

Gruggies Burn Flood Alleviation Scheme

Summary Report

April 2024



Balfour Beatty



FAIRHURST

Gruggies Burn Flood Alleviation Scheme

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CONTROL SHEET

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1. Introduction

1.1 Background

The Gruggies Burn is one of the principal watercourses which runs through the town of Dumbarton, West Dunbartonshire. The watercourse flows south from its source in the Kilpatrick Hills, discharging to the River Clyde immediately south of Dumbarton. While the burn's catchment is largely rural, its flow through Dumbarton is characterised by canalisation and the land use pressures associated with a heavily urbanised area. The hydrological characteristics of the watercourse are such that it regularly experiences fluvial flooding, creating significant challenges for Dumbarton's communities. This pressure is compounded by coastal flooding during high tides and storm surges at the burn's confluence with the River Clyde.

West Dunbartonshire Council (WDC) has appointed Balfour Beatty as the Design and Build Contractor for the Gruggies Burn Flood Alleviation Scheme (the Scheme), who have in turn appointed Fairhurst as designer. The objective is to develop proposals that allow for the justification, outline design and submission ('notification' or publication under the Flood Risk Management (Scotland) Act 2009) of the Scheme that is technically, socially, environmentally and economically acceptable, to alleviate the risk of flooding to the local community during the extreme design event.

1.2 Location

The Gruggies Burn is located in Dumbarton, and specifically within the Dumbarton East area of the town. The watercourse is formed from the confluence of the Garshake Burn and the Overtoun Burn and the catchment upstream of the A82 Stirling Road is rural with its source in the Kilpatrick Hills. These hills are steep, resulting in high runoff rates that can rapidly direct rainwater into the tributary burns, with limited potential for attenuation.

The Gruggies Burn flows under the A82 Stirling Road via a bridge and enters the urban conurbation area of Dumbarton East. Downstream of this point the watercourse is heavily modified with engineered river banks and walls. Residential and commercial properties are located close to the edge of the river and there are numerous road crossings which are achieved with culvert or bridging structures of limited flow capacity. The watercourse flows into the River Clyde to the south of Dumbarton and is consequently subject to tidal influence.

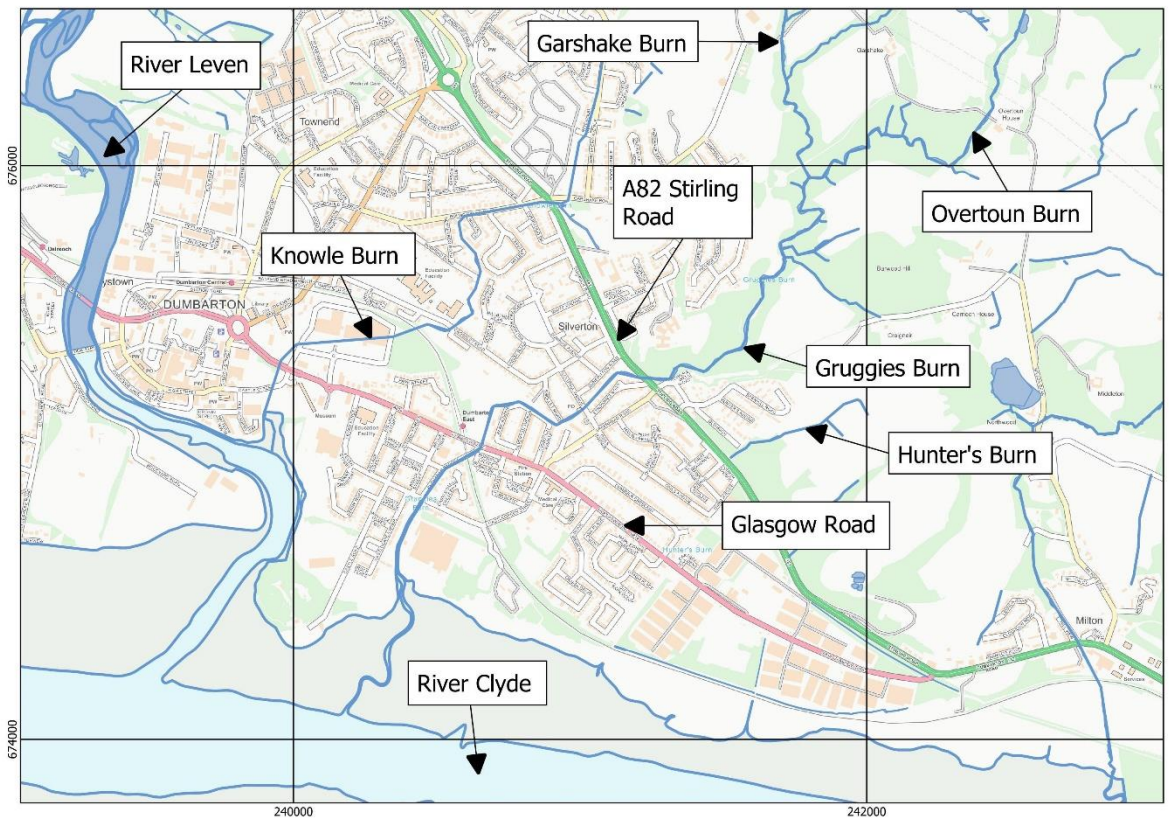


Figure 1: Gruggies Burn Location

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1.3 Need for the Scheme

Dumbarton East surrounding Gruggies Burn has seen several flooding incidents over numerous years. Local residents have reported being regularly affected by flooding, including impact on roads, accesses, gardens and buildings. The most recent severe flood event occurred in October 2023, which resulted in widespread flooding.



Figure 2: Flooding in Dumbarton East, October 2023 (Source: West Dunbartonshire Council)

There are two distinct sources which can cause flooding from the Gruggies Burn – high flows in the river coming from the topographic catchment, and high tide levels in the River Clyde. These can act in combination if high flows coincide with high tides. The Scheme takes account of both sources.

The area of Dumbarton East between the A82 Stirling Road and Glasgow Road is predominantly at risk from high flows. The risk of flooding is exacerbated by the road crossings of the watercourse which have a limited capacity to convey flow before flooding occurs. The area between Glasgow Road and the River Clyde is predominantly at risk from high tides.

1.4 Previous Work

There has been a relatively long history of previous work to consider flood alleviation to Dumbarton East from the Gruggies Burn. A summary of previous work is provided in Table 1.

Table 1: Previous Gruggies Burn Studies

Document	Issue Date	Source
Gruggies Burn, Dumbarton Flood Prevention Scheme Options Report	September 2004	Scott Wilson
Gruggies Burn, Dumbarton Flood Prevention Scheme Peer Review	August 2007	Jacobs
Gruggies Burn, Dumbarton Flood Prevention Scheme Flood Risk Assessment	January 2009	Jacobs
Gruggies Burn, Dumbarton Flood Prevention Scheme Pre-Feasibility Assessment	October 2011	Jacobs
Gruggies Burn Hydrology Update Report	November 2013	Jacobs
Gruggies Burn Flood Alleviation Scheme Site Appraisal Desk Study	December 2014	Mott MacDonald
Gruggies Burn Flood Alleviation Scheme Update of Cost-Benefit Assessment	April 2015	Mott MacDonald
Gruggies Burn Flood Alleviation Scheme Technical Note Optioneering Update	December 2015	Mott MacDonald
Gruggies Burn Flood Alleviation Scheme Options Report	August 2021	RPS

The findings of the August 2021 Flood Alleviation Scheme Options Report was presented to West Dunbartonshire Council’s Infrastructure, Regeneration and Economic Development Committee in a Report by Chief Officer – Roads & Neighbourhood (Shared Service), dated 15th September 2021. This set out that “Option 4 – Hard Defences and Flood Relief Culvert Route 1” was the recommended option, which was approved by the Committee on 15th September 2021. The recommended option forms the basis of the Scheme design presented in this Summary Report.

1.5 Scheme Summary

The Scheme consists of a number of distinct elements, summarised below and indicated on Figure 3.

- **Flow Diversion Weir and Culvert**

Construction of a raised weir in the Gruggies Burn upstream of A82 Stirling Road to control the flow of water downstream and divert peak flood flows into a flow diversion culvert.

Construction of a below ground culvert from the flow diversion weir to the River Clyde via Greenhead Road, National Cycle Route 7, Oaktree Gardens and Dogs Loan to divert peak flows and thereby reduce the risk of flooding within Dumbarton East from high flows in the Gruggies Burn.

The culvert outfall headwall will be located within land which is partly below the MHWS level of 2.0 mAOD, as shown on Drawing GBFAS-FRH-ZZ-ZZ-DR-W-102502.

- **Flood Walls**

Construction of new or replacement walls to the Gruggies Burn between Glasgow Road and the River Clyde shoreline to reduce the risk of flooding from extreme tidal flood events within Dumbarton East.

The bed of Gruggies Burn is below the MHWS level of 2.0 mAOD between the River Clyde confluence and Castlegreen Street, as shown on Drawing GBFAS-FRH-ZZ-ZZ-DR-W-102201. Upstream (north) of this the bed of Gruggies Burn is above MHWS.

- **Tidal Embankments**

Construction of a raised embankment from the east side of the Gruggies Burn above the River Clyde shoreline normal tides levels eastward towards the Scottish Water treatment works to reduce the risk of extreme tidal flood events within Dumbarton East and specifically properties on the south side of the rail line.

Construction of an embankment south of Dogs Loan at the outfall of Hunter's Burn and the flow diversion culvert to reduce the risk of extreme tidal flood events within Dumbarton East.

The embankments have been designed such that they are located on ground which is above MHWS, as shown on Drawings GBFAS-FRH-ZZ-ZZ-DR-W-102002 and GBFAS-FRH-ZZ-ZZ-DR-W-102003.

- **Tidal Flood Gate**

Construction of a removable or swing tidal gate and associated walls on Castle Road immediately to the south of Castlegate Avenue and the entrance to Dumbarton Football Stadium to reduce the risk of extreme tidal flood events resulting in water passing northward towards Dumbarton.

The tidal flood gate and associated walls are located on ground which is above MHWS, as shown on Drawing GBFAS-FRH-ZZ-ZZ-DR-W-102302.

