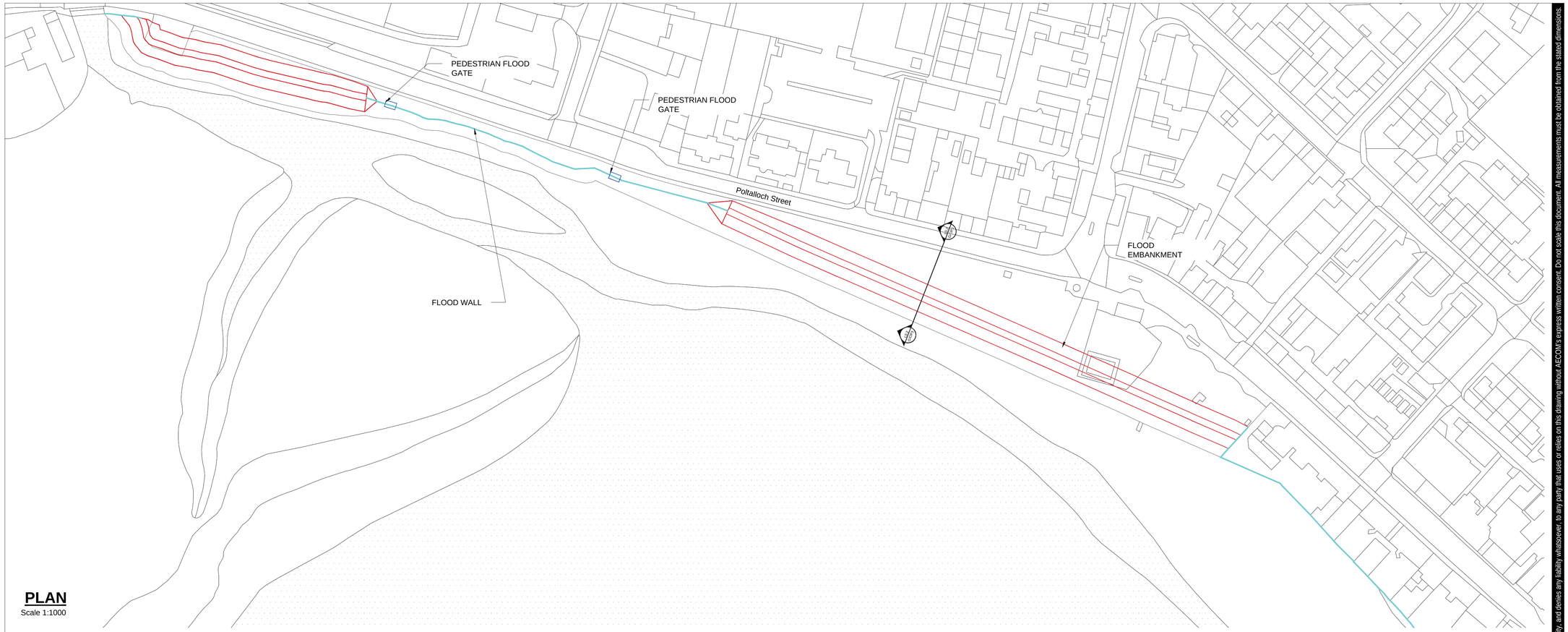

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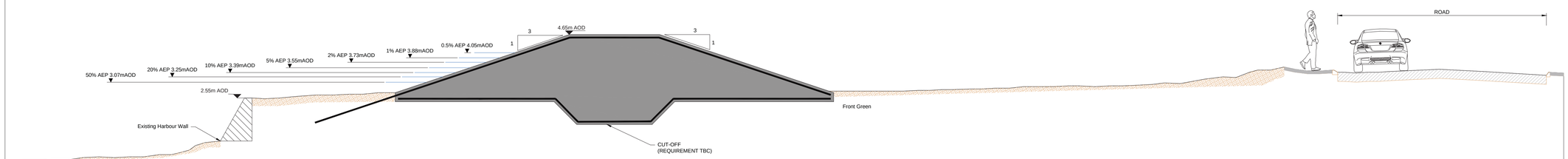

