Kilkee Flood Relief Scheme – Options Report

Final Report

July 2024

Kilkee Flood Relief Scheme

OPW Oifig na nOibreacha Poiblí Office of Public Works

Tionscadal Éireann Project Ireland 2040

COMHAIRLE CONTAE AN CHLÁIR
CLARE COUNTY COUNCIL

JBA Project Manager

Michael O'Donoghue
24 Grove Island
Corbally
Limerick

Revision History

Revision Ref/Date	Amendments	Issued to
S3-P01/ 16.05.23	Draft for review and comment regarding report structure	Steering Group
S3-P02/13.11.23	Amended following comments.	Steering Group
S3-P03/05.01.24	Amended following comments.	Steering Group
S3-P04/12.02.24	Amended following comments.	Steering Group
S3-P05/05.03.2024	Amended following comments.	Steering Group
S3-P06/31.05.2024	Amended following Public Consultation Event	Steering Group
S3-P07/13.06.2024	Amended following comments.	Steering Group
S3-P08/20.06.2024	Minor amendments.	Steering Group
A3-C01/12.07.2024	Final Report	Steering Group

Contract

This report relates to the Kilkee Flood Relief Scheme commissioned by Clare County Council, on behalf of the Office of Public Works. Conor O'Neill, Christos Papachristou, Caoimhe Downing, and Michael O'Donoghue of JBA Consulting carried out this work.

Prepared by ..... Caoimhe Downing BEng MSc

Analyst

..... Conor O'Neill B.A. (Mod) M.Sc. Adv. Dip.

Environmental Scientist

..... Paul Browne BE(Hons) MIEI

Engineer

..... Christos Papachristou MSc MA CMLI

Chartered Senior Landscape Architect

Reviewed by ..... Bernadette O'Connell B.A. MSc CMLI

Managing Director

..... Michael O'Donoghue BEng (Hons) CEng MIEI

Associate Director

Purpose

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Executive Summary

The OPW, working in partnership with Clare County Council and other Local Authorities, commissioned and completed the Shannon Catchment Flood Risk Assessment and Management (CFRAM) Study. The objectives of the CFRAM Study were to identify and map flood risk and to identify viable measures and options for the effective and sustainable management of flood risk in the Areas for Further Assessment (AFAs). The Shannon CFRAM Study Area included Kilkee as an AFA and concluded that a flood relief scheme would be viable and effective for the community.

In 2019, the OPW commissioned JBA Consulting Engineers & Scientists Ltd. to develop and assist in the implementation of a flood relief scheme for Kilkee.

The first stage of the project, the Scheme Development and Design (Stage 1) is now complete and has identified a preferred option for mitigating fluvial flood risk in Kilkee. As part of this exercise, a full review of all viable flood risk management measures and options were appraised for their viability and suitability to resolving fluvial flooding in Kilkee. The Kilkee Scheme Area was divided into three areas for the purpose of determining options. These are the Victoria Stream, Atlantic Stream and Atlantic Stream Outfall.

From the objective analysis of the Multi-Criteria Assessment and in applying professional judgement a preferred option has been deduced. This is a combination of the preferred options from each of the three aforementioned study areas. The preferred options are 1a (Victoria), 1 (Atlantic) and 2 (Atlantic Stream Outfall).

The key elements of Option 1a for the Victoria Stream Study Area are:

- Well Stream:
  - Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream.
  - Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level.
  - Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events.
  - Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place.
  - Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high).
- Victoria Court:
  - Reconstruction of Victoria Court boundary wall.
- Victoria Stream:
  - Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place.
  - Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level.

- Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level.
- Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in.
- Reconstruction of Victoria Crescent boundary wall c. 130m long.
- Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent.

- Western Tributary:
  - Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain.
  - Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel.
  - Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max.
  - Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section.
  - Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.

The key elements of Option 1 for the Atlantic Stream Study Area:

- Kilkee Bay Hotel:
  - Construction of c. 200m long embankment c. 1.3-1.6m high.
  - Diversion of c. 110m of open channel into centre of floodplain.
  - Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert.
- Dún an Óir estate:
  - Increase the height of the existing boundary wall by c. 300mm over c. 103m length.
- Sandpark mobile park:
  - Construction of c. 110m long embankment c. 700mm high.
- Waterworld:
  - Installation of new debris screen at upstream culvert headwall.
- Meadow View Court:
  - Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert.

The key elements of Option 2 for the Atlantic Stream Outfall are:

- Upgrade existing overflow chamber with raised cover (c. 2.7m long x 2m wide x 400mm high) with flap valves.
- Reconstruction of outfall manhole and installation of non-return valve on upstream 750mmØ culvert.
- Install non-return valve to existing 750mmØ overflow outfall culvert and seal existing cover of manhole downstream of overflow chamber on main outfall culvert at existing ground level.

1 Introduction

1.1 Context

Kilkee is located adjacent to Moore Bay along the west coast of County Clare. The study area for the scheme comprises the town centre with rural lands stretching outwards to the east. The Victoria Stream and the Atlantic Stream are the two main watercourses that flow through the town of Kilkee. Historically, the town has been subject to fluvial flooding and as such, Kilkee was part of the Office of Public Works (OPW) Catchment Flood Risk Management (CFRAM) study programme. The Preliminary Options Report from this study concluded that a flood relief scheme would be viable and effective for the local community. The viable scheme option for Kilkee, as identified in the CFRAM Options Report, included a series of hard defences consisting of flood embankments and walls.

The overall purpose of the Kilkee Flood Relief Scheme (FRS) project is to design and build flood defences that will protect properties and critical infrastructure in future flood events. Accordingly, following a public competition, JBA Consulting/JB Barry and Partners, were commissioned by Clare County Council (CCC) to provide engineering and environmental services for the Kilkee Flood Relief Scheme (the Scheme).

There are five stages in the project:

- Stage I – Development of a number of flood defence options and the identification of a preferred Scheme.
- Stage II – Part 10 Planning & Detailed Design.
- Stage III & IV – Tender & Construction.
- Stage V – Project Close-Out (Handover to Client).

This Options Assessment Report is produced as part of Stage I of the project: it follows on from work carried out to date and the report should be read in conjunction with the earlier Constraints Study.

1.2 Project Objectives

The overarching objective of the project is:

"*…to assess, develop and design an appropriate viable, cost-effective and sustainable flood relief scheme which aims to minimise risk to human beings, the existing community, social amenity, environment and landscape character.*"

The scheme is to be developed primarily to protect the affected areas against fluvial flooding. In addition, consideration will be given to the potential impact of any flood relief scheme on groundwater and pluvial flood risk.

This scheme will be designed to provide protection to properties in the study area from the 1% Annual Exceedance Probability (AEP) fluvial flood event (1 in 100-annual probability).

It is to be noted that this Options Report only considers fluvial options and does not present any tidal flooding solutions. Coastal flooding mitigation is being undertaken as a separate study.

1.3 Study Area

The study area is as outlined red in Figure 1-1: Kilkee FRS Study Area.

Kilkee is nestled adjacent to Moore Bay on the West coast of County Clare. The AFA boundary defined by the CFRAM has an approximate area of 3.6km². The Victoria Stream and the Atlantic Stream are the two main watercourses that flow through the town of Kilkee. These are the two main watercourses considered in the Flood Relief Scheme. Both streams flow from southeast to northwest, with the Victoria Stream located to the south of the town and the Atlantic Stream located to the north of the town. The two streams have a number of

tributaries and drainage channels which contribute to the flow through the area. Both watercourses are tidal. Kilkee is susceptible to both coastal and fluvial flood risk.

There have been a number of instances of flooding in Kilkee. The Victoria Stream is noted to overflow its banks over a length of 200-300m on an regular basis, causing flooding of Carrigaholt Road, Well Road and putting a number of residential and commercial properties at risk.

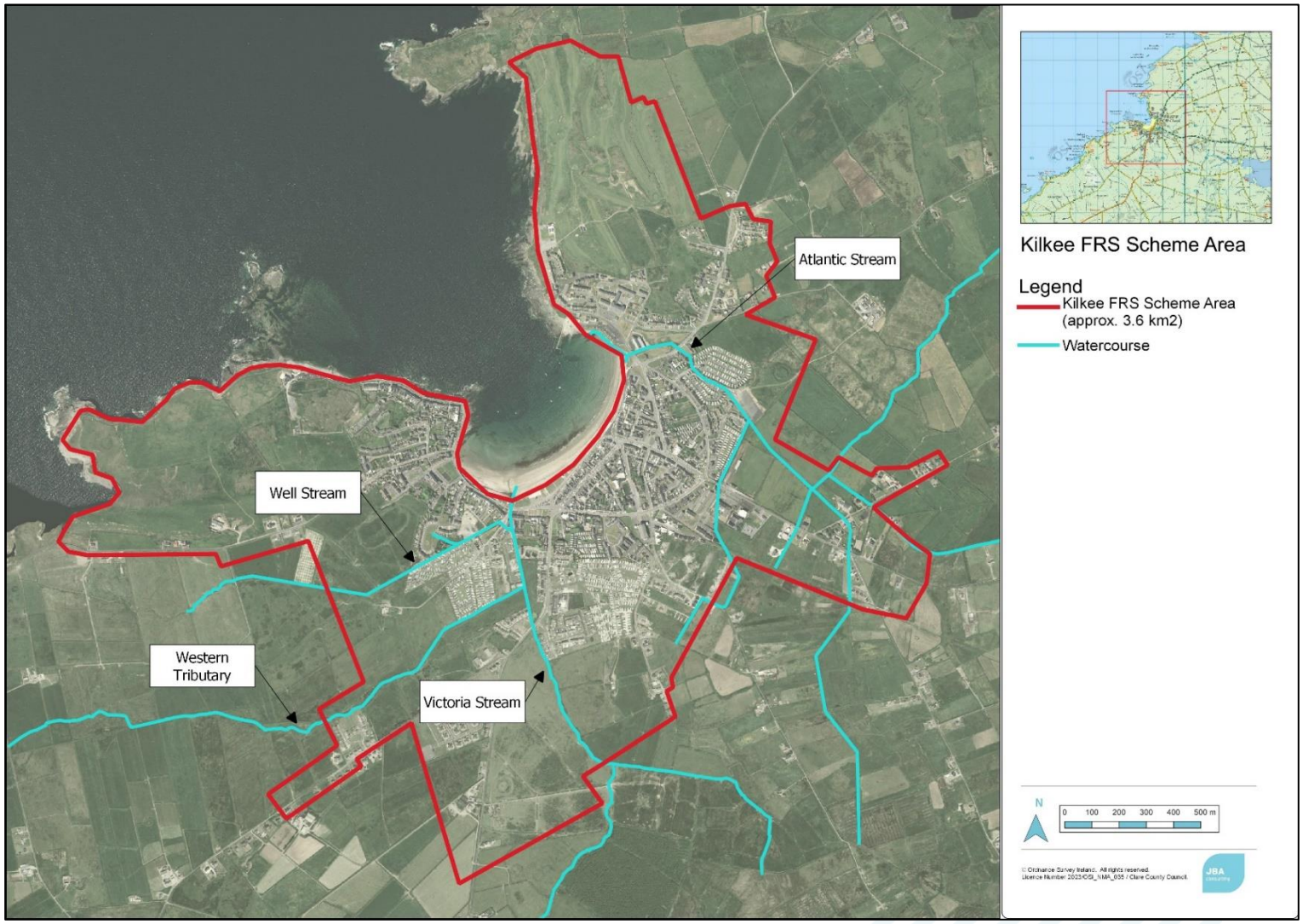

Figure 1-1: Kilkee FRS Study Area

1.4 Scope of Report

The purpose of this report is to outline the development of possible flood relief options that could be implemented in the Kilkee catchment and to describe the procedure for options assessment and selection of a preferred option.

The process is outlined as follows:

- An initial screening was carried out on alternative Flood Risk Management Approaches to set the strategic context for the different measures and options to manage flood risk. An extensive list of possible flood risk management measures, grouped by their approach to flood risk management and the spatial scale of benefits, are assessed against a predetermined set of criteria, to determine their viability;
- A technical assessment of potentially viable flood risk management measures was undertaken;
- Potential flood relief options for all locations around the site were developed using combinations of those flood risk management measures which were determined to be technically viable. Each flood relief option was assessed from an environmental, engineering and economic perspective;
- The flood relief options were then subjected to a multi-criteria assessment consisting of technical, economic and environmental criteria;
- The public were consulted on the options, including the emerging preferred option;
- The final solution was selected taking account of the following;
    - Multi Criteria Analysis;
    - Feedback from the Public and other stakeholders;
    - Cost benefit assessment;
    - Consideration of wider CCC objectives for the area;
    - Professional judgement of the project steering group.

This report is deemed to fulfil the requirements of an equivalent Flood Risk Assessment as required for this planning application.

2 Stakeholder Input and Constraints

2.1 Constraints Study

The Constraints Study was the first step in determining the key environmental constraints and drivers which would inform the development of potential flood relief options and will ultimately inform the preparation of Environmental Assessment for the final Kilkee Flood Relief Scheme. The purpose of the Constraints Study was to determine what constraints (physical, procedural, legal, environmental etc.) exist that could affect the design of the scheme, might delay the progress of the scheme and could influence the cost of the scheme.

While the Constraints Study is not a statutory document, the EPA's Draft Guidelines on the Preparation of Environmental Impact Assessments (2017) were used as a template for the study. The headings used in the Constraints Study, repeated here, are:

- Human Beings
- Material Assets
- Waterbodies
- Biodiversity
- Soils and Geology
- Landscape and Visual Amenity
- Cultural Heritage
- Air and Noise

A summary of the Constraints Study key findings is presented below in Sections 2.1.1 to 2.1.8. This information was used by the design team during the development of potentially viable measures and the development of potential options. A detailed assessment of the preferred options, building on the information gathered at the Constraints Study stage, is in Section 6 of this report.

2.1.1 Human Beings

Kilkee is a popular and well-established seaside resort, with its important role as a service centre and employment hub recognised in the Clare County Development Plan (CDP) 2023-2029. Recreational amenities are focused largely on natural assets, such as the sheltered bay, cliff walks, and beaches in the town. Constraints include residential properties along Marine Parade, tourism facilities, and mobile home parks off Well Road and Circular Road. With the importance of tourism, retention and protection of aspects such as the Blue Flag beach and 'Excellent' bathing water quality will be key to the success of the FRS.

2.1.2 Material Assets

It is likely that the proposed FRS will be located along parts of the road network which will require identification and protection of utilities during construction. The local traffic will be impacted by the construction traffic to/from the site, road closure and diversion will also be required, and communication of these measures will be developed for the scheme. Liaison with both ESB and Uisce Eireann will occur before and during the works to ensure that the works do not impact on their operations.

2.1.3 Waterbodies

The objectives of the Water Framework Directive (WFD) are to protect or enhance all waterbodies, to achieve 'Good' status for all waterbodies, and to take a catchment-scale management approach to water quality in Ireland.

There are two WFD waterbodies in the scheme area: KILKEE_LOWER_010, which includes the three streams in the study area (Atlantic Stream, Victoria Stream, Well Stream), and Shannon Plume coastal waterbody, which includes Moore Bay and the surrounding sea area. Both WFD waterbodies' risk status is 'Not at Risk'. KILKEE_LOWER_010 was assigned a water quality status 'Moderate' and Shannon Plume a 'High' for 2013-2018, the latest WFD reporting period.

During construction, there is a risk of accidental release of contaminants into surface and groundwater, or the mobilisation of nutrients and suspended solids. This could have an adverse impact on water quality, negatively impacting on the WFD status of the waterbody and preventing the waterbody from achieving its WFD objectives. Such release of contaminants can also impact the habitats and species of the Kilkee Reefs SAC.

2.1.3.1 Interaction of the WFD and the Habitats Directive

Article 4.7 of the WFD and Article 6.4 of the Habitats Directive deal with 'new modifications changing the physical characteristics of a water body' and 'plans or projects not directly connected with or necessary for the management of a Natura 2000 site', respectively. Both articles allow for the possibility of using derogations or exemptions for the implementation of such projects, once certain requirements outlined under the relevant articles are met. It is important to note that 'if a measure or project fulfils the conditions of one directive, but not the other, then the authorities may not authorise it under either directive' (European Commission, 2011, pp. 27) and that the WFD does not allow for derogation under the Habitats Directive, and vice versa. Therefore, if an exemption under the WFD for meeting Good ecological status is sought, it will be necessary to also meet the requirements of Article 6.4 of the Habitats Directive in relation to the Kilkee Reefs SAC. Several of the Qualifying Interests of the SAC rely directly on water flow and water quality, such as species of Lamprey, Salmon and Otter.

2.1.3.2 Hydrogeology and Groundwater

Kilkee and Miltown Malbay groundwater body is at 'Good' Status. Kilkee is considered 'Not at Risk' of not achieving its WFD objectives. Miltown Malbay is 'Under Review', which means that the exact status of risk is unknown. Any pollution or contamination which is released into the surface or groundwater bodies mentioned above could result in a reduction in water quality or impact on the Kilkee Reefs SAC. Impacts on water quality could have further knock-on effects on recreation and tourism in Kilkee.

During construction, accidental spillage or release of pollution, or mobilisation of sediments, could result in contaminated water entering the groundwater body in the area. This has the potential to impact on the existing WFD status of the groundwater body.

The impermeable precast concrete U-channel could alter the amount and quality of groundwater. Once operational, the scheme is expected to reduce the likelihood of potentially contaminated floodwaters entering the groundwater body in Kilkee.

2.1.4 Biodiversity

Moore Bay and the surrounding coastal waters are all part of Kilkee Reefs SAC (Figure 2-1); any works in or near the SAC have the potential to adversely impact the SAC or its qualifying interests.

The SAC boundary is adjacent to the outfall of the Atlantic Stream options. Both the Atlantic Stream and the Victoria Stream discharge into Moore Bay and consequently to the Kilkee Reefs SAC. During construction accidental spillage or release of pollutants could affect the SAC. Works such as regrading of the soil surface and excavation of the Well Stream to replace it with a precast concrete U-channel are expected to affect habitats that provide foraging and nesting grounds to protected species during construction. The use of precast concrete U-channer could also increase the risk of permanent habitat loss along Well Stream.

2.1.4.1 Invasive species

The invasive plant Japanese Knotweed is present at two locations in Kilkee (Figure 2-1). These were identified during the preparation of the Constraints Report. In particular, a site along the main channel of the Victoria Stream was heavily overgrown with Japanese Knotweed; as this area is within an area prone to flooding, the spread of this species will be

inevitable without treatment. In recent years, this section has been treated approximately once per year. The proposed flood defence works require that these plants be managed in accordance with the guidance that will be set out in the Environmental Impact Assessment Report (EIAR).

2.1.4.2 Fisheries

It is unlikely that the Atlantic Stream and Victoria Stream are a major feature for salmonids, lamprey and other protected fish species. Both streams are culverted onto the beach and there is no seawater connection with the streams at lower tides. In summer the water level gets very low in these small streams which would make it unsuitable for salmonids.

However, the Anadromous (lives at sea but reproduces in freshwater – like salmonids) fish species Three-Spined Stickleback (Gasterosteus aculeatus) was observed in the Victoria stream. This indicates that fish can still migrate between the streams and the sea and therefore European Eel (Anguila anguila) may also be present. There is sufficient suitable habitat for European Eel available in the streams, pools, and marsh areas.

The inclusion of in-channel works, or permanent modification of channel banks or bed is not likely to have an adverse impact on aquatic populations and water quality to affect these populations. Timing constraints will apply to any in-channel working to avoid the salmonid spawning season (usually between November and March) and Inland Fisheries Ireland must be consulted during the design stage, prior to works commencing. Appropriate measures shall be included in the design of the selected working option to ensure appropriate fish passage is maintained, and that fish species do not get trapped in any storage areas created and habitat value within the existing channel is not reduced.

Appropriate measures shall also be required to prevent pollution incidents and silt mobilisation. Maintenance of fish passage and good water quality are constraints.

Any instream works or culvert works will require consultation with Inland Fisheries Ireland (IFI) and will be subject to seasonal constraints, i.e., must be carried out from July to September inclusive.

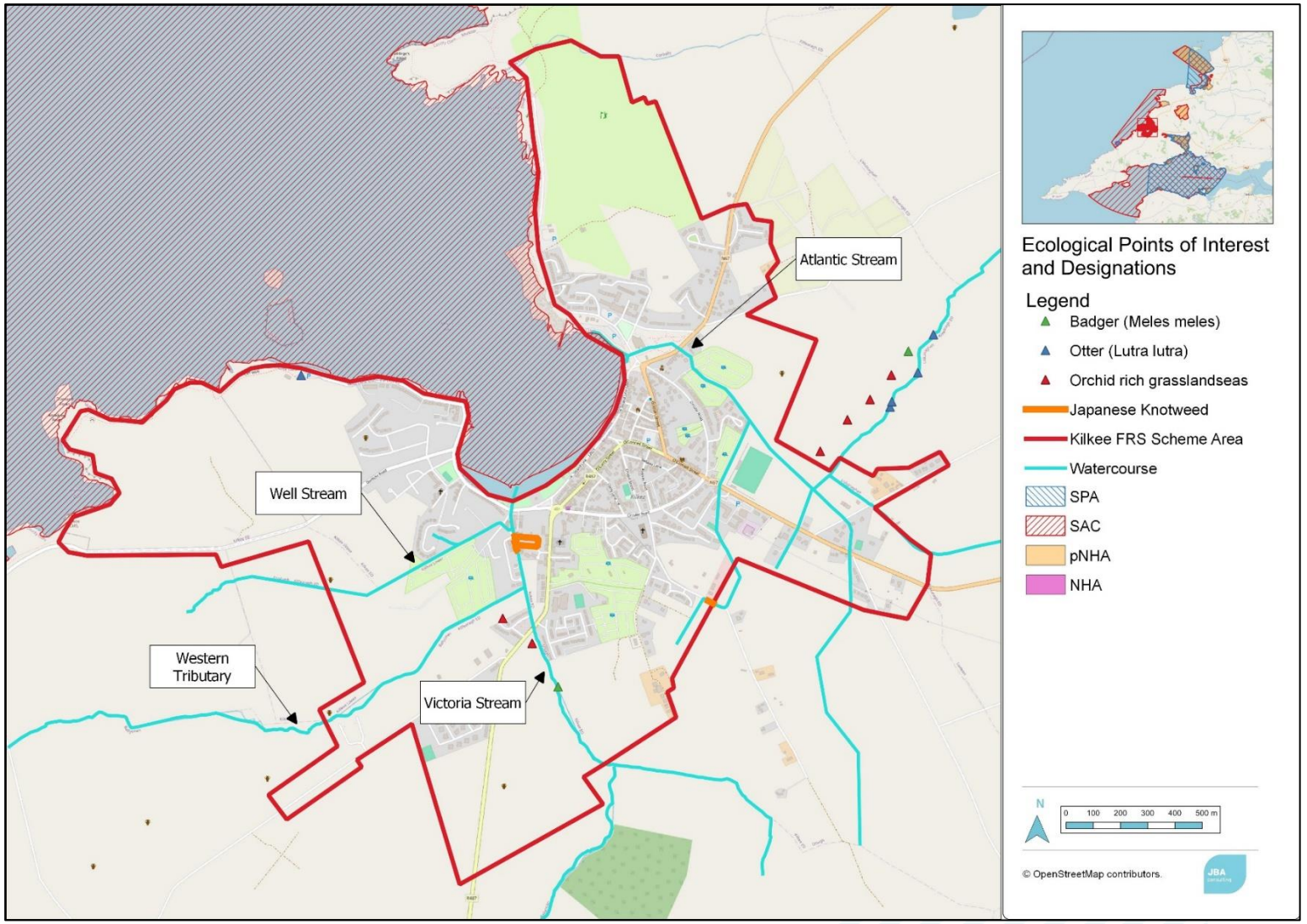

Figure 2-1: Ecological Points of interest

2.1.4.3 Appropriate Assessment

The EU Habitats Directive requires an Appropriate Assessment to be carried out where a plan or project is likely to have a significant adverse effect on a Natura 2000 site. The Natura 2000 network of European sites in Ireland comprises Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).

An AA Screening Report will be prepared for the preferred option.

2.1.5 Soils and Geology

The aquifer vulnerability in the Kilkee FRS study area has been mainly classified as low and moderate, however sections to the south and north have high and extreme classifications (Figure 2-2). Kilkee is underlain by a locally important aquifer, moderately productive in local zones only. Construction works and changes to flow regimes could result in changes to groundwater flows, with further impacts on groundwater quality.

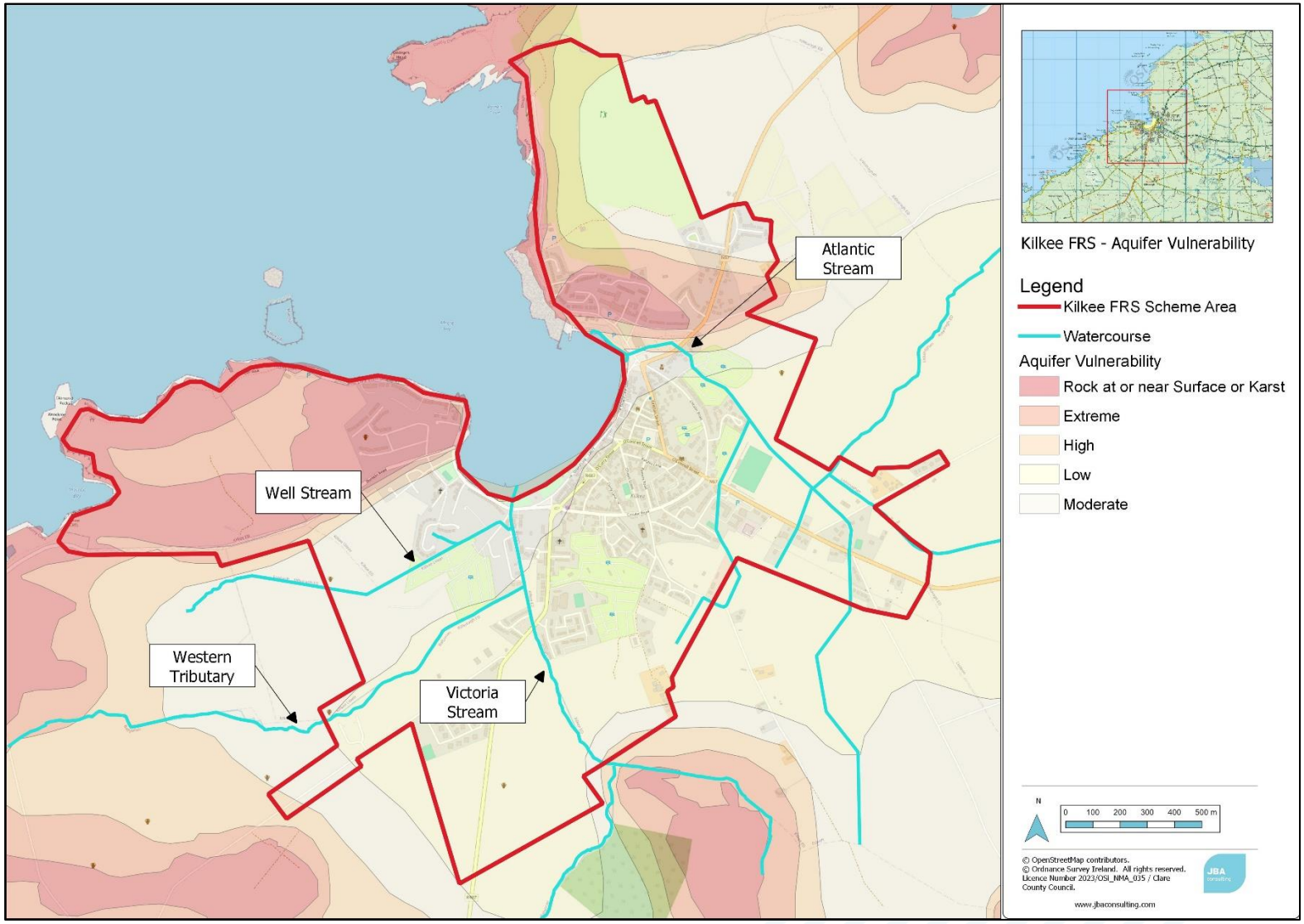

Figure 2-2: Aquifer vulnerability in the study area

2.1.6 Landscape and Visual Amenity

The coastal roads approaching Kilkee from the southwest (Dunlicky Road and R487) and the north-east (Corbally to Bealaha) are designated as Scenic Routes. The coastal fringe is described as Heritage Landscape in the County Development Plan.

Potential constraints relating to landscape and visual amenity are the presence of much valued, open and interrupted visibility across Moore Bay and the good accessibility onto the beach from the surrounding town. The construction of hard defences above eye level may lead to a degree of visual intrusion and obstruction of views and an altering of the urban seaside landscape character by any engineered solutions.

Figure 2-3: Moore Bay and Marine Parade

2.1.7 Cultural Heritage

There are 15 structures on the National Inventory of Architectural Heritage (NIAH) in the scheme area, as well as 18 archaeological sites listed with the National Monuments Service and an Architectural Conservation Area (Figure 2-4). The proposed measures are not expected to have any significant impact to these features and their notification zones.

Further consultation though should be requested in the EIA stage for impacts to underground archaeology.

2.1.8 Air and Noise

Constraints relating to air and noise would be temporary in nature, during the construction phase. Mitigation measures should be implemented during construction to limit any impacts.