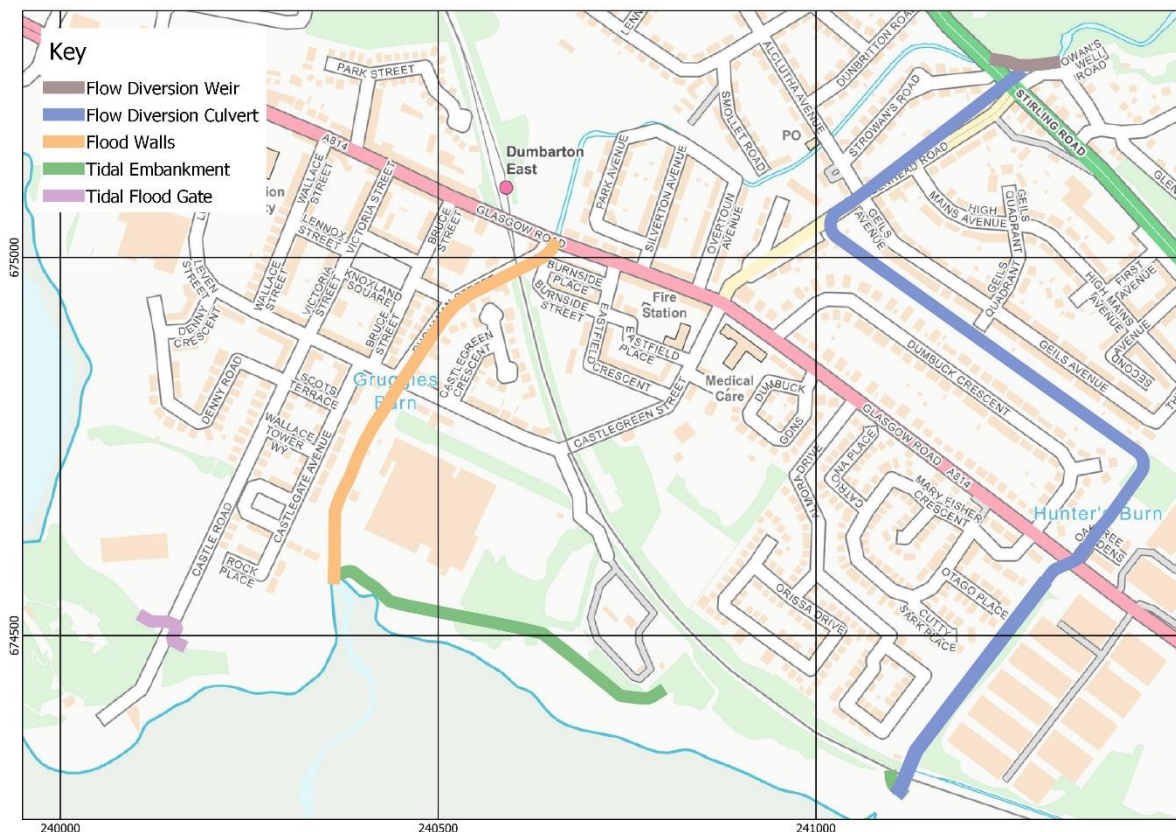


Figure 3: Scheme Summary

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The assessments for the Scheme have considered a range of floods and taken into account the potential impact of climate change on river flows and tide levels in the future. The Scheme has been designed to provide alleviation for an extreme design flood event.

2. Flood Protection Proposals

2.1 Introduction

The Scheme consists of a number of distinct elements which are described in the sections below. The assessments for the Scheme have considered a range of floods and taken into account the potential impact of climate change on river flows and tide levels in the future. The Scheme has been designed to provide alleviation for an extreme design flood event.

2.2 Flow Diversion

To alleviate the risk of flooding from high flows in the Gruggies Burn the Scheme will divert peak flows away from the watercourse and convey them to the River Clyde in a buried conduit. This will involve:

- Construction of a raised weir in the Gruggies Burn upstream of the A82 Stirling Road to control the flow of water downstream and divert flood flows into a flow diversion culvert.
- Construction of a below ground culvert from the flow diversion weir to the River Clyde via Greenhead Road, National Cycle Route 7, Oaktree Gardens and Dogs Loan.

The raised weir will include a pass forward flow control flume which will allow normal flows and bed material to continue down the watercourse to ensure that the Scheme does not have a significant adverse impact on the natural environment, including the habitat, wildlife, fish population and ecology of the river. The weir will divert flood flows into the culvert to be conveyed below ground in concrete structures without causing flooding elsewhere during the design event. In floods which exceed the design capacity of the buried conduit, water will flow over the 'exceedance control spillway' and continue down the Gruggies Burn.

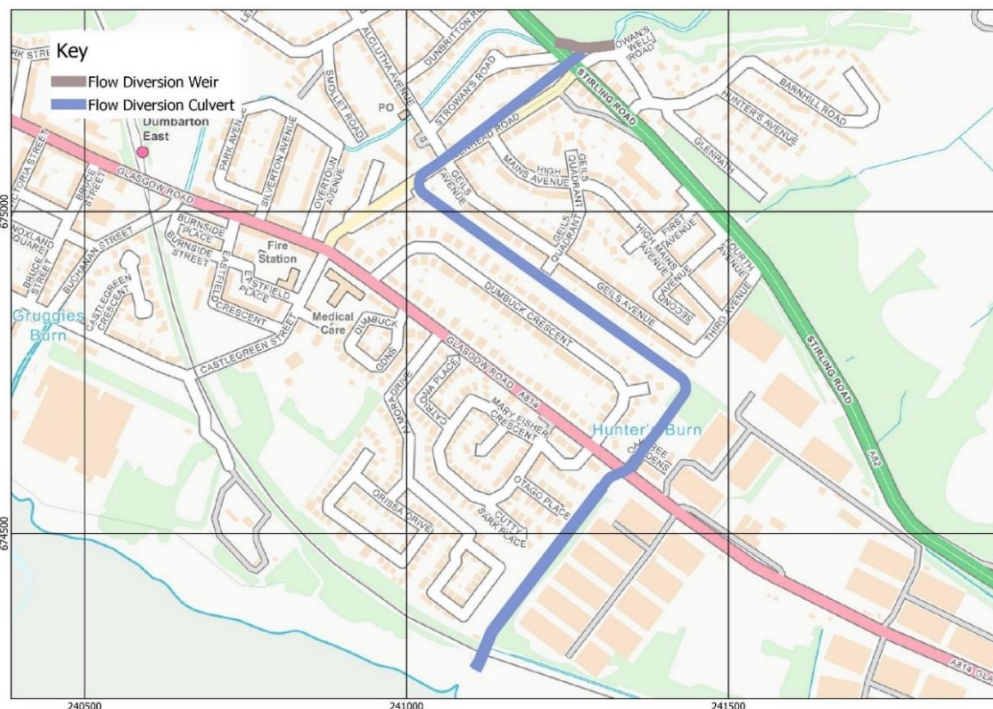


Figure 4: Flow Diversion Weir and Culvert Locations

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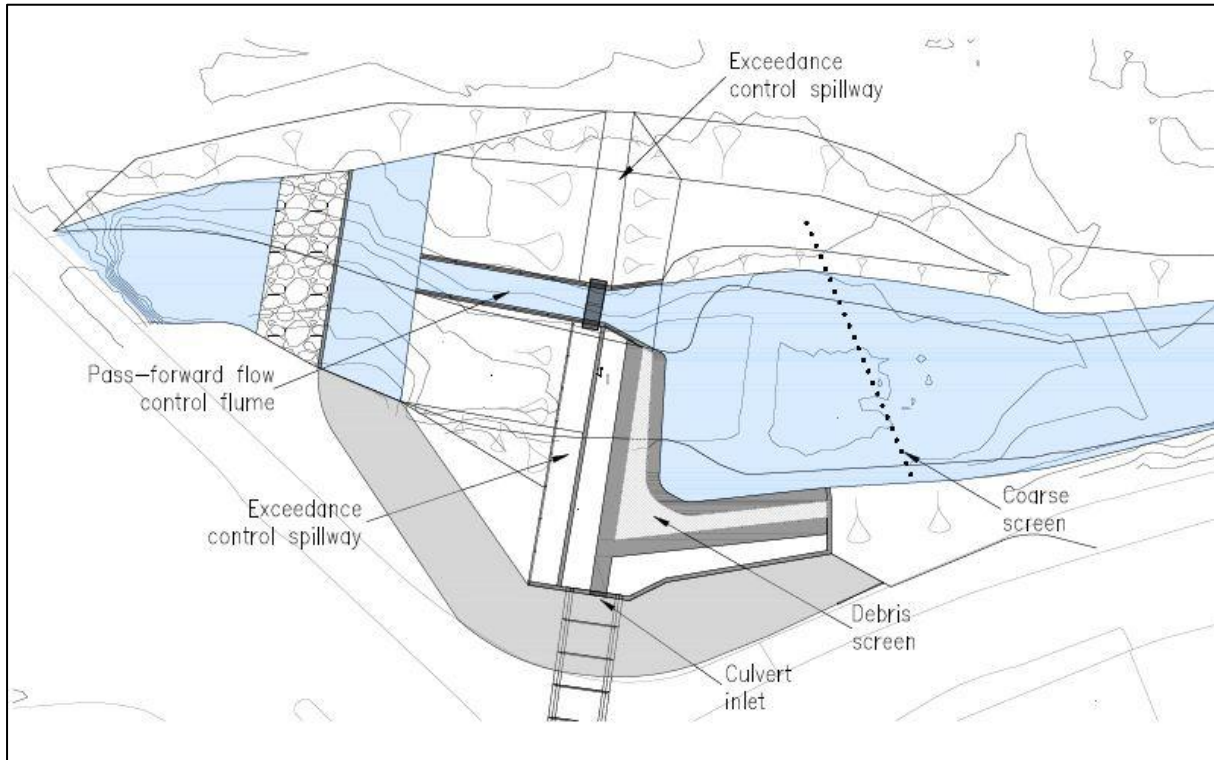


Figure 5: General arrangement of the flow diversion weir

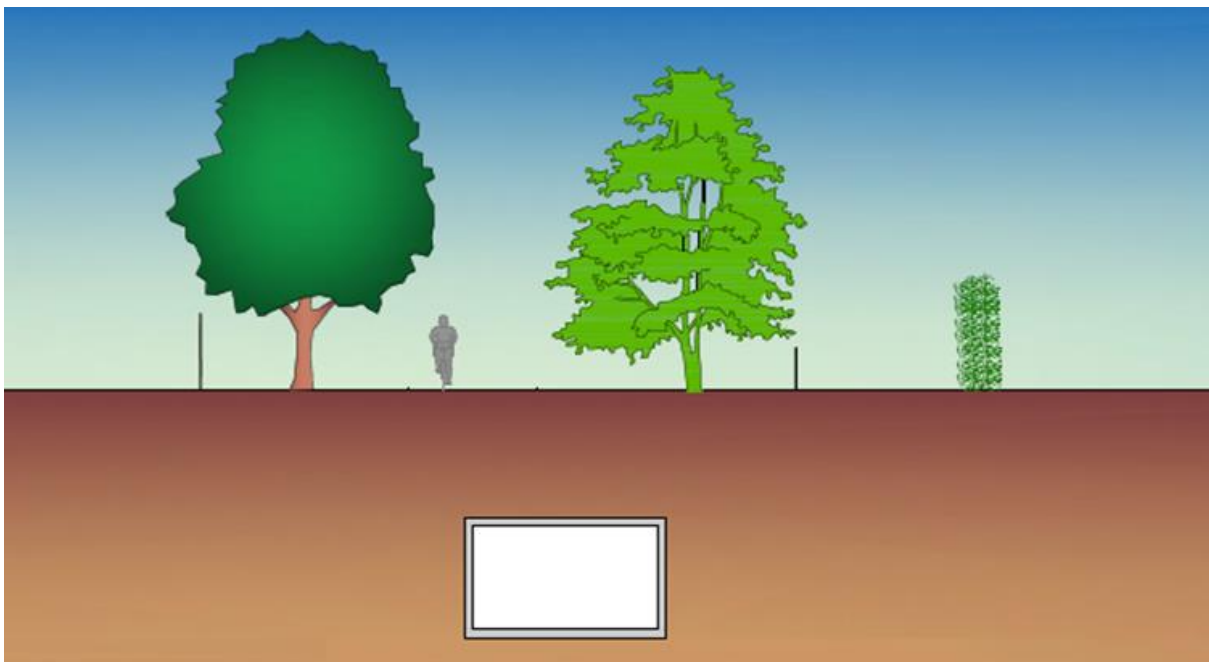


Figure 6: Illustrative cross section of buried conduit

2.3 Flood Walls

To alleviate the risk of flooding from high tide levels in the Gruggies Burn the Scheme will include the construction of new or replacement walls to the Gruggies Burn between Glasgow Road and the River Clyde shoreline.