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LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

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LEGEND

- Option 3 Existing defence line embankmnet
- Option 3 Flood Wall
- Option 3 Flood Gate

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LOCHGILPHEAD FLOOD STUDY
Option 3
Existing defence line embankmnet

SHEET NUMBER

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LEGEND

- Option 4 Set back flood wall
- Option 4 Raising of existing embankment
- Option 4 Flood Gate

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KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 4
Set back wall

SHEET NUMBER

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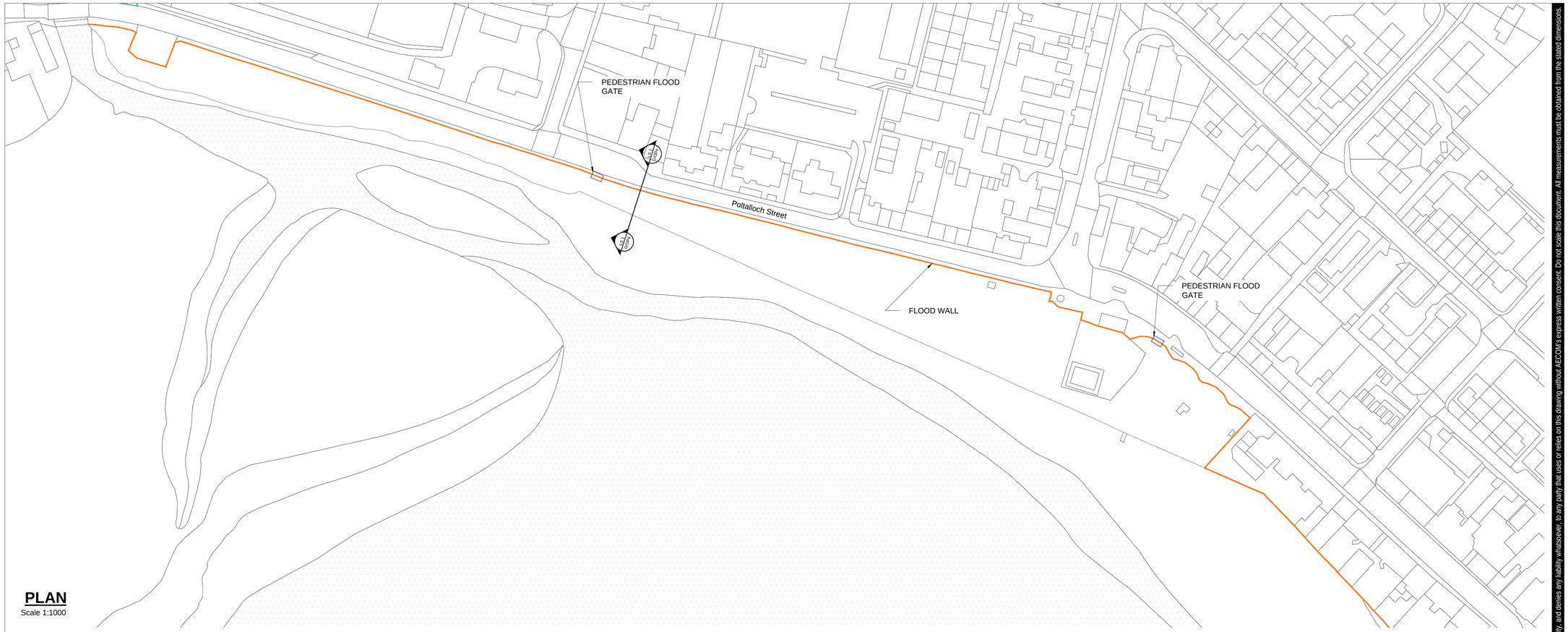