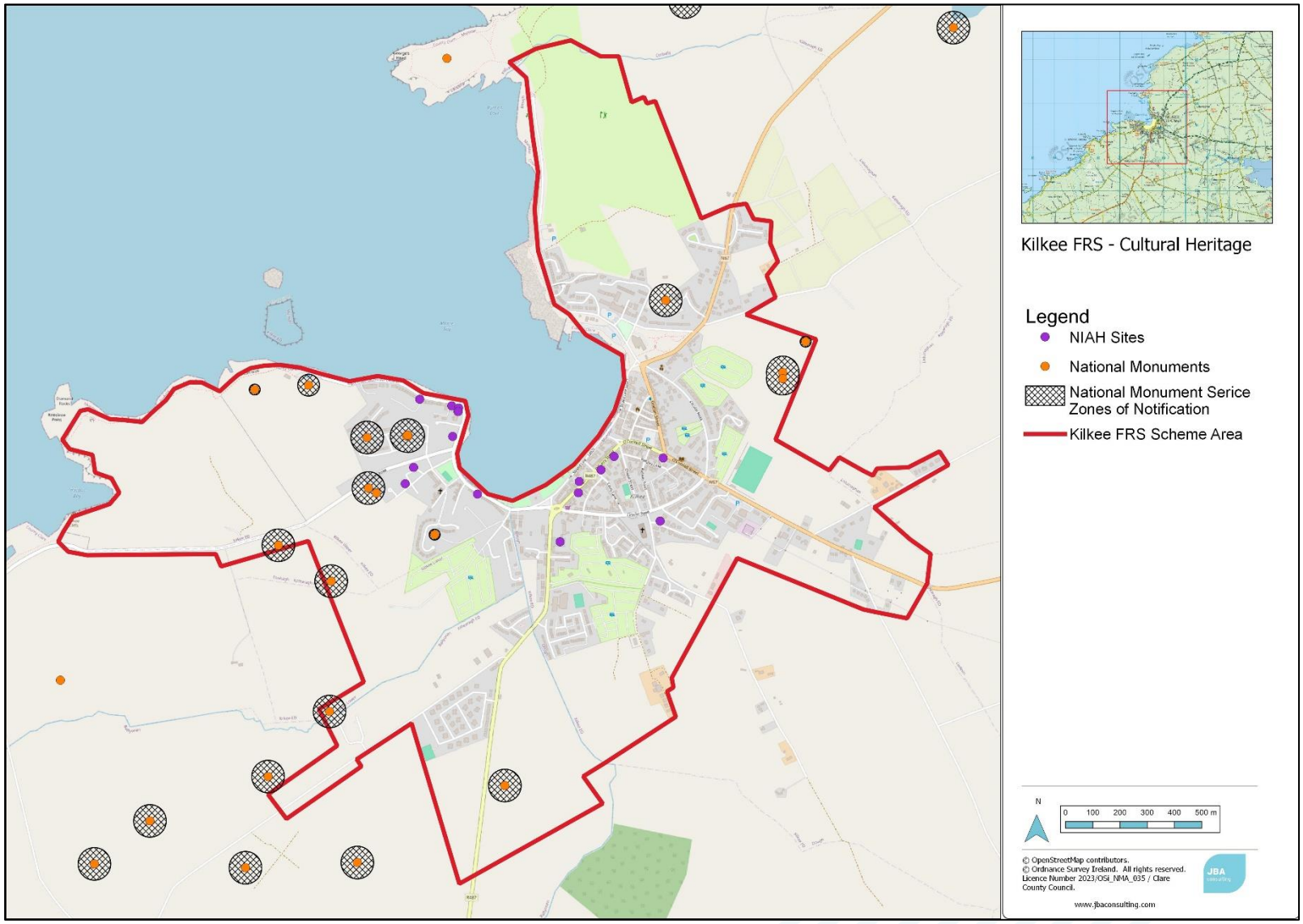

Figure 2-4: Cultural Heritage sites in Kilkee

2.2 Design Constraints

In so as far as is practicable, flood defence proposals have considered the preliminary constraints identified in the preparation of the 'Constraints Study for Flood Relief Scheme at Kilkee', through Public Consultation Questionnaires and through public engagement. A summary of the main design constraints are as follows:

- Flood defence solution shall ensure access to Moore Bay for amenity.
- An exclusion zone of one metre around existing buildings and/or walls has been applied to account for their foundations.
- Timing constraints will apply to any in-channel work.
- To avoid the need to re-excavate along the line of the new defence spare ducting will be laid along its length.
- A safe-guarding height of between 1.1m to 1.2m is to be provided on all walls; where this is substantially higher than the FDL would otherwise require. In many cases this can be achieved through the addition of railings atop the defence walls.
- Clare CC have wider objectives:
    - to safeguard and maintain the areas of open space and outdoor recreation as important amenity areas within the town,
    - to retain the overall special historic or architectural character of an area or place.

2.2.1 Hydromorphology

There are no hydromorphological pressures identified in the River Basin Management Plan (RBMP) for the reaches in the study area. The reefs in Moore Bay however are exposed to wave action, with some protection afforded by the bay itself. Potential constraints include alteration of sediment transport processes on the beach and the condition of the existing sea wall.

2.3 Consultation

Proactive consultation was a key requirement of the project. The purpose of the consultation is to obtain feedback on the proposals from all relevant affected stakeholders and landowners who might be impacted by the Scheme. Feedback throughout the project has been taken seriously, carefully considered, and where appropriate has influenced decisions on the final FRS. The goal is that this ensures the public's opinion is taken into consideration when developing the plan and that people are informed of the influence they had.

Detailed consultation planning for the project has been developed stage-by-stage, and will be updated when necessary, in partnership with the Steering Group (SG).

2.3.1 Public Consultation

At the beginning of the project, the steering group and design team sought to take the opportunity to interact with the stakeholders that may be directly or indirectly affected by the FRS. The project team also sought the opportunity to listen to the views of those living or working in areas near the scheme. The goal of such consultation was to elicit these views and to start to build a relationship with members of the local community. The consultation was open to any and all interested parties, including political stakeholders.

Four public consultation events were held throughout the duration of Stage 1. These were coordinated so that they were held at critical junctures in the design making process, used as hold points to get feedback prior to moving forward with any particular option or measure.

Due to COVID 19, no in-person public consultation event was possible at project inception. Instead, a virtual event was hosted including the promotion of a scheme video and online questionnaire access.

The feedback provided via the completed questionnaires was very useful in the development of the FRS. There is a lot of genuine interest in the works and in particular the timeline of the construction. For the most part, attendees agreed that a solution was needed and although many expressed their concern in terms of protecting local roads in addition to houses and businesses, they understood that it was more important to provide flood protection in a timely manner. Where opportunities or constraints were highlighted by attendees, these have been detailed in the 'Design Constraints' sections of this report under the relevant Area headings.

2.3.2 Ongoing Consultation

Comprehensive communication and engagement plans have been developed and adopted by the team, including an information link on the Clare CC website, direct emails, newsletters, local media, and public consultation among other approaches as listed in Table 2-1 below.

Key elements of the project include the establishment of social media forums, such as a Facebook project page (Kilkee Flood Relief Scheme) and website (www.kilkeefrs.ie). The purpose of the social media accounts is to maintain communication flow and provide updates for all interested stakeholders that have access to it; it can be a faster and more efficient way to keep the public informed of the progress of the project and is already established as a method of communication amongst community groups in the town.

During Stage 2 of the project, a Scoping Report will be prepared for the EIAR and Statutory Bodies, non-statutory bodies, and interested stakeholders will also be consulted with. Their views will be considered in the preparation of the EIAR.

Table 2-1: Kilkee FRS Communication and Consultation Approaches

Communication Activity	Purpose
Direct email	Stakeholders have supplied their contact details, project updates and invitations to consultation events were shared via email. Contact details for key project team members from JBA and JB Barry were provided in the first newsletter and the subsequent public consultation package. Some local residents have been in regular contact following this. Names and addresses are held securely in compliance with the Data Protection Act 1998.
Local authority / community publications such as parish newsletters	Stories in local authority / community group newsletters are likely to reach a wide range of citizens and will be considered for future project updates and events. Project newsletters were distributed to inform the public of key updates and information regarding the scheme development.
Clare CC website	Links to newsletters and consultation documentation are on the Clare CC website.
Kilkee Flood Relief Scheme website	Information regarding the scheme development is on the Kilkee FRS website www.kilkeefrs.ie
Local Media TV, radio, newspapers, magazine or publications	Press releases were prepared in advance of public meetings and distributed to the media.
Paid for Advertising - in a media publication	There were various options for advertising available – such as online, radio, television, outdoor, press and more. All means were considered for each public consultation event.

Communication Activity	Purpose
Public Consultation Days / workshops - held at a community venue.	Consultation exhibitions / events offered a more extensive and open form of engagement on a personal basis. They provided opportunities for members of the public to express views on the consultation subject area, ask questions, take on board the information at their leisure, discuss any concerns, provide a view and receive feedback on the issues they raise. The events were geared towards a specific issue, based on consultation stage of the project programme. The consultation events were held in community facilities – providing an environment conducive to actively seeking views in the relevant communities. These events can combine the presentation of information, visual displays, verbal presentations, computer presentations (eg video loop) and other details whilst giving people the opportunity to provide views and opinions. Members of the design team and environmental team were available on the day to answer any specific queries that arose. Events were held in venues that were accessible for disabled users or users with special needs to maximize possible attendance. Given the Covid-19 pandemic and associated restrictions it was not possible to hold the Stage 1 Public Consultation Day within the town. To comply with the Government restrictions and guidelines, the format of the public consultation event was altered to ensure that all contact was via electronic means. An information video was developed and displayed on the Kilkee FRS website (www.kilkeefrs.ie). Questionnaires were also available on the website for people to download. The consultation was publicised via newspapers and radio stations and via local Facebook groups. An additional Early Emerging Options Public Participation Day was held in August 2022 at the community centre in Kilkee. A presentation was given by the project manager to attendees at various sessions throughout the day. Drawings and documents were also displayed on the walls in the community centre. A further Public Consultation Day was held on the 13th April 2023. The aim of this PCD was to present the emerging fluvial preferred options to the locals. The reasons behind the choice of option and alternatives considered was conveyed and discussed. Constraints related to both preferred and alternative options were also presented. A final public consultation day was held between the 26th February and 06th March 2024. This PCE was to give the public an opportunity to comment on the draft planning document set. The documents were put on public display throughout the period specified above and a public consultation day was held in the afternoon of the 6th March 2024 at Kilkee Library.
Community groups and forums	Community groups provide opportunities to reach a wider community. Meetings can be used as an opportunity to promote a project event. The design team and Steering Group will ensure that the primary groups are involved / represented in the project.
Face to face meetings and site visits	Site meetings have taken place between JBA and a number of key stakeholders including Clare CC officers, residents and local groups. Site visits provided an opportunity for a less formal conversation with local residents, who have shared important information regarding previous flood events and suggestions for inclusion in the FRS.

2.3.3 Early Public Consultation Event

Shortly after project commencement, an early public consultation event was held with the aim of engaging with stakeholders that may be directly or indirectly affected by the FRS. The goal of the event was to find out more about the flood history of the town, elicit early opinions and to start to build a relationship with members of the local community.

Due to COVID-19 restrictions, this event was held on-line. An information video was produced which described the background and plans for the FRS. The video was displayed on

the Kilkee FRS website (www.kilkeefrs.ie). The video went live on the 27th of August 2020 and is still available to view on the website.

Questionnaires were also available on the website and in the Sweeney Memorial Library in Kilkee for interested parties to fill out and return to the JBA office via email or post. A total of six responses were received, some key notes raised were:

- Importance of water quality and maintaining tourism
- Separation of wastewater and storm water
- Waste Water Treatment Plant (WwTP) upgrade

The promotion of the public consultation workshop was carried out through various means such as posters, traditional media (newspaper, radio), social media (Facebook), leaflet drop and word of mouth.

2.3.4 Early Emerging Fluvial Options - Public Participation Day (PPD)

A second Public Participation Day was held on Thursday 18th of August 2022 in Kilkee Community Centre from 2pm to 8pm. The event was set-up in a drop-in format with scheduled presentations to be given by the project manager at 2:30pm, 4:30pm and 6:30pm. The exhibition room had posters, a registration table, one-to-one and small group discussions, information leaflets and questionnaires to be completed or taken away for later submission. All the information provided at the consultation event was subsequently made available on the website.

Approximately 60 people attended the event. Although the event was well attended only 3 questionnaires were returned to the JBA offices. The feedback provided on the day, and in following conversations, has been useful in developing the flood relief scheme. There was a lot of genuine interest in the works. The key discussion points were as follows:

- Water quality is an issue in both streams.
- Questioning why the Uisce Éireann scheme and the FRS aren't integrated / working together to solve the WQ issues.
- New development along sea wall (terraces) have changed the regime in the bay – more water noted by the slipway along marine parade and less down at the Waterworld side than before construction. Beach level has dropped over the years, this was noted by a number of residents.
- Interest in coastal element with resident mentioning the damage done in 2014.
- Mention of stop logs at Victoria Stream outfall used during the bathing season - some residents blaming the stop logs for the flooding.
- Victoria Court (number of residents in attendance including representative of management company) - concerns over poor condition of the boundary wall on the riverside. Consider stream is the reason the wall is failing. Subsidence in the grounds have resulted in pipes cracking and foul water entering the stream. Pipes have also failed/crushed and needed replacement. Rising damp in properties was identified as a concern. No flooding of properties was reported.
- CCC compound area was built on marsh lands, and this has affected the flooding extents in the area – pluvial options were explained in response.

A meeting was held with local councillors the week prior to the PPD with the aim to keep them fully informed of progress and of getting feedback.

2.3.5 Emerging Fluvial Preferred Option - Public Consultation Day

A further Public Consultation Day was held on the 13th April 2023. The aim of this PCD was to present the emerging fluvial preferred options to the locals. The reasons behind the choice of option and alternatives considered was conveyed and discussed. Constraints related to both preferred and alternative options were also presented.

The proposals were positively received by the attendees. Further feedback was requested and one response was received that provided additional photographic evidence of the flooded areas and biodiversity at the time of flooding.

2.3.6 Pre-planning Public Consultation Day

A final public consultation day was held between the 26th February and 06th March 2024.

This PCE was to give the public an opportunity to comment on the draft planning document set. The documents were put on public display throughout the period specified above and a public consultation day was held in the afternoon of the 6th March 2024 at Kilkee Library. The feedback received was largely positive towards the scheme.

3 Baseline Flood Hazard, Exposure, Vulnerability and Risk

3.1 Baseline Design Event

The baseline flood extents for the 1% AEP event are shown for the Atlantic and the Victoria Stream in Figure 3-1: Atlantic Stream Baseline Flood Extents and Figure 3-2: Victoria Stream Baseline Flood Extents, respectively.

There are two screens located along the Atlantic Stream, a security screen at the inlet to the outfall culvert, and a trash screen approximately 30m upstream of this. Significant blockage has been noted at these screens in previous events. The baseline design event therefore includes for this potential blockage through 80% blockage at both the trash and security screens.

The Victoria Stream flooding is both fluvial and tidal. Therefore, joint probability was considered when developing the baseline design extents. The joint probability analysis determined that there was no intertidal zone, there is a fluvial dominant zone and a tidal dominant zone. Therefore, the fluvial dominant extents and levels will dictate the baseline design flood extents within the fluvial dominant zone and the tidal dominant extents will dictate the baseline design extents. The Atlantic Stream is not impacted by tide levels.

For both the Victoria and the Atlantic Streams a number of walls and informal defences have been included. These walls / informal defences have been included if they have been known to affect the flood extents in historic events. The walls in place therefore influence the baseline design extents.

3.1.1 Flood cells and flood mechanism

There are a number of mechanisms of flooding in Kilkee.

Flooding from the Atlantic Stream is generally attributed to blockage of the trash screens at the outfall culvert and undersized outfall culverts. Flooding upstream on the Atlantic Stream is restricted to mainly agricultural lands.

Flooding from the Victoria Stream is both fluvial and tidal – options will therefore have to defend against both. A short description of the main mechanisms and flow paths for the Victoria Stream network are below:

- The Victoria Stream overtops its banks along the downstream section through the town.
- The Victoria Stream backs up along the Well Stream overtopping its banks along Well Road.
- There is a restriction in the channel at the downstream end of the Victoria Stream, and these walled sections of watercourse contains riparian assets in danger of collapse.
- Upstream of the Well Stream floods, resulting in flow down through the mobile home park and into the town.
- The western tributary overtops its banks resulting in flooding down through the mobile home park and into the town.
- Incomplete and inadequate provision of flood defences currently exists.
- The Clare County Council compound area adjacent to the Well Stream and the area around the Well Road/Victoria Park junction are at most risk of flooding as these areas are low lying.

Due to the tidal risk to the town a level of protection along the Victoria and the Well Stream will be required regardless of the fluvial option tested.

Pluvial risks will be potentially exacerbated by some of the options and that will be factored into the option selection.

The proposed measures are split into flood cells as shown in Figure 3-3: Atlantic Stream Flood Cells and Figure 3-4: Victoria Stream Flood Cells.

3.1.2 Performance of existing flood defences and influence other non-flood defence infrastructure on flood hazard and risk

There are currently no formal flood defences within the Kilkee AFA. There are a number of informal embankments and walls which were retained in the model to ensure onset of flooding is realistic. Although informal the walls and embankments do provide some level of protection. Details on the location of the walls retained in the model can be found in the 19109-JBAI-XX-XX-RP-C-00368_Hydraulic_Model_User_Report.

The existing pumping station on the Victoria Stream currently has no effect on flood risk. The pumping station pumps flow from the Victoria Stream to Intrinsic Bay during the summer months when the stop logs prevent the channel from flowing to Moore Bay via the beach. However, pumped flows are negligible in comparison to the flood flows and also in significant events the pumps are turned off and therefore have no impact on flood levels or extents in the AFA.

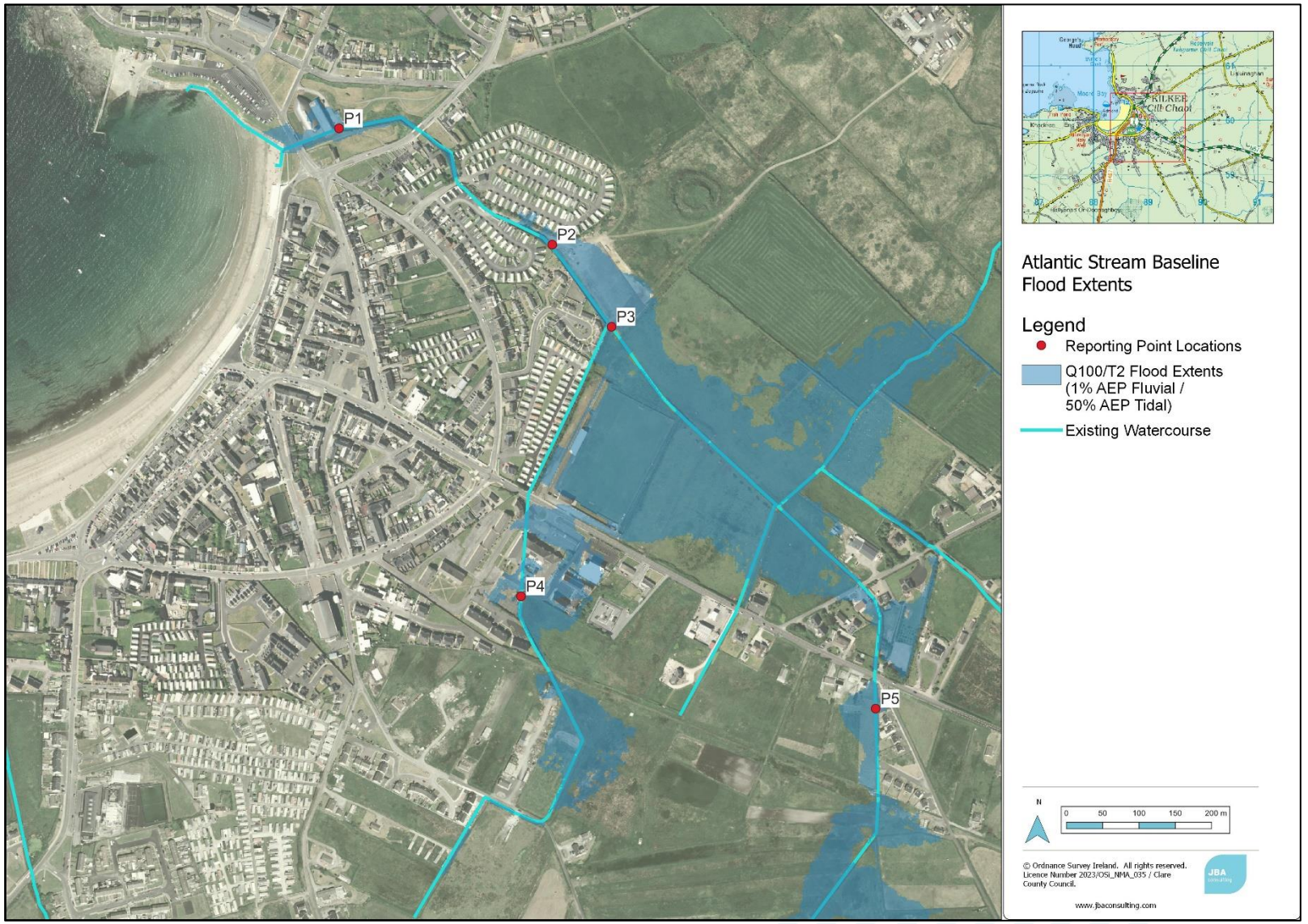

Figure 3-1: Atlantic Stream Baseline Flood Extents

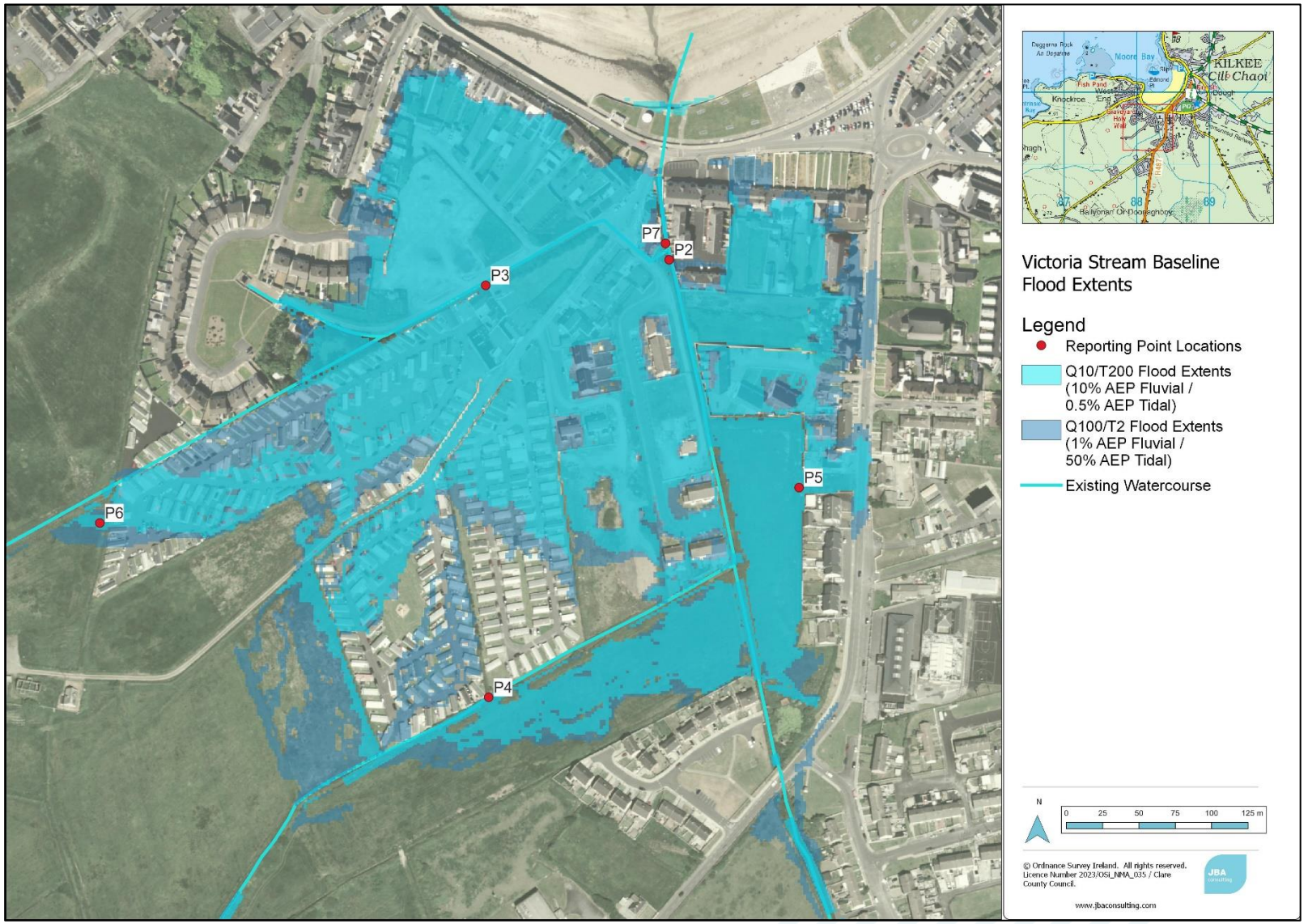

Figure 3-2: Victoria Stream Baseline Flood Extents

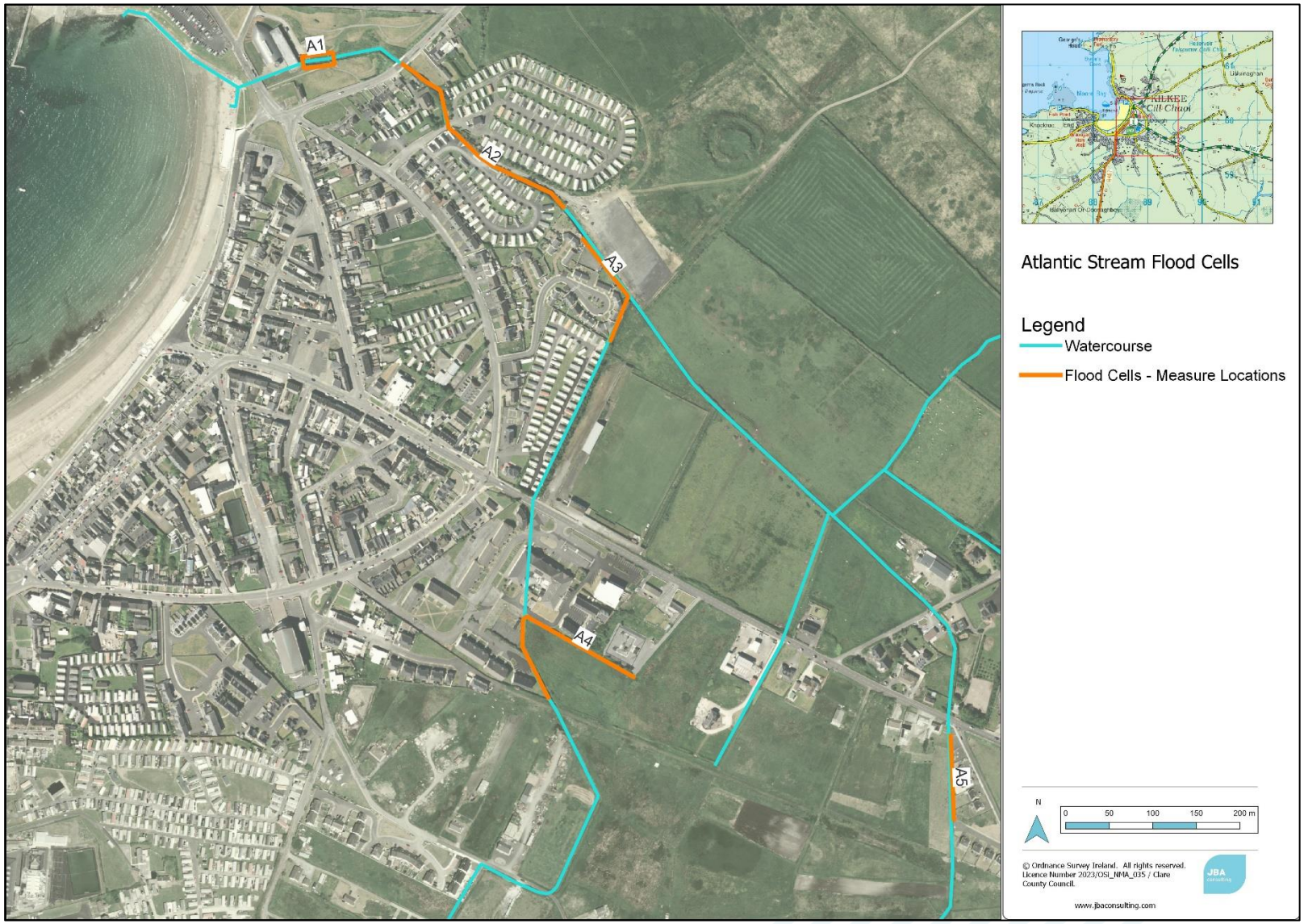

Figure 3-3: Atlantic Stream Flood Cells

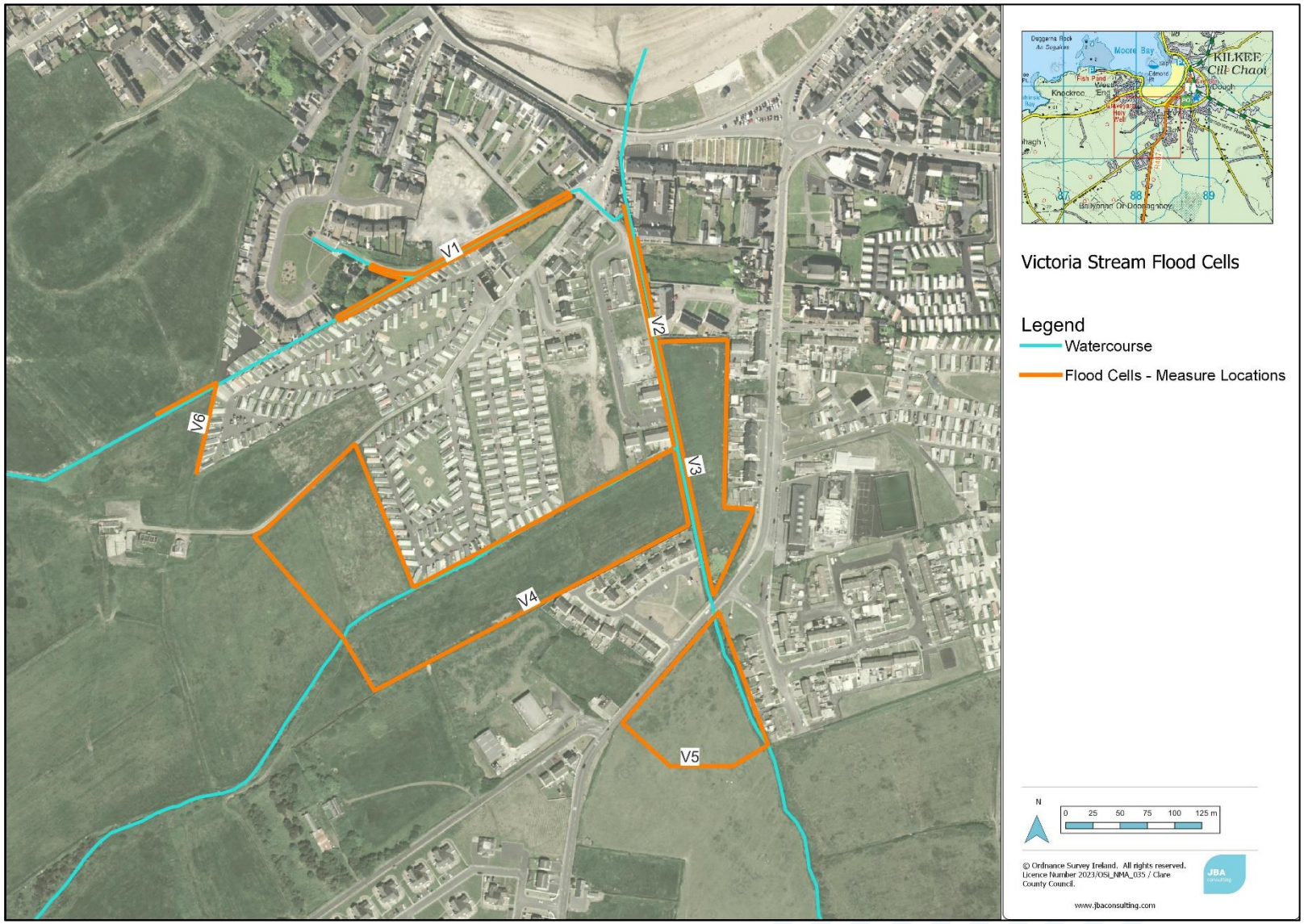

Figure 3-4: Victoria Stream Flood Cells

4 Initial Screening of Potentially Viable Measures

4.1 Initial Screening of Potentially Viable Measures

This section details all the flood risk management measures considered during the initial screening stage. These measures were assessed with regard to their viability in terms of the following criteria and are detailed in Table 4-1 below.

- Applicability to the area.
- Effectiveness.
- Economic (potential benefits, impacts, likely costs etc.).
- Environmental (potential impacts and benefits).
- Social (impacts on people, society and the likely acceptability of the measure).
- Cultural (potential benefits and impacts upon heritage sites and resources).