Walls currently exist along one bank of the Gruggies Burn at Buchanan Street. However these do not meet the requirements of a modern flood alleviation scheme due to their condition and the numerous drainage holes which would allow high tide levels to flood the road.

New walls will be constructed on both banks of the river which will be continued across bridges/culverts by solid parapets to replace existing open fence arrangements. These will be of a similar height to the existing walls on Buchanan Street. The walls will incorporate drainage outfalls with non-return valves. These will allow surrounding drainage systems to discharge to the Gruggies Burn under normal conditions, but prevent water from flowing back into the drainage systems when tide levels are high. A seepage analysis has been undertaken which shows that there would be no water seepage on the dry side of the defences for the proposed design of the flood walls. Full details are provided in the Seepage Analysis Report for the Scheme (Reference GBFAS-FRH-ZZ-ZZ-RP-W-100003). In the vicinity of the Knoxland Square Conservation Area the walls are to be clad with a material that reflects the stone of the adjacent dwellings.



Figure 7: Existing flood wall at Buchanan Street (Source: Balfour Beatty)

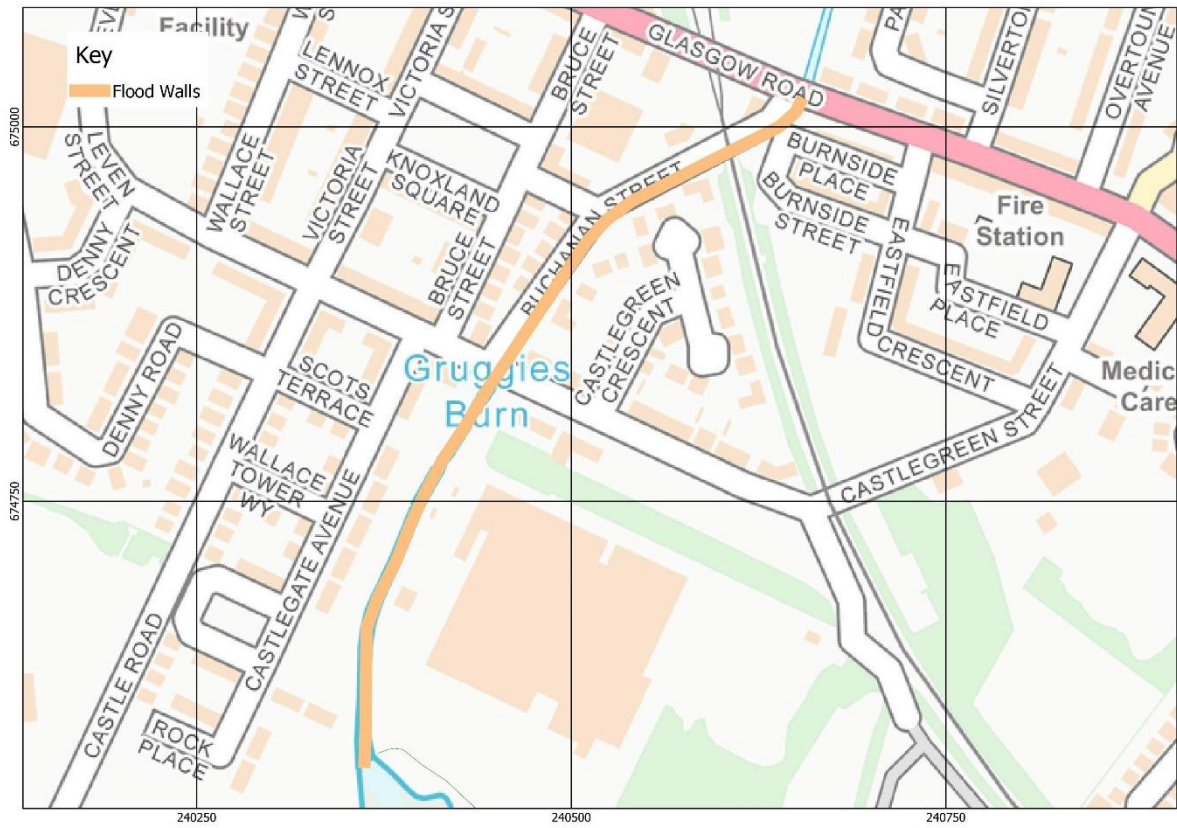


Figure 8: Flood Wall Locations

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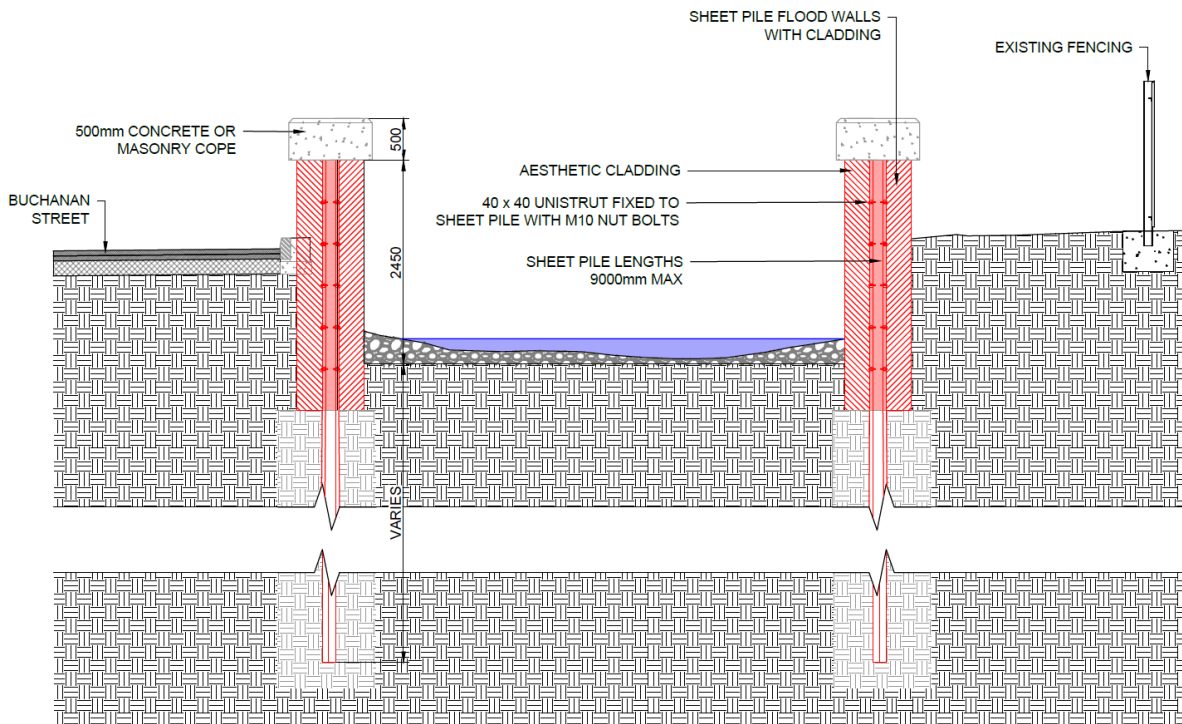


Figure 9: Typical cross section of new flood wall

2.4 Tidal Embankments

Dumbarton East is at risk of tidal flooding directly from the River Clyde shoreline, particularly those properties located south of the railway line. The Scheme therefore includes the construction of a raised embankment from the east side of the Gruggies Burn above the River Clyde shoreline normal tides levels eastward towards the Scottish Water treatment works. A separate embankment is to be constructed south of Dogs Loan at the outfall of Hunter’s Burn and the flow diversion culvert to reduce the risk of extreme tidal flooding via the existing railway underpass in this location.

A seepage analysis has been undertaken which shows that there would be no water seepage on the dry side of the defences for the proposed embankment design. Full details are provided in the Seepage Analysis Report for the Scheme (Reference GBFAS-FRH-ZZ-ZZ-RP-W-100003). The embankments will tie in to the existing Core Path network and will include stepped crossings to ensure continued pedestrian access. The embankments will be grass covered earth structures and measures will be incorporated to ensure that these features blend in to the surrounding landscape.