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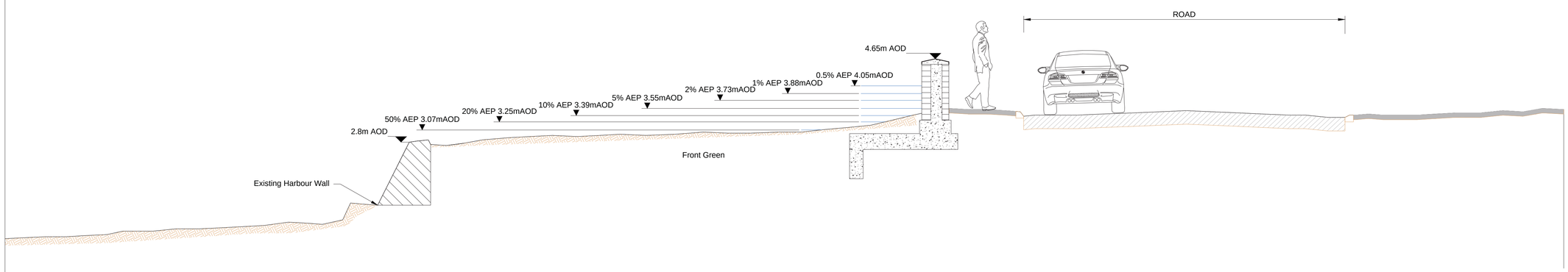

LS1 | SECTION LS1 OPTION 4
G/OP4-A
1:50

0 1.25 2.5 m
1:50

0 5 10 m H=1:200 V=1:200
0 5 10

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

CLIENT

ARGYLL AND BUTE COUNCIL

CONSULTANT

AECOM Limited
1 Tanfield
Edinburgh EH3 5DA
0131 301 8600 tel 0131 301 8699 fax
www.aecom.com

NOTES

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LEGEND

Option 4 Set back flood wall

Option 4 Flood Gate

ISSUE/REVISION

A	2019-11-08	FOR INFROMATION
I/R	DATE	DESCRIPTION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 4
Set back wall

SHEET NUMBER

60578115/SHT/20/G/OP4-2-A

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ISO A1 594mm x 841mm

Approved:

Checked:

Designer: BC

Project Management Initials:

PLAN
Scale 1:2000

0 50 100 m

1:2000

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

CLIENT

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LEGEND

- Option 5 Set back embankment
- Option 5 Raising of existing embankment
- Option 5 Flood Wall
- Option 5 Flood Gate

ISSUE/REVISION

I/R	DATE	DESCRIPTION
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 5
Set back embankment

SHEET NUMBER

60578115/SHT/20/G/OP5-1-A

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ISO A1 594mm x 841mm

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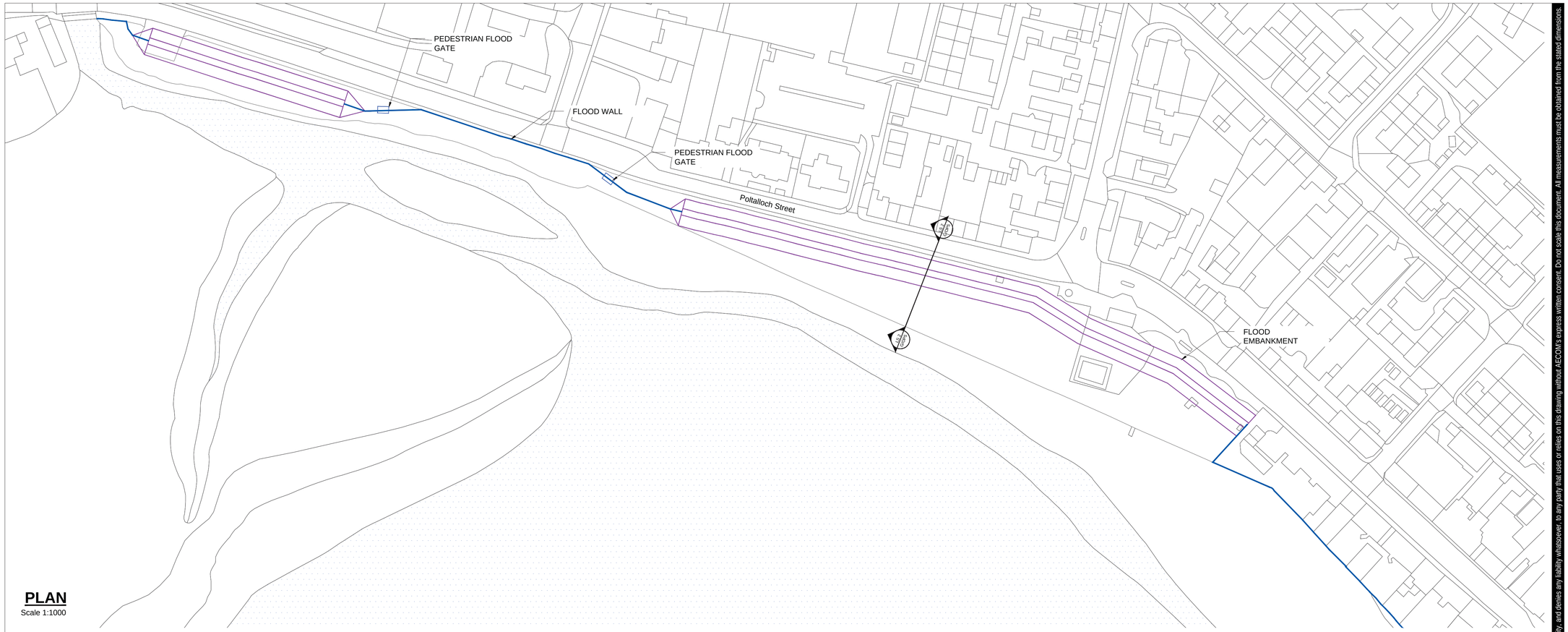
Designer: BC