The constraints detailed in Section 2. Stakeholder Input and Constraints were also taken into account when screening the possible measures.

4.2 Screening of Alternative FRM Approaches and Spatial Scales of Benefits

A review of alternative Flood Risk Management (FRM) approaches has been undertaken to consider the different FRM methods that could potentially be viable and the spatial scales at which benefits could be realised. The spatial scale of benefits, alternative approaches, and examples of measures that could be relevant to Kilkee are listed in Table 4-1. Table 4-2 outlines how the alternative FRM approaches can typically contribute to hydraulic and flood risk management objectives.

The initial findings of the desktop screening of measures for Kilkee are presented in Table 4-3, with further explanation below the table.

Table 4-1. Examples of the alternative FRM approaches considered for Kilkee.

Spatial Scale of benefits	Spatial Scale for Kilkee FRS	FRM Alternative Approaches that apply to the spatial scale of benefits	Examples of the measures which could be appropriate for this study
Measures which would benefit multiple settlements flood cells, and in exceptional cases could also benefit the sub-catchment.	At risk settlements at downstream section of channels.	FRM Approach 1: Re-purpose of existing non-flood management infrastructure.	Existing pumping station.
		FRM Approach 2: Catchment scale and disperse actions to reduce flow downstream.	Storage or break/buffer between surface water network and fluvial channels. Distributed storage areas. Catchment Floodplain and Riparian Woodland.
		FRM Approach 3: Inline storage on main watercourses or tributaries to reduce flow downstream.	Single storage area. Cascading storage. Combinations of storage.
		FRM Approach 4: Diversion of flow around and away from risk areas.	Relief channel around specific assets, culverts. Longer length diversion channel.
Measures which could benefit a whole or part of a flood cell. Measure could reduce scale of other measures.	Kilkee Flood Cells.	FRM Approach 5: Improved conveyance of flow.	Culvert or bridge replacement or enhancement. Maintenance of river corridor. Removal of floodplain or channel constraints.
		FRM Approach 6: Refurbish or enhance defences to achieve standard of protection.	Extend existing defence lines. Raise existing defence crest

Spatial Scale of benefits	Spatial Scale for Kilkee FRS	FRM Alternative Approaches that apply to the spatial scale of benefits	Examples of the measures which could be appropriate for this study
			levels. Increase storage capacity.
Containment measures are specific to a hydraulic flood cell.	Kilkee Flood Cells.	FRM Approach 7: Containment of flood level.	Flood walls. Flood embankments.
		FRM Approach 8 Containment of flood levels with other options.	
Design level and freeboard may be similar for nearby hydraulic flood cells, but for containment measures alignment, height above ground and profile would be specific to the topography, settlement pattern and receptors on each riverbank.			
Measures which apply to all spatial scales.		FRM Approach 9: Flood resilience, preparedness, and emergency response.	Flood forecasting and warning. Emergency response plan.

Table 4-2. How each FRM approach contributes to hydraulic/FRM objectives

Alternative FRM Approaches	Potential FRM Approach to ACHIEVE Hydraulic and Flood Risk Outcomes						
	Reduces WL	Delays Peak Flow	Reduces duration of flooding	Improved conveyance of flow	Contains high WL	Reduces exposure and vulnerability	Potential for multi-functional benefits and integrated FRM
1: Re-purpose of existing non-flood management infrastructure	Yes	No	No	Yes	Yes	Contributes to	Yes
2:Catchment scale and disperse actions to reduce flow downstream	Yes	Yes	Yes	No	No	Contributes to	Yes
3. Inline storage on main watercourses or tributaries to reduce flow downstream	Yes	Yes	Yes	No	No	Contributes to	Yes
4. Diversion of flow around and away from risk areas	Yes	Yes	Yes	No	No	Contributes to	Yes
5. Improved conveyance of flow	No	No	No	Yes	No	Contributes to	Yes
6. Refurbish or enhance defences to achieve standard of protection	No	No	No	No	Yes	Contributes to	Yes
7. Containment of flood level	No	No	No	No	Yes	Contributes to	Yes
8.Containment of flood levels with other options	Yes	Yes	Yes	Yes	Yes	Contributes to	Yes
9. Flood resilience, preparedness, and emergency response	No	No	No	No	No	Yes	Yes

Table 4-3. Screening of alternative FRM approaches for Kilkee

Alternative FRM Approaches	Technical Performance of measure			Deliverability		Potential effect of measures			
	Approach has potential to achieve target design standard as a standalone measure	Approach has potential to achieve target design standard in combination with other measures	Approach offers benefits to other flood cells	Scale of costs	Complexity	Economic Activity	Social Criteria	Environmental and Biodiversity	Cultural Heritage
1: Re-purpose of existing non-flood management infrastructure	No	Yes	No	€€€	High				
2:Catchment scale and disperse actions to reduce flow downstream	No	Yes	Yes	€€€	High				
3. Inline storage on main watercourses or tributaries to reduce flow downstream	No	Yes	Yes	€€	Medium				
4. Diversion of flow around and away from risk areas	No	Yes	Yes	€€€	High				
5. Improved conveyance of flow	No	Yes	Yes	€€	High				
6. Refurbish or enhance defences to achieve standard of protection	No	Yes	No	€€€	High				
7. Containment of flood level	Yes	Yes	No	€	Medium				
8.Containment of flood levels with other options	Yes	Yes	Yes	€	Medium				
9. Flood resilience, preparedness, and emergency response	No	No	Yes	€	Medium				
Legend:									
? to ???: uncertain to very uncertain		× to ×××: slightly negative to very negative		✓ to ✓✓✓: slightly positive to very positive			€ to €€€: low cost to high cost in relation to scale of damages		

4.2.1 FRM Approach 1: Re-purpose of existing non-flood management infrastructure

An Uisce Eireann pumping station resides on the left-hand bank of the Victoria Stream. To re-purpose this pumping station as a fluvial defence measure would require a large-scale upgrade. This pumping station is not designed to cater for fluvial flood flows of the magnitude that the scheme is required to defend against. For context, the Victoria Stream at 1% AEP has a flow of 6.373 m3/s at the location of the pumping station. The existing pumping is not equipped to cater for this level of inundation. To re-purpose the pumping station as a fluvial measure would result in a disproportionate amount of a third-party asset's operations being used as flood defence infrastructure.

In addition to this, the existing pumping system caters for foul and pluvial storm flows. A high level of uncertainty on available capacity would exist during a flood event as the storage element is also used for Uisce Eireann foul pumping operations. To remove this uncertainty, it would be required to, in effect, construct a wholly independent pumping station as a fluvial defence measure. The cost of this would be disproportionate to the benefit provided.

The complexity of the interaction, the uncertainty around the capacity availability and the scale of alterations potentially required means that this is a not a viable solution as part of the present day scheme.

Measures associated with this approach should only be considered for future flood risk management and reviewed as a monitoring measure within the climate change adaptation plan.

4.2.2 FRM Approach 2: Catchment scale and disperse actions to reduce flow downstream

The steep topography of the upper catchments of both streams in Kilkee limits the potential of sufficient storage areas in these upper catchments. Therefore, the provision of storage in the lower reaches closer to the town would provide more benefits, this is discussed in FRM Approach 3. Storage and flow reduction in the form of leaky barriers or buffer zones in the upstream catchments would have the potential to produce some benefits if combined with other measures.

Catchment, floodplain and riparian woodland creation may also be a potential measure for Kilkee as much of the upstream catchments are greenfield. However, soil type in the upstream catchments is not favourable for woodland creation. Although this would have environmental benefits, it would be a complex option due to management of the woodlands in the future.

Measures associated with this approach are not viable for the Kilkee Flood Relief Scheme. In the future they may form part of a wider catchment scale restoration project.

4.2.3 FRM Approach 3: Inline storage on main watercourses or tributaries to reduce flow downstream

The provision of storage along the main Victoria Stream channel and its tributaries could provide benefits to the town of Kilkee by reducing the peak of the hydrograph and slowing the water release. Storage would be in the form of NWRM, for example, constructed wetlands, so would therefore benefit the environmental and tourism criteria.

Dispersed storage areas would not be a viable standalone option however should be taken for further analysis in conjunction with other measures.

4.2.4 FRM Approach 4: Diversion of flow around and away from risk areas

Due to the topography of the area, there is no opportunity to divert flow from the upstream catchments into the sea or other watercourses or for a complete flow diversion channel around Kilkee. The complexity and cost of a full diversion channel to cover the whole AFA would likely significantly outweigh the flood risk benefits. There is potential for a diversion channel to create a controlled link between Victoria Stream Western Tributary and the Well Stream. This cannot achieve the target standard of protection alone and so will be considered as a component to measures and options in the next stage of the process.

Measures associated with this approach are technically possible and should progress for further analysis as either standalone measures or smaller measures to optimise a combination of measures.

4.2.5 FRM Approach 5: Improved conveyance of flow

For Kilkee the following methods can be applied to increase the conveyance of the stream

- Removal of Pipe Crossings (Victoria Stream)
- Removal of structures (Atlantic and Victoria Streams)
- Widening of channel (Atlantic Stream)
- Widening of channel downstream of ESB Substation at Sandpark (Atlantic Stream)
- Dredging (Atlantic and Victoria Streams)

Increased conveyance through dredging and continued maintenance would only result in minor reductions in flood risk and is therefore not viable as a standalone measure. Enhanced maintenance could also have significant environmental impacts.

Removal of pipe crossings and structures does not sufficiently reduce water levels to achieve a sufficient level of protection. Widening of the channel on the Atlantic Stream may have adverse effects on social and tourism criteria due to loss of some Mobile Homes in the adjacent holiday home park. There would be a requirement to maintain the access road adjacent to the water course. If the Atlantic Stream was widened on its right—hand bank, this would require this access road to move towards the holiday home park, thus risking the necessity to remove some mobile homes.

Measures associated with this approach are technically possible and should progress for further analysis as either standalone measures or smaller measures to optimise a combination of measures.

4.2.6 FRM Approach 6: Refurbish or enhance defences to achieve standard of protection

There are currently no formal defences in Kilkee, however there are a number of informal defences including boundary walls and embankments. There is potential for refurbishment of these existing embankments and walls to turn them into formal defence to a design flood height.

4.2.7 FRM Approach 7: Containment of flood level

Containment through the erection of flood walls and embankments along the streams is potentially viable as a standalone measure. This would result in very high walls which would have adverse effects on environmental criteria so it would be recommended that Approach 8: Containment of flood levels with other options be considered for further analysis instead of Approach 7.

4.2.8 FRM Approach 8: Containment of flood level with other options.

Combining containment with other options for example increased conveyance, and/or storage results in much less effect on social, cultural and environmental criteria than containment on its own. This FRM approach should therefore progress for further analysis.

4.2.9 FRM Approach 9: Flood resilience, preparedness, and emergency response

Preparedness and resilience measures address the vulnerability and exposure to flood hazard. This is different to the other approaches which look to reduce flood hazard.

Individual Property Protection (IPP) would protect properties on an individual basis. This typically consists of demountable barriers, which are effective to approximately 0.6m flood depth. Above this depth, the water pressure on the walls of typical domestic properties may cause structural damage. IPP would also include measures to seal or otherwise secure windows and vents and may involve tanking buildings above and below ground to resist ingress of water.

It is important that a continuous and passive response to flood management is provided where possible. Because of the risks associated with the timely erection of the barrier, any measure involving IPP which places a high number of people or properties behind demountable defences has been screened out as being non-technically viable. In localised situations, and where alternatives are either non-viable or non-cost beneficial, the use of IPP has been considered.

Relocation of a property / infrastructure refers to abandoning the existing at-risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at-risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

Although it is always technically possible to relocate properties, there can be socially negative impacts so it should only be considered should no other method be found suitable.

4.3 Nature Based Solution Opportunities and Benefits

4.3.1 Opportunities

Natural Water Retention Methods (NWRM) were considered in the development of options. A NWRM review was completed and areas with NWRM potential were identified. These potential areas are shown in Figure 4-1: NWRM potential locations. These methods were assessed for their flood reduction potential and appraised as defence measures where potential benefit was evident.

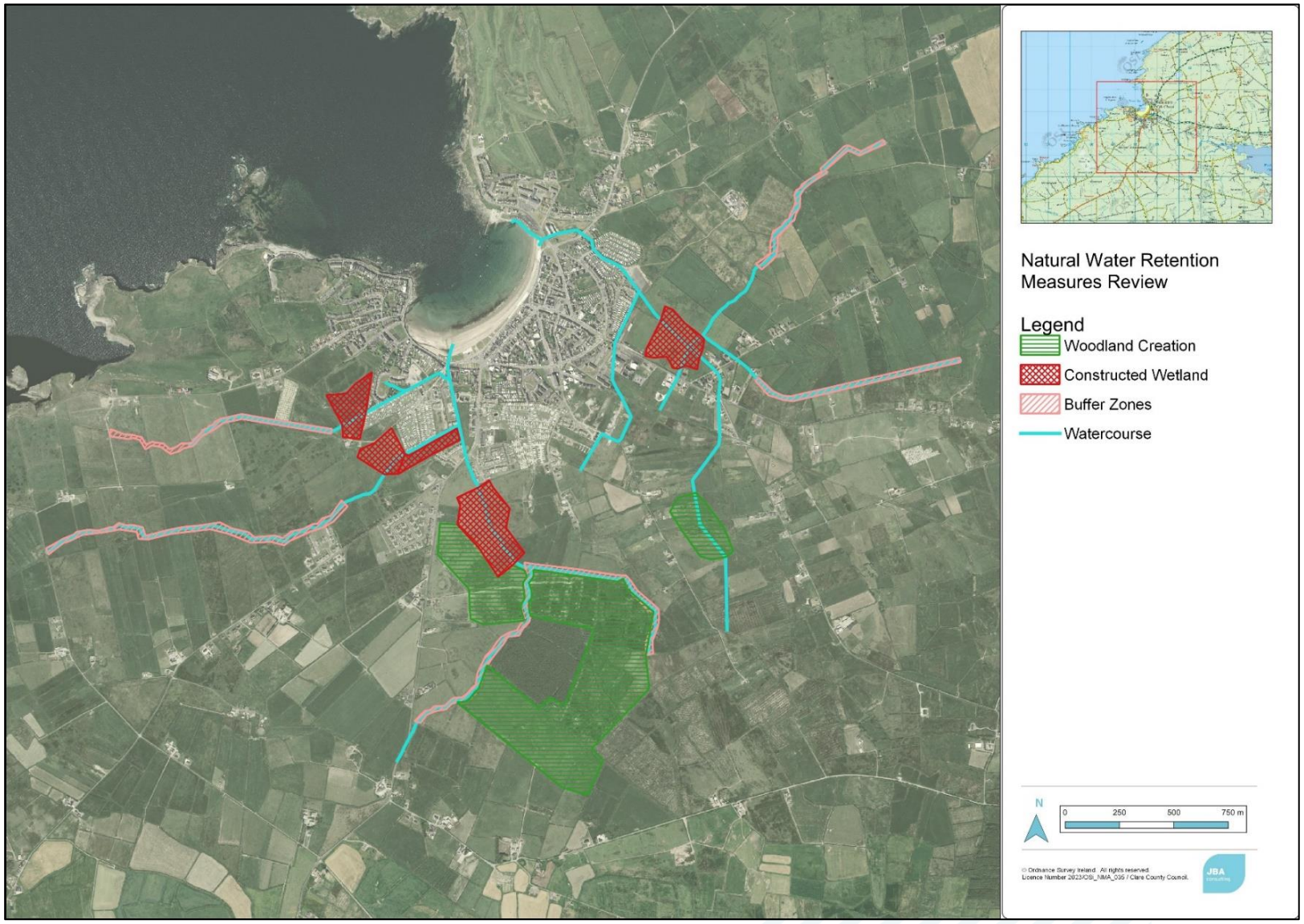

Figure 4-1: NWRM potential locations

4.3.2 Flood Risk Benefits

The effects of the various Nature Based Solutions (NBS) which are identified as potential opportunities above were tested in the model. Leaky dams, buffer zones and woodland creation were all tested through a reduction in peak flow, and the constructed wetlands were tested as storage areas in the model. It was determined that NBS on their own were not sufficient in reducing flood risk and therefore a combination of NBS and other measures would be necessary to reduce the flood risk in Kilkee.

4.3.3 Other Benefits

Natural Water Retention Measures (NWRM) have many environmental and ecological benefits. The NWRM which may be considered for this scheme, in particular integrated constructed wetlands (ICW) provide water quality improvement benefits. Water quality is of particular importance to Kilkee and the local people. This is because the Kilkee beach has a blue flag status and the quality of the water flowing into the bay from the streams can affect this and result in losses to the town, socially and economically. Therefore, measures which may provide an improvement to the current condition of the water quality will be given careful consideration.

NWRM can also have ecological benefits of habitat creation. As water quality is improved there is a potential for fishery habitat to increase. The creation of constructed wetlands can also increase, create, and enhance existing habitats.

5 Potentially Viable Measures

5.1 Further Assessment of Potentially Viable Measures

Further to the initial screening, the following flood risk management measures were identified as being potentially viable for Kilkee and have been taken forward for further technical assessment in the following section. Those measures which are viable are then considered on an area by area basis in section 6, taking into account any identified constraints. The potentially viable measures consist of:

- Do nothing
- Do minimum
- Structural Measures
  - Flood storage
  - Flood flow bypass channel
  - Increase channel conveyance
  - Walls and/ or embankments
- Natural Water Retention Measures
- Pumping

5.1.1 Do Nothing

The 'Do nothing' scenario is defined as the option involving no future expenditure on flood defences or maintenance of existing defences / channels. The implication is that the existing risk of flooding persists in the study area and possibly worsens over time due to openings and the condition of the existing walls and embankments reduces and climate change impacts are felt.

Doing noting when resilience measures to manage the response to flooding are possible is not acceptable. This is not a sustainable option so has not been considered.

5.1.2 Do Minimum

The baseline scenario measure consists predominantly of ongoing maintenance works. This is in order to maintain the existing standard of protection and would generally involve repairing and reinforcing existing walls and embankments now and as repairs are needed in the future.

It has been represented in the modelling as the current condition of walls and embankments, which have been modelled at their current height. This is not a sustainable option as the existing location and height of walls/embankments are not sufficient to reduce the risk of flooding. This option has therefore not been considered.

5.1.3 Structural Measures

5.1.3.1 Flood Storage

This measure involves the construction of walls and embankments along the streams to contain flood volumes and flows inside and outside the river channel and may take the form of embankments, reinforced concrete walls, culverts and dams.

The final choice of method would be determined following further review of the detailed site investigation and subsequent detailed design.

In general, it is considered that embankments will be more suited to the southern part of Kilkee, where there is sufficient space to accommodate them in the adjoining fields. Towards the north, there is limited opportunity to provide an earth embankment as there is less space due to the more densely built environment.

5.1.3.2 Flood Flow Bypass Channel

The combination of high flow rates and a confined stream cross section contributes to raised flood levels with resultant flooding within Kilkee.

Diversion of the channel from the Well Stream to the Western Tributary floodplain and from the Western Tributary and Well Stream to Victoria Stream would result in greater flood depths adjacent to the caravan park and therefore higher embankment levels and would require long length of culvert through serviced area and would have increased maintenance at the outfall. As this would provide some benefit to the scheme it will be considered in the options combined with other measures.

Whereas there are existing channels to the west of Kilkee Bay Hotel, at the outflow of the Atlantic Stream and Victoria Stream to Moore Bay, hydraulic modelling indicates that local diversion will provide only negligible reduction of flood levels for the southern and western part of Kilkee. A flow diversion at the back of Kilkee Bay Hotel is expected to reduce the amount of water affecting south western Kilkee in combination with storage and conveyance measures.

5.1.3.3 Increase channel conveyance

An increase in the conveyance of Atlantic Stream would mean the widening of channel at narrow points. Hydraulic modelling has shown that synergistically with other measures it would contribute to the flood levels upstream although it would require land acquisition from the adjoining caravan parks resulting in a potential loss of some caravans.

Along the Victoria Stream the increased conveyance through removal of pipe crossings would provide no benefit to key impacted areas and has therefore been scoped out of the optioneering process. However, this may be revisited once preferred option is chosen to reduce residual risk of blockage.

5.1.3.4 Walls and/ or embankments

Bunding at Kilkee Bay Hotel is expected to provide protection to the building. It is expected to increase flood extents in the agricultural land upstream on the tributary. Bunding at Sandpark Caravan Park is expected to contribute towards storage as well as reduction of flood risk to the caravan park. Walls along both streams are expected to prevent flooding by preventing overtopping, by increasing the conveyance capacity of the streams and the storage capacity upstream.

5.1.4 Natural Water Retention Measures

A range of NWRM could be considered to reduce the risk of flooding as well as enhance local habitats. Woodland creation and leaky dams could be considered upstream on both streams. Leaky barriers would result in a delay in peak flow along the upstream. Woodland creation would reduce the runoff from the upstream Victoria Stream Catchment. However, woodland creation is not an effective measure in the short term as its benefits are not borne out immediately due to the need for the woodland to establish. A woodland may be preferable, therefore, as a climate adaptation measure.

6 Development of Flood Relief Options with Environmental Assessment

The following options are a combination of the measures that were determined to be the most appropriate for Kilkee. The Options are grouped under each of the three corresponding areas of proposed interventions of the FRS.

The three areas are:

- Atlantic Stream, with three options (Option 1, 2 and 3)
- Atlantic Stream Outfall, with two options (Option 1 and 2) and
- Victoria Stream, with four options (Option, 1A, 1B, 2 and 3)

Each of these options has considered how the scheme may need to be altered in the future to allow for climate change and the defences will allow for this future adaption in terms of alignment and height. This is discussed further in Section 7.

The potential environmental impact associated with each option are also discussed in this section. To facilitate comparison, Table 6-1 shows the expected impacts and how they vary between the options.

The likely impacts were assessed in the following categories:

- Waterbodies
- Soils, Geology and Hydrogeology
- Construction
- Biodiversity
- Landscape and Visual Amenity

Following review of the Constraints Report, the options are not expected to have a significant negative effect nor differ significantly amongst the various options in impacts relating to:

- Human Beings
- Cultural Heritage
- Material Assets
- Air and Noise

At the end of the assessment of all options for each area, the following colour coded system has been used to visually represent the expected level of impact per option:

Legend	
High potential effect	
Moderate potential effect	
Slight/no potential effect	

It should be noted that the above classification was used for the comparative assessment of options only and does not reflect the eventual assessment of potential impacts of the proposed development as outlined in the Environmental Impact Assessment (EIA) Screening or other environmental assessments.

It is recognised that positive impacts can derive from the proposed measures to the assessed environmental sections. These have been factored in the assessment. All impacts and effects mentioned in this assessment are negative unless otherwise stated.

6.1 Atlantic Stream

The Atlantic Stream options have been developed by combining potential measures. As the main flood mechanism on the Atlantic is screen blockage, a redesign of the screen system has been included in all options.

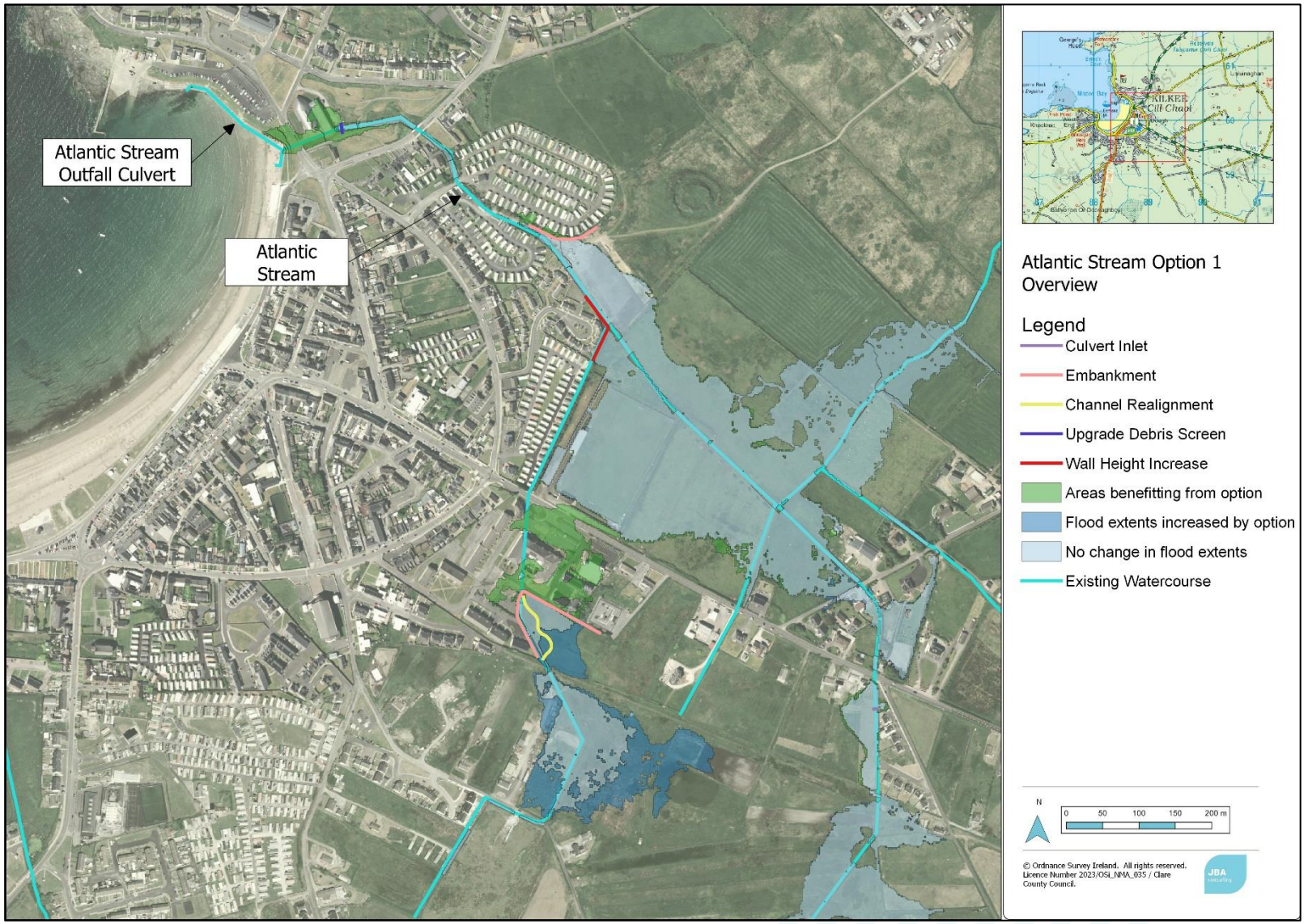

Figure 6-1: Atlantic Stream – Option 1 Overview

6.1.1 Option 1

6.1.1.1 Potential Measure(s)

Option 1 includes the following proposed defences. Text in *italics* indicates items which are common to each Option:

- Kilkee Bay Hotel:
  - *Construction of c. 200m long embankment c. 1.3-1.6m high.*
  - *Diversion of c. 110m of open channel into centre of floodplain.*
  - *Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert.*
- Dún an Óir estate:
  - Increase the height of the existing boundary wall by c. 300mm over c. 103m length.
- Sandpark mobile park:
  - Construction of c. 110m long embankment c. 700mm high.
- Waterworld:
  - *Installation of new debris screen at upstream culvert headwall.*
- Meadow View Court:
  - *Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert.*

6.1.1.2 Design Constraints

The measures proposed in Option 1 would provide sufficient flood protection for the Kilkee Bay Hotel, the Dún an Óir estate, the Sandpark mobile park and Waterworld.

The existing retaining wall at the Dún an Óir estate limits proposals in that location to one bank.

The stream is extensively culverted downstream from the Kilkee Bay Hotel to the Dún an Óir estate. This limits floodplain re-connection and measures in that section.

6.1.1.3 Ongoing maintenance, ownership, and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankment would be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended.

The debris screen proposed upstream of the culvert at Waterworld will have its own maintenance strategy, with both routine maintenance and pre and post-event inspections and clearance.

The raising of the wall behind the Dún an Óir estate does have access restrictions during the construction phase and will result in the removal and replacement of party fences and garden sheds. The raising of this wall will result in it being a flood asset, and thus will require regular inspections. Ownership of the boundary wall and access for maintenance will be agreed on an individual property owner basis.

6.1.1.4 Environmental Assessment

a. Waterbodies

During construction, temporary slight negative effects are possible on the water quality and hydromorphology of the Atlantic Stream, with indirect effects downstream as it discharges to Moore Bay. Improvement of a short length of flood wall (wall height increase using in-situ concrete), construction of embankments, construction of in-line manholes and the new pipe under the embankment have the potential to increase sedimentation and runoff entering the nearby waterways. Mitigation measures for managing the risk to water quality are feasible. Adherence to best practice guidance, pollution prevention and sediment management measures including the use of oil booms, spill kits, and silt fences, supervision by an Ecological Clerk of Works (ECoW), and safe concreting measures during wall construction. These will ensure that these temporary impacts are further reduced, however due to the use of concrete adjacent to the Atlantic stream the risk of pollution exists.

Operational stage impacts in this area are not expected to be significant.

b. Soils, Geology and Hydrogeology

During construction, slight negative effects are possible on the groundwater flows. Improvement of flood walls, construction of embankments, diversion of open channel and the new pipe under the embankment have the potential to alter the flow regimes and groundwater flows.

Operational stage impacts in this area are expected to be slight.

c. Landscape and Visual Amenity

Permanent imperceptible to slight negative effects on visual amenity are expected in this area due to increase in the height of the wall and construction of embankment south of the Kilkee Bay Hotel.

During construction, temporary slight negative effects will occur due to works affecting views from visual receptors. Machinery and excavations will be visible from the road and adjacent residencies. These effects will be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the erection of hoarding and restriction of working hours.

d. Biodiversity

The construction and excavation works could lead to slight negative effects due to disturbance, loss of habitat, and pollution or increased sedimentation.

Slight negative impacts on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, an imperceptible to slight negative impact could result from the upgrade of the debris screen upstream from Waterworld. This will be designed adhering to IFI guidance to reduce impacts to fish. Overall, the impact on biodiversity in this area will be of slight negative significance.

e. Construction

There is the potential for temporary slight negative effects for residents, pedestrians and road users through disturbance associated with construction works at the Dún an Óir estate, Meadow View Court and Sandpark mobile park. Measures to mitigate impact on access and

residential amenity will be outlined in the operating plans to be devised by the contractor, however the extent of safety work zones required means that partial or full road closures are likely to occur.

Once operational, access to Kilkee should return to the previous condition allowing for no residual negative impacts.