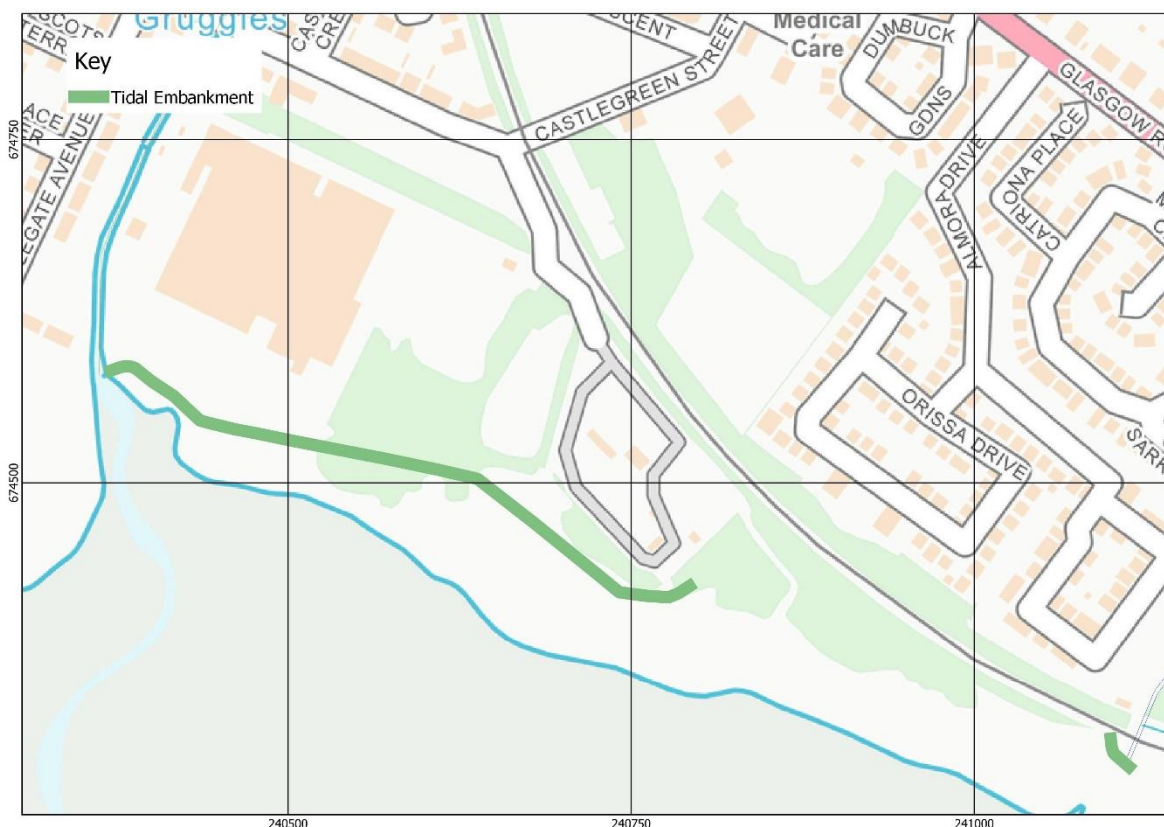


Figure 10: Tidal Embankment Locations

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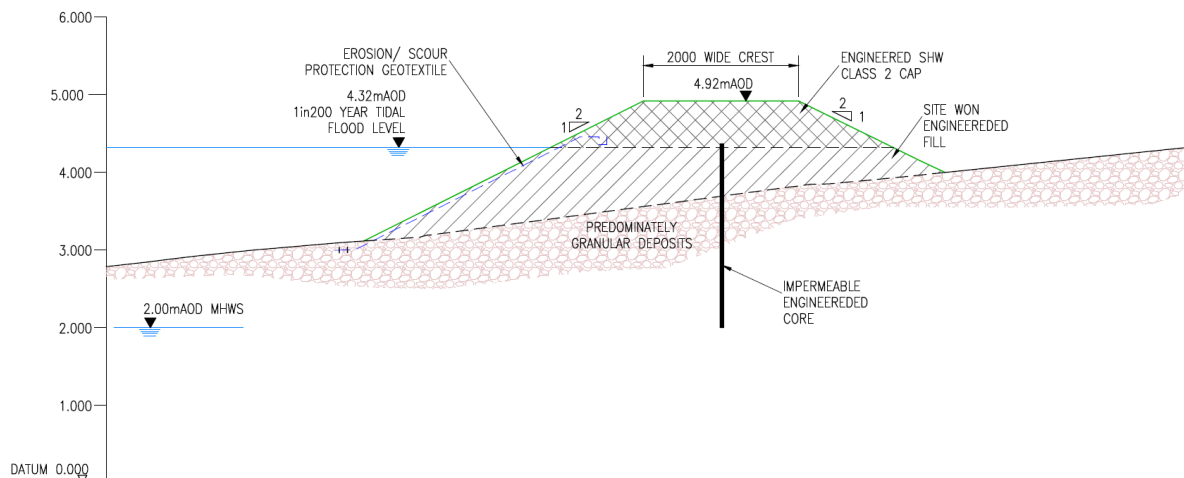


Figure 11: Typical cross section of flood embankment

2.5 Tidal Flood Gate

Castle Road provides a possible pathway for flooding of Dumbarton during tidal events, when water could travel north up the road and into the town. To alleviate this flood risk the Scheme includes the construction of a removable or swing tidal gate on Castle Road immediately to the south of Castlegate Avenue and the entrance to Dumbarton Football Stadium. To the east and west of Castle Road walls will be constructed to connect the tidal gate to higher ground to provide a continuous line of defence. The tidal gate will only be closed during tidal flood events or when these are predicted to happen.



Figure 12: Tidal Flood Gate Location

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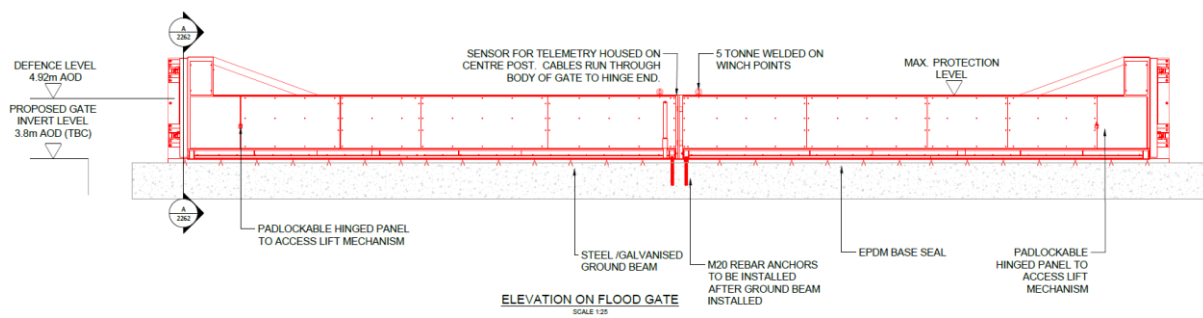


Figure 13: Typical cross section of flood gate

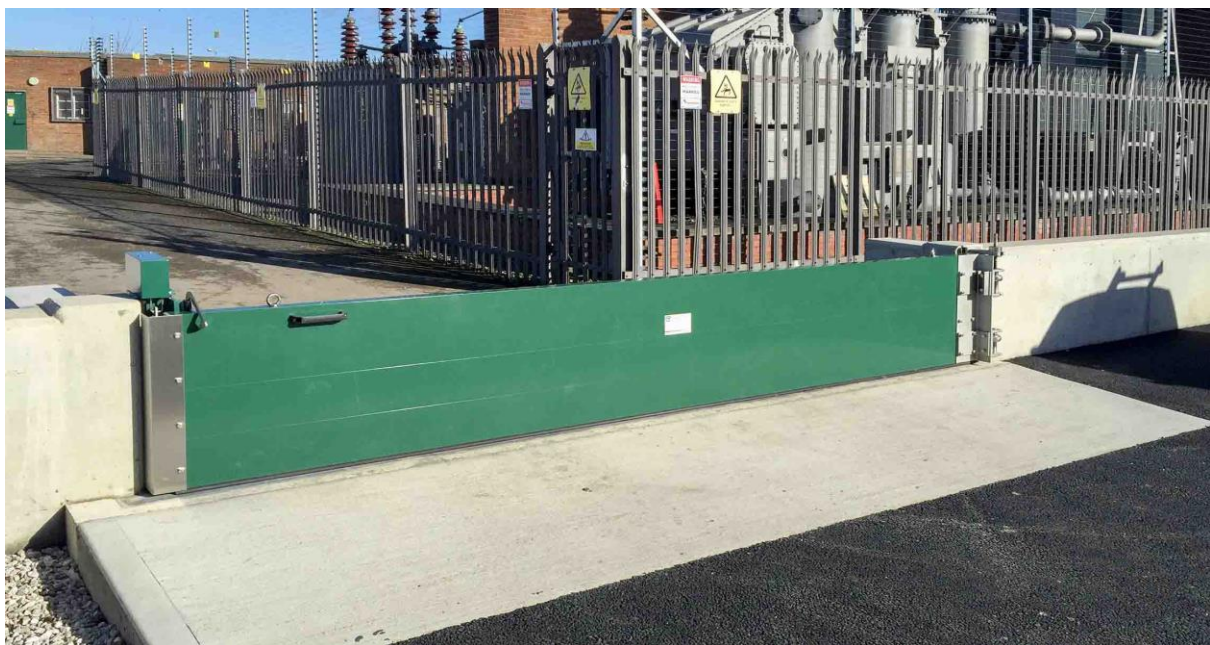


Figure 14: Photograph of a swing flood gate (Source: Flood Control International)

2.6 Public Utility Diversions

A significant number of locations have been identified where the Scheme conflicts with the existing public utility services and as these are in close proximity to residential and commercial areas, there may be additional locations or alterations to those identified. The utilities will be diverted or protected as required and operations will be in association with the relevant organisation, as summarised below:

- Any operations to existing water mains will be in association with Scottish Water or other organisation as appropriate.
- Any operations to existing sewer mains will be in association with Scottish Water or other organisations as appropriate.
- Any operations to existing gas mains will be in association with SGN or other organisations as appropriate.
- Any operations to existing telecoms will be in association with British Telecommunication or other organisations as appropriate.
- Any operations to existing power cables will be in association with Scottish Power or other organisation as appropriate.
- Any operations to street lighting in association with WDC.
- Any operations to trunk road drainage or other road management systems in association with Transport Scotland.
- Any operations to local road drainage in association with WDC.

2.7 Other considerations

Following refinement of the design, the Scheme extents will be subject to a risk assessment for unexploded ordnance (UXO) based on historic records of war time and land use activity.

3. Analysis of Flood Risk

3.1 Introduction

Hydrological and hydraulic modelling analysis has been undertaken to understand the dynamics and extents of fluvial flooding from the Gruggies Burn in Dumbarton. A summary of the work undertaken is provided below. Full details will be provided in the Hydraulic Modelling Report for the Scheme (Reference GBFAS-FRH-ZZ-ZZ-RP-W-100002) which will be issued to the relevant consultative parties during the consultation period.

3.2 Hydrology

Hydrological analysis has been undertaken to quantify flows in the Gruggies Burn and also in Hunter's Burn which will be linked to the Scheme. Details of the analyses undertaken are summarised below.

3.2.1 Gruggies Burn

The Gruggies Burn is located in Dumbarton, Scotland and is formed from the confluence of the Garshake Burn and the Overtoun Burn. Upstream of the A82 Stirling Road the catchment is rural and relatively steep, with a number of small reservoirs present. Downstream of the A82 the catchment is heavily urbanised and watercourse gradients are shallower. The watercourse flows out to the River Clyde, which is tidally dominated at this location.

Catchment descriptors were obtained from the Flood Estimation Handbook (FEH) web service¹ for the rural catchment and the total catchment at the confluence with the River Clyde. Disaggregation was applied in accordance with the area weighting method set out FEH Volume 5² to derive representative catchment descriptors for the urban area between the A82 and the River Clyde.

An analysis of topographic catchments has been undertaken using Geographic Information System (GIS) software and Light Detection & Ranging (LiDAR) topographic data to verify and improve the estimate of the FEH catchments. This resulted in a slight increase in the rural catchment (+0.02 km²) and a more significant increase in the urban catchment (+0.26 km²).

The catchment areas used in the analysis are therefore:

- Rural catchment = 8.41 km²
- Urban catchment = 0.53 km²

A map of the catchments is shown in Figure 15.

¹ CEH 2015. The Flood Estimation Handbook (FEH) Online Service, Centre for Ecology & Hydrology, Wallingford, UK.