Project Management Initials:



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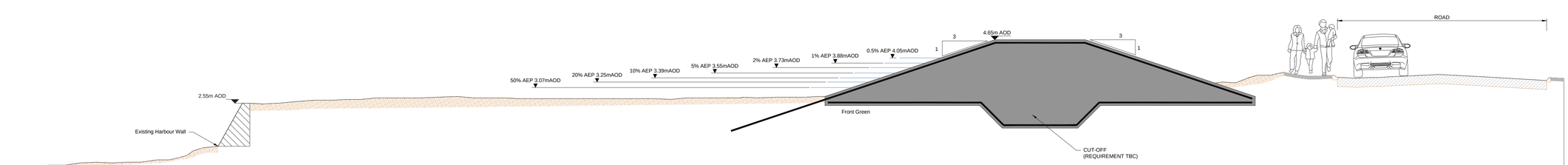

LS2 | **SECTION LS2 OPTION 5**
G/OP5-A | 1:75

0 1.875 3.75 m
1:75

0 5 10 m H=1:200 V=1:200
0 5 10

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

CLIENT

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LEGEND

- Option 5 Set back embankment
- Option 5 Flood Wall
- Option 5 Flood Gate

ISSUE/REVISION

I/R	DATE	DESCRIPTION
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 5
Set back embankment

SHEET NUMBER

60578115/SHT/20/G/OP5-2-A

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ISO A1 594mm x 841mm

Approved:

Checked:

Designer: BC

Project Management Initials:

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

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LEGEND

- Option 6 Set back embankment
- Option 6 Raising of existing embankment
- Option 6 Flood Wall
- Option 6 Demountable flood wall
- Option 6 Flood Gate

ISSUE/REVISION

I/R	DATE	DESCRIPTION
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 6
Combination of direct defence measures