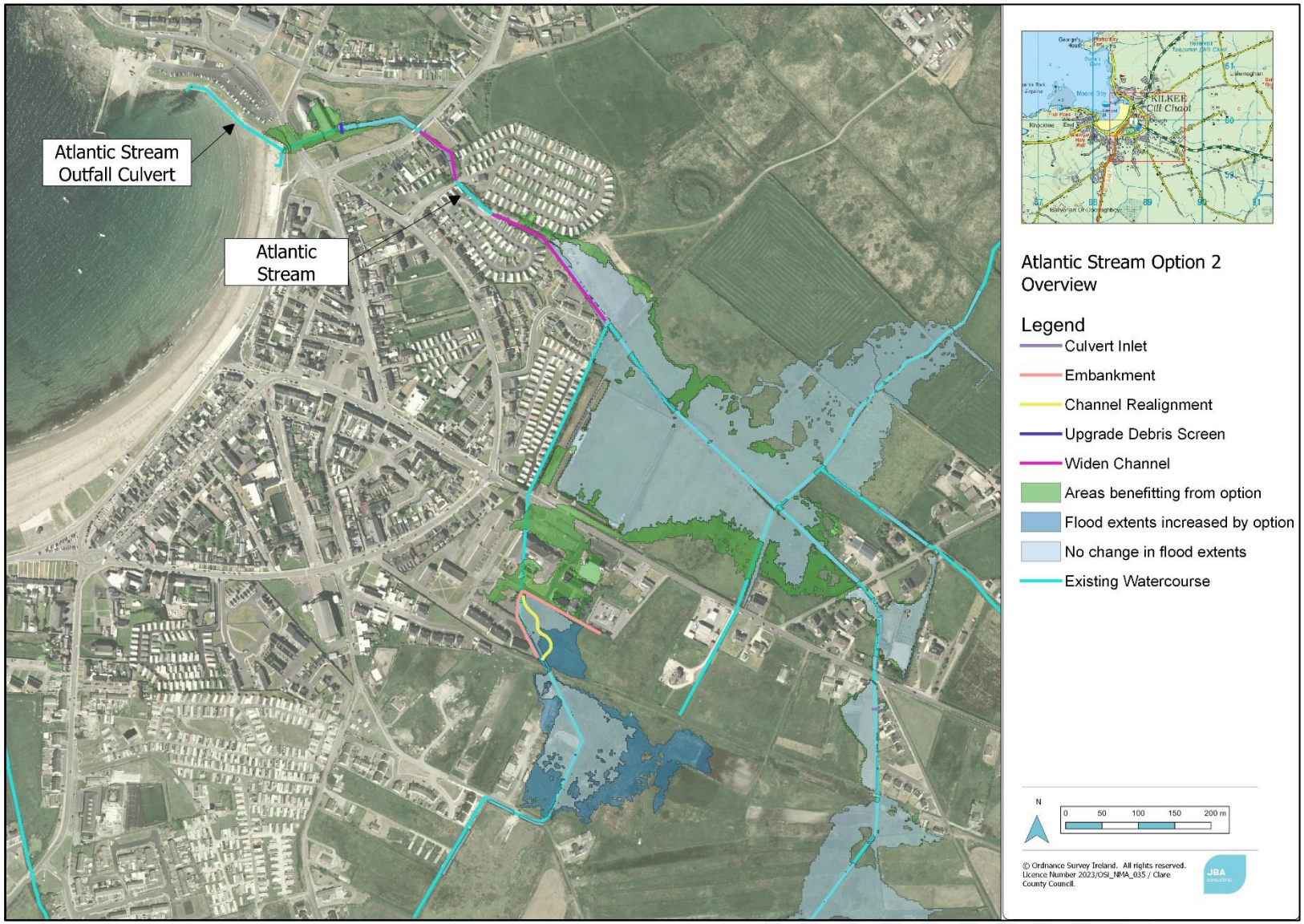

Figure 6-2: Atlantic Stream – Option 2 Overview

6.1.2 Option 2

6.1.2.1 Potential Measure(s)

Option 2 includes the following proposed defences. Text in *italics* indicates items which are common to each Option:

- Kilkee Bay Hotel:
  - *Construction of c. 200m long embankment c. 1.3-1.6m high.*
  - *Diversion of c. 110m of open channel into centre of floodplain.*
  - *Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert.*
- Sandpark mobile park:
  - Channel widening c. 200m upstream of Sandpark culvert and c. 85m downstream.
- Waterworld:
  - *Installation of new debris screen at upstream culvert headwall.*
- Meadow View Court:
  - *Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert.*

6.1.2.2 Design Constraints

The measures proposed in Option 2 would provide sufficient flood protection for the Kilkee Bay Hotel, Meadow View Court, the Dún an Óir estate, the Sandpark mobile park and Waterworld.

The stream is extensively culverted downstream from the Kilkee Bay Hotel to the Dún an Óir estate. This limits floodplain re-connection and measures in that section.

The widening of the channel immediately upstream of the N67 is restricted on the left-hand bank due to a private residence.

6.1.2.3 Ongoing maintenance, ownership, and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankment would be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended.

The debris screen proposed upstream of the culvert at Waterworld will have its own maintenance strategy, with both routine maintenance and pre- and post-event inspections and clearance.

6.1.2.4 Environmental Assessment

a. Waterbodies

During construction, temporary moderate negative effects are possible on the water quality and hydromorphology of the Atlantic Stream, with indirect effects downstream as it discharges to Moore Bay due to the increased excavation and instream works for stream widening. The widening of the channel, construction of in-line manholes, construction of embankments, and the new pipe under the embankment have the potential to increase sedimentation and runoff entering the Atlantic Stream. However, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during construction. These will ensure that these temporary impacts are further reduced.

Operational stage impacts in this area are not expected to be significant.

b. Soils, Geology and Hydrogeology

During construction, slight negative effects are possible on soils, geology, and hydrogeology. Construction of embankments, changes to the width of the channel, diversion of open channel and the new pipe under the embankment have the potential to alter the flow regimes and groundwater flows.

Operational stage impacts in this area are not expected to be significant.

c. Landscape and Visual Amenity

During construction, temporary slight negative effects will occur due to works affecting views over Moore Bay. Machinery and excavations will be visible from the road and adjacent residencies. These effects will be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the erection of hoarding and restriction of working hours.

Permanent slight negative effects on visual amenity are expected in this area due to increase in the width of the channel and construction of embankment south of the Kilkee Bay Hotel.

d. Biodiversity

The construction and excavation works could lead to moderate negative effects due to disturbance, loss of habitat, and pollution or increased sedimentation.

Moderate negative impacts on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, a positive impact could result from the increase in the riparian habitat. An imperceptible negative impact could be the result of the upgrade of the debris screen upstream from Waterworld This will be designed adhering to IFI guidance to reduce impacts to fish. Overall, the impact on biodiversity in this area will be of moderate negative significance.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works at the Sandpark mobile park. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor, however the extent of safe work zones required means that partial or full road closures are likely to occur.

Once operational, access to Kilkee will return to the previous condition allowing for no residual negative impacts.

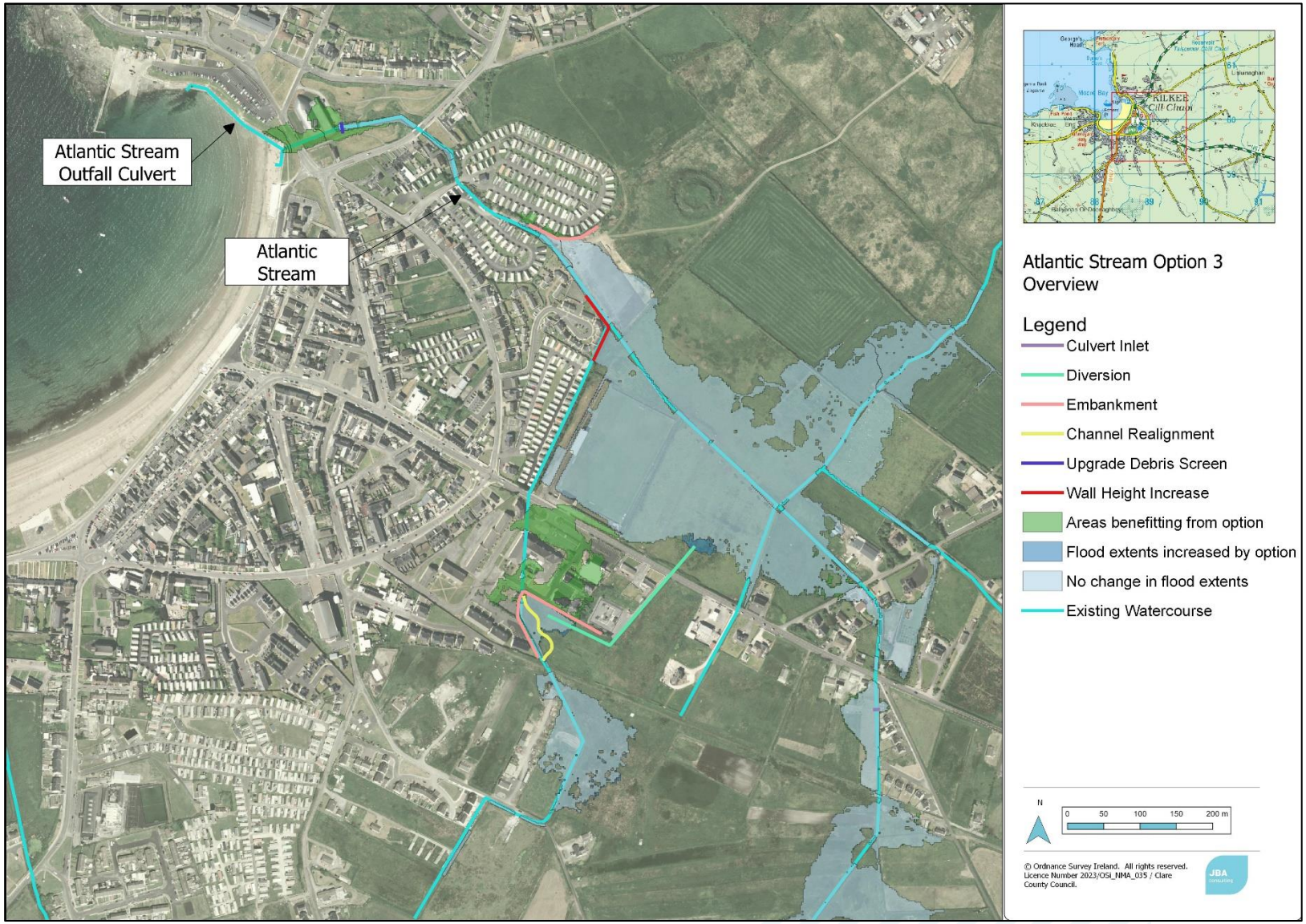

Figure 6-3: Atlantic Stream – Option 3 Overview

6.1.3 Option 3

6.1.3.1 Potential Measure(s)

Option 3 includes the following proposed defences. Text in *italics* indicates items which are common to each Option:

- Kilkee Bay Hotel:
  - *Construction of c. 200m long embankment c. 1.3-1.6m high.*
  - *Diversion of c. 110m of open channel into centre of floodplain.*
  - *Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert.*
  - Construction of RC box culvert (c. 1.8m wide x 900mm high) c. 270m long under N67 road.
- Dún an Óir estate:
  - Increase the height of the existing boundary wall by c. 300mm over c. 103m length.
- Sandpark mobile park:
  - Construction of c. 110m long embankment c. 700mm high.
- Waterworld:
  - *Installation of new debris screen at upstream culvert headwall.*
- Meadow View Court:
  - *Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert.*

6.1.3.2 Design Constraints

The measures proposed in Option 3 would provide sufficient flood protection for the Kilkee Bay Hotel, Meadow View Court, the Dún an Óir estate, the Sandpark mobile park and Waterworld.

The proposed option includes a new culvert from the storage area upstream of Kilkee Bay Hotel. Topographically, the levels result in a significantly deep culvert, removing the ability to create a viable open stream.

6.1.3.3 Ongoing maintenance, ownership, and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankment would be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended.

The debris screen proposed upstream of the culvert at Waterworld will have its own maintenance strategy, with both routine maintenance and pre and post-event inspections and clearance.

The raising of the wall behind the Dún an Óir estate does have access restrictions during the construction phase and will result in the removal and replacement of party fences and garden sheds. The raising of this wall will result in it being a flood asset, and thus will require regular inspections. Ownership of the boundary wall and access for maintenance will be agreed on an individual property owner basis.

The new culvert would require debris protection at its inlet, which would in-turn require a regular maintenance regime. The culvert would also have a way-leave over its footprint within the lands it is proposed in.

6.1.3.4 Environmental Assessment

a. Waterbodies

During construction, temporary slight negative effects are possible on the quantity and quality of the water flowing into the stream and discharged to Moore Bay. Improvement of flood walls (wall height increase using in-situ concrete), construction of in-line manholes, construction of embankments, and the construction of the 270m long culvert have the potential to increase sedimentation and runoff entering the nearby waterways. Mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during wall construction. These will ensure that these temporary impacts are further reduced however due to the use of concrete adjacent to the Atlantic stream the risk of pollution exists.

Operational stage impacts in this area are not expected to be significant.

b. Soils, Geology and Hydrogeology

During construction, slight negative effects are possible on soils, geology, and hydrogeology. Improvement of flood walls, construction of embankments, diversion of open channel and the new pipe under the embankment have the potential to alter the flow regimes and groundwater flows.

Operational stage impacts in this area are expected to be slight.

c. Landscape and Visual Amenity

Permanent imperceptible to slight negative effects on visual amenity are expected in this area due to increase in the height of the wall and construction of embankment south of the Kilkee Bay Hotel.

During construction, temporary slight negative effects will occur due to works affecting views over Moore Bay. Machinery and excavations will be visible from the road and adjacent residencies. These effects will be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the erection of hoarding and restriction of working hours.

d. Biodiversity

The construction and excavation works could lead to slight negative effects due to disturbance, loss of habitat, and pollution or increased sedimentation.

Slight negative impacts on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, an imperceptible to slight negative impact could result from the upgrade of the debris screen upstream from Waterworld. This will be designed adhering to Inland Fisheries Ireland (IFI) guidance to reduce impacts to fish. Overall, the impact on biodiversity in this area will be of slight negative significance.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works at Meadow View Court, the Dún an Óir estate and Sandpark mobile park. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor,

however the extent of safe work zones required means that partial or full road closures are likely to occur.

Once operational, access to Kilkee should return to the previous condition allowing for no residual negative impacts.

6.1.4 Summary of Environmental Assessment of Options

The three options have been discussed and their likely environmental impacts assessed in the sections above. The proposed new debris screen at the upstream culvert wall east of Waterworld is identical across all three options. This will therefore have the same impact in each option and will be discussed briefly here before the other measures are discussed in greater detail.

The proposed screen will require some vegetation clearance, excavation, and limited ground regrading. This is expected to have a localised negative impact on the established habitats and potentially impact the connectivity between Moore Bay and the Atlantic Stream where there is potential for presence of protected species, e.g., Otter. Mitigation measures for the protection of biodiversity during construction are possible. The potential impact here is common for all three options.

Similarly, the works at Meadow View Court are common to all options. The construction of the in-line manholes poses a minor risk to water quality downstream during the construction phase. The areas of work on Meadow View Court involve working on existing informal inlets, therefore the scale of intervention is very small. This risk is common to all options.

At Kilkee Bay Hotel all three options propose the construction of the embankment which is expected to have a temporary slight negative impact on the existing grassland habitat for each option. All options will require limited excavations for the installation of the pipe under the embankment to link to the existing culvert. Option 3 requires the construction of a 270m long culvert. Option 3 has a slightly greater risk of releasing pollutants and sediment to the Atlantic Stream than Options 1 or 2 in this area, due to the greater level of construction required.

The increase in the height of the existing wall by Dún an Óir estate is common to Options 1 and 3 only and is expected to impact the use of the road network and local views slightly.

Option 2 and 3 have the highest expected environmental impact. The proposed excavations for the widening of the existing stream under Option 2 pose a higher risk to biodiversity, water quality, and hydromorphology compared to the other options.

Option 1 is therefore the preferred option with regard to environmental issues.

Table 6-1: Comparative Environmental Assessment of Atlantic Stream Options

	Atlantic Stream		
Option	**1**	**2**	**3**
Waterbodies			
Biodiversity			
Soils and Geology			
Landscape and Visual Amenity			
Construction			
Comments	Use of insitu concrete to increase height of flood walls poses risk to water quality and aquatic species. No channel widening nor extensive culverting therefore less excavation. This would reduce the risk on waterbodies.	Widening of channel poses greater risk to water quality and aquatic species. Greater extents of habitat loss. Potential of higher impacts to visual amenity from removal of vegetation. Higher volume of earth removal.	Higher volume of earth removal due to culvert at Kilkee Bay Hotel and extent of excavations than Option 1. Less potential for impacts to waterbodies and biodiversity due to reduced instream and bank-side works.

6.2 Summary of Measures and Potential Flood Relief Options

Following the screening stage, a number of potentially viable measures have been identified to protect against flooding in the baseline design event. This section further develops the potentially viable measures into options. Multi Criteria Analysis (MCA) for each option will be carried out to aid in the selection of the preferred option. Table 6-2 provides a summary of potential options.

Table 6-2: Summary of Options

Option	Potential Measures
Option 1	Kilkee Bay Hotel: • Construction of c. 200m long embankment c. 1.3-1.6m high. • Diversion of c. 110m of open channel into centre of floodplain. • Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert. Dún an Óir estate: • Increase the height of the existing boundary wall by c. 300mm over c. 103m length. Sandpark mobile park: • Construction of c. 110m long embankment c. 700mm high. Waterworld: • Installation of new debris screen at upstream culvert headwall. Meadow View Court: • Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert. •
Option 2	Kilkee Bay Hotel: • Construction of c. 200m long embankment c. 1.3-1.6m high. • Diversion of c. 110m of open channel into centre of floodplain. • Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert. Sandpark mobile park: • Channel widening c. 200m upstream of Sandpark culvert and c. 85m downstream. Waterworld: • Installation of new debris screen at upstream culvert headwall. Meadow View Court: • Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert. •
Option 3	Kilkee Bay Hotel: • Construction of c. 200m long embankment c. 1.3-1.6m high. • Diversion of c. 110m of open channel into centre of floodplain.

	• Installation of new headwall and 600mmØ inlet culvert under embankment to link with existing culvert. • Construction of RC box culvert (c. 1.8m wide x 900mm high) c. 270m long under N67 road. Dún an Óir estate: • Increase the height of the existing boundary wall by c. 300mm over c. 103m length. Sandpark mobile park: • Construction of c. 110m long embankment c. 700mm high. Waterworld: Installation of new debris screen at upstream culvert headwall. Meadow View Court: • Construction of 2 no. 2100mm dia. inlet manholes with grated covers on existing 1200mm dia. culvert. •

6.3 Atlantic Stream Outfall

The outfall culvert system at the downstream of the Atlantic Stream was shown to be undersized from a hydraulic review. Two options are presented to prevent the under-capacity system from causing flooding upstream of the culvert.

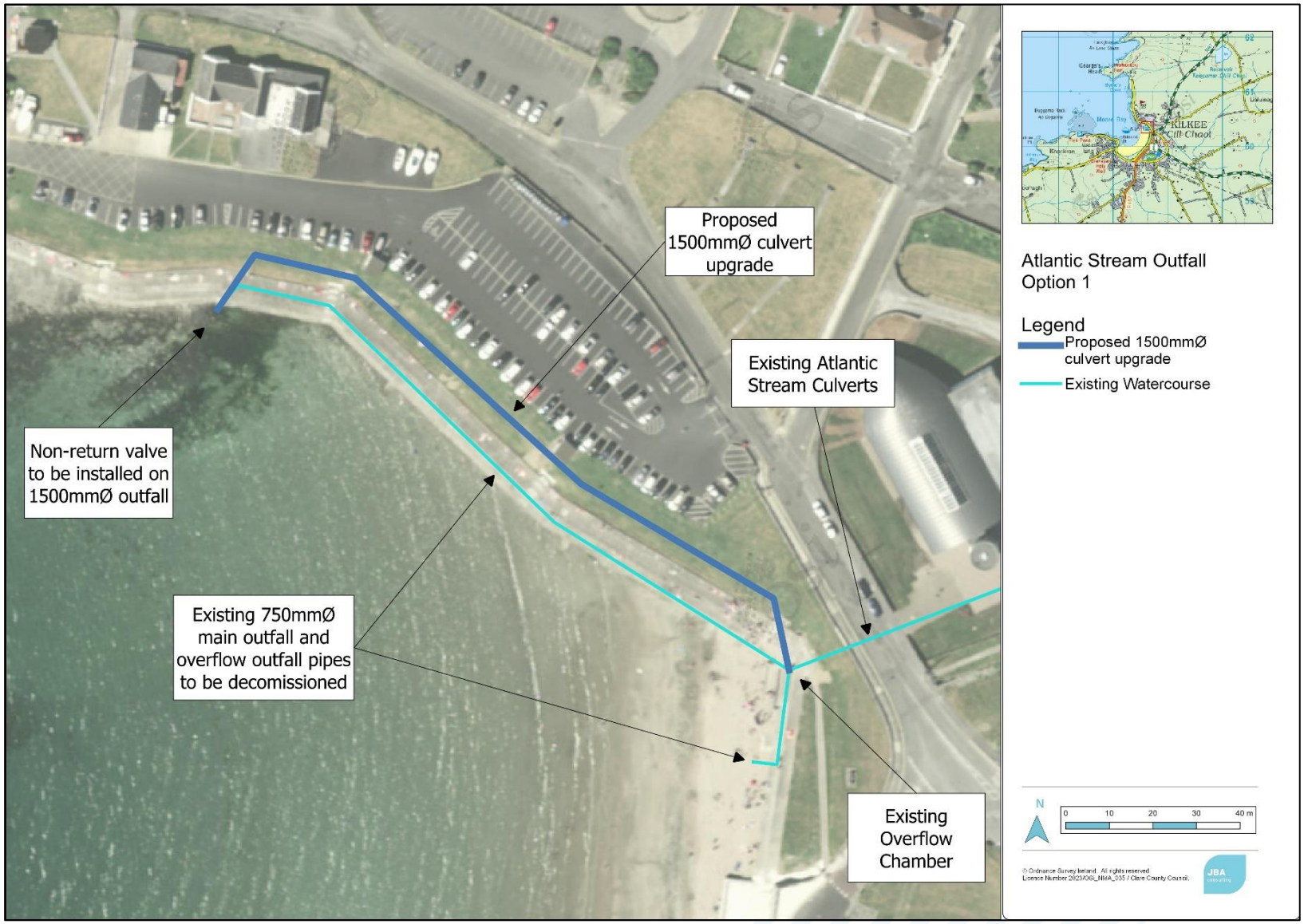

Figure 6-4: Atlantic Stream Outfall– Option 1 Overview

6.3.1 Option 1

6.3.1.1 Potential Measure(s)

- Upgrade main outfall culvert to 1500mmØ and associated manholes.
- Decommission existing 750mmØ main outfall and overflow outfall culverts.
- Install non-return valve to upgraded 1500mmØ outfall culvert.

This option consists of an upgrade of the existing outfall culvert as shown in Figure 6-4, from the existing manhole chamber to the bay at the existing outfall location. The upgraded culvert has increased capacity and will therefore minimise any impact upstream.

6.3.1.2 Design Constraints

Any proposed alignment of a new outfall culvert is restricted by the footprint of the existing quay wall and associated amenities present. Levels are dictated by the upstream incoming levels.

6.3.1.3 Ongoing maintenance, ownership and responsibilities

The new outfall and new network would be incorporated into the Kilkee stormwater network maintenance regime.

6.3.1.4 Environmental Assessment

a. Waterbodies

During construction, temporary moderate negative effects are possible on the quality of the waters in Moore Bay. The excavations along the seafront have the potential to increase sedimentation and pollutants entering the stream and Moore Bay which is immediately adjacent. However, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during construction. These will ensure that temporary impacts to water quality are further reduced.

Operational stage impacts in this area are expected to be neutral.

b. Soils, Geology and Hydrogeology

During construction, slight negative effects are possible on hydrogeology. The northern corner of Kilkee is lying on an increased sensitivity aquifer however the excavations for the proposed culvert will not be deep and will be on ground elevated above the shore line.

Operational stage impacts in this area are expected to be low to neutral.

c. Landscape and Visual Amenity

Temporary slight impacts on visual amenity are expected in this area due to the expected construction activity affecting the mid- and long-range views over Kilkee. These effects will be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the restriction of working hours.

The operational impact is expected to be permanent slight negative to neutral.

d. Biodiversity

The construction and excavation works could lead to moderate negative effects on fish and aquatic species and overwintering birds during works adjacent to Moore Bay (designated as Kilkee Reefs SAC) due to the potential for accidental release of pollutants or increases in sedimentation. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls,

pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, no negative impacts are expected.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works on/near the promenade. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor, however the extent of safe work zones required means that partial or full road, car parking and sections of the seafront closures are likely to occur.

Once operational, these will return to the previous condition allowing for no residual negative impacts.

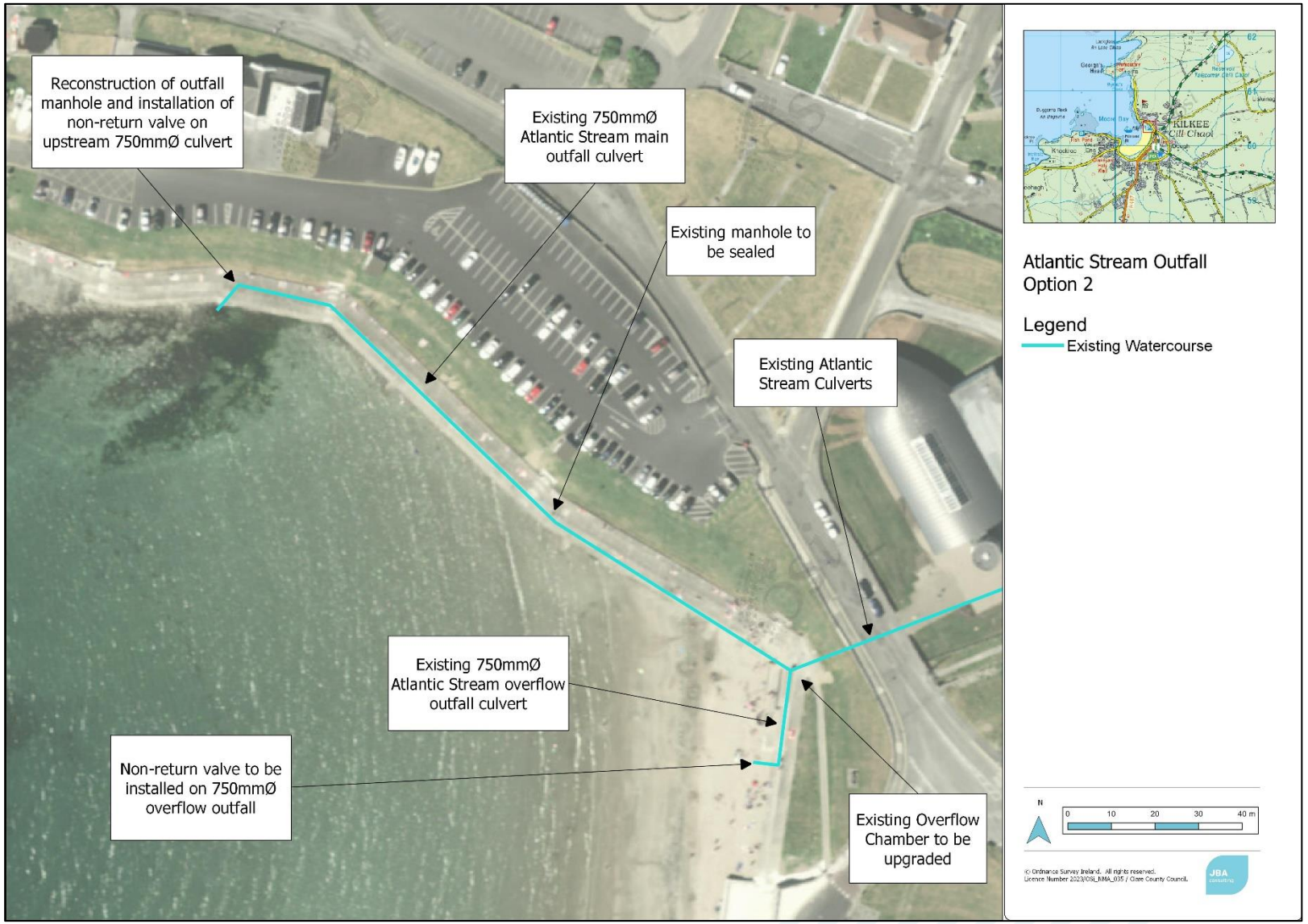

Figure 6-5: Atlantic Stream Outfall– Option 2 Overview

6.3.2 Option 2

6.3.2.1 Potential Measure(s)

- Upgrade existing overflow chamber with raised cover (c. 2.7m long x 2m wide x 400mm high) with flap valves.
- Reconstruction of outfall manhole and installation of non-return valve on upstream 750mmØ culvert.
- Install non-return valve to existing 750mmØ overflow outfall culvert.
- Seal existing cover of manhole downstream of overflow chamber on main outfall culvert at existing ground level. (c. 2m long x 0.8m wide x 400mm high RC slab and new sealed lid).

Option 2 consists of a reconstruction of the overflow manhole with a new pressure-releasing chamber cover to allow surcharged flows to be dissipated in a controlled fashion and allow flood waters to run down the promenade terracing and onto the beach. Non-return valves are proposed to the existing main outfall and overflow outfall culverts. The manhole on the main outfall culvert alignment downstream of the upgraded overflow manhole is to be sealed at its existing ground level. This option is shown in Figure 6-5.

6.3.2.2 Design Constraints

The proposed outfall is on the promenade, so any design here needs to consider the visual impact that that might pose.

6.3.2.3 Ongoing maintenance, ownership and responsibilities

The new outfall would be incorporated into the Kilkee stormwater network maintenance regime. Regular maintenance of the flap valves is important as the design is critical to their operation. As they are located within the public realm, they have a risk of being damaged or having debris blocking them.

6.3.2.4 Environmental Assessment

a. Waterbodies

During construction, temporary slight negative effects are possible on the quality of the waters in Moore Bay. The excavations along the seafront have the potential to increase sedimentation and pollutants entering the adjacent waterbody. This risk is lower than Option 1 due to the smaller works area. Also, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during construction. These will ensure that these temporary impacts are further reduced.

Operational stage impacts in this area are expected to be neutral.

b. Soils, Geology and Hydrogeology

During construction, slight negative effects are possible on hydrogeology. The northern corner of Kilkee is lying on an increased sensitivity aquifer and therefore it is expected that operations in this area pose a higher risk to more severely impacting groundwater flows.

Operational stage impacts in this area are expected to be low to neutral.

c. Landscape and Visual Amenity

Temporary slight impacts on visual amenity are expected in this area due to the expected construction activity affecting the mid- and long-range views over Kilkee. These effects will

be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the restriction of working hours.

The operational impact is expected to be permanent slight negative to neutral.

d. Biodiversity

The construction and excavation works could lead to slight negative effects due to disturbance and pollution or increased sedimentation.

Slight negative impacts on fish and aquatic species and overwintering birds are possible during works adjacent to Moore Bay (designated as Kilkee Reefs SAC) due to localised disturbance and potential for accidental release of pollutants or increases in sedimentation. These are impacts that can be partly mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, no negative impacts are expected.

e. Construction

There is the potential for temporary slight negative effects for residents, pedestrians and road users through disturbance associated with construction works on/near the promenade. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor, however the extent of safe work zones required means that partial road, car parking and sections of the seafront closures are likely to occur.

Once operational, these should return to the previous condition allowing for no residual negative impacts.

6.3.3 Summary of Environmental Assessment of Options

The construction works of the proposed culvert of Option 1 are expected to require excavation works extending approximately 180m along the northern corner of the sea-front promenade. Compared to the scale of works proposed for Option 2, Option 1 is expected to have much higher probability to mobilise pollutants, disrupt views and the use of the area. Option 2 is therefore the preferred option with regard to environment for the Atlantic Stream Outfall.