² Bayliss, A.C. (1999) Catchment descriptors. Volume 5 of the Flood Estimation Handbook. Centre for Ecology & Hydrology

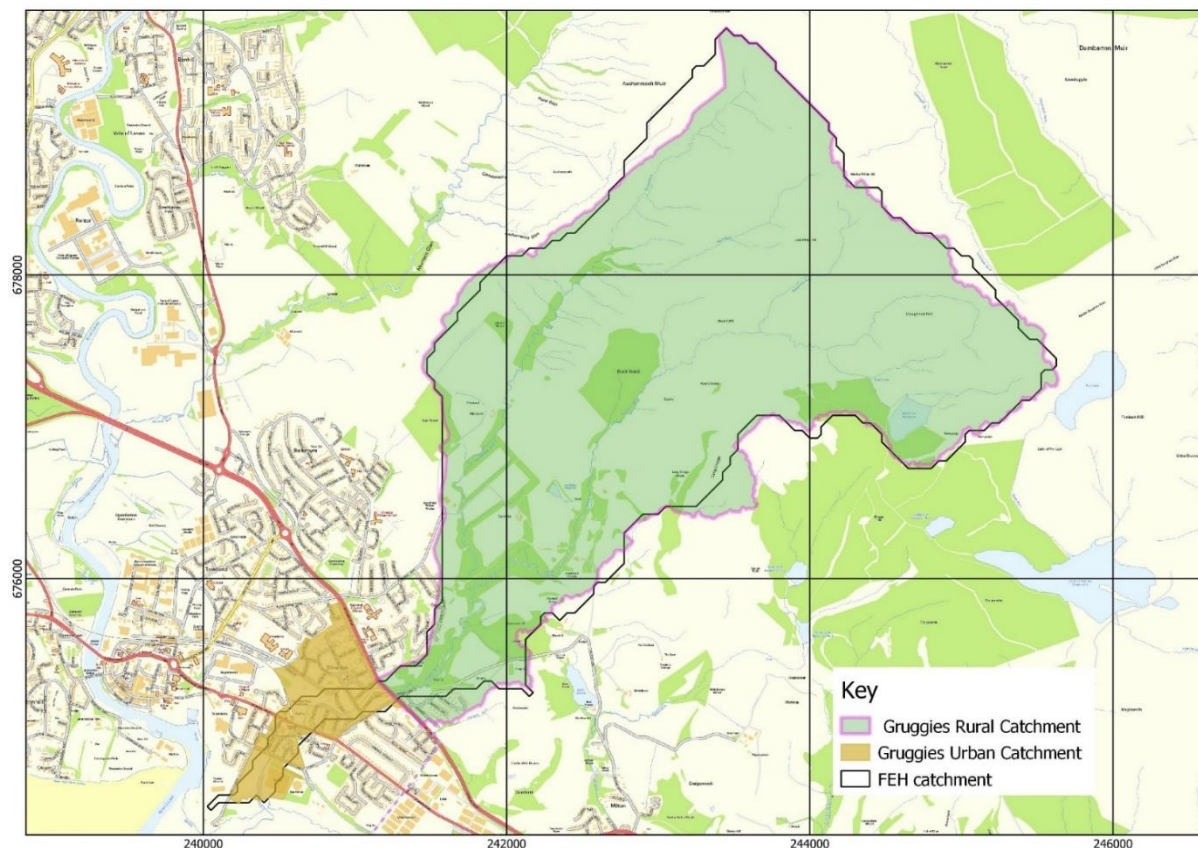


Figure 15: Gruggies Burn Catchment Areas

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A number of flow estimation methods have been considered to quantify the hydrology of the Gruggies Burn. For the rural upper catchment the following methods have been applied:

- Revitalised Flood Hydrograph Method (ReFH2);
- Flood Estimation Handbook Rainfall-Runoff Method (FEH R-R)³; and
- Flood Estimation Handbook Statistical Method (WINFAP)⁴.

There is a river flow gauge in the Gruggies Burn immediately downstream of the A82 Stirling Road, which is owned and operated by WDC and has been in place since 2010. Data from this gauge has therefore been used in the analysis.

For the final analysis of rural flows the WINFAP statistical method has been selected as this gave the most conservative growth factor for a 1 in 200 year flood. The QMED index flood has been based on a figure derived from AMAX data from the river flow gauge and a level-flow rating relationship derived from Fairhurst's 2023 hydraulic model of the Gruggies Burn. This QMED value was the most

³ Houghton-Carr, H.A. (1999) Restatement and application of the Flood Studies Report rainfall-runoff method. Volume 4 of the Flood Estimation Handbook. Centre for Ecology & Hydrology.

⁴ Robson, A.J. and Reed, D.W. (1999) Statistical procedures for flood frequency estimation. Volume 3 of the Flood Estimation Handbook. Centre for Ecology & Hydrology.

conservative from a range of alternative methods and is also higher than previous documented estimations⁵.

For the urban sub-catchment of the Gruggies Burn the ReFH2 method has been used to estimate flows. This method has been developed to be suitable for use in urban environments, whereas other methods are not considered suitable. In order to adopt a conservative approach urbanisation variables in the ReFH2 software have been increased compared to default values.

Scottish Water sewer plans show that some sewers may take water away from the topographic catchment boundary, including in combined sewers. A conservative approach has been adopted by setting both sewer capacity and exporting drained area to zero.

Scottish Water sewer plans show that there is no transfer of water via sewers across the topographic catchment boundary into the catchment, other than potentially via a 525mm diameter surface water sewer which discharges to the Gruggies Burn immediately downstream of the A82 Stirling Road and may be conveying highway drainage which is not within the topographic catchment. The maximum capacity of this pipe has been estimated as 0.3 m³/s and this has been included as an additional flow in the urban sub-catchment, as shown in Table 3 and Table 4.

A summary comparing the peak flows for the methods used is provided in Table 2.

Table 2: Peak flows comparisons

Catchment	Peak Flows (m ³ /s)					
	Return Period 2 years / 50% AEP ⁶			Return Period 200 years / 0.5% AEP		
	ReFH2	FEH R-R	WINFAP	ReFH2	FEH R-R	WINFAP
Rural	8.1	6.8	9.1	22.7	22.4	32.3
Urban	0.6	N/A	N/A	1.9	N/A	N/A

The final peak flows used in the Gruggies Burn hydraulic model are summarised in Table 3. These have been applied in the model as hydrographs using ReFH2 hydrograph shapes scaled to the relevant peak flows.

⁵ Jacobs (2013). West Dunbartonshire Council, Gruggies Burn Hydrology Update Report, November 2013, Ref B1888300.

⁶ Annual Exceedance Probability (AEP)

Table 3: Gruggies Burn peak flows summary

Catchment	Flood peak (m ³ /s) for the following return periods (in years)							
	2	5	10	20	50	100	200	1000
	Flood peak (m ³ /s) for the following AEP (%) events							
	50	20	10	5	2	1	0.5	0.1
Rural	9.1	12.5	15.1	18.1	22.8	27.1	32.3	48.4
Urban	0.6	0.9	1.0	1.2	1.5	1.7	1.9	2.4
Scottish Water 525mm sewer ⁷	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Climate change has been taken into consideration in accordance with SEPA's current guidance⁸, which recommends that for catchments less than 30km² in size a 41% increase in rainfall is applied for the Clyde River Basin Region, and for catchments greater than 30km² a 49% increase in flow is considered. Although the rural catchment is less than 30km² it is not possible to apply an increase to climate change in the WINFAP statistical method which is based solely on flows. For the rural catchment a 49% increase to flows has therefore been applied. The peak flows accounting for climate change are summarised in Table 4 below.

Table 4: Gruggies Burn peak flows summary including climate change

Catchment	Flood peak (m ³ /s) for the following return periods (in years)							
	2	5	10	20	50	100	200	1000
	Flood peak (m ³ /s) for the following AEP (%) events							
	50	20	10	5	2	1	0.5	0.1
Rural	13.6	18.6	22.5	27.0	34.0	40.4	48.1	72.2
Urban	0.8	1.2	1.5	1.7	2.1	2.4	2.7	3.4
Scottish Water 525mm sewer ⁷	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

The peak flows estimated for this assessment have been compared to the highest flows recorded at the Gruggies Burn river gauge in order to determine return periods. These are summarised in Table 5 below. The period of record is relatively short, however the order of magnitude of the return periods attributed to these events provides some additional confidence in the results.

⁷ Applied based on pipe full capacity so no change due to increasing return period or climate change.

⁸ SEPA, 2003. LUPS-CC1 Climate change allowances for flood risk assessment in land use planning. Version 4.

Table 5: Gauged Flood Events

Date of Event	Peak Flow (m ³ /s) ⁹	Approximate Flood Return Period
29/11/2011	15.4	1 in 11 years
30/12/2015	11.9	1 in 4 years
09/08/2019	10.8	1 in 3 years
07/10/2023	17.7	1 in 19 years

3.2.2 Hunter's Burn

Hunter's Burn is a small watercourse which is located at the east side of Dumbarton and has two distinct geographical entities. Upstream of the A82 Stirling Road the catchment is natural and the watercourse flows in an open channel. Downstream of the A82 Stirling Road the catchment is heavily urbanised and the watercourse is within a below ground culvert for its entire route to its outfall to the River Clyde. The flow diversion culvert to be constructed for the Scheme will coincide with the current route of Hunter's burn between the east end of the National Cycle Route 7 cycle path and the outfall to the River Clyde. Allowance has therefore been made within the capacity of the flow diversion culvert to incorporate the flows currently conveyed by the Hunter's Burn culvert and an analysis of flows has been undertaken to inform the design.

Catchment descriptors for Hunter's Burn are not available from the FEH web service, therefore an analysis of topographic catchments has been undertaken using GIS LiDAR topographic data. The urban sub-catchment has been estimated based on surface topography and a review of Scottish Water sewer records. A conservative approach has been adopted considering that the watercourse is entirely culverted within the urban catchment which could restrict the ability for water to enter. The catchment areas used in the analysis are:

- Rural catchment = 0.12 km²
- Urban catchment = 0.47 km²

A map of the catchments is shown in Figure 16.

⁹ Based on gauged river level and Fairhurst 2023 rating relationship

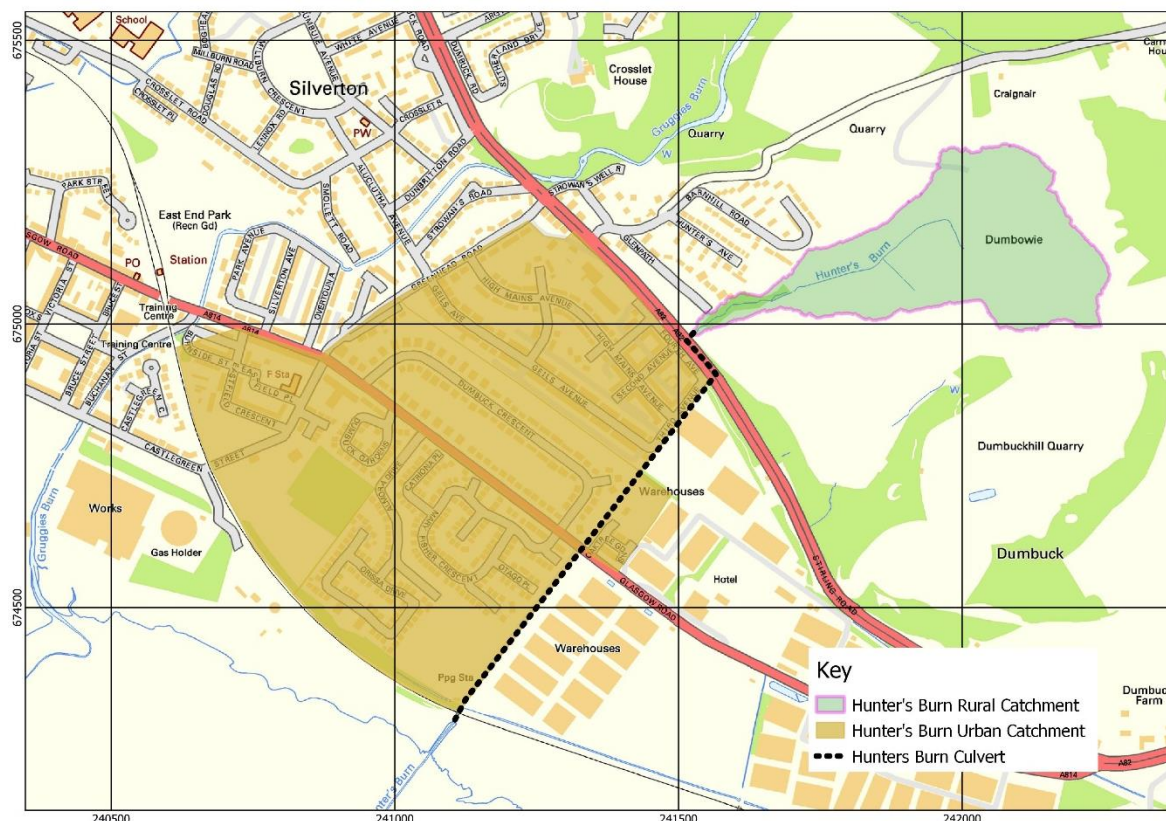


Figure 16: Hunter's Burn Catchment Areas

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The ReFH2 method has been used to estimate peak flows in Hunter's Burn. For the rural catchment the ReFH2 plot scale approach is the most suitable flow estimation method available as it has been designed for catchments which are less than 0.5 km², whereas other flow estimation methods are not considered appropriate. Point descriptors have been obtained from the FEH web service for the analysis.