SHEET NUMBER

60578115/SHT/20/G/OP6-1-A

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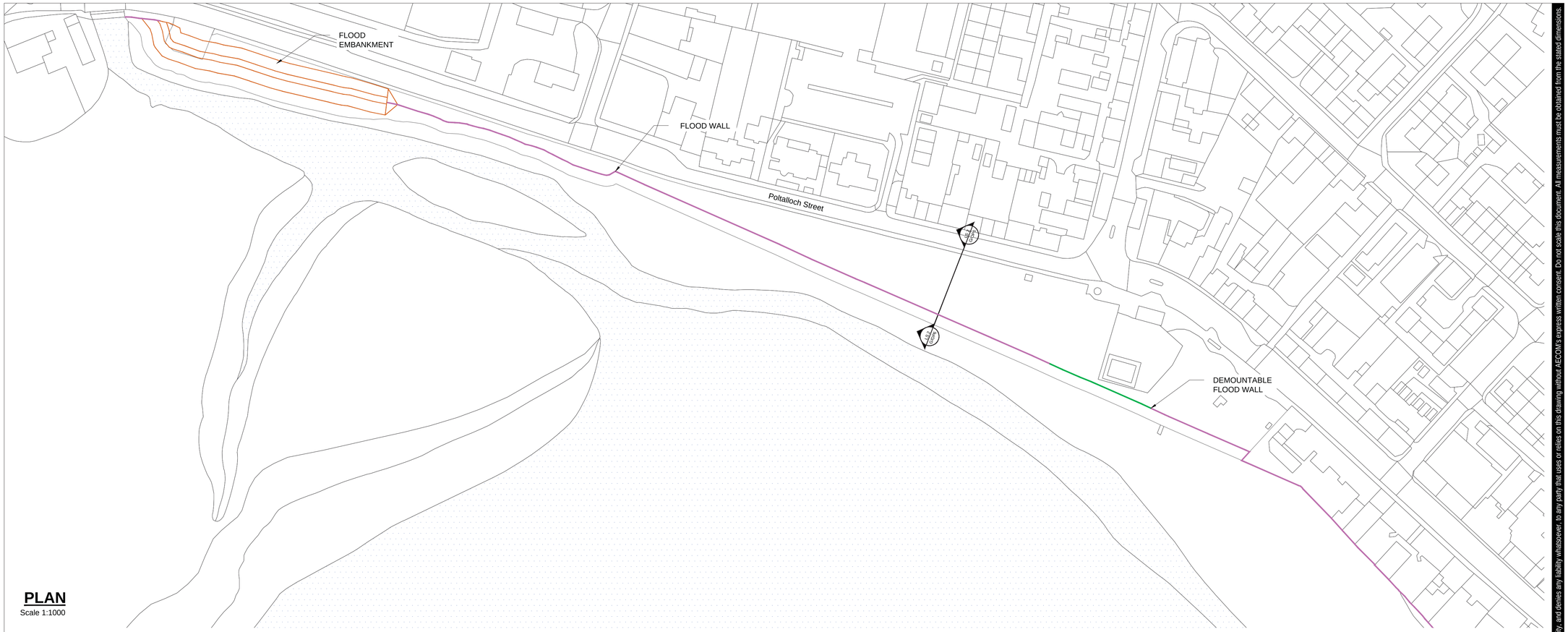
Project Management Initials: Designer: BC Checked: Approved:



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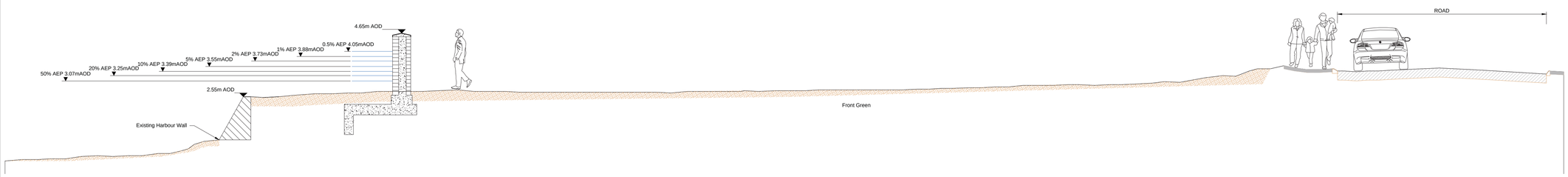

LS2 | **SECTION LS2 OPTION 6**
G/OP6-A | 1:75

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1:75

0 5 10 m H=1:200 V=1:200
0 5 10

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

CLIENT

ARGYLL AND BUTE COUNCIL

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LEGEND

- Option 6 Set back embankment
- Option 6 Flood Wall
- Option 6 Demountable flood wall
- Option 6 Flood Gate