Table 6-3: Comparative Environmental Assessment of Atlantic Stream Outfall Options

	Atlantic Stream Outfall	
Option	**1**	**2**
Waterbodies		
Biodiversity		
Soils and Geology		
Landscape and Visual Amenity		
Construction		
Comments	Due to the extent of excavations along the seafront promenade, higher impacts are expected on adjacent shoreline and aquatic species. This is the least preferred Option.	Option 2 has reduced risks due to the limited area being altered, that is around the existing chamber and culvert system. This is the preferred Option over Option 1.

6.4 Summary of Measures and Potential Flood Relief Options

Following the screening stage, two potentially viable measures have been identified to protect against flooding in the baseline design event. This section further develops the potentially viable measures into options. Multi Criteria Analysis (MCA) for each option will be carried out to aid in the selection of the preferred option. Table 6-4 provides a summary of potential options.

Table 6-4: Summary of Options

Option	Potential Measures
Option 1	• Upgrade main outfall culvert to 1500mmØ and associated manholes. • Decommission existing 750mmØ main outfall and overflow outfall culverts. • Install non-return valve to upgraded 1500mmØ outfall culvert.
Option 2	• Upgrade existing overflow chamber with raised cover (c. 2.7m long x 2m wide x 400mm high) with flap valves. • Reconstruction of outfall manhole and installation of non-return valve on upstream 750mmØ culvert. • Install non-return valve to existing 750mmØ overflow outfall culvert. • Seal existing cover of manhole downstream of overflow chamber on main outfall culvert at existing ground level. (c. 2m long x 0.8m wide x 400mm high RC slab and new sealed lid).

6.5 Victoria Stream

The Victoria Stream options have been developed by combining potential measures. All options have been designed to deal with fluvial and pluvial flooding. The pluvial scheme is common for all options and includes the following:

- *Installation of pump station, sub-surface storage and rising main at Clare Co. Co. compound at Well Road.*
- *Installation of pump station, sub-surface storage and rising main in field north of Victoria Crescent to cater for Carrigaholt Road drainage systems.*
- *Construction of c. 375-450mmØ carrier sewers and associated manholes under Well Road and Victoria Park for interception / overflow of existing surface water network outfalls and direct them to a single outfall at the Well Stream RC u-channel (with non-return valve fitted) / pump station at Clare Co. Co. compound.*
- *Construction of c. 200m of 225mmØ carrier drain and associated manholes to cater for overflows from Carrigaholt Road drainage systems to link with pump station north of Victoria Crescent.*
- *Upgrade of Carrigaholt Road surface water drainage network – construction of c. 115m of 300mmØ sewer, new manhole, headwall, gullies and non-return valve fitted to outfall.*

Option 2 includes additional measures:

- Carrier drains, associated manholes, non-return valve fitted to existing outfall pipe, pump station, rising main and underground storage to cater for Marion Estate surface water drainage network.

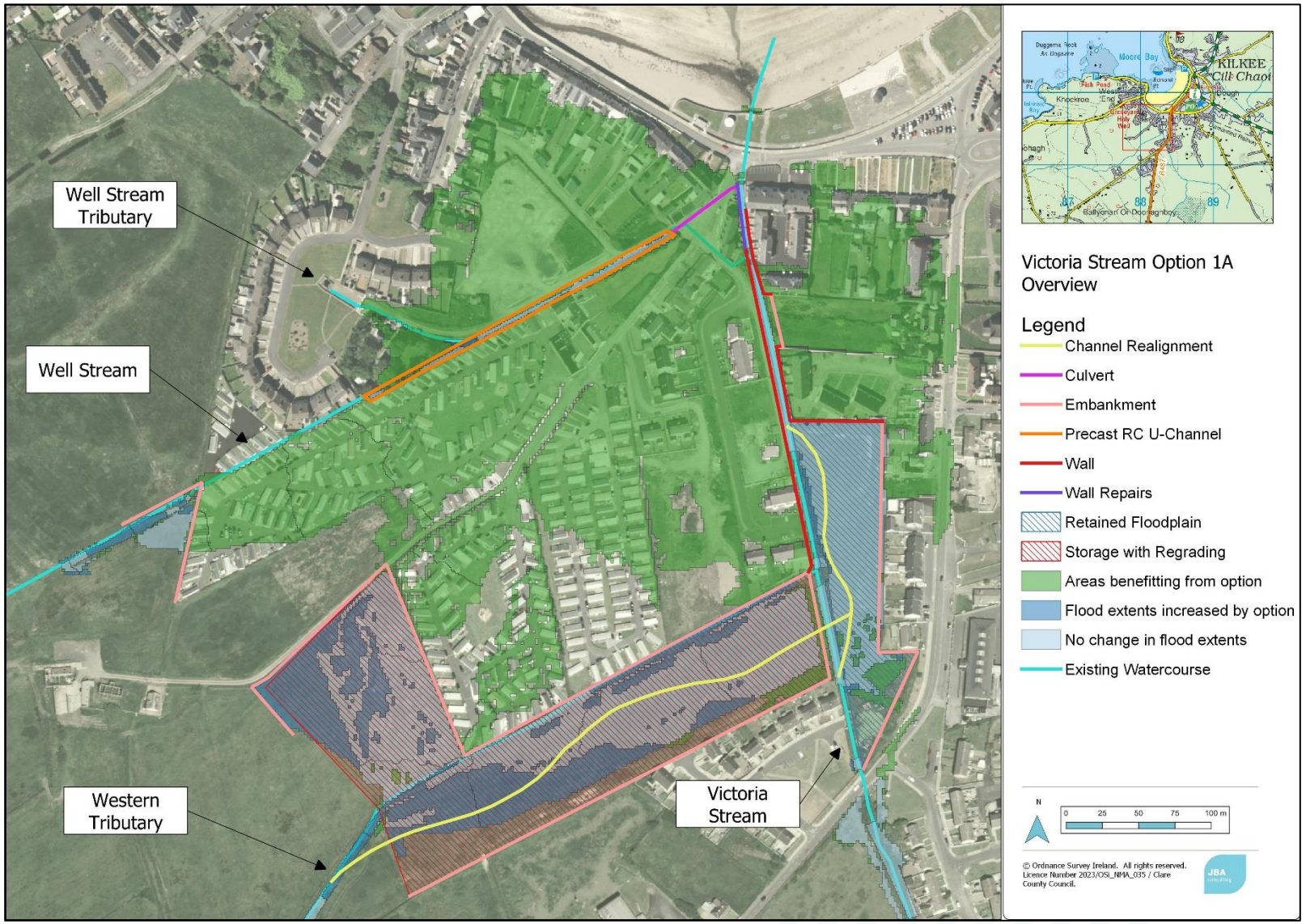

Figure 6-6: Victoria Stream – Option 1A Overview

6.5.1 Option 1A

6.5.1.1 Potential Measure(s)

Option 1A includes the following proposed fluvial flood defences. Text in *italics* indicates items which are common to each Option:

- Well Stream:
  - *Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream.*
  - Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level.
  - *Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events.*
  - *Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place.*
  - *Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high).*
- Victoria Court:
  - *Reconstruction of Victoria Court boundary wall.*
- Victoria Stream:
  - *Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place.*
  - *Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level.*
  - *Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level.*
  - *Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in.*
  - *Reconstruction of Victoria Crescent boundary wall c. 130m long.*
  - *Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent.*
- Western Tributary:
  - *Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain.*
  - *Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel.*
  - *Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max.*
  - Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section.

- *Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.*

6.5.1.2 Design Constraints

Both the Victoria Stream and the Well Stream traverse adjacent and between urban developments. The Well Stream has a perimeter wall to Cunningham's Holiday Park along much of its lower reach. This restricted proposals for flood plain re-connection and the allowance of out of bank flows. Similarly, the Victoria Stream in its lower reaches is bound by property boundary walls.

6.5.1.3 Ongoing maintenance, ownership and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankments will be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended. Maintenance paths will be included adjacent to all embankments for ease of access.

The outlet of the Victoria Stream is critical to the performance of the entire system, and has had noted debris blockage issues, including debris carried by high tides.

6.5.1.4 Environmental Assessment

a. Waterbodies

During construction, temporary moderate negative effects are likely on hydrology and hydromorphology on the streams and downstream in Moore Bay. The regrading of the field that the Western Tributary flows through and the construction of the U-shaped precast channel at the Well Stream will increase the risk of sedimentation, pollutants and runoff entering the waterways. However, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during wall construction. These will ensure that these temporary impacts are moderate.

Operational stage impacts on the Well Stream are likely to be slight negative, due to changes to the stream hydromorphology and temporary disruption of the bed materials. Positive impacts to hydrology and hydromorphology are likely on the Western Tributary and the Victoria Stream due to the channel realignment and flood storage area allowing the river to be connected to its floodplain.

The overall impact on waterbodies is moderate.

b. Soils, Geology and Hydrogeology

During construction, moderate negative effects are likely on soils, geology, and hydrogeology mainly because of the extensive requirements for earthworks and disruption of the courses of the three streams. Works related to the improvement of flood walls, construction of embankments, and new piping under the proposed embankments have the potential to impact the geology and hydrogeology of the site, yet these effects are expected to be slight.

Operational stage impacts in this area are expected to be moderate. This is mainly due to the impermeable character of the proposed rechannelling of the Well Stream as well as changes in flood zones.

c. Landscape and Visual Amenity

During construction, temporary slight negative effects will occur due to the extents of the proposed works and the proximity to residential receptors. Heavy plant movement and

construction operations are expected to reduce the amenity received by the local landscape. Most of these effects will be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the erection of hoarding and restriction of working hours.

Permanent slight negative effects on visual amenity and landscape elements are expected in this area due to the replacement of the Well Stream with a precast concrete channel.

d. Biodiversity

The construction and excavation works will lead to temporary moderate negative effects due to disturbance, loss of riparian and grassland habitat, foraging grounds and pollution or increased sedimentation released to the riparian habitats. As the field west of Carrigaholt Road has the potential to be nesting grounds for snipe and is a known winter roosting site, the stream realignment is expected to have a temporary negative effect on this species' activities, but will have a long-term positive impact through habitat enhancement.

A negative impact on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, a moderate residual impact is expected due to the loss of habitat along the Well Stream. Overall, the impact on biodiversity in this area will be of moderate negative significance.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works mainly at Victoria Court and Well Road. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor, however partial or full road closures are likely to occur.

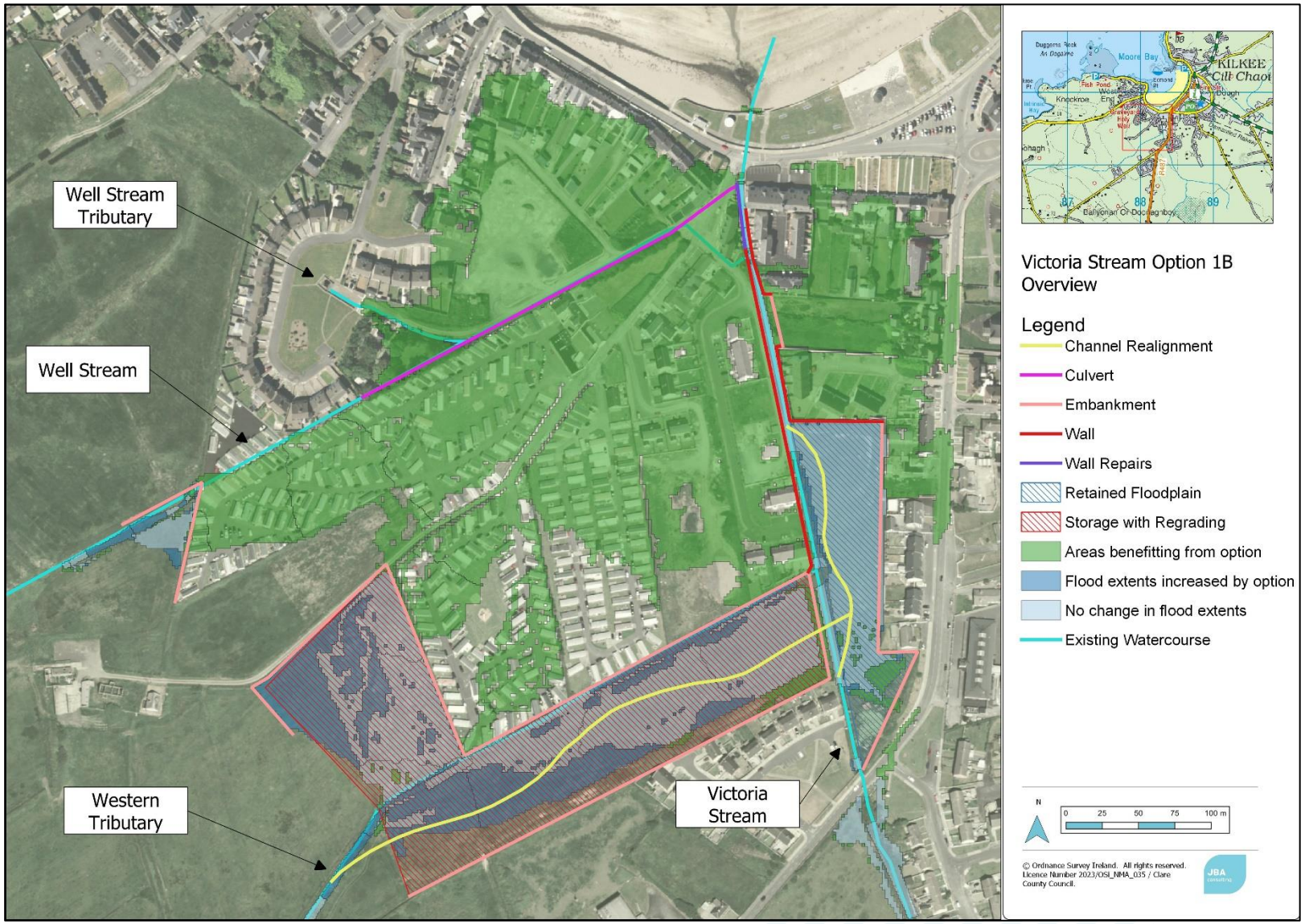

Figure 6-7: Victoria Stream – Option 1B Overview

6.5.2 Option 1B

6.5.2.1 Potential Measure(s)

Option 1B includes the following proposed fluvial flood defences. Text in *italics* indicates items which are common to each Option:

- Well Stream:
  - *Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream.*
  - *Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events.*
  - *Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place.*
  - Replacement of Well Stream with RC box culvert (c. 2m wide x 900mm high) c.240m long from Well Field to Crescent Place.
  - *Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high).*
- Victoria Court:
  - *Reconstruction of Victoria Court boundary wall.*
- Victoria Stream:
  - *Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place.*
  - *Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level.*
  - *Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level.*
  - *Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in.*
  - *Reconstruction of Victoria Crescent boundary wall c. 130m long.*
  - *Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent.*
- Western Tributary:
  - *Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain.*
  - *Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel.*
  - *Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max.*
  - Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section.

- *Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.*

6.5.2.2 Design Constraints

Both the Victoria Stream and the Well Stream traverse adjacent and between urban developments. The Well Stream has a perimeter wall to Cunningham's Holiday Park along much of its lower reach. This restricted proposals for flood plain re-connection and the allowance of out of bank flows. Similarly, the Victoria Stream in its lower reaches is bound by property boundary walls.

It is necessary to connect the Well Stream via a culvert to the outlet at the Victoria Stream in all options.

6.5.2.3 Ongoing maintenance, ownership, and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankments will be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended. Maintenance paths will be included adjacent to all embankments for ease of access.

The outlet of the Victoria Stream is critical to the performance of the entire system, and has had noted debris blockage issues, including debris carried by high tides.

The proposed culverted Well Stream will require regular maintenance of its inlets to protect from debris blockage.

6.5.2.4 Environmental Assessment

a. Waterbodies

During construction, temporary high negative effects are likely on hydrology and hydromorphology on the streams and downstream in Moore Bay. The regrading of the field that the Western Tributary flows through and the construction of the culvert at the Well Stream will increase the risk of sedimentation, pollutants and runoff entering the waterways. However, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during wall construction. These will ensure that these temporary impacts are reduced to moderate.

Operational stage impacts on the Well Stream are likely to be high negative, due to the long section of culvert to be installed. Positive impacts to hydrology and hydromorphology are likely on the Western Tributary and the Victoria Stream due to the channel realignment and flood storage area allowing the river to be connected to its floodplain, but these will not fully offset the negative impact of culverting the Well Stream. Overall the impact on waterbodies is expected to be high negative.

b. Soils, Geology and Hydrogeology

During construction, moderate negative effects are likely on the groundwater flows mainly because of the extensive requirements for earthworks and disruption of the courses of the three streams. The improvement of flood walls, construction of embankments, and new piping under the proposed embankments have the potential to alter the flow regimes and groundwater flows and therefore impact the geology and hydrogeology of the site, yet these effects are expected to be slight.

Operational stage impacts in this area are expected to be moderate. This is mainly due to the impermeable character of the proposed rechannelling of the Well Stream as well as changes in flood zones.

c. Landscape and Visual Amenity

During construction, temporary slight negative effects will occur due to the extents of the proposed works and the proximity to residential receptors. Heavy plant movement and construction operations are expected to reduce the amenity received by the local landscape. Most of these effects will be temporary and not significant and will be mitigated against by operating plans to be put in place by the appointed contractor, such as the erection of hoarding and restriction of working hours.

Permanent slight negative effects on visual amenity and landscape elements are expected in this area due to the change from a softer verge to an unvegetated hard boundary along Well Stream that would not allow for revegetation.

d. Biodiversity

The construction and excavation works could lead to high negative effects due to disturbance, loss of riparian and grassland habitat, foraging grounds and pollution or increased sedimentation released to the riparian habitats. As the field west of Carrigaholt Road has the potential to be nesting grounds for snipe and is a known winter roosting site, the stream realignment is expected to have a temporary negative effect on this species' activities, but will have a long-term positive impact through habitat enhancement.

Negative impacts on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, a permanent negative impact is expected due to the culverting of the Well Stream and subsequent loss of habitat. Overall, the impact on biodiversity in this area will be of high negative significance.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works mainly at Victoria Court and Well Road. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor, however partial or full road closures are likely to occur.

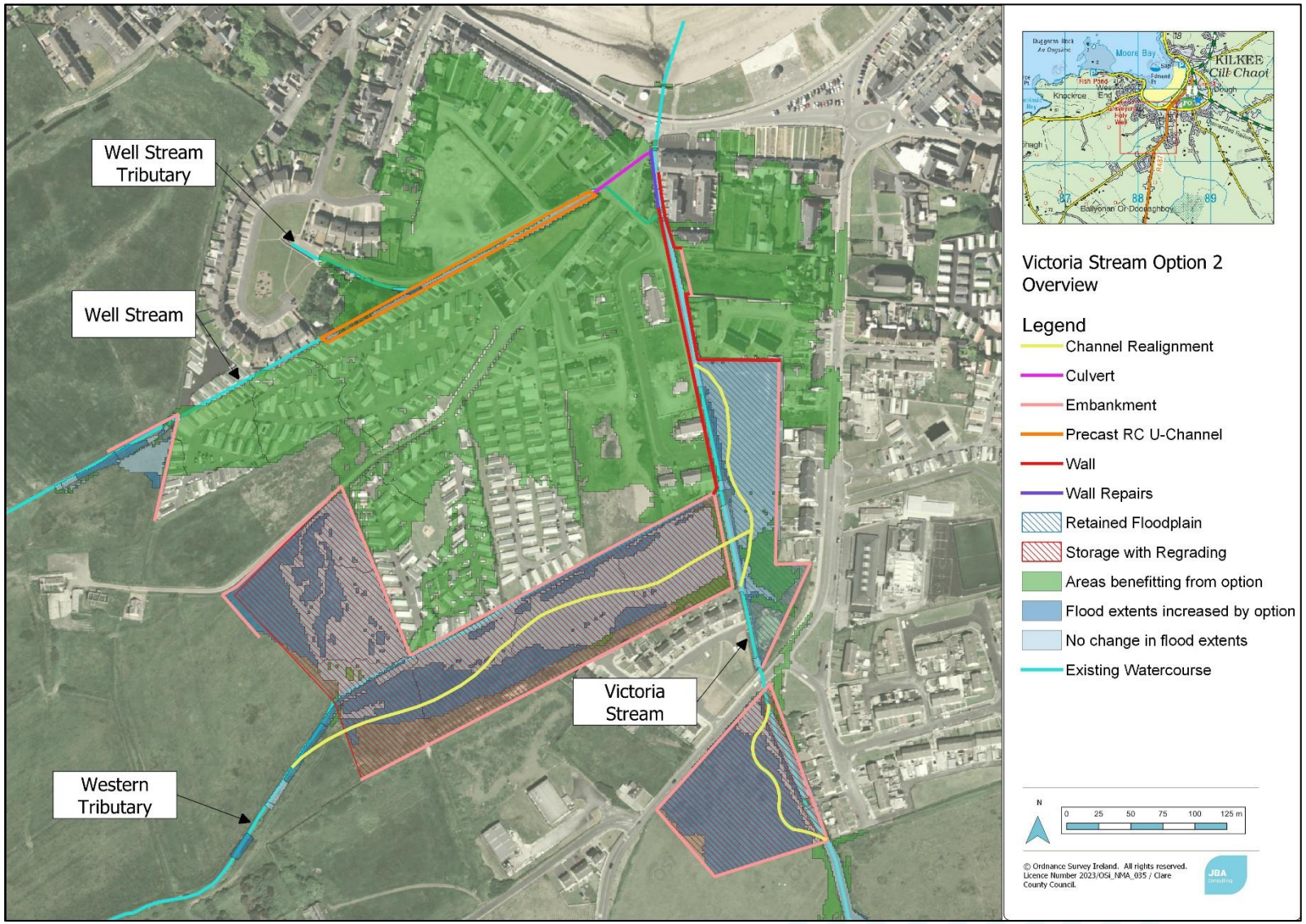

Figure 6-8: Victoria Stream – Option 2 Overview

6.5.3 Option 2

6.5.3.1 Potential Measure(s)

Option 2 includes the following proposed fluvial flood defences. Text in *italics* indicates items which are common to each Option:

- Well Stream:
  - *Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream.*
  - Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level.
  - *Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events.*
  - *Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place.*
  - *Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high).*
- Victoria Court:
  - *Reconstruction of Victoria Court boundary wall.*
- Victoria Stream:
  - *Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place.*
  - *Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level.*
  - *Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level.*
  - *Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in.*
  - *Reconstruction of Victoria Crescent boundary wall c. 130m long.*
  - *Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent.*
  - Construction of embankment upstream of R487 bridge c. 430m long and c. 1.5-2.0m high above ground level.
  - Regrading of lands upstream of R487 bridge for floodplain storage c. 400mm max.
  - Diversion of c. 140m of open channel to centre of floodplain upstream of R487 bridge. Existing open channel to be filled in.
  - Installation of 900mmØ inlet and outlet culverts from floodplain storage upstream of R487 bridge.
- Western Tributary:
  - *Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain.*
  - *Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel.*

- *Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max.*
- Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section.
- *Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.*

6.5.3.2 Design Constraints

Both the Victoria Stream and the Well Stream traverse adjacent and between urban developments. The Well Stream has a perimeter wall to Cunningham's Holiday Park along much of its lower reach. This restricted proposals for flood plain re-connection and the allowance of out of bank flows. Similarly, the Victoria Stream in its lower reaches is bound by property boundary walls.

It is necessary to connect the Well Stream via a culvert to the outlet at the Victoria Stream in all options.

6.5.3.3 Ongoing maintenance, ownership and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankments will be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended. Maintenance paths will be included adjacent to all embankments for ease of access.

The outlet of the Victoria Stream is critical to the performance of the entire system, and has had noted debris blockage issues, including debris carried by high tides.

6.5.3.4 Environmental Assessment

a. Waterbodies

During construction, temporary moderate negative effects are likely on hydrology and hydromorphology on the streams and downstream in Moore Bay. The regrading of the field that the Western Tributary flows through and the construction of the U-shaped precast channel at the Well Stream will increase the risk of sedimentation, pollutants and runoff entering the waterways. However, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during wall construction. These will ensure that these temporary impacts are reduced to moderate.

Operational stage impacts on the Well Stream are likely to be slight negative, due to changes to the stream hydromorphology and temporary disruption of the bed materials. Positive impacts to hydrology and hydromorphology are likely on the Western Tributary and the Victoria Stream due to the channel realignment and flood storage area allowing the river to be connected to its floodplain. The inclusion of an additional flood storage area upstream on the Victoria Stream will increase the potential for benefits to hydrology and hydromorphology compared to the other options.

The overall impact on waterbodies is moderate.

b. Soils, Geology and Hydrogeology

During construction, moderate negative effects are likely on the groundwater flows mainly because of the extensive requirements for earthworks and disruption of the courses of the three streams. Works related to the improvement of flood walls, construction of

embankments, new piping under the proposed embankments have the potential to alter the flow regimes and groundwater flows and therefore impact the geology and hydrogeology of the site, these effects are expected to be slight.

Operational stage impacts in this area are expected to be moderate. This is mainly due to changes in flood zones.

c. Landscape and Visual Amenity

During construction, temporary slight negative effects will occur due to the extents of the proposed works and the proximity to residential receptors along Well Road and Marion Estate. Heavy plant movement and construction operations are expected to reduce the amenity received by the local landscape. Most of these effects will be temporary potentially moderate with little capacity for mitigation The operating plans that will be put in place by the appointed contractor will have to include careful consideration of measures such as the erection of hoarding and restriction of working hours especially along the residencies 1 to 12 on Marion Estate.

Permanent slight negative effects on visual amenity and landscape elements are expected in this area due to the introduction of the embankments south of Carrigaholt Road and the u-channel wall defences along the Well Stream. These proposals have the potential to allow for revegetation that is expected to reduce the visual impacts.

d. Biodiversity

The construction and excavation works will lead to temporary moderate negative effects due to disturbance, loss of riparian and grassland habitat, foraging grounds and pollution or increased sedimentation released to the riparian habitats. As the field west of Carrigaholt Road has the potential to be nesting grounds for snipe and is a known winter roosting site, the stream realignment is expected to have a temporary negative effect on this species' activities, but will have a long-term positive impact through habitat enhancement.

A negative impact on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, a moderate residual impact is expected due to the loss of habitat along the Well Stream. Overall, the impact on biodiversity in this area will be of slight negative significance.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works mainly at Victoria Court, south of Carrigaholt Road and Well Road. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor. However partial or full road closures are likely to occur.

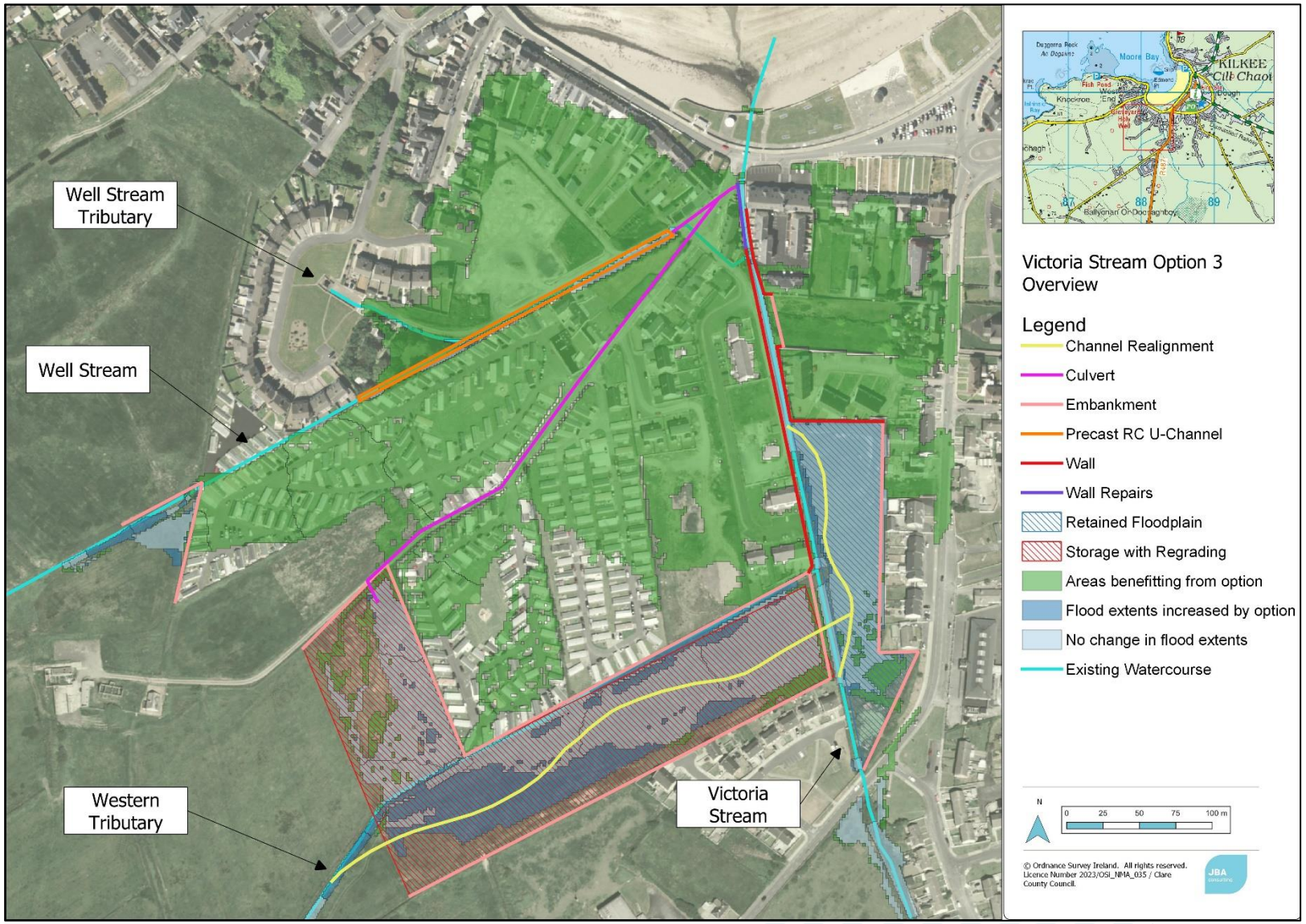

Figure 6-9: Victoria Stream – Option 3 Overview

6.5.4 Option 3

6.5.4.1 Potential Measure(s)

Option 3 includes the following proposed fluvial flood defences. Text in *italics* indicates items which are common to each Option:

- Well Stream:
  - *Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream.*
  - Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level.
  - *Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events.*
  - *Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place.*
  - *Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high).*
- Victoria Court:
  - *Reconstruction of Victoria Court boundary wall.*
- Victoria Stream:
  - *Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place.*
  - *Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level.*
  - *Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level.*
  - *Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in.*
  - *Reconstruction of Victoria Crescent boundary wall c. 130m long.*
  - *Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent.*
- Western Tributary:
  - Construction of RC box culvert (c. 2.1m wide x 800mm high) under Caravan Park Road c. 360m long to discharge to Well Stream RC box culvert at Crescent Place. Inclusion of headwall and local deepening of lands around the culvert inlet.
  - *Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain.*
  - *Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel.*
  - *Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max.*

- *Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.*

6.5.4.2 Design Constraints

Both the Victoria Stream and the Well Stream traverse adjacent and between urban developments. The Well Stream has a perimeter wall to Cunningham's Holiday Park along much of its lower reach. This restricted proposals for flood plain re-connection and the allowance of out of bank flows. Similarly, the Victoria Stream in its lower reaches is bound by property boundary walls.

It is necessary to connect the Well Stream via a culvert to the outlet at the Victoria Stream in all options.

6.5.4.3 Ongoing maintenance, ownership, and responsibilities

Each proposed measure will have its own bespoke management plan.