For the urban sub-catchment of Hunter's Burn the ReFH2 method has been used to estimate flows. This method has been developed to be suitable for use in urban environments, whereas other methods are not considered suitable. The Gruggies Burn urban sub-catchment is very similar in size and character to the Hunter's Burn urban sub-catchment, therefore the Gruggies Burn catchment descriptors have been used as a donor for Hunter's Burn.

In order to adopt a conservative approach urbanisation variables in the ReFH2 software have been increased compared to default values. Scottish Water sewer plans show that some sewers may take water away from the topographic catchment boundary, including in combined sewers. A conservative approach has been adopted by setting both sewer capacity and exporting drained area to zero.

The final peak flows used in the Gruggies Burn hydraulic model are summarised in Table 6. These have been applied in the model as hydrographs using ReFH2 hydrograph shapes scaled to the relevant peak flows.

Table 6: Hunter’s Burn peak flows summary

Catchment	Flood peak (m ³ /s) for the following return periods (in years)							
	2	5	10	20	50	100	200	1000
	Flood peak (m ³ /s) for the following AEP (%) events							
	50	20	10	5	2	1	0.5	0.1
Rural	0.07	0.09	0.11	0.13	0.16	0.18	0.20	0.26
Urban	0.73	1.05	1.27	1.50	1.80	2.04	2.29	2.93

Climate change has been taken into consideration in accordance with SEPA’s current guidance¹⁰, which recommends that for catchments less than 30km² in size a 41% increase in rainfall is applied. The peak flows accounting for climate change are summarised in Table 7 below.

Table 7: Hunter’s Burn peak flows summary including climate change

Catchment	Flood peak (m ³ /s) for the following return periods (in years)							
	2	5	10	20	50	100	200	1000
	Flood peak (m ³ /s) for the following AEP (%) events							
	50	20	10	5	2	1	0.5	0.1
Rural	0.10	0.13	0.16	0.19	0.23	0.26	0.30	0.40
Urban	1.03	1.48	1.81	2.13	2.57	2.91	3.27	4.20

3.2.3 Joint Probability Analysis

Joint probability analysis was undertaken to assess the degree of correlation between extreme fluvial flows from the Gruggies Burn / Hunter’s Burn and extreme water levels in the River Clyde. The assessment has been undertaken in accordance with DEFRA/EA methodology^{11 12}, noting that the extreme water levels along the River Clyde are themselves a combination of extreme surge and high astronomical tide conditions. The assessment concluded that peak flows from Gruggies Burn and extreme water levels along the River Clyde are ‘modestly correlated’; therefore the Mean High Water Spring (MHWS) level of 2.00 mAOD (derived from the Admiralty charts) has been adopted as a downstream boundary condition when modelling extreme fluvial flood events.

¹⁰ SEPA, 2003. LUPS-CC1 Climate change allowances for flood risk assessment in land use planning. Version 4.

¹¹ Defra/Environment Agency (2005) Joint Probability: Dependence Mapping and Best Practice: Technical report on dependence mapping R&D Technical Report FD2308/TR1

¹² Defra/Environment Agency (2005) Use of Joint Probability Methods in Flood Management A Guide to Best Practice R&D Technical Report FD2308/TR2

3.3 Hydraulic Modelling

3.3.1 Gruggies Burn Baseline Model

Hydraulic modelling has been undertaken to provide a quantitative assessment of the fluvial flood risk from the Gruggies Burn. A 1D-2D linked hydraulic model of the watercourse has been constructed using the industry standard Infoworks ICM software package. The model set-up is illustrated in Figure 17 below.

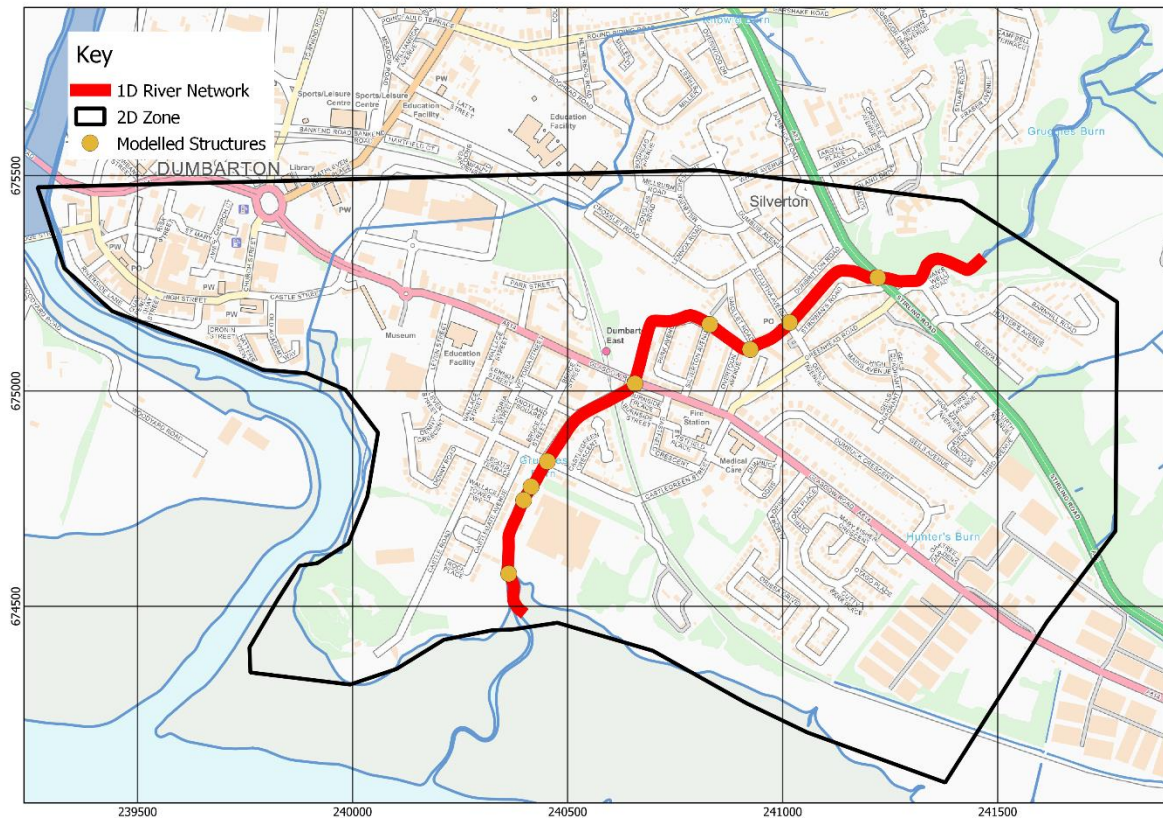


Figure 17: Gruggies Burn Hydraulic Model

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The hydraulic model analysis indicates that fluvial flooding could occur at Castlegreen Street in a 1 in 2 year return period due to the limited capacity of the crossing structure. This assumes that the river flood coincides with a Mean High Water Springs tide level. Flooding at Park Avenue and East End Park is predicted for 1 in 5 year return period due to the limited channel capacity combined with the impact of the structure under Glasgow Road. Flooding is also predicted upstream of Alclutha Avenue crossing in a 1 in 5 year event. These model results are corroborated by anecdotal evidence of regular flood problems in these areas reported during the public consultation event for the Scheme. In larger flood events widespread flooding of Dumbarton East is predicted. This is consistent with WDC's historic flood records.

3.3.2 Hydraulic Modelling of Proposed Scheme

From the baseline scenario analysis it was determined that fluvial flooding along the Gruggies Burn occurs due to the capacity exceedance of the watercourse channel and crossing structures. To alleviate the risk of flooding from peak flows in the Gruggies Burn the Scheme will divert design flows away from the watercourse and convey them to the River Clyde in a buried conduit.

In recognition of the constraints associated with the Gruggies Burn, including the relatively shallow depth of the channel and the low height of the watercourse crossing structures, the Scheme has been designed based on the provision of a 300 mm freeboard between peak fluvial flood levels and the ground levels adjacent to the Gruggies Burn. This degree of protection will provide a significant betterment compared to existing and allows for potential model uncertainty and physical processes such as bed movement and vegetation growth.

To achieve a 300 mm freeboard the maximum allowable flow in the urban reach of the Gruggies Burn is 10.0 m³/s. Allowing for the contributions from the urban catchment in the extreme design event, the allowable pass forward flow from upstream of the flow diversion weir is 7.2 m³/s. The weir will divert peak flows into the culvert to be conveyed below ground in concrete structures without causing flooding elsewhere during the design event. In floods which exceed the design capacity of the buried conduit water will flow over the 'exceedance control spillway' and continue down Gruggies Burn.

Hydraulic analysis was carried out to inform the preliminary design of the flow control structure:

- The flow control flume, expected to perform as an inlet control rectangular structure was sized using HY-8 software
- The intake weir geometry dimensions were defined using a broad crested weir equation, with the weir discharge coefficient based on guidance from the CIRIA Technical Note 134, Part B13.
- The capacity of the receiving intake channel was assessed using a 1D hydraulic model using the industry standard Flood Modeller software package, to confirm that the intake weir would perform in free flowing mode at the peak of the design event.

The complex hydraulics of the flow diversion weir and its interaction with the flow diversion culvert should be confirmed using Computational Fluid Dynamics (CFD) or physical modelling at detailed design.

Hydraulic modelling of the proposed flow diversion culvert was undertaken using the industry standard Infoworks ICM software package to assess the performance of the culvert in conveying a design flow of 25.1 m³/s. Inflows to the model from the Gruggies Burn are applied at the diversion culvert inlet while flows from the existing Hunter's Burn are applied at the end of the cycle path to the south of Geils Avenue. The downstream boundary is set to a fixed water level of 2.00 mAOD to represent Mean High Water Spring tidal conditions. The model results indicate that the culvert dimensions proposed for the Scheme are able to convey the design flow without surcharging.