ISSUE/REVISION

A	2019-11-08	FOR INFROMATION
I/R	DATE	DESCRIPTION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 6
Combination of direct defence measures

SHEET NUMBER

60578115/SHT/20/G/OP6-2-A

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ISO A1 594mm x 841mm

Approved:

Checked:

Designer: BC

Project Management Initials:

PLAN
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Last saved by: BEN.COOPER(2019-11-19) Last Plotted: 2019-11-19
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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

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LEGEND

- Option 7 Reclaimed land boundary
- Option 7 Raising of existing embankment
- Option 7 Flood wall
- Option 7 Flood Emabnkment
- Option 7 Flood Gate

ISSUE/REVISION

I/R	DATE	DESCRIPTION
B	2019-11-19	WALL SETBACK
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 7
Small scale land reclamation

SHEET NUMBER

60578115/SHT/20/G/OP7-1-B

ISO A1 594mm x 841mm

Approved:

Checked:

Designer: BC

Project Management Initials:

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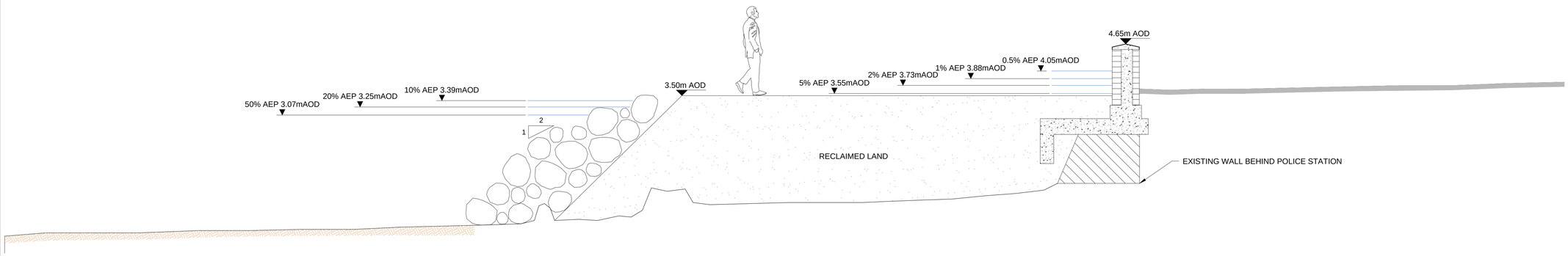

LS4 | SECTION LS4 OPTION 7
G/OP7-A

1:50

0 1.25 2.5 m
1:50

0 5 10 m H=1:200 V=1:200
0 5 10

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

CLIENT

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LEGEND

- Option 7 Reclaimed land boundary
- Option 7 Flood wall
- Option 7 Flood Emabnkment
- Option 7 Flood Gate

ISSUE/REVISION

I/R	DATE	DESCRIPTION
B	2019-11-19	WALL SETBACK
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 7
Small scale land reclamation