Annual inspections of the embankments will be needed, together with investigations of its performance after each flood event. Monitoring of seepage will be recommended. Maintenance paths will be included adjacent to all embankments for ease of access.

The outlet of the Victoria Stream is critical to the performance of the entire system, and has had noted debris blockage issues, including debris carried by high tides.

The proposed culvert would require inlet protection, which would have associated maintenance requirements to ensure blockages are cleared on a regular basis.

6.5.4.4 Environmental Assessment

a. Waterbodies

During construction, temporary moderate negative effects are likely on hydrology and hydromorphology on the streams and downstream in Moore Bay. The regrading of the field that the Western Tributary flows through and the construction of the U-shaped precast channel at the Well Stream will increase the risk of sedimentation, pollutants and runoff entering the waterways. However, mitigation measures for managing the risk to water quality are feasible, such as adherence to best practice guidance, pollution prevention and sediment management measures such as the use of oil booms, spill kits, and silt fences, supervision by an ECoW, and safe concreting measures during wall construction. These will ensure that these temporary impacts are reduced to moderate.

Operational stage impacts on the Well Stream are likely to be slight negative, due to changes to the stream hydromorphology and temporary disruption of the bed materials. Positive impacts to hydrology and hydromorphology are likely on the Western Tributary and the Victoria Stream due to the channel realignment and flood storage area allowing the river to be connected to its floodplain. However the inclusion of a long culvert from the Western Tributary storage area to the Well Road area downstream will lead to high negative effects in the operational stage, meaning that the overall impact on waterbodies is moderate.

b. Soils, Geology and Hydrogeology

During construction, negative effects are likely on groundwater flows mainly because of the extensive requirements for earthworks and disruption of the courses of the three streams. Works related to the improvement of flood walls, construction of embankments, new piping under the proposed embankments have the potential to alter the flow regimes and groundwater flows and therefore impact the geology and hydrogeology of the site, yet these effects are expected to be slight.

Operational stage impacts in this area are expected to be moderate. This is mainly due to changes in flood zones.

c. Landscape and Visual Amenity

During construction, temporary slight negative effects will occur due to the extents of the proposed works and the proximity to residential receptors along Well Road. Heavy plant movement and construction operations are expected to reduce the amenity received by the local landscape. Most of these effects will be temporary with some capacity for mitigation. The operating plans that will be put in place by the appointed contractor will have to include careful consideration of measures such as the erection of hoarding and restriction of working hours especially to the residencies and caravans on Well Road.

Permanently slight negative effects on visual amenity and landscape elements are expected in this area due to the wall defences along Well Stream that have the potential to allow for retention and revegetation that is expected to reduce the visual impacts.

d. Biodiversity

The construction and excavation works will lead to temporary moderate negative effects due to disturbance, loss of riparian and grassland habitat, foraging grounds and pollution or increased sedimentation released to the riparian habitats. As the field west of Carrigaholt Road has the potential to be nesting grounds for snipe and is a known winter roosting site, the stream realignment is expected to have a temporary negative effect on this species' activities, but will have a long-term positive impact through habitat enhancement.

A negative impact on fish and aquatic species are possible during instream works or works adjacent to the riverbank due to the potential for accidental release of pollutants or increases in sedimentation, and temporary changes to habitat connectivity. These are impacts that can be mitigated during construction, such as the adoption of a surface water management plan including appropriate barrier controls, pollution and spill prevention measures, phased installation of silt fences along the site boundary where works are taking place, and periodic monitoring by an Ecological Clerk of Works (ECoW).

Once operational, a moderate residual impact is expected due to the loss of habitat along the Well Stream. Overall, the impact on biodiversity in this area will be of moderate negative significance.

e. Construction

There is the potential for temporary moderate negative effects for residents, pedestrians and road users through disturbance associated with construction works mainly at Victoria Court and Well Road. Measures to mitigate impact on access and residential amenity will be outlined in the operating plans to be devised by the contractor, however partial and full road closures are likely to occur.

Once operational, access to Kilkee should return to the previous condition allowing for no residual negative impacts.

6.5.5 Summary of Environmental Assessment of Options

The four options have been discussed and their likely environmental impacts assessed in the sections above. A summary of this assessment follows below.

Impacts to soils and geology, landscape and visual amenity, and construction stage impacts will be similar across all options, with small variations depending on length and extent of defences, small changes in flood zones once operational, and construction duration and extents. The proposed flood defence heights are slightly lower in Option 3 than in the other options, meaning that impacts on visual amenity are slightly lower for Option 3.

On the Well Stream, the proposals are identical in Options 1A, 2 and 3. A pre-cast concrete U-shaped channel will be installed to replace the existing Well Stream channel. This will lead to temporary significant negative impacts during construction, as instream works will be required to divert the stream and replace the existing bed and bank materials with the pre-cast channel. These works will negatively impact hydrology and hydromorphology on the

Well Stream during construction. Once operational, the changes to hydromorphology will result in long-term slight negative impacts. The bed materials will be reinstated where possible, meaning long-term impacts are expected to be slight negative. The works on the Well Stream in Options 1A, 2 and 3 will also negatively impact biodiversity during construction, with moderate negative residual impacts once operational.

Option 1B will see the Well Stream partially replaced with a pre-cast concrete box culvert. This would have similar construction stage impacts on hydrology and hydromorphology as in the other options. However, once operational the culvert would result in permanent significant negative impacts on both hydrology and hydromorphology, and biodiversity. Due to this, Option 1B is the least preferred environmentally.

Options 1A, 2 and 3 all include a flood storage area and channel realignment along the Western Tributary. Overall, this would result in a long-term positive impact on biodiversity and hydrology and hydromorphology, following short term construction stage impacts. However, Option 3 includes an overflow culvert flowing from this storage area to the Well Stream culvert at Crescent Place, which would lead to negative impacts on hydrology and hydromorphology. This means that Option 3 is less preferred than Options 1A and 2.

Options 1A and 2 are similar in their construction and operation stage impacts. Option 2 has slightly less impacts on biodiversity as it includes an additional flood storage area upstream on the Victoria Stream. This will include channel realignment, and as such Option 2 will have more potential for habitat creation and benefits to hydrology and hydromorphology in the operational phase than Option 1A. Option 2 is therefore the preferred option from an environmental point of view, followed by Option 1A.

Table 6-5: Comparative Environmental Assessment of Options

	Victoria Stream			
Option	**1A**	**1B**	**2**	**3**
Waterbodies				
Biodiversity				
Soils and Geology				
Landscape and Visual Amenity				
Construction				
Comments	The replacement of the Well Stream with a precast U-shaped channel will lead to temporary high negative impacts on the waterbody during construction. The reinstatement of the original bed materials in the channel after construction, and the use of an open channel instead of a culvert, means that this is preferable to Option 1B, with a permanent moderate negative impact on the waterbody. Option 1A and 2 are similar and both preferred to Option 1B and 3. Option 1A has less flood storage area than Option 2, meaning it has less potential for habitat creation and long term permanent biodiversity benefits. Option 2 is therefore slightly preferred over Option 1A.	The replacement of the Well Stream with a culvert for much of its length would lead to permanent high negative impacts on the stream's hydromorphology and its ability to function naturally. This would have further high negative effects on its water quality and on biodiversity, with the Well Stream effectively ceasing to act as an ecological corridor once the culvert is operational. Due to the significant negative effects on the Well Stream in terms of biodiversity, hydrology, and hydromorphology, Option 1B is least preferred.	The replacement of the Well Stream with a precast U-shaped channel will lead to temporary high negative impacts on the waterbody during construction. The reinstatement of the original bed materials in the channel after construction, and the use of an open channel instead of a culvert, means that this is preferable to Option 1B, with a permanent moderate negative impact on the waterbody. The inclusion of a flood storage area on the Victoria Stream, upstream of Cluain Na Mara, will lead to a long-term permanent benefit for biodiversity as it has the greatest potential for habitat creation. This combined with the storage area on the Western Tributary means that Option 2 is slightly preferred over Option 1A.	The replacement of the Well Stream with a precast U-shaped channel will lead to temporary high negative impacts on the waterbody during construction. The reinstatement of the original bed materials in the channel after construction, and the use of an open channel instead of a culvert, means that this is preferable to Option 1B, with a permanent moderate negative impact on the waterbody. The inclusion of a long culvert from the Western Tributary north to Crescent Place will lead to a permanent moderate negative impact on hydromorphology and water quality. This makes Option 3 less preferred than Options 1A or 2.

6.6 Summary of Measures and Potential Flood Relief Options

Following the screening stage, a number of potentially viable measures have been identified to protect against flooding in the baseline design event. This section further develops the potentially viable measures into options. Multi Criteria Analysis (MCA) for each option will be carried out to aid in the selection of the preferred option. Table 6-6 provides a summary of potential options.

Table 6-6: Summary of Options

Option 1 A Potential Measures
Well Stream: • Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream. • Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level. • Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events. • Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place. • Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high). Victoria Court: • Reconstruction of Victoria Court boundary wall. Victoria Stream: • Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place. • Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level. • Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level. • Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in. • Reconstruction of Victoria Crescent boundary wall c. 130m long. • Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent. Western Tributary: • Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain. • Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel. • Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max. • Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section. • Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.

Option 1 B Potential Measures
Well Stream: • Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream. • Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events. • Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place. • Replacement of Well Stream with RC box culvert (c. 2m wide x 900mm high) c.240m long from Well Field to Crescent Place. • Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high). Victoria Court: • Reconstruction of Victoria Court boundary wall. Victoria Stream: • Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place. • Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level. • Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level. • Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in. • Reconstruction of Victoria Crescent boundary wall c. 130m long. • Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent. Western Tributary: • Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain. • Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel. • Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max. • Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section. • Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.
Option 2 **Potential Measures**
Well Stream: • Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream. • Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level. • Installation of overflow on the Well Stream Tributary and non-return valve on the Well

Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events.

- Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place.
- Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high).

Victoria Court:

- Reconstruction of Victoria Court boundary wall.

Victoria Stream:

- Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place.
- Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level.
- Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level.
- Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in.
- Reconstruction of Victoria Crescent boundary wall c. 130m long.
- Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent.
- Construction of embankment upstream of R487 bridge c. 430m long and c. 1.5-2.0m high above ground level.
- Regrading of lands upstream of R487 bridge for floodplain storage c. 400mm max.
- Diversion of c. 140m of open channel to centre of floodplain upstream of R487 bridge. Existing open channel to be filled in.
- Installation of 900mmØ inlet and outlet culverts from floodplain storage upstream of R487 bridge.

Western Tributary:

- Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain.
- Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel.
- Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max.
- Regrading of floodplain in field west of Cunningham's Holiday Park (north of existing alignment of filled-in Western Tributary) by raising to 6.70mOD for the northern two-thirds section and lowering to 6.40mOD for the southern third section.
- Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.

Option 3 Potential Measures
Well Stream: • Construction of c. 146m long embankment c. 1.1m high upstream of Cunningham's Holiday Park with inclusion of new headwall and 1050mmØ inlet culvert to existing culvert downstream. • Installation of precast reinforced concrete u-channel along the existing Well Stream alignment c. 240m long and c. 1.6m above the adjacent road level. • Installation of overflow on the Well Stream Tributary and non-return valve on the Well Stream u-channel left bank wall to maintain connectivity during normal flows and enable overflow to the carrier drain system during flood events. • Decommissioning of existing Well Stream box culvert and circular overflow culverts at Crescent Place. Installation of new RC box culvert (c. 1.6m wide x 900mm high) c. 55m long under Crescent Place. • Resurfacing and regrading of Well Road (c. 300m long x 5.5m wide x 300mm high). Victoria Court: • Reconstruction of Victoria Court boundary wall. Victoria Stream: • Local repointing and thickening of existing left bank wall behind Crescent Place properties. Replacement of c. 3m section of wall to facilitate Well Stream RC box culvert installation at Crescent Place. • Construction of c. 280m long embankment behind Carrigaholt Road c. 1.2-1.4m high above ground level. • Construction of new flood defence wall c. 230m long along filled-in left hand bank from Victoria Park to Crescent Place c. 1.2-1.8m high above ground level. • Diversion of c. 170m of open channel to centre of floodplain. Existing open channel to be filled in. • Reconstruction of Victoria Crescent boundary wall c. 130m long. • Construction of c. 37m long embankment c. 800mm high north of Victoria Crescent. Western Tributary: • Construction of RC box culvert (c. 2.1m wide x 800mm high) under Caravan Park Road c. 360m long to discharge to Well Stream RC box culvert at Crescent Place. Inclusion of headwall and local deepening of lands around the culvert inlet. • Construction of embankment c. 980m long and c. 1.3-1.8m high around Western Tributary floodplain. • Diversion of c.400m of open channel to centre of floodplain and filling in of existing channel. • Regrading of floodplain in field north of Cluain na Mara estate by c. 700mm max. • Installation of 900mmØ culvert under Western Tributary embankment to link to diverted Victoria Stream alignment. Inclusion of headwalls on inlet and outlet of culvert.

6.7 Adverse Flood Risk due to fluvial measures

When considering fluvial defence measures, it needs to be assessed as to whether they will increase flood risk from other sources. Aside from fluvial risk, there exists both a pluvial and coastal risk. The following sections detail what elements are included in the scheme to ensure that the flood risk from these other sources isn't made worse by the fluvial defences.

6.7.1 Coastal Flood Risk

Kilkee is at risk of significant flooding due to wave overtopping of the seawall. The baseline coastal flood risk is shown in Figure 6-10.

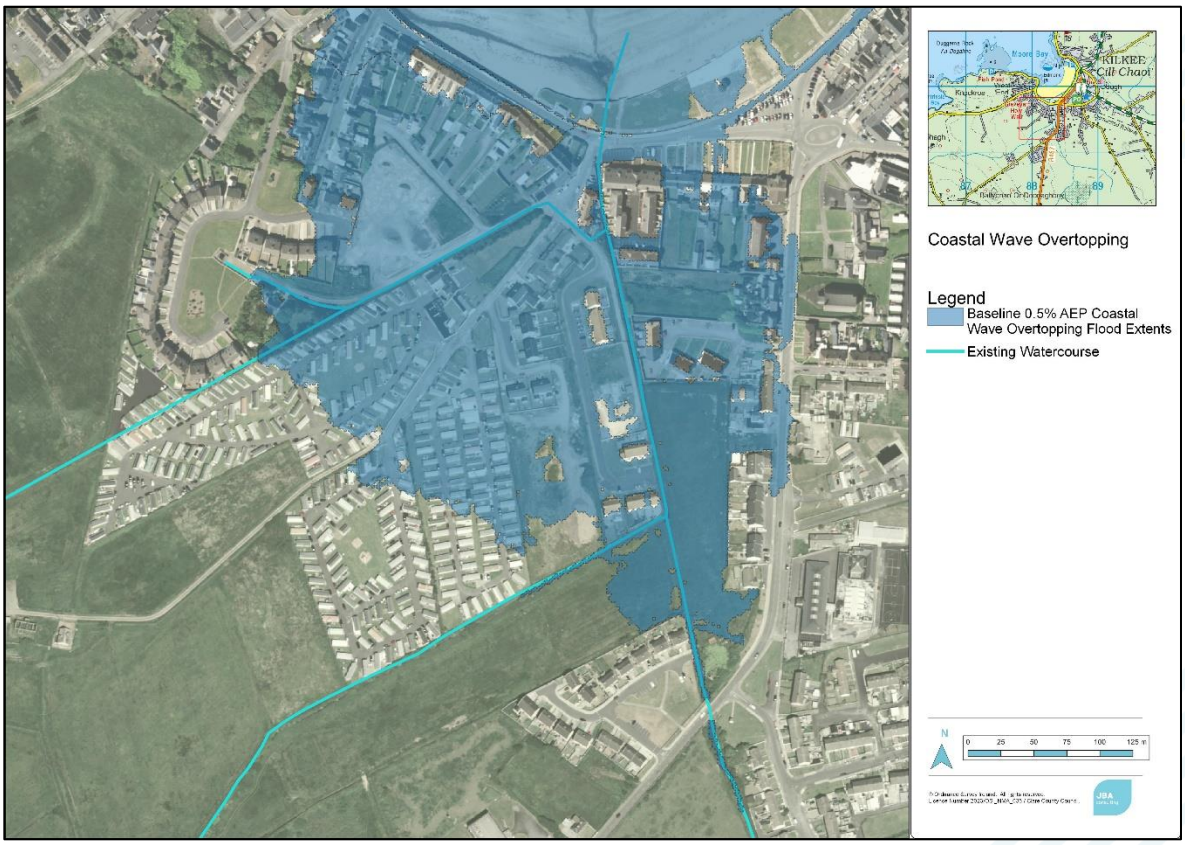

Figure 6-10: Baseline 0.5% AEP Coastal Wave Overtopping Flood Extents

The means by which this flood volume returns to the sea is via the Victoria and Well Streams. In all proposed options, it is intended to provide hard defences on both the Well Stream and Victoria Stream. Therefore, this route for the overland volume is restricted. Therefore, it is proposed to introduce the following measures to allow the flood volume to drain via their baseline flow routes:

- 8no. sluice gates (c. 2m wide x 900mm high) to left hand bank of Victoria Stream walls with invert level set at ground level.
- 1no. sluice gate (c. 2m wide x 900mm high) to right hand bank of Victoria Stream with invert level set at ground level.
- 3no. sluice gates (c. 2m wide x 900mm high) to left hand bank of Well Stream u-channel wall with invert level set at ground level.
- 2no. junctions reprofiling by c. +300mm at Well Road (c. 20m long x 10m wide x 300mm high) and Geraldine Place (c. 20m long x 12m wide x 300mm high).

The road raising is proposed to restrict surface flows entering the Well Road and Geraldine Place. An overview of these proposed measures is presented in Figure 6-11.

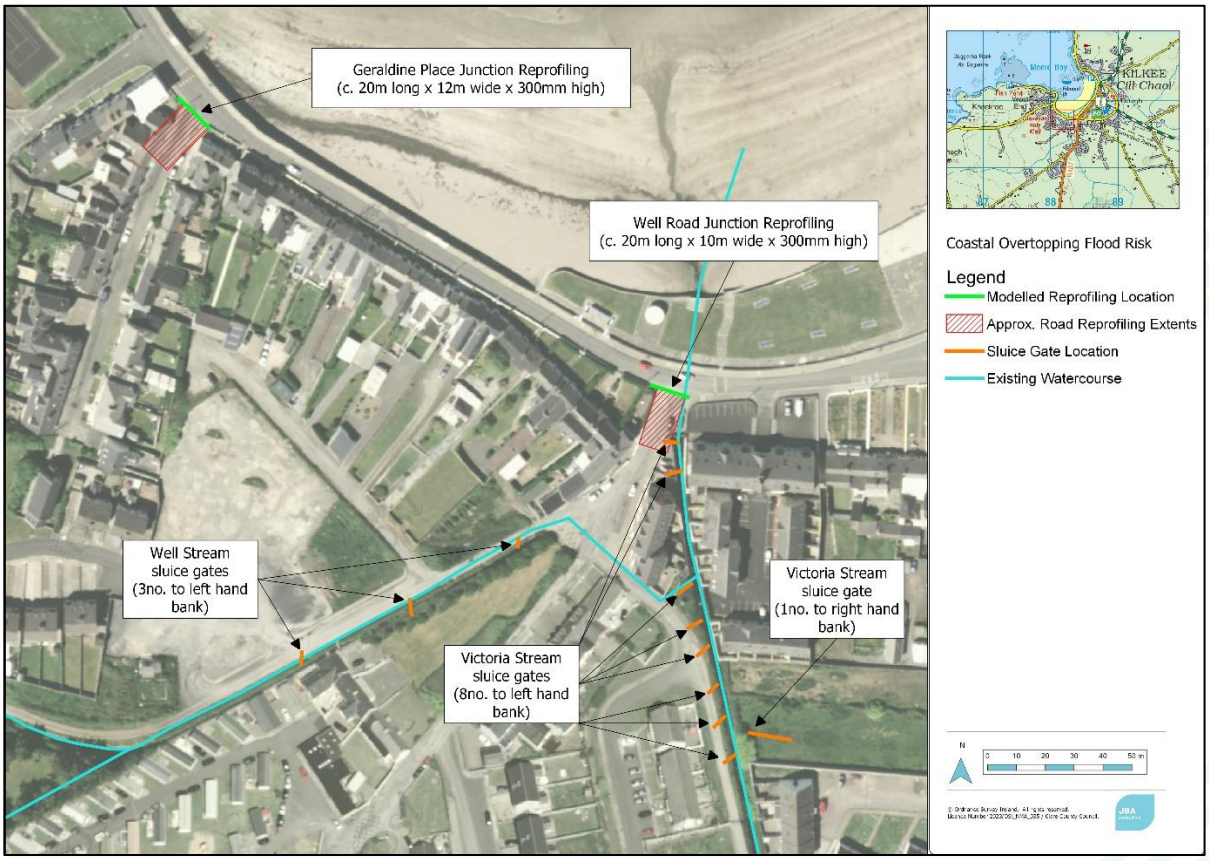

Figure 6-11: Coastal Overtopping Flood Risk Measures

6.7.2 Pluvial Flood Risk

Both the Victoria Stream and Well Stream have pluvial drainage outlets discharging into them. As containment measures are being considered on these watercourses, the water levels will increase from the baseline. This results in the pluvial outfalls becoming more surcharged compared to that of their current downstream condition.

To ensure that the fluvial defences don't result in an increase in pluvial flooding, a number of stormwater drainage elements including pump stations and sub-surface storage are included in the scheme. These are outlined in Section 6.5, and presented graphically in Figure 6-12.

Note, the scale of pluvial drainage elements is option-dependent. All options require a pump station and sub-surface storage on the Well Road (at Clare Co. Co. compound) and the Carrigaholt Road (in lands north of Victoria Crescent). Option 2 only requires an additional pump station and sub-surface storage at the Marion Estate.

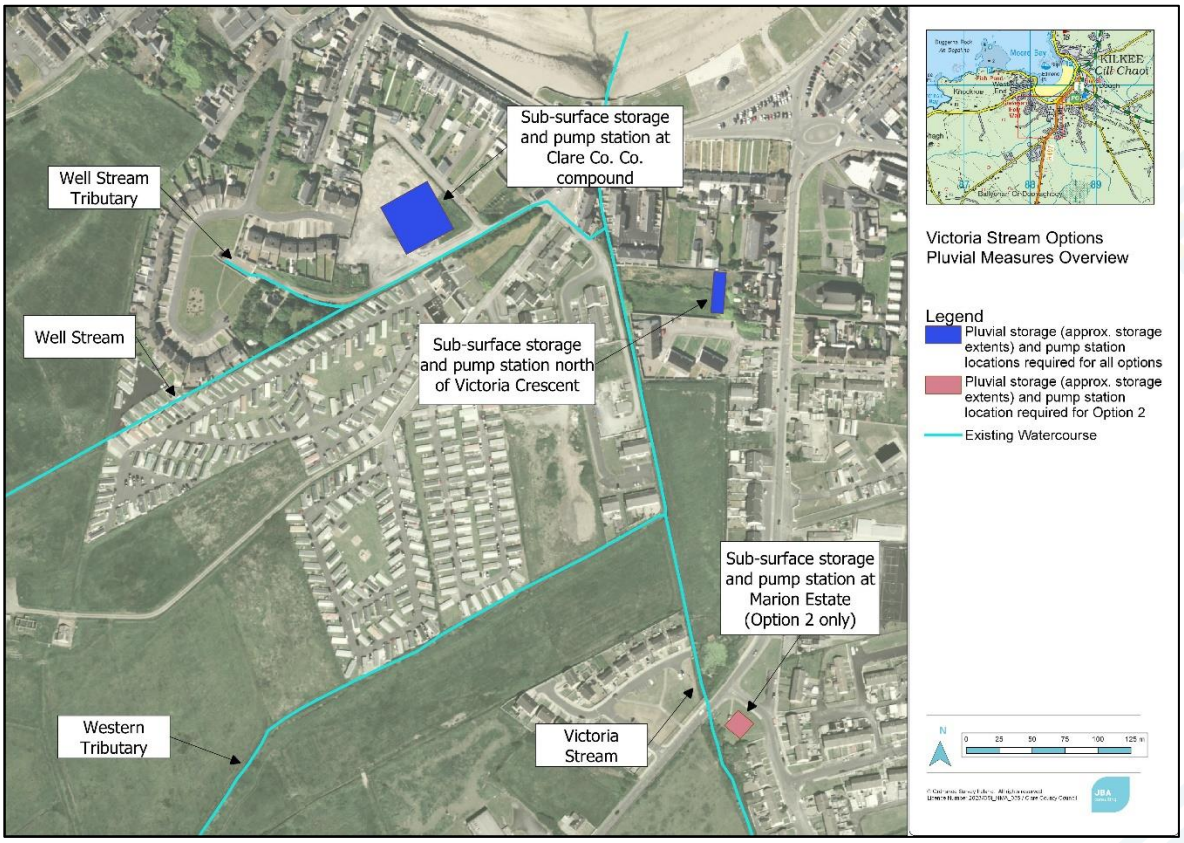

Figure 6-12: Pluvial Measures - Victoria Stream Options

6.8 Residual Risks Post Scheme

The intention of the flood relief scheme is to provide a Standard of Protection up to and including the 1% AEP fluvial flood event, protecting all risk receptors. While the scheme does provide this protection, it is important to understand residual risks outside of those normally considered (e.g. blockage of structures) and the impacts on the scheme and the desired protection. The main residual risks are identified for the scheme and are discussed in the following sections.

6.8.1 Consideration of Future Development within the Scheme Area

Kilkee and its surrounds is a key area for development within County Clare. The proposed scheme's intention is to only protect existing developments. The scheme's land use allocation is in line with the current County Development Plan.

6.8.2 Design flood level and extent

The 1% AEP flood level at Kilkee varies throughout the town and generally follows the fall in hydraulic gradient from south to north, or in a downstream direction.

6.8.3 Freeboard

Soft defences are vulnerable to long term consolidation of the earthworks (settlement), so are normally assigned a higher freeboard than hard defences, such as walls.

The freeboard allowance adopted for scheme design will therefore be as follows:

- Walls/Hard defences 0.3m.
- Embankments 0.4m.

The actual freeboard achieved in some areas is greater than those above, due to the minimum guarding height of 1.2m required for health and safety reasons.

The 400mm freeboard for embankments takes into account the intention to raise all proposed Victoria embankments in the MFRS, therefore the impact of consolidation is low. The Atlantic Stream embankments are set to HEFS from the outset.

6.8.4 Final Flood Defence Levels

The Scheme FDL (Flood Defence Level) varies throughout Kilkee and is summarised in Table 6-7 hereunder for the preferred option.

Table 6-7: Defence heights

VICTORIA STREAM					
Reporting Location	**Flood Level**	**Defence Level**	**Existing Ground Level**	**Defence Height**	**Flood Measure**
P2	4.86mOD	6.97mOD	5.00mOD	1.97m	Wall
P3	4.91mOD	5.48mOD	3.87mOD	1.61m	U-Channel Wall
P4	7.15mOD	7.55mOD	6.20mOD	1.35m	Embankment
P5 (Wall)	4.96mOD	5.74mOD	4.00mOD	1.74m	Wall
P5 (Embankment)	4.96mOD	5.36mOD	4.00mOD	1.36m	Embankment
P6	8.08mOD	8.48mOD	7.28mOD	1.20m	Embankment
P7	4.76mOD	6.97mOD	4.75mOD	2.22m	Wall

ATLANTIC STREAM					
Reporting Location	**Flood Level**	**Defence Level**	**Existing Ground Level**	**Defence Height**	**Flood Measure**
P1	6.64mOD	N/A	7.37mOD	N/A	Culvert Relief
P2	9.41mOD	10.01mOD	9.29mOD	0.72m	Embankment
P3	9.49mOD	10.00mOD	9.70mOD	0.30m	Wall
P4	11.23mOD	11.80mOD	10.42mOD	1.38m	Embankment
P5	12.13mOD	N/A	12.31mOD	N/A	Culvert Inlets

7 Climate Change Adaptability

7.1 Introduction to Climate Change Adaptation

Climate change is an important consideration in any scheme to ensure it is operational into the future. Predicted increases in rainfall, flows and tidal levels amongst other pressures will put pressure on the scheme performance. To account for this, climate change analysis has been carried out on the preferred option to examine the necessary changes required to make it operational into the future.

As both the Victoria and Atlantic systems are separate hydraulically, Climate Change Adaptation Plans have been compiled for both. These are found within the appendix of this report. A summary of key information has been included in this section. The adaptation plans include details of the processes and decision making involved in developing a robust Scheme Climate Change Adaptation Plan (SCCAP).

Following the establishment of the key mechanisms at risk areas, testing of potential adaptations was carried out. From the performance of the proposed scheme in climate change scenarios, the climate change adaptation plan was created, based on a decision tree analysis to ensure an adaptable scheme into a range of potential futures. The potential futures are based on the rate of climate change. The SCCAP will be maintained as a live document during the lifetime of the scheme.

7.2 Climate Change Adaptation Plan summary – Atlantic Stream

The vast majority of required adaptations for the Atlantic Stream will be included in the baseline construction stage.

The increase in levels for across the Atlantic Stream system due to climate change are presented in Figure 7-1 below.

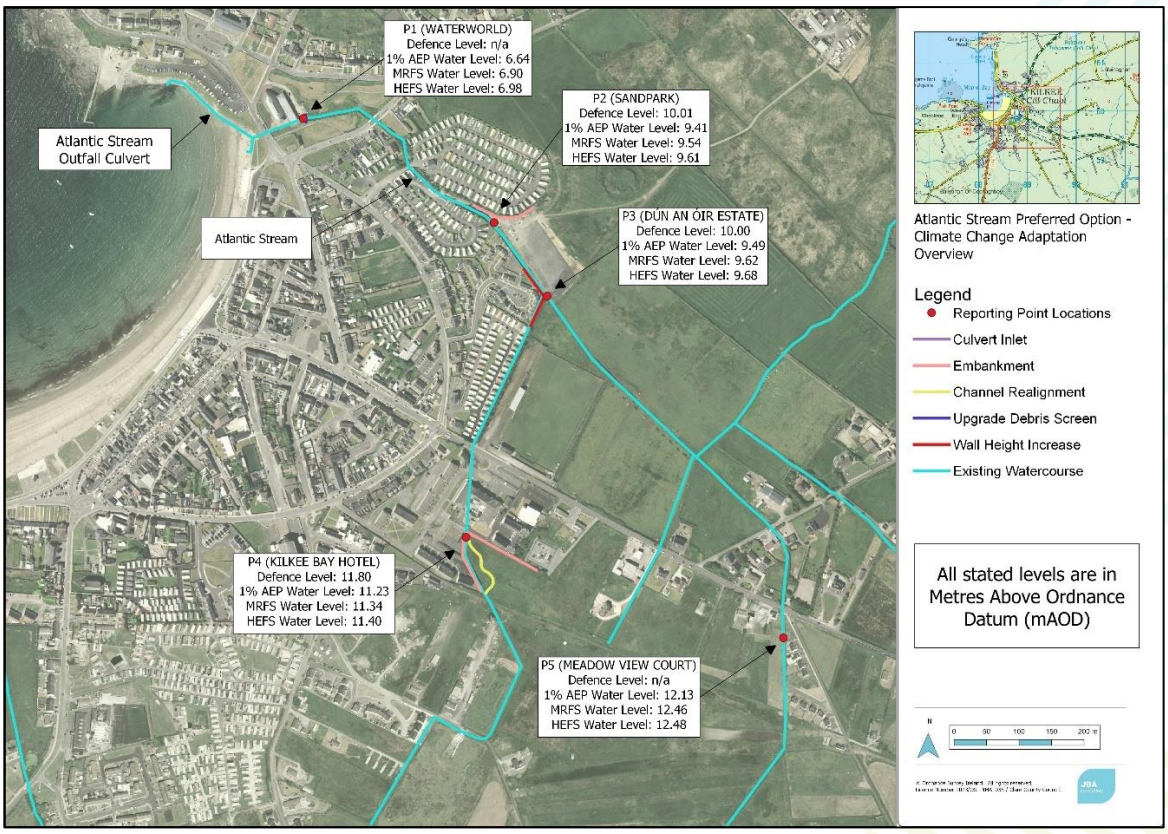

Figure 7-1 Atlantic Stream Level increases across scheme area

The levels presented here indicate a minor increase in water levels in both the MRFS and HEFS scenarios. The intended adaptability approach is as follows:

Table 7-1 Atlantic Stream CCA Stages

Climate Change Stage	Adaptation Measure
Present Day	Increase heights of all embankments to HEFS requirement. Increase height of Dún an Óir boundary wall to HEFS required height
MRFS	Replacement of downstream outfall network at the promenade. To avoid inundation of the Moonin Estate, some flood storage is required. The intended land bank to accommodate this is immediately to the south of the estate itself. The storage capability of the flooded land to the west of Meadow View Court will need to be increased for the MFRS. This is to ensure flood levels do not encroach on the properties to the east of the existing culvert.
HEFS	No further required changes.