¹³ Ellis J R (1989). CIRIA, Report TN 134. Guide to analysis of open channel spillway flows.

3.4 Tidal Flooding

Tidal flood levels have been derived using the River Clyde Flood Model (the RCFM), which was developed in 2020 by Fairhurst for Glasgow City Council¹⁴. The RCFM extends from Greenock to the Tollcross Burn Junction, east of Glasgow City Centre. The model was developed to improve the representation of the tidal reach of the river and allow a better assessment of flood risk to riverside development. To achieve, this hydraulic modelling was undertaken using the TUFLOW software, informed by detailed bathymetry of the Clyde Estuary, current LiDAR and hydrology. As part of the RCFM study an update to the statistical analysis of the tidal boundary at Greenock was undertaken by the University of Strathclyde¹⁵. The impact of climate change was included in the RCFM for both river flows and tide levels in accordance with SEPA guidance¹⁶.

Flood levels in the River Clyde at the Gruggies Burn confluence were extracted from the RCFM for various return periods for tidally dominant flooding events, and are presented in Table 8 below.

Table 8: Tide Levels in the River Clyde at the Gruggies Burn Confluence

Return Period (years)	River Clyde Peak Flood Levels (m AOD)	
	Current Climate	Future Climate
1 in 2	3.31	4.15
1 in 5	3.52	4.36
1 in 10	3.67	4.50
1 in 20	3.82	4.66
1 in 50	4.02	4.85
1 in 100	4.18	5.00
1 in 200	4.32	5.14
1 in 1000	4.67	5.49

Tidal flooding to Dumbarton East is limited to the areas between Glasgow Road and the River Clyde under current climate conditions. For future climate conditions, flooding extends to the St. James Retail Park, Crosslet Road Park Avenue and Silverton Avenue.

The Scheme will mitigate the risk of tidal flooding through the construction of flood walls, tidal embankments and a tidal gate. These elements have been designed to provide a freeboard above the peak still water tide level in an extreme flood event. Potential impacts of waves will be reviewed at detailed design.

¹⁴ Fairhurst (2021) River Clyde Model Update Technical Report (Reference 129384/G/W/001)

¹⁵ White, C.J., MacDonald, E. and Mannix, N. 2020. Tidal storm surge residuals and extreme still-water return periods at Greenock and Renfrew, River Clyde. University of Strathclyde, Glasgow, UK.

¹⁶ SEPA (2019). SEPA Guidance, Climate change allowances for flood risk assessment in land use planning, Version 1.

3.5 Secondary Flooding

The proposed Scheme has the potential to impact existing surface water drainage features and to alter flow routes for water draining back to the Gruggies Burn following a flood which exceeds the design capacity of the Scheme. Reviewing Scottish Water asset plans and scheduling existing outfalls based on site inspection suggests these locations will be limited in scale and number. Mitigation measures will include the provision of new drainage outfalls to Gruggies Burn with non-return valves to ensure that there is no detrimental impact compared to existing conditions in the extreme design event, and that water can flow away from the urban areas in an exceedance event. These measures will be considered further at detailed design.

4. Economic Appraisal

An economic appraisal will be undertaken to ascertain the benefit-cost ratio of the Scheme. This will involve quantification of the expected cost of flooding in a 'Do Minimum' baseline scenario – with no intervention and maintenance of existing assets only – for both coastal and fluvial flood mechanisms; followed by benefit-cost analysis of the Scheme.

Scottish Government option appraisal guidance for flood risk management¹⁷, together with the colloquially termed *Multi-Coloured Manual* (MCM)¹⁸ and supplementary *Multi-Coloured Handbook* (MCH)¹⁹, have been utilised to inform the scope and methodology for the appraisal. This guidance outlines the approach to define the total cost of flooding over a defined appraisal period in present value terms i.e. whole life present value damages (PVD) and is utilised to quantify the expected cost of flooding and potential reduction in this cost associated with proposed management measures.

Based on this guidance, the following steps will be carried out:

- Identification of an appropriate economic appraisal period over which to compare Scheme costs and benefits.
- Identification of appropriate return period flood events required to provide a refined estimate of PVD for the appraisal period; and appropriate assessment area.
- Identification of flood risk receptors based on flood risk extents for targeted events.
- Quantification of the cost of potential flood damages associated with identified receptors in a 'Do Minimum' baseline scenario, which assumes continued maintenance and repair of existing watercourse infrastructure and drainage systems to preserve current condition over the appraisal period.
- Quantification of the expected reduction in damages associated with the Gruggies Burn Flood Alleviation Scheme.
- Quantification of the whole life costs (WLC) of the Scheme.
- Benefit-cost analysis of the Scheme.

The Economic Appraisal is currently being undertaken and preliminary indications are that the Scheme will achieve a positive benefit-cost ratio, which would indicate that the Scheme is cost effective.

¹⁷ Scottish Government (2016). Option appraisal for flood risk management: Guidance to support SEPA & responsible authorities.

¹⁸ Penning-Rowsell E, Priest S, Parker D, Morris J, Tunstall S, Viavattene C, Chatterton J and Owen D (2013) Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal. Routledge, Abingdon.

¹⁹ Priest S, Viavattene C, Penning-Rowsell E, Parker D, Hardman D, Joyce J, Morris J, and Chatterton J (2023) Flood and Coastal Erosion Risk Management: Handbook for Economic Appraisal.

5. Public Consultation

A public information event was held at Dumbarton Football Stadium on Thursday 15th February 2024 from 2pm until 7.30pm. Over 100 members of the public attended the event with over 50 leaving written feedback.

Consultation responses have been summarised below:

- 62% of respondents had experienced flooding in their current or previous property.
- 100% of respondents want to see a Flood Alleviation Scheme provided for the Gruggies Burn.
- 94% of respondents agree with the approach being taken in developing the scheme.

Of the remaining 6% the issues identified were:

- Work required more urgently, including temporary measures.
- Lack of information presented on alternative options.
- Concern about impact on other areas.
- 84% of respondents agree that reasonably deliverable options to address the flooding have been included and considered.

Of the remaining 16% the issues identified were:

- Capturing runoff at Eastend Park / use of detention pond, similar to Knowle Burn Flood Alleviation Scheme
- Temporary/short term implementation of solutions to resolve flooding at Park Avenue
- Clearance of river bank vegetation
- Dredging the river bed
- Maintenance of drainage systems

Other issues which were identified in written responses or in discussion during the event are:

- Attendance of Council staff and police to assist during flood events
- Impact on traffic
- Impact on properties along the route of the construction

While not specifically referred to in written comments, discussions were held at the event in relation to the protection of fisheries interests in the Gruggies Burn and particularly habitat and populations of sea trout and salmon. Following the event, consultations have been conducted with the Loch Lomond Angling Improvement Associated (LLAIA) who, while a non-statutory body, have interests and knowledge in relation to the Gruggies Burn.



Figure 18: Public consultation event on 15th February 2024

Responses to the comments raised during the event are summarised below.

Comment: Work required more urgently, including temporary measures.

Response: The work being considered for this project is a comprehensive package of flood alleviation measures and the implementation is dictated by Scottish Government timescales. However WDC is acting to implement the project as quickly as possible. In the interim the Council made available a subsidy scheme²⁰ to provide support to people living in Dumbarton East whose property is at risk of flooding.

²⁰ <https://www.west-dunbarton.gov.uk/media/dhnbdbyu/flood-subsidy-scheme-leaflet.pdf>

Comment: Lack of information presented on alternative options.

Response: Information has been provided on alternative options at earlier stages in the project. This can be found in The Gruggies Burn Flood Alleviation Scheme Options Report²¹ which was presented to West Dunbartonshire Council's Infrastructure, Regeneration and Economic Development Committee and approved on 15th September 2021²².

Comment: Concern about impact on other areas from work being done and ongoing maintenance/failure.

Response: The Scheme has been designed to ensure that the alleviation measures do not result in an increase in flood risk to other areas. A Construction Environmental Management Plan will be used to manage and mitigate the potential impacts of the work. Further information is provided in Section 6.4 of this report and included with the documents that support the Scheme notification.

Comment: Capturing runoff at Eastend Park / use of detention pond, similar to Knowle Burn Flood Alleviation Scheme

Response: The use of flood storage has been considered and discounted as a viable means of alleviating flooding in the Gruggies Burn²¹. The Gruggies Burn catchment area is approximately ten times larger than that of Knowle Burn at the location of the flood storage pond, so a much larger pond would be required to have an equivalent effect.

Comment: Temporary/short term implementation of solutions to resolve flooding at Park Avenue, such as flood walls along the garden boundaries with the river.

Response: The placement of walls along the riverside properties of Park Avenue may have some impact on water flowing directly towards houses, however it is likely that other flood mechanisms (e.g. via Glasgow Road) would result in flood risk remaining. The proposed Scheme will address the risk comprehensively by diverting flood flows away from the river.

Comment: Clearance of river bank vegetation

Response: Clearance of river bank vegetation is generally the responsibility of the 'riparian owner', i.e. the person who owns the riverbank. WDC is limited in the amount of vegetation clearance which can be undertaken. The Scheme will result in the removal of some river bank vegetation to facilitate the construction of new or replacement flood walls, and this will be carefully managed to avoid adverse impacts on the environment.

Comment: Dredging the river bed

Response: Dredging the river bed would have limited impact on the flow capacity of the river, but could have significant adverse impacts on ecology. Over a relatively short period of time the bed material would re-establish to current levels. The proposed Scheme will address the risk comprehensively by diverting flood flows away from the river and by constructing new or replacement flood walls along the riverbanks.

²¹ Gruggies Burn Flood Alleviation Scheme Options Report. RPS, 5th August 2021. Reference IBE1560 D03. <https://bit.ly/3IF4R5A>

²² <https://bit.ly/4al9Nbo>

Comment: Maintenance of drainage systems

Response: Maintenance of drainage systems is part of WDC's regular maintenance activities and not being specifically considered by this project. Regular maintenance of the drainage systems will help to alleviate the risk of surface water flooding.

Comment: Attendance of Council staff and police to assist during flood events

Response: During a flood event Council staff and police resources are normally very stretched and have to be prioritised. Consequently it is not always possible for staff to be in locations where their assistance would be useful as they are required in other places.

Comment: Potential impact of the Scheme on fish

Response: The Scheme will ensure that natural flows are allowed to continue in the Gruggies Burn during normal flow ranges to support ecology and fish. The flow diversion weir will include a pass forward flow control flume which ensures a continuous flow in the river and would allow for the passage of fish and movement of bed material by ensuring bed levels throughout are similar to existing. The potential impacts on ecology (including fish) are considered in the Ecological Appraisal, Habitats Regulation Appraisal and the outline Construction Environmental Management Plan, all of which are discussed in Section 6 of this report and included with the documents that support the Scheme notification. Further consultations will be conducted with the LLAIA once documents are publicly available.