SHEET NUMBER

60578115/SHT/20/G/OP7-2-B

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ISO A1 594mm x 841mm

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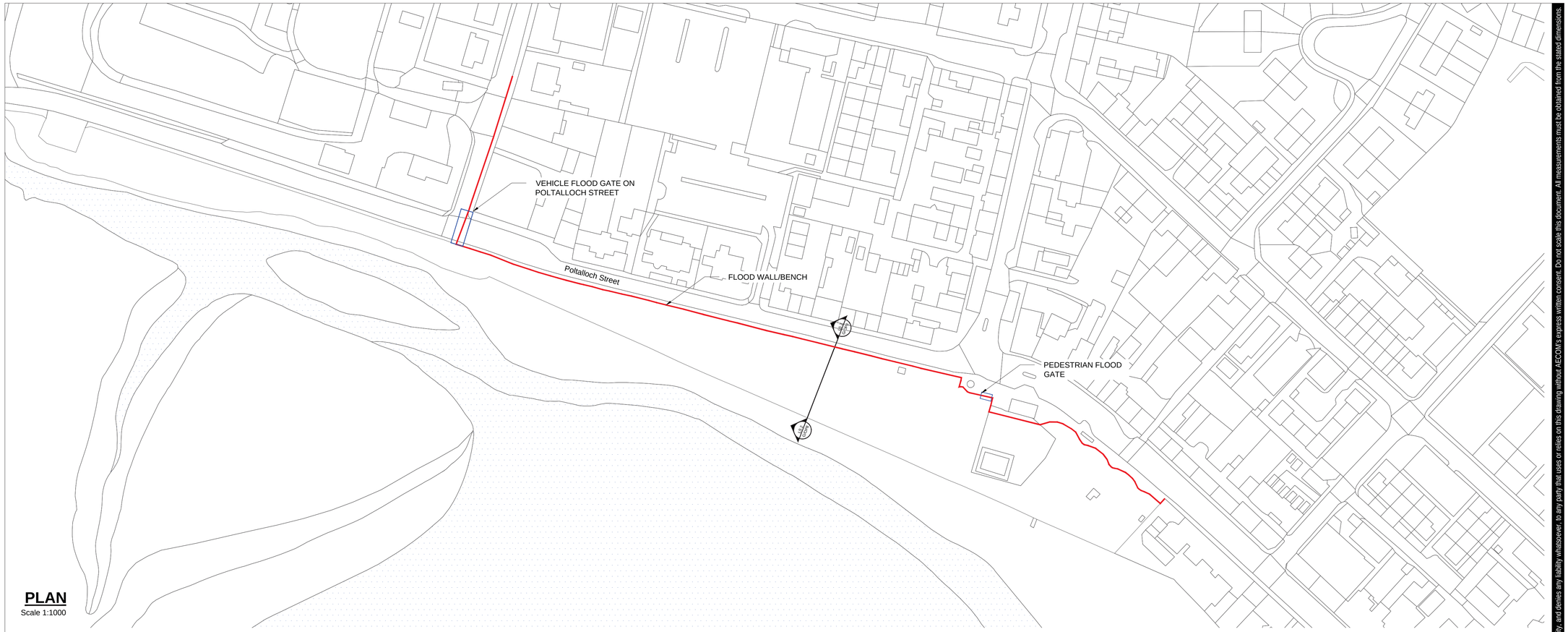
Designer: BC

Project Management Initials:



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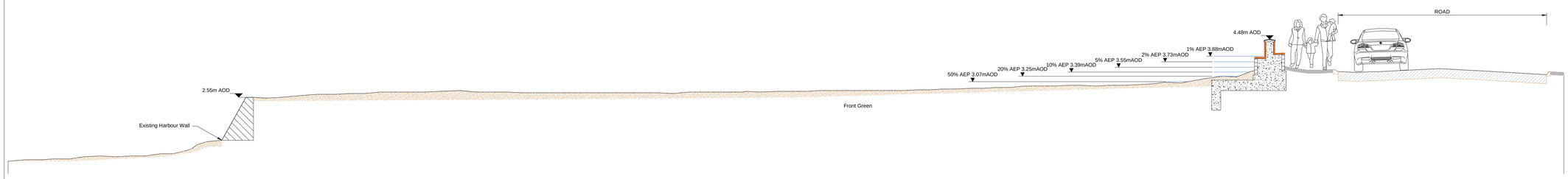

LS2 | SECTION LS2 OPTION 8
G/OP8-A
1:75

0 1.875 3.75 m
1:75

0 5 10 m H=1:200 V=1:200
0 5 10

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PROJECT

LOCHGILPHEAD FLOOD STUDY - PHASE 4 OPTIONS APPRAISAL

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LEGEND

- Option 8 Flood wall with built in bench
- Option 8 Flood Gate

ISSUE/REVISION

I/R	DATE	DESCRIPTION
A	2019-11-08	FOR INFROMATION

KEY PLAN

PROJECT NUMBER

60578115

SHEET TITLE

LOCHGILPHEAD FLOOD STUDY
Option 8
Bench defence along Poltalloch Street

SHEET NUMBER

60578115/SHT/20/G/OP8-A

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