As is seen, the most significant intervention is at the MRFS. This is included in the Climate Change Adaptation Plan and repeated here for reference.

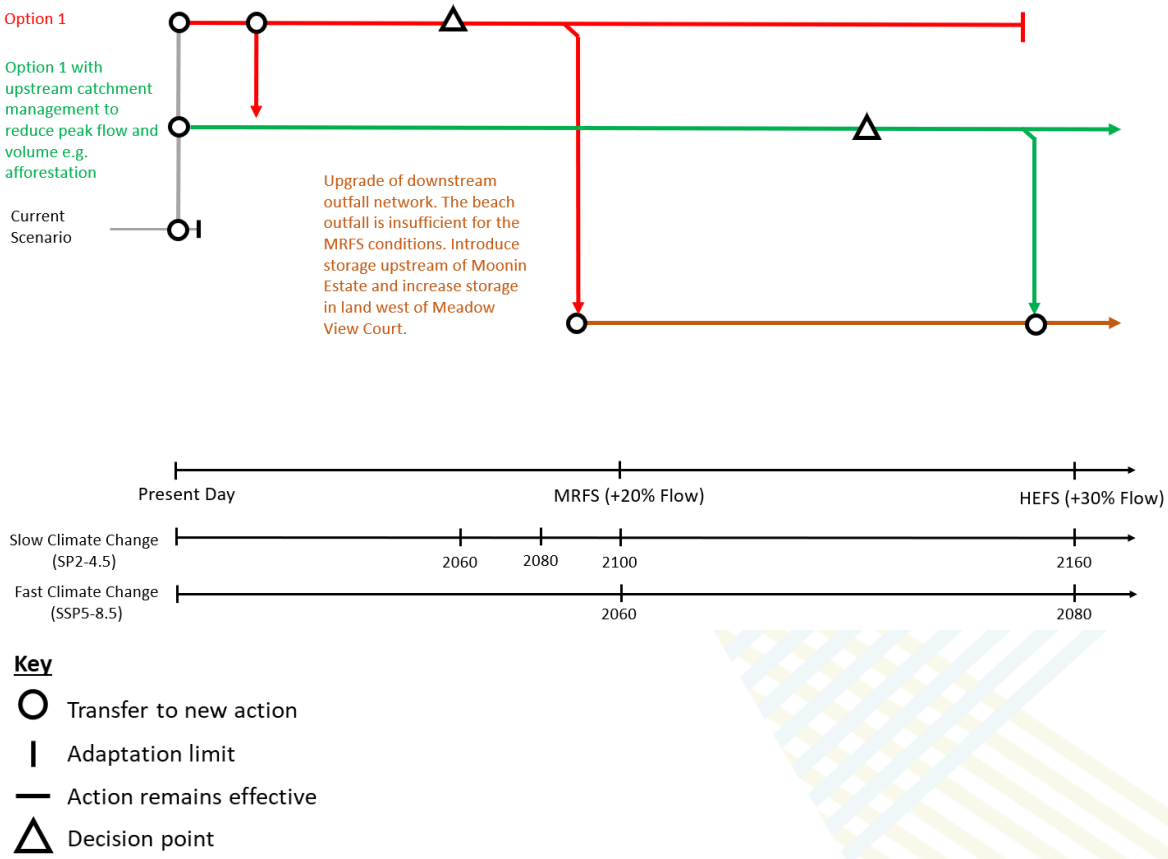

Figure 7-2 Atlantic Stream Climate Change Pathway

7.3 Climate Change Adaptation included in Atlantic Stream Preferred Option

The following elements are intended to be constructed to their climate change adaptation levels as part of the present-day scheme.

- The Dún an Óir boundary wall.
- The Kilkee Bay Hotel embankment.
- The Sandpark embankment.

The levels to which these are being constructed to vs. their respective climate change water levels is shown in Figure 7-1.

These costs have been included in the proposed scheme construction costs.

7.4 Climate Change Adaptation Plan summary – Victoria Stream

Figure 7-3 shows the increase in water levels across the scheme area for both the MRFS and HEFS.

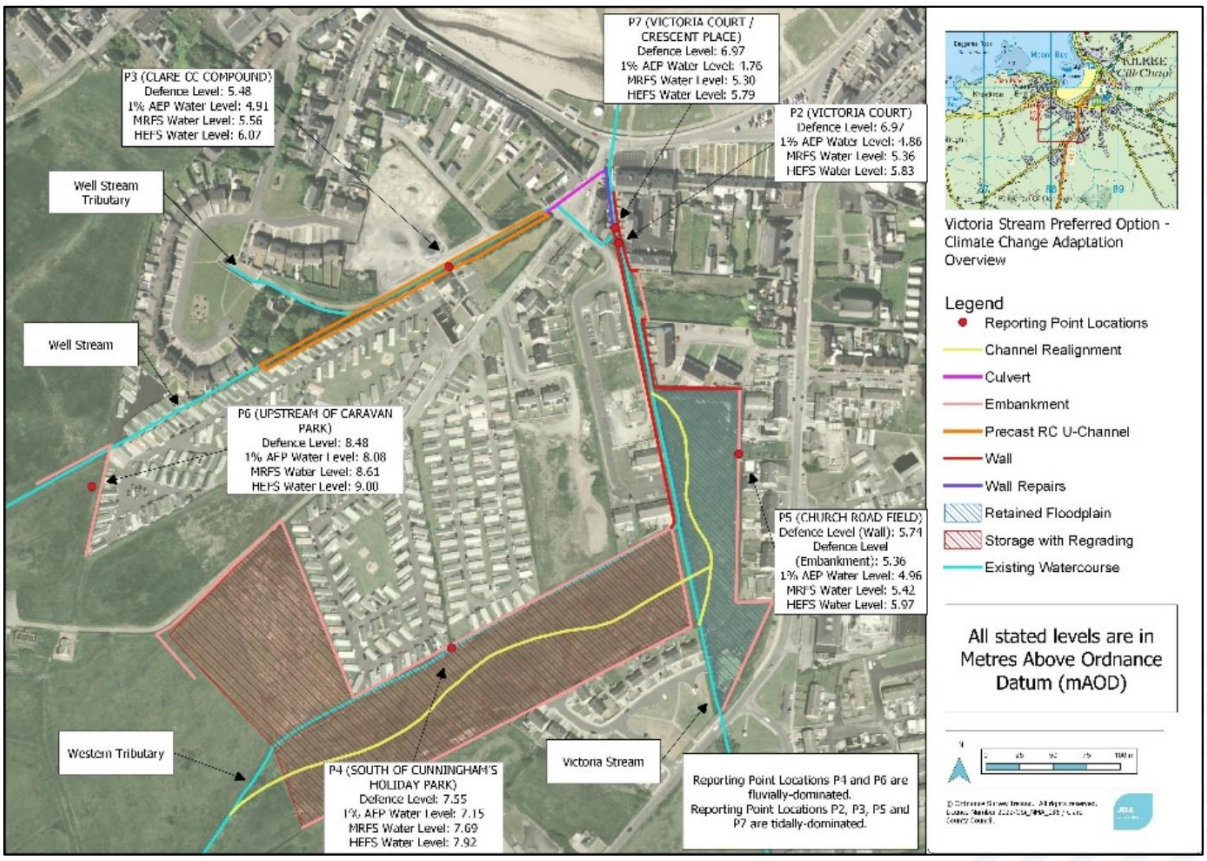

Figure 7-3 Victoria Stream level increases across scheme area

As is seen, there is significant increases in water levels at the Well Stream and downstream of the Carrigaholt Road field in both the MRFS and HEFS. This is dominated by the increased tidal boundary, with the dominant event being the T200/Q10.

These levels require more significant interventions at both the MRFS and HEFS.

Table 7-2 Victoria Stream – Climate Change Stages

Climate Change Stage	Adaptation Measure
Present Day	Increase Well Stream u-channel wall height to MRFS height now to accommodate increasing sea level. Increase Victoria Stream left hand bank wall height to MRFS height now.
MRFS	Introduction of Well Stream diversion into Western Tributary storage.
HEFS	Further increase in embankment heights. Throttle of flows to retain MRFS flows from Western Tributary storage into Carrigaholt Road Field. Introduction of storage upstream of R487 Bridge.

The introduction of the Well Stream diversion is clearly the most onerous intervention here. The impact on levels of this is shown in Figure 7-4.

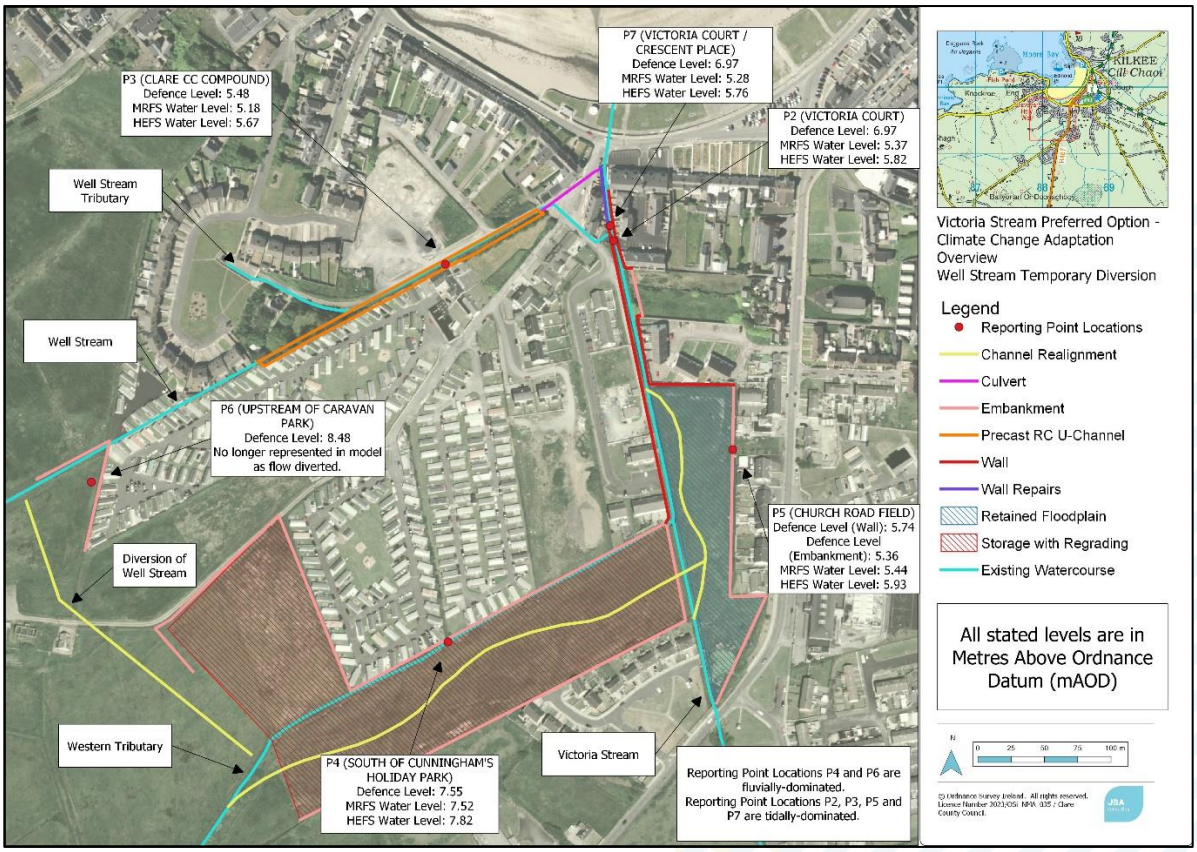

Figure 7-4 Victoria Stream with Well Stream diversion in place

It should be noted that significant uncertainty exists with the downstream boundary level considered in the climate change scenario. This downstream boundary considers no coastal flood alleviation scheme being implemented. This, therefore, is the worst-case scenario. It is important to include this in the Climate Change Pathway. This is included in the Climate Change Adaptation Plan and repeated here for reference.

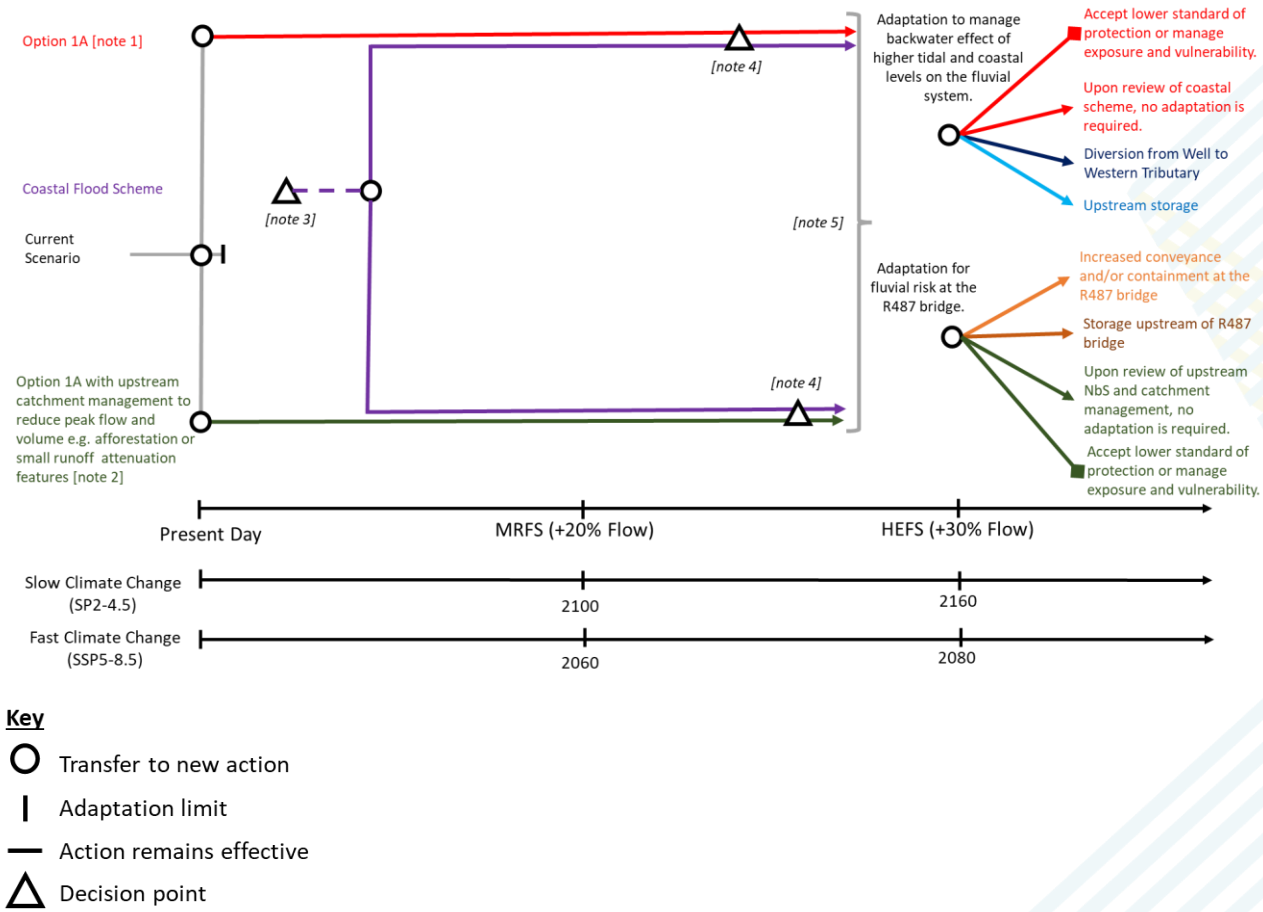

Figure 7-5 Victoria Stream Climate Change Pathway

This pathway identifies a hold point approximately halfway towards the MRFS. This is to review any completed/pending coastal scheme and appraise the fluvial scheme with these new parameters.

7.6 Climate Change Adaptation included in Victoria Stream Preferred Option

The following elements are intended to be constructed to their climate change adaptation levels as part of the present-day scheme.

- The Victoria Court boundary walls.
- The Well Stream u-channel walls, up to MRFS.
- The Victoria Stream left-hand bank flood defence wall, up to MRFS.

The levels to which these are being constructed to vs. their respective climate change water levels is shown in Figure 7-3.

These costs have been included in the proposed scheme construction costs.

8 Economic Appraisal of Shortlisted Options

The scope of this assessment is to derive flood damages for the Kilkee Flood Relief Scheme. The economic flood damages of the scheme have been calculated in the form of Annual Average Damage (AAD), based on a range of probabilities and a resulting Net Present Value (NPV) of damages. This section provides the results and supporting data for the assessment. The methodology contained in the OPW CFRAM Guidance Note 27 has been used to calculate the damages for this study.

8.1 Option Benefits

Benefits of a scheme can be divided into either tangible or intangible benefits.

Tangible benefits are those to which it is possible to assign monetary values. In general, the benefit is assigned a valuation equivalent to the monetary loss that would occur if the scheme were not in place. These include a reduction in:

- Direct Damage to buildings and contents
- Indirect Property, community, and business
- Disruption of road traffic

Intangible benefits are those to which it is not possible to assign a monetary value from recognised economic principles. Monetary values placed on these benefits are therefore subjective. Intangible benefits include:

- Avoidance of anxiety, inconvenience, and ill health
- Avoidance of the inconvenience of post flood recovery.

For this appraisal, the range of benefits comprise the following:

- Tangible Benefit – Residential properties flooding avoided.
- Tangible Benefit – Non-Residential properties flooding avoided.
- Infrastructure utility cost, damages avoided
- Emergency services costs, damages avoided
- Intangible benefits for residential properties and some locally owned commercial properties

8.2 Baseline and Climate Scenarios Flood Damage Data

Flood damages are a potential tangible benefit of the scheme that have been calculated using the baseline scenario**.** To carry out this assessment flood damage data is used.

A considerable amount of research has been undertaken by the Middlesex Flood Hazard Research Centre (FHRC) on the costs of flood damage in urban areas in the U.K.

The land use in a flood prone area (often referred to as the Benefit Area) influences the likely damage characteristics and costs. Houses are affected differently from offices and warehouses, which in turn, suffer different kinds and costs of damage from those experienced in industrial premises. Various land use sectors have been chosen to assess the impact of different depths of flooding on each. Flood damage data for the residential, retail, distribution, office and manufacturing sectors are provided in the Multi-Coloured Handbook (MCH) 2019. Detailed descriptions of these data sets are provided in Chapters 4 and 5 of the Manual. Additional costs for emergency services in dealing with flooding are also given in Chapter 6. All cost data in the MCH is in sterling values, which have been converted to Euro values for the purposes of this scheme.

In the MCH, for a particular property, the damage due to flooding is a function of both flooding depth and its duration. Depths considered in the residential dwellings sector range from -0.3m to +3.0m in relation to the ground floor of the buildings. Information is tabulated for flood durations less than and greater than 12 hours.

The MCH provides a set of databases for retail, commercial and industrial flood damage. The FHRC derived the depth/damage data sets based on data collections and discussions with representatives from a range of non-residential properties.

8.2.1 Property Categorisation Assumptions

The geodirectory database (property point attributes) from An Post Geodatabase was used in GIS shapefile format. Each point was assigned a building polygon derived from the OSI vector mapping.

Threshold levels for each property were assigned from the survey contract. For the un-surveyed buildings the MEAN Digital Terrain Model (DTM) value within perimeter was calculated in GIS and used as threshold. For non-surveyed caravans an average threshold of 650mm above ground level was applied (average surveyed threshold).

To link these data to the property descriptions and hence damage curves outlined in the Multi-coloured Manual the following assumptions were made:

- Residential damages would be based on the sector average for each type of property with the sector average applied where no category was available. No age or social class data was included in the assessment.
- Commercial property damages have been based on a conversion of the An Post GeoDirectory data to Multi-Coloured Handbook (MCH) codes using conversion tables provided by the OPW. Site visits and google street view was used to aid the identification of property types to ensure the correct MCH code has been applied.
- Unknown properties were verified by using google street view, google maps and site visit.

FRISM©JBA (FRISM is a GIS package that computes a range of flood risk metrics based on flood hazard and receptor data) was used to estimate direct damages per property per event. The following parameters have been applied:

- The depth of flooding at each receptor is the maximum flood level within the perimeter of the property boundary.
- MCH 2019 curves used. Residential split by type. Using floor area from building footprint from OSI vector mapping to factor depth-damage curve per m^2. Floor area calculated using GIS analysis.
- Residential curves from 2019 applied.
- Damage curve conversion factor: CPI for inflation from 2019 to 2020, Purchasing Price Parity for conversion of £ to €.

Some outbuildings have been retained in the receptor database, where they could incur damages. These have not been grouped with the main building within the property as threshold levels differ. If it was clear that the outbuilding is a garage or shed, it was removed from the assessment as suggested in the Multi-Coloured Handbook (MCH).

In summary, the total number of properties being defended by the scheme are:

Table 8-1 Breakdown of protected properties

	Atlantic	Victoria	Total
Residential	35	83	118
Non-residential	2	7	9
Non-residential (caravan attribute)		7	7
			134

8.2.2 Flood Duration

For the Kilkee Flood Relief Scheme the eight events (AEP) used were 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% from Baseline (Existing) hydraulic model for each scenario:

- Baseline Current (Present Day)
- Baseline Medium Range Future Scenario +20% increase (MRFS)

And 10%, 1%, and 0.1% for:

- Baseline High End Future Scenario +30% increase (HEFS)

8.2.3 Property Capping Assumptions

For residential sector, capping values are available from property tax valuation and *daft.ie*. *Daft.ie* provides real up to date values and it was decided to use average values per building type from this website in this damage assessment study. The value has been multiplied by 2 to represent the intangible and indirect damages.

For commercial sector, the rateable values would be usually used from *valoff.ie* but the existing valuation for Kilkee area is not complete and the properties have not been revalued under the Valuation Act 2001. Therefore, the commercial capped values were taken from other similar studies. The capping values for non-residential properties is an average rateable price per m^2 per each type multiplied by 10 and by the floor area.

8.2.4 Infrastructure Utility Assets and Emergency Sector

For the area, economic damages to infrastructural utility assets (e.g. electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) was calculated as 20% of total direct property costs. Costs to emergency services (which include evacuation costs) have been included in the economic damages and have been calculated as 8.1% of the total direct property costs for the area.

8.2.5 Intangible and Indirect Damages

Flood events can cause significant stress, anxiety and ill health to potentially affected people, during and then after a flood. Individuals generally also incur some costs due to their properties flooding that are not directly related to damage, such as evaluation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc.

For residential properties, the intangible and indirect flood damages were set equal to the total (direct) property damage.

For commercial properties, the following properties have been assumed as family businesses whose loss to the community could not be replaced by an alternative in a separate location.

- O'Neill's Amusements
- Cunningham's Caravan Park Main Building

8.2.6 Traffic Disruption

No significant traffic disruptions resulting from flooding in the area were identified and therefore not considered in the damages calculations.

8.2.7 Discounting and Present Day Value Damages (PVd)

Given a choice between receiving a specific sum now and the same amount sometime later, most people will express a preference for the present sum. The tangible benefits accruing from a flood alleviation scheme will not provide cash sums to the beneficiaries; however, they will prevent a negative cash flow (avoidance of associated flooding costs) from the individuals.

The avoidance of fixed negative cash flow now is also preferable to avoidance sometime in the future. The "social time preference" (STP) can be measured by an appropriate Discount

Rate (STPDR) and is taken as the compound rate of interest 'r' (% per annum) by which 'y' Euros in 'x' years' time is equal to one euro now.

The benefits arising from a flood relief scheme commence on the completion of the scheme and exist for the life of the works. To obtain a method of the overall benefit in present day monetary values, it is necessary to:

- Estimate the average damage arising each year of the project life, termed the Average Annual Damages (AAD).
- Discount the AAD to present values using the appropriate discount rate.
- Total the present values to obtain the overall damages.

The Department of Finance's discount rate for public investment is 4%. The lifetime over which the damages are discounted is taken as 50 years. For computation purposes, it is assumed that the residual value of the scheme at the end of the period is null. This may be regarded as somewhat conservative, since works typically have a design life of 100 years.

8.2.8 Calculation of Annual Average Damage (AAD) and Present Value of Damages (PVd)

The Annual Average Damage (AAD) was calculated using linear interpolation between damage values for each of the eight defined design event probabilities. The AAD is calculated as the sum of the damage values of each probability, up to and including the 1% AEP event (the design standard of the scheme) as the upper bounding event.

The analysis ignores both the damages and any additional design benefits arising from events greater than the design standard.

Accordingly, as damages have not been calculated for events greater than the Design Standard of the Scheme, construction of the Scheme would result in the total benefit being equal to the calculated total damages figure.

The Average Annual Damage, discounted at a rate of 4% per annum, is then calculated over a time-horizon of 50 years to produce a Net Present Value of the potential flood damage. This represents the Net Present Value of the benefit of the Scheme.

The uncapped and capped properties are shown in Figure 8-1 and Figure 8-2, respectively. The estimated 1% AEP event present-day is €10,441,803.

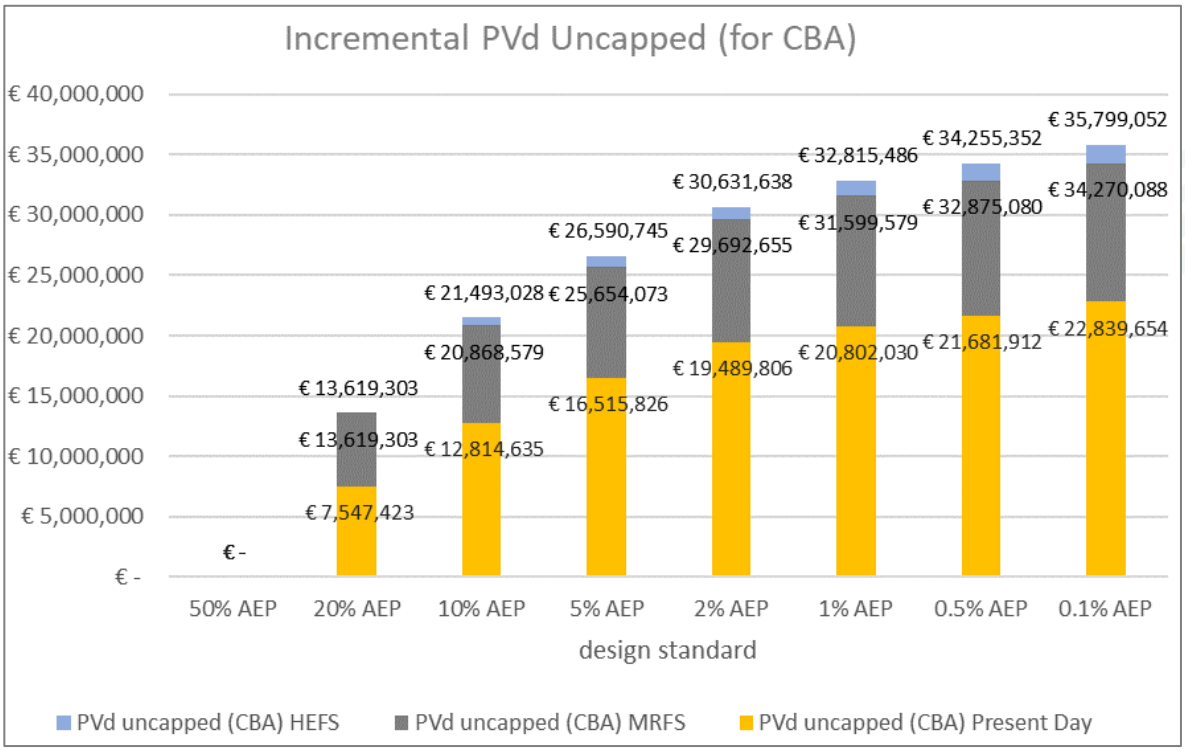

Figure 8-1 Incremental PVd of uncapped properties

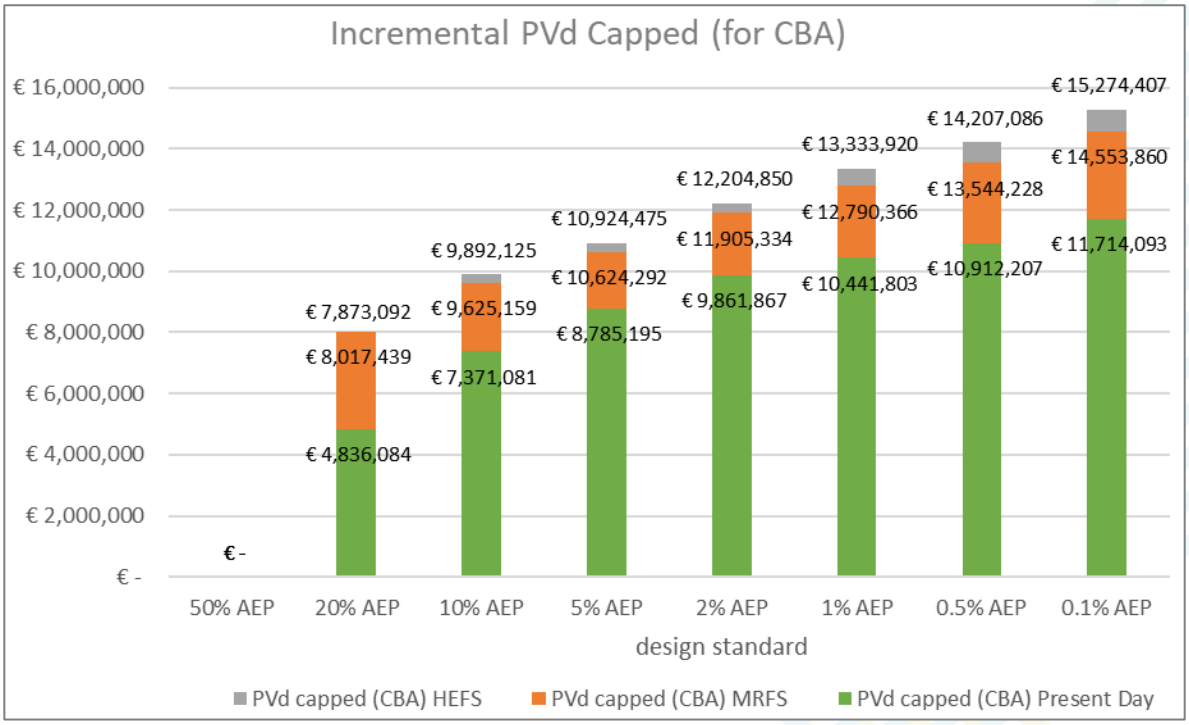

Figure 8-2 Incremental PVd of capped properties

It is the capped property damages that is used for the purpose of the Cost Benefit Analysis.

For the Victoria Stream, the damages are €7,576,098 or 72% of the overall damages. The remaining €2,865,706 damages are linked to the Atlantic Stream.

8.3 Option Costs

The Victoria Stream and Atlantic Stream were separated for costing purposes. They are separate watercourses and have their own extent of damages. Therefore, to determine their Cost Benefit, it was necessary to separate both.

8.3.1 Methodology

When building up cost estimates for a scheme of this scale, it is important that the expected whole life costs of the works and its management are developed and not just the scheme capital costs. The following are the elements that were considered when developing cost estimates for the project:

- Construction costs (including environmental mitigation measures)
- Design and site supervision costs
- Site investigation and survey costs
- Land purchase and compensation costs
- Maintenance costs
- Allowance for optimism bias
- Allowance for art
- The following costs were excluded:
- Value Added Tax

8.3.2 Construction Costing Method

Base costs for construction elements of the scheme were obtained from the following sources: -

- Estimates and tendered rates from similar civil engineering contracts and
- Published cost databases, including the NRA unit cost database and the draft OPW unit cost database.

The following assumptions have been made when compiling the construction cost estimates:

- Normal working week for construction personnel and plant.
- No exceptional adverse weather.
- Construction contracts with values of between €15m and €20m and durations of 18 to 24 months.
- Significant costs of traffic management within space restrictions in urban environment.
- Allowance of 10% for known unmeasured items such as local drainage, services etc. This is based on the Unit Cost Database recommended values.
- A 16% allowance for preliminaries has been included in line with Unit Cost Database recommended values.

Environmental and archaeological monitoring will be required during the construction of the works. It is also likely that some environmental mitigation and improvement works will be necessary.

An allowance has been made for design and site supervision costs, reflecting the current best estimate of the likely duration of the construction contracts and required size of site supervision teams for the construction phase only.

The total maintenance cost over the 50-year life span of the scheme is accounted for by applying a factor of 20% to the baseline cost in Net Present Value terms as costs are discounted over time.

There can be a tendency for budget cost estimates for flood defence schemes to be overly optimistic. In a project of this nature where access for labour, plant and materials will be difficult, including a robust contingency in the cost estimate is essential. A contingency/optimism bias of 30% of the construction cost has been included in the whole project cost. This is to account for the uncertainty around final costs at this outline design stage and to allow for inflation risks between now and the time of construction.

The "per cent for art" scheme is compulsory for all major public works contracts. For this size of project, the required allowance for art is 1% of the capital cost up to a maximum of €64,000.

8.3.3 Victoria Stream Options Costs

Table 8-2 below presents the total cost of each of the Victoria Options. The pricing references the areas where measures are proposed, these are identified in Figure 8-3.

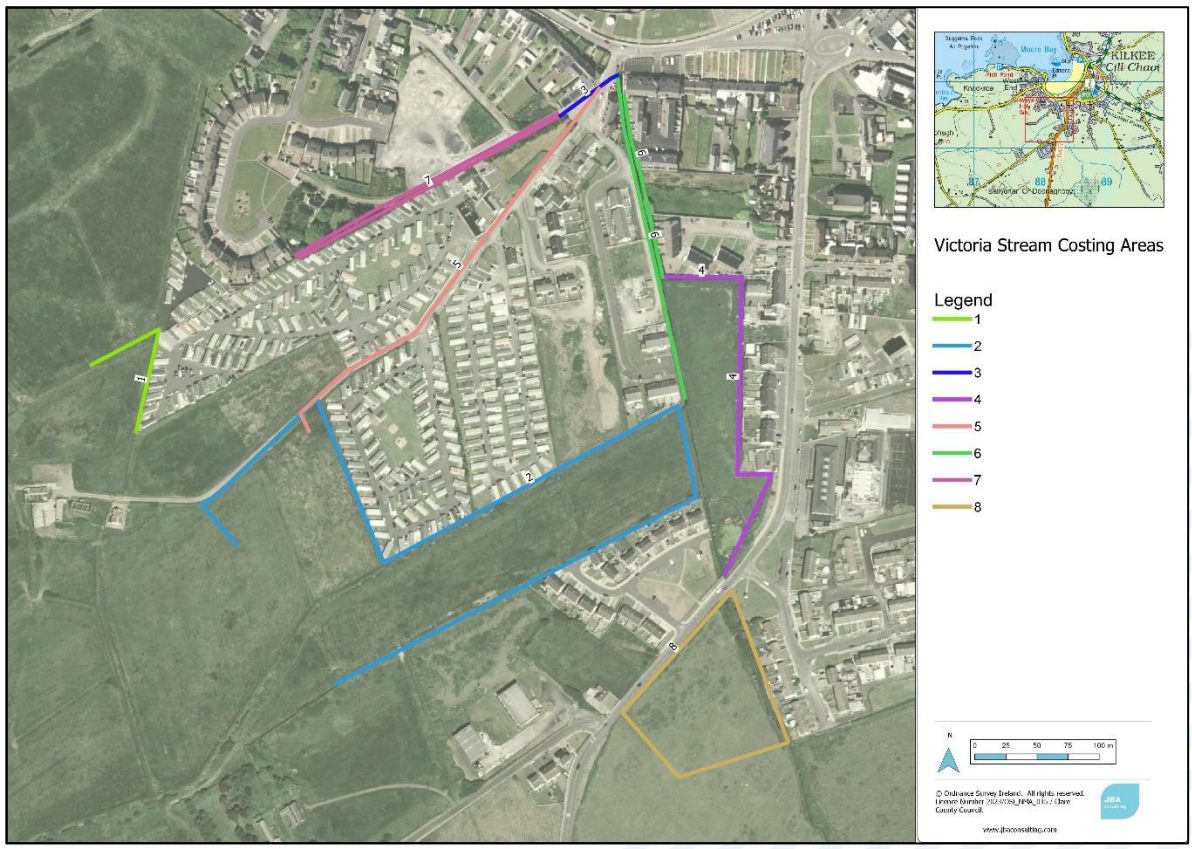

Figure 8-3 Victoria Stream Costing Areas

Table 8-2 Victoria Stream Costs

	Option 1a	Option 1b	Option 2	Option 3
Construction Costs				
Measured:				
Area 1	€11,692.69	€11,692.69	€11,692.69	€12,462.13
Area 2	€469,472.66	€469,472.66	€522,274.46	€575,257.92
Area 3	€146,500.00	€146,500.00	€146,500.00	€146,500.00
Area 4	€228,977.45	€228,977.45	€436,388.18	€209,039.83
Area 5	-	-	-	€765,912.00
Area 6	€457,730.78	€457,730.78	€457,730.78	€457,730.78
Area 7	€566,700.00	€1,061,934.22	€566,700.00	€566,700.00
Pluvial	€615,000.00	€615,000.00	€615,000.00	€615,000.00
Subtotal	€2,496,073.58	€2,991,307.80	€2,756,286.11	€3,348,602.66
10% Contingency	€249,607.36	€299,130.78	€275,628.61	€334,860.27
10% Unmeasured Works	€249,607.36	€299,130.78	€275,628.61	€334,860.27
16% Preliminaries	€399,371.77	€478,609.25	€441,005.78	€535,776.43
Sub total	€3,394,660.07	€4,068.178.61	€3,748,549.12	€4,554,099.62
Optimism Bias 30%	€1,018,398.02	€1,220,453.58	€1,124,564.73	€1,366,229.89
Land Purchase	€116,000.00	€116,000.00	€138,000.00	€110,000.00
Art	€33,946.60	€40,681.79	€37,485.49	€45,451.00
Enabling Works				
Design & Construction Supervision	€677,338.12	€777,153.57	€729,784.48	€849,167.06
Investigation & Surveys	€50,000.00	€50,000.00	€50,000.00	€50,000.00
Environmental & Arch Monitoring	€22,065.29	€26,443.16	€24,365.57	€29,601.65
Operation & Maintenance (50 yrs)	€1,062.481.62	€1,259,782.14	€1,170,549.88	€1,400,927.84
Total	**€6,374,889.72**	€7,558,692.84	€7,023,299.27	€8,405,567.06

As can be seen from Table 8-2, Option 1a is the most cost-effective solution.

8.3.4 Atlantic Stream Options Costs

Table 8-3 presents the costs for the Atlantic Stream Options. As with the Victoria Stream Options, a number of areas have been identified to delineate the measures proposed for purposes of costing. These are presented in Figure 8-4.

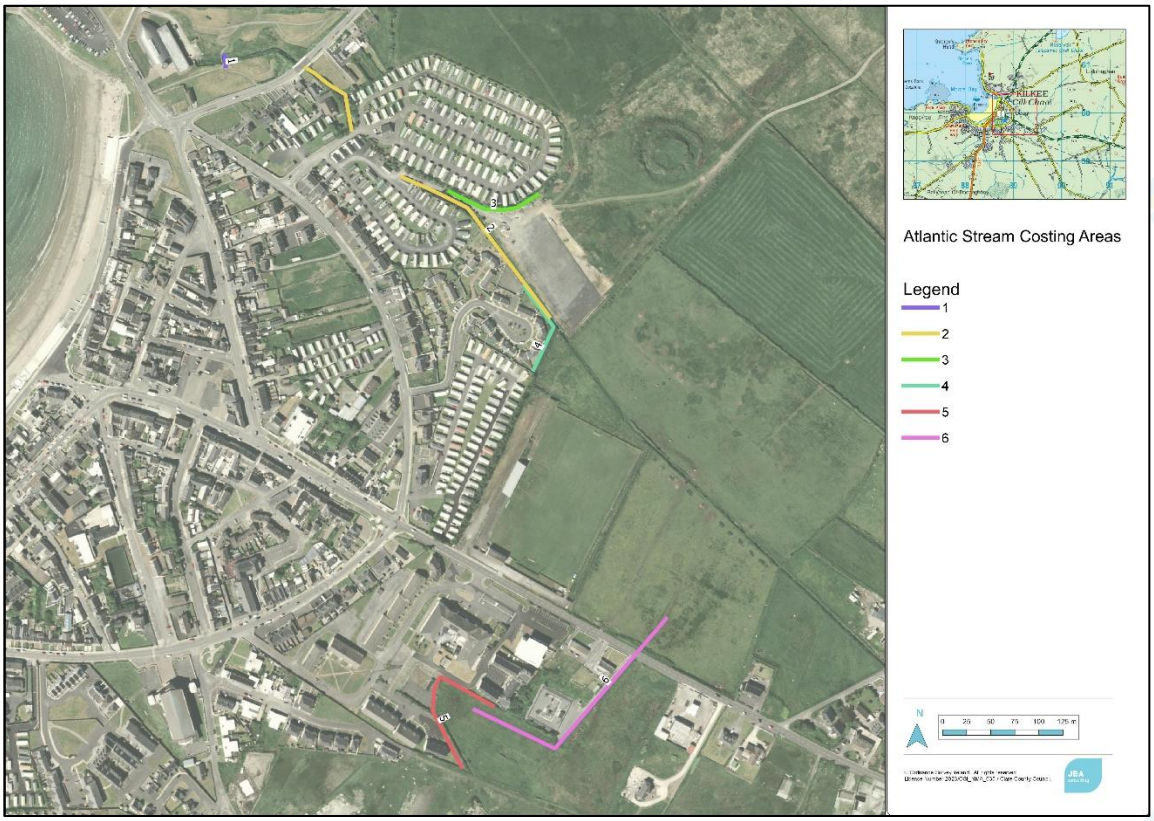

Figure 8-4 Atlantic Stream Costing Area Breakdown

Table 8-3 Atlantic Stream Costs

	Option 1	Option 2	Option 3
Construction Costs			
Measured:			
Area 1	€60,000.00	€60,000.00	€60,000.00
Area 2	-	€109,792.00	-
Area 3	€38,071.32	-	€17,740.79
Area 4	€35,300.00	-	€35,300.00
Area 5	€49,958.27	€49,329.88	€30,134.80
Area 6	-	-	€495,597.12
Subtotal	€183,329.59	€219,121.88	€638,772.71
10% Contingency	€18,332.96	€21,912.19	€63,877.27
10% Unmeasured Works	€18,332.96	€21,912.19	€63,877.27
16% Preliminaries	€29,332.73	€35,059.50	€102,203.63
Subtotal	€249,328.20	€298,005.80	€868,730.90
Optimism Bias 30%	€74,798.47	€89,401.73	€260,619.27
Land Purchase	€88,000.00	€89,401.73	€26,000.00
Art	€2,493.28	€2,980.06	€8,687.31
Enabling Works			
Design & Construction Supervision	€211,199.95	€218,413.95	€302,995.42
Investigation & Surveys	€50,000.00	€50,000.00	€50,000.00
Environmental & Arch Monitoring	€1,620.63	€1,937.04	€5,646.75
Operation & Maintenance (50 yrs)	€135,488.12	€150,947.71	€304,535.93
Total	**€812,928.70**	€905,686.25	€1,827,215.56

As is seen from Table 8-3, Option 1 is the most economically advantageous option for the Atlantic Stream.

8.3.5 Atlantic Stream Outfall Options

A separate costing of options for the Outfall upgrade on the Atlantic Stream was undertaken. This was solely an exercise in assessing viable engineering options. As can be seen from Table 8-4, There is a standout option that results from the costing exercise. This cost (Option 2) was thus included in the MCA costing exercise with each of the Atlantic Stream Options. Note, design and Construction supervision were not included in this costing exercise, as these would be deemed to be included in the overall Atlantic Stream costing.

Table 8-4 Atlantic Stream Outfall Options

	Option 1 (New Culvert)	Option 2 (Upgrade of existing MH)
Construction Costs		
Measured Construction Cost: 10% Contingency 10% Unmeasured Works 16% Preliminaries	€485,300 €48,530 €48,530 €77,648	€30,000 €3,000 €3,000 €4,800
Optimism Bias 30%	€198,002.40	€12,240
Art	€6,600.08	€408
Enabling Costs		
Design & Construction Supervision	-	-
Investigation & Surveys	€50,000.00	€50,000.00
Environmental & Arch Monitoring	-	-
Operation & Maintenance (50 yrs)	€182,922.10	€20,689.60
Total	€1,097,532.58	€124,137.60

8.4 Adverse flood risk mitigation

As identified in Section 6.7, there are certain mitigation measures needed where the fluvial scheme interacts with other flood mechanisms. There are both pluvial and coastal flood risks that are exacerbated by the flood relief scheme being in place. Therefore, mitigation measures are being included to ensure that this flood risk is reduced back to at least the baseline flooding.

In order to ensure these measures don't influence the fluvial options decision making, a consistent cost has been attributed to all options. Note, these costs are only required in the Victoria Stream works. The costs are identified in Table 8-2.

8.5 Cost Benefit Analysis

Cost benefit analysis examines the ratio between the total scheme cost and the total damages for the 1% AEP design event (the SoP event). A cost benefit ratio (CBR) of one indicates the scheme costs and damages are equal, values above one indicates a cost beneficial scheme and less than one a non-cost beneficial scheme.

The total damages for the Victoria Stream 1% AEP are: €7,576,098

The total damages for the Atlantic Stream 1% AEP are: €2,865,706

Table 8-5 below presents the cost benefit ratios for both the Victoria and Atlantic Streams. All of the proposed Atlantic Stream Options are cost beneficial. Only two of the proposed options in the Victoria Stream are cost beneficial. Option 1A (Victoria) & Option 1 (Atlantic) are the most economically advantageous.

Table 8-5 CBRs

	Victoria Stream Options				Atlantic Stream Options[1]		
	Option 1a	**Option1b**	**Option 2**	**Option 3**	**Option 1**	**Option 2**	**Option 3**
Estimated Cost	€6,374,889.72	€7,558,692.84	€7,023,299.27	€8,405,567.06	**€ 937,066.30**	€ 1,029,823.85	€ 1,951,353.16
Damages Benefitting from scheme	€7,576,098	€7,576,098	€7,576,098	€7,576,098	€2,865,706	€2,865,706	€2,865,706
Cost Benefit Ratio	1.19	1.00	1.08	0.9	3.06	2.78	1.47

1. Costs include both main Atlantic Stream Option cost and Atlantic Outfall Option 2 cost for each.

9 Multi Criteria Analysis of Options

Multi-Criteria Analysis (MCA) is a tool to compare proposed scheme options against one another using a set of flood risk management objectives. The following objectives are considered in the MCA:

- Technical
- Economic
- Social
- Environmental

Each of these objectives include subcategories for further assessment.

9.1 Technical Objective

The technical objective of the MCA relates to the overall success of the scheme in protecting receptors from flood risk. There are three sub-objectives under the technical objective listed in Table 9-1 which also details how the proposed scheme meets the objectives.

Table 9-1: MCA Technical Sub-objectives

Technical Sub-objective	Guidance on Scoring
Ensure flood risk management options are operationally robust	Scoring is to be by professional judgement, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems ('systems'), or on human intervention, action or decision ('intervention') to operate or perform successfully (i.e., to design).
Minimise health and safety risks associated with the construction and maintenance of flood risk management options	Scoring is to be by professional judgement. The PSDP (or person assigned the duties of PSDP where a company is nominated as PSDP) should review the scoring afforded to the preferred option(s) and other options that would be realistically in contention to be adopted as a preferred option based on other objectives, to ensure that the scoring is appropriate and reasonable.
Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it is always a consideration in option design and selection. It is recognised that the impacts of, and vulnerability to, potential future changes will vary significantly from community to community. However, this objective is used only for option selection, and is not used for prioritisation, and so the relative significance of the impacts and vulnerability to potential future change between communities is not relevant. As promoting adaptability is always important, the local weighting is to be kept constant.

9.2 Economic Objectives

The economic objective of the MCA considers the total benefits the scheme provides to the area. There are four sub-objectives, refer to Table 9-2.

Table 9-2: MCA Economic Sub objectives

Economic Sub-objective	Comments
Minimise economic risk	Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits. This indicator should be calculated on the basis of the economic damage analysis, to be undertaken in accordance with Guidance Note 27, but with no allowance for social / intangible benefits as these are provided for under other objectives within the MCA. The AAD values are presented in the results in Section 8.2.7. As all options protect the same properties the AAD with the option in place will be the same for all options and therefore all options will receive the same MCA score under this category, regardless of the AAD value.
Minimise risk to transport infrastructure	The local weightings should be calculated based on a score derived from the number and type of transport routes potentially blocked by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that route, taking account of the duration of flooding and the diversion time (in relation to road flooding). The following roads are impacted by the scheme: Marine Parade; Well Road; Carrigaholt Road; Crescent Place Road; Pumping Station Access Road. All roads are classified as local urban roads.
Minimise risk to utility infrastructure	Both the Uisce Eireann Pumping Station and the ESB Sub-station are at risk of flooding in the 1% AEP.
Minimise risk to agriculture	Some agricultural lands on the Western Tributary are proposed to be used for flood storage. This land is already subject to flooding in the baseline.

9.3 Social Objectives

The social objective of the MCA examines the impact the scheme has in relation to the local community and the visual changes to the area the scheme will have. There are four sub-objectives under this heading described in Table 9-3.

Table 9-3: MCA Social Sub-objectives

Social objective	Comments
Minimise risk to human health and life of residents	Options are scored based on the degree of reduction in the risk to residential properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5. $$Option\ Score = 5 \times \frac{Local\ Weighting - Residual\ Risk\ Score}{Local\ Weighting}$$
Minimise risk to high vulnerability properties	Each type of high vulnerability property is assigned a score. The types of high vulnerability properties are categorised and scored as follows: • Hospitals – 500 • Nursing Home – 250 • Prisons – 250 • Camping Sites – 100 • Schools - 50

Minimise risk to infrastructure and amenity	All social infrastructure and amenity assets should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each asset should be afforded a score of 25. A weighting has not been applied to the scores, as all social infrastructure and amenity assets (where included) were designated during the PFRA vulnerability assessment as being of 'moderate' vulnerability, except for schools where a 'high' vulnerability classification was assigned due to elevated risk to human health and life arising from the concentration of children, which is provided for under Objective 3.A. (ii).
Minimise risk to local employment	All non-residential properties that are not derelict should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each property should be afforded a score of 5. A differential weighting has not been applied to the count, as reliable information would not be available as to the number of employees for any given property, nor of the indirect employment associated with that property / business.

9.4 Multi-Criteria Analysis (MCA) Results

The environmental objective includes the most sub-objectives which are shown in Table 9-4. The scheme should be as environmentally neutral or beneficial as possible given the works undertaken and the final configuration.

Table 9-4: MCA Environmental Sub-Objective

Environmental objective	Comments
Support the objectives of the Water Framework Directive (WFD)	The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on water body status elements, the sensitivity of the receiving water bodies, and the potential sources of pollution in the flood extent area. As there are no hydromorphology pressures identified in the River Basin Management Plan (RBMP) for the reaches in the study area, constraints are limited to construction works and operational effects potentially impacting on sensitive EU protected sites. The dominant impacts are where in-stream works are proposed (negative) or storage/wetland proposals (positive). For example, the wetland proposal upstream of the Victoria Stream provides a positive intervention for Water Framework Directive (WFD). However, the construction of walls adjacent to the existing watercourse present a temporary risk to the water quality.
Support the objectives of the Habitats and Birds Directive	There is no connection to Natura 2000 sites, and no impact on Annex IV species. No impact on existing SAC, SPA or Ramsar sites as a result of flood risk management measures. All options thus score 0.
Avoid damage to or loss of, and where possible enhance, the flora and fauna of the catchment	Re-alignment of channels creating new wetland habitats and floodplain retention will keep habitat suitable for birds, particularly red listed Snipe. Construction of flood storage areas could allow for creation of local conservation sites. Conservation management of Eels on these watercourses are not listed, but scheme will provide improved spawning

	habitats. Where the Well Stream is culverted (Option 1b), a reduced score results.
Protect, and where possible enhance, fisheries resource within the catchment	All existing fish migration routes will be maintained when the scheme is in place. There is a creation of fisheries potential in the ICW, given the reinstatement of the natural hydrological and morphological regime through channel realignment.
Protect, and where possible enhance, visual amenity, landscape protection zones and views into/from designated scenic areas within the river corridor	Interventions such as the flood storage areas provide a permanent enhancement of the visual amenity. There will be a temporary negative impact during the construction of all elements.
Avoid damage to or loss of features of architectural value and their setting	A minor positive score is assigned to all options equally for the protection of the church (Reg. no. 20301012) at Geraldine Place.
Avoid damages to or loss of features of archaeological value and their setting	There are no known architectural features that are impacted by the proposed scheme.

9.5 Environmental Objectives

9.5.1 Victoria Stream MCA

The following table presents the results of the MCA Assessment for the Victoria Stream measures.

Table 9-5 Victoria Stream MCA Score

		Option 1a	Option 1b	Option 2	Option 3
Technical	**a**	300	300	300	300
	b	100	100	100	100
	c	300	100	300	100
	Total	**700**	**500**	**700**	**500**
Economic	**a**	60	60.0	60.0	60
	b	246.0	246.0	246.0	246
	c	336.00	336.0	336.0	336
	d	72	72.0	36.0	72
	Total	**714**	**714**	**678**	**714**
Social	**a (i)**	151	151	151	151
	b (ii)	-166	-166	-166	-166
	c (iii)	3	3	3	3
	d (iv)	3	3	3	3
	Total	**-8**	**-8**	**-8**	**-8**
Environmental	**a**	240	80.0	320.0	160
	b	0	0.0	0.0	0
	c	125	75.0	100	125
	d	52	-26	78	26
	e	16	0	24	16
	f	8	8	8	8
	Total	**441**	**137**	**530**	**335**
Option Selection Score (Total Sum of all criteria)		1847	1343	1900	1541
MCA Benefit Score		1147	843	1200	1041
Cost		€6,374,889.72	€7,558,692.84	€7,023,299.27	€8,405,567.06
Damages		€7,576,098.00	€7,576,098.00	€7,576,098.00	€7,576,098.00
Economic BCR (Damages/Cost)		1.19	1.0	1.08	0.9
MCA BCR (benefits per 1000 Euro) (MCA Benefit Score/Cost x 1000)		0.18	0.11	0.17	0.12

9.5.2 Atlantic Stream MCA

The following table presents the results of the MCA Assessment for the Atlantic Stream measures. Note the cost here includes both the Atlantic Stream plus the Atlantic Stream Outfall.

Table 9-6 Atlantic Stream MCA Score

		Option 1	Option 2	Option 3
Technical	**a**	-100	-100.0	-100.0
	b	200	200.0	100.0
	c	400	200.0	100.0
	Total	**500**	**300**	**100**
Economic	**a**	18	18	18
	b	243	243	243
	c	0	0	0
	d	-60	-60	-60
	Total	**201**	**201**	**201**
Social	**a (i)**	11	11	11
	b (ii)	0	0	0
	c (iii)	98	98	98
	d (iv)	1	1	1
	Total	**110**	**110**	**110**
Environmental	**a**	80	80	-240
	b	0	0.0	0
	c	12.5	37.5	0
	d	0	0	-26
	e	-16	-8.0	-16
	f	0	0.0	0.0
	Total	**76.5**	**110**	**-282**
Option Selection Score (Total Sum of all criteria)		887	720	129
MCA Benefit Score		387	420	29
Cost		€937,066	€1,029,824	€1,951,353
Damages		€2,865,706	€2,865,706	€2,865,706
Economic BCR (Damages/Cost)		3.06	2.78	1.47
MCA BCR (benefits per 1000 Euro) (MCA Benefit Score/Cost x 1000)		0.413	0.408	0.015

9.6 MCA Results Review

When the MCA Benefit scores are considered for both areas, the emerging preferred options are:

- Option 1A – Victoria Stream.
- Option 1 – Atlantic Stream.

In the Victoria Stream assessment, there is very little difference in the economic and social benefits or impacts. The dominant metrics are technical and environmental. Both option 1B & 3 score lowest on technical due to their inclusion of extensive culverted works.

Option 2 scores highest for environmental benefits due to its extent of wetlands area compared to the other areas.

In the Atlantic Stream assessment, Option 3 places lowest in all metrics. This negative scoring is dominated by its extensive culvert requirements.

Option 2 provides some additional environmental benefits over Option 1 due to the widening of the watercourse. Option 2's benefits are somewhat offset by the construction phase risk to the watercourse due to the extensive in-stream works required.

10 Selection of Preferred Option

Having assessed the various measures and options for both the Victoria & Atlantic Stream, preferred options for each emerges. Whilst cost is an important metric in option determination, it is not the deciding factor. The multi-criteria analysis allows for each option to be judged on multiple merits with location specific weightings. This allows for environmental, social and technical impacts to have tangible inputs into the decision process.

10.1 Victoria Stream

Four options were considered for the Victoria Stream. Options 1B & 3 contained significant culverted solutions. This resulted in both receiving low scores in the environmental and technical criteria, lower than that of either 1A or 2. There is very little in the way of economic benefits or impacts across all options, and all scored the same with regard to social impacts. Therefore, the environmental scoring becomes a dominant metric.

Both 1A & 2 provide very similar schemes, in each case the construction of wetlands and the minimisation of culverting solutions. The difference between both lies to the south of the Victoria Stream, with the creation of an additional storage area. Assessed environmentally, this option does become the most favourable solution, for its habitat creation and water quality improvement potential. Option 1A's MCA score is 1147, versus Option 2 with 1200. Both options are equally adaptable for climate change on a technical basis, with similar visual impacts when constructed.

The additional land acquisition does, however, impact on the cost of Option 2. So it needs to be considered then whether the additional benefits are proportionate to the extra spend. As seen in Table 9-5, the MCA BCR for Option 1A is 0.19, with Option 2 scoring 0.18. This scoring metric weighs the cost of an MCA point. This still shows very little in the difference.

Acquiring new land, regardless of cost, has potential in a time delay risk to a project. Therefore, any decision that includes this option, needs to be done so where appreciable benefits are being provided. The difference between the MCA BCRs of both Option 1A & 2 is 0.009. This is not a substantial difference to justify the additional cost of Option 2. Therefore, taking into account all factors, Option 1A is the preferred option. This is the option that was presented to the public at the Public Consultation Day in April 2023.

10.2 Atlantic Stream

Three options were considered for the Atlantic Stream. These can be classified as either containment, increased conveyance, or diversion solutions. All options are cost beneficial. Option 3, due to the increased costs related to the culvert diversion, has significantly higher costs. In addition to this, the culverting of the watercourse results in a poor environmental score. For these reasons, Option 3 is not considered as the preferred option.

Option 1 & 2 include interventions at similar locations. The storage behind the Kilkee Bay Hotel is included in both options. Elsewhere, Option 1 proposes containment of the watercourse using an embankment at the Dún an Óir estate, with a minor increase in the existing boundary wall. Option 2 proposes to widen the watercourse at this location as well as widening further downstream.

Whilst the stream-widening solutions provide some habitat potential and water quality benefits, it increases the risk of watercourse pollution during the construction phase. Therefore, the benefits need to be substantial to justify the risk. The MCA scores are similar for Option 1 & 2, 387 to 420 respectively. Comparing the MCA BCR for both results in Option 1 being slightly more favourable, 0.413 to 0.408. These scores show the additional cost and additional risk associated with Option 2 are not justified for the minor benefits that result from the option. Therefore, Option 1 is deemed to be the preferred option.

11 Conclusion

The aim of the Kilkee FRS scheme is to produce a scheme that will protect at-risk properties up to the 1% AEP event (Standard of Protection (SoP) event). The total baseline damages for the undefended 1% AEP event are €10,441,803.

The Options report follows on from the establishment of the baseline and existing scenario work to establish flood risk in the area and examines what could be put in place to provide the protection required. It considers all the constraints in the area, key flood risk mechanisms and receptors.

An initial high-level consideration of flood risk management methods was first carried out with viable methods used to develop measures that could be built within the existing system. The flood risk management methods identified as most beneficial were storage, containment, and conveyance.

Several measures were then tested and their impact on the overall flood risk to see which were viable. The overall benefit, buildability, environmental impact and complexity of each measure was taken into consideration when screened. From the measures testing, four options were identified for the Victoria Stream and three options for the Atlantic Stream.

These options were assessed through the Multi-Criteria Analysis (MCA) scoring which resulted in a preferred option for both. These were Option 1A for the Victoria Stream and Option 1 for the Atlantic Stream. In parallel with this, an options assessment was undertaken to define a preferred solution for the Atlantic Stream Outfall. Option 2 was found to be the preferred option for the Atlantic Stream Outfall.

The total project cost of the scheme is calculated to be €7,311,956.02 (ex VAT). Whilst there are, in-effect, two different hydraulic systems being considered it is one Flood Relief Scheme. Therefore, it is worth presenting a whole scheme CBR. With €10,441,803 worth of damages, and a scheme cost estimate of €7,311,956.02, the whole scheme has a CBR of 1.43.

In conclusion, a viable scheme option that is technically and environmentally possible and economically viable has been developed and is proposed for Kilkee.

Offices at

Dublin
Limerick

Registered Office
24 Grove Island
Corbally
Limerick
Ireland

+353(0)61 345463
info@jbaconsulting.ie
www.jbaconsulting.ie
Follow us:

JBA Consulting Engineers and Scientists Limited

Registration number 444752

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