Comment: Temporary Impact on traffic

Response: The design and construction of the Scheme will take into account the potential temporary impact on traffic, with a view to minimising the disruption as much as possible. This is taken into account in the Highways and Core Path Matters report which is discussed in Section 6.6 of this report and included with the documents that support the Scheme notification.

Comment: Temporary Impact on properties along the route of the construction

Response: The design and construction of the Scheme will take into account the potential impact on properties and residents, with a view to minimising the disruption as much as possible. This is taken into account in the Highways and Core Path Matters report, and the outline Construction Environmental Management Plan, both of which are discussed in Section 6 of this report and included with the documents that support the Scheme notification.

6. Environmental Assessments

6.1 Environmental Impact Assessment

6.1.1 Screening Opinion Request

The Flood Risk Management (Flood Protection Scheme, Potentially Vulnerable Areas and Local Plan Districts) (Scotland) Regulations 2010 Part II stipulates that there is a duty to consider environmental impact of a proposed flood protection scheme.

Where a local authority considers that a proposed flood protection scheme is not likely to have a significant effect on the environment it is directed to request a screening opinion from consultative bodies. These include SPEA, Scottish Natural Heritage (now NatureScot), Scottish Water, any planning authority whose district is likely to be affected by the proposed flood protection scheme and any other body designated by statutory provision as having specific environmental responsibilities which, in the opinion of the local authority proposing the flood protection scheme has an interest in relation to the environmental effects of that scheme.

An Environmental Impact Assessment (EIA) Screening Opinion request was therefore submitted to WDC Planning Department and subsequently to consultative bodies to determine the requirement for an EIA in accordance with The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017. The responses are summarised in the subsequent sections.

6.1.2 West Dunbartonshire Council

WDC's response (2nd October 2023) states that

“It is considered the proposed development is unlikely to have effects on the environment to the extent that an Environmental Assessment would be justified and required. Nevertheless, there are a variety of issues which may be expected to ordinarily form part of an Environmental Assessment that will require to be considered and addressed as noted above.

The screening opinion therefore concludes that an Environmental Impact Assessment (EIA) is not required in this instance and the Council as Planning Authority formally adopts this opinion.”

The potential issues identified that would require consideration are as follows:

- Impacts from construction noise, traffic, dust and vibration would require to be considered. Managing this through a robust Construction Environmental Management Plan will be key to reducing and mitigating the impacts during construction.
- Impacts relating to ecology, biodiversity and protected species, noting the potential to impact on Local Nature Conservation Site designations and most notably the Inner Clyde Special Protection Area (SPA), will require to be addressed.
- The potential for impact upon the SPA will likely require to be considered in a Habitat Regulations Appraisal.
- Any implications from the ground disturbances in terms of archaeological potential will also require to be considered.
- The core path network will be impacted upon and this will require to be managed with suitable core path diversions as required and this includes the cycle path.

- The proposal will impact upon the A82 Trunk Road and this will require to be carefully managed in consultation with Transport Scotland.
- The impact upon local roads together with managing residents' access during the works will also be key.

Assessments have been undertaken in response to these potential issues and these are included with the documents that support the Scheme notification. Summaries are provided in subsequent sections of this report.

6.1.3 SEPA

SEPA's response (12th February 2024, Reference 116600) states:

"Following our review of the Request for EIA Screening Opinion letters (dated 08 June 2023 and 15 January 2024) and with reference to Schedule 1 of the regulations, we agree EIA is not required for this proposal. This is on the basis that modest or plainly and easily achievable environmental mitigation measures will be put in place during the construction works and operation as discussed in the screening letters."

6.1.4 NatureScot (formerly Scottish Natural Heritage)

NatureScot's response (18th January 2024) states:

"I can confirm that we are happy to concur with the view expressed in your screening opinion document. Namely – that the development may not meet the threshold for EIA requirement but that there are nevertheless a variety of environmental issues which will none-the-less require to be considered and addressed."

6.1.5 Scottish Water

Scottish Water has not provided a response to the request for an EIA Screening Opinion.

6.1.6 Historic Environment Scotland

Historic Environment Scotland's response (18th March 2024, Reference 300070522) states:

"I can confirm that for the purposes of our role in Environmental Impact Assessment the proposals are unlikely to have significant environmental effects. We do not require any further assessment for this aspect."

6.1.7 Royal Society for the Protection of Birds

Royal Society for the Protection of Birds has not provided a response to the request for an EIA Screening Opinion.

6.1.8 West Dunbartonshire Council Environmental Health

WDC Environmental Health's response (6th February 2024) states:

"I have reviewed the submitted documentation and in conclusion I am in agreement with my colleagues in Planning that an EIA is not required for this development proposal."

6.1.9 Marine Scotland

A request was submitted to Marine Scotland to determine whether it would be necessary to undertake an EIA in accordance with The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 in support of future Marine Licence applications. In accordance with the regulations the request only covered those elements of the Scheme which involve works in the Marine Environment, which is defined as areas below the Mean High Water Springs tide level.

Marine Scotland responded on 26th January 2024 to state that they did not consider that sufficient information had been provided to allow a screening opinion to be adopted and that further information was required on the following:

“In relation to 10(2)(b)(ii), the Scottish Ministers require you to provide further information as to the description of the current options for the proposed works, construction method and scale of proposed works below mean high water springs.”

A meeting was held with Marine Scotland on 2nd February 2024 where the Scheme was discussed and further information was provided. While Marine Scotland indicated that an EIA in support of a Marine Licence may not be required if appropriate mitigation is embedded in the design, they asked that more detailed drawings showing the Scheme elements below MHWS be provided to allow a screening opinion to be adopted. The drawings prepared for the Scheme notification have subsequently been issued to Marine Scotland, along with the shadow Habitats Regulations Assessment, Ecological Appraisal and outline Construction Environmental Management Plan and a screening opinion is currently awaited. These assessments identify that the design of the Scheme should not require an EIA in accordance with the Marine Works Regulations 2017, subject to the appropriate consideration of potential impacts on the Marine Environment and the adoption of the recommended mitigation measures.

6.2 Habitat Regulations Appraisal

A shadow Habitats Regulation Appraisal (sHRA) has been undertaken in recognition of the Scheme's relationship with the Inner Clyde Special Protection Area (SPA)/Ramsar/Site of Special Scientific Interest (SSSI) designated site complex. Full details are provided in a standalone report included with the documents that support the Scheme notification.

The sHRA considers the potential for effects on species and habitats, including those not listed as qualifying features, to result in secondary effects upon the qualifying features of European Sites, including the potential for complex interactions and dependencies. In addition, the potential for offsite impacts, such as through impacts to functionally linked land, and or species and habitats located beyond the boundaries of European site, but which may be important in supporting the ecological processes of the qualifying features, have also been fully considered.

The sHRA has demonstrated that, in the absence of mitigation, the Scheme may result in Likely Significant Effects (LSEs) on European Sites. However, once mitigation measures are fully considered, as part of an Appropriate Assessment, it has been determined that there will be no adverse effects on the integrity of European Sites. Mitigation measures to be embedded in the detailed design and construction methods are set out in the sHRA report.

6.3 Ecological Appraisal

An Ecological Appraisal has been undertaken for the Scheme and full details are provided in a standalone report included with the documents that support the Scheme notification, which sets out the methods by which baseline ecological data was collected, provides an overview of the baseline, and an interpretation of baseline in relation to relevant legislation and policy. The Ecological Appraisal also establishes mitigation measures that ensure the Scheme can be delivered in an environmentally responsible manner and considers opportunities for biodiversity enhancement.

The Ecological Appraisal reports that, owing to its largely urban location and limited footprint, the Flood Alleviation Scheme is largely unconstrained by sensitive ecological features. However, the key ecological features must be considered:

- The proximity of the Proposed Development to the Inner Clyde Special Protection Area (SPA)/Ramsar/Site of Species Scientific Interest (SSSI) complex will require the careful management of construction activity to ensure the conservation objectives of the Special Area of Conservation (SAC) are not adversely affected.
- The prevalence of invasive non-native species throughout the Site will require comprehensive management throughout construction activity.

Mitigation measures to address the potential impacts of the Scheme to be embedded in the detailed design and construction methods are set out in the Ecological Appraisal report.

6.4 Construction Environmental Management Plan

An outline Construction Environmental Management Plan (CEMP) has been created for the Scheme to establish a strategic approach to environmental management and protection whilst creating space for iterative, emerging specialist Management Plans, which will develop as the Scheme proceeds.

The outline CEMP adopts a four-tiered structure that is set out as follows:

- Tier 1: General Requirements;
- Tier 2: Site Specific Requirements;
- Tier 3: Appendices (Management Plans etc.)
- Tier 4: Annexes (Additional Resources, such as Toolbox talks).

The purpose of Tier 1 is:

- To provide guiding principles and governance of the CEMP;
- To establish those construction activities that will be subject to environmental management measures;
- To inform the Scheme's notification process; and
- To provide a live, dynamic environmental guidance document which can be implemented for all work activities as part of the Scheme.

Tier 2 of the CEMP acts as a strategic management document and sets out the overarching site specific ecological and environmental constraints relevant to the Scheme. Tier 2 captures all of relevant ecological and environmental constraints and presents them in easy to access tables. These tables can be used as tools to view and manage constraint compliance requirements and signposts

the reader to all relevant management plans and helpful additional resources. Tier 2 also provides a checkpoint tool to plan actions, as well as review and monitor actions taken against them.

Information contained within the CEMP has several purposes including:

- Details of specific ecological and environmental management required throughout the construction phase of the Scheme;
- Details of monitoring of environmental performance;
- Ensuring that required mitigation commitments are implemented;
- Acting as a mechanism to reduce the likelihood of potentially significant ecological and environmental incidents that could occur as a result of the Scheme;
- Providing a mechanism for control should unexpected adverse ecological or environmental effects occur during construction;
- Defining the role of Environmental Clerk of Works in relation to the Scheme; and
- Providing detail on relevant legislation and good practice which will be adopted and can be used as reference by the Designer and contractors to further reduce environmental impacts during construction of the Scheme.

The outline CEMP is included with the documents that support the Scheme notification and this will be adapted as the design of the Scheme progresses.

6.5 Geomorphology

The Gruggies Burn is a non-baseline water body which means it has a catchment area below 10 km². Non-baseline water bodies are not given a Water Framework Directive (WFD) classification but engineering activities on them are still regulated under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR).

A preliminary hydromorphological assessment has been undertaken which indicates that there is an active sediment transport regime in the Gruggies Burn, with sediment sources predominantly driven from the steep upper catchment in the Kilpatrick Hills. Sediment deposition was noted within berms in the urban areas of the river, however these were limited in number and extent.

Further detailed hydromorphological assessments will be undertaken to inform subsequent design stages, with a particular focus on:

- The realignment of the Gruggies Burn channel at the flow diversion weir
- The afflux and changes in velocity conditions upstream of the flow diversion weir
- The impact of the flow limitation to the sediment regime along the Gruggies Burn downstream of the flow diversion weir through Dumbarton and at its mouth in the River Clyde

The construction of the flow diversion weir and culvert will reduce the severity of flood events along the Gruggies Burn. In doing so, it is anticipated that the Gruggies Burn will become a more stable environment, which will provide benefits for the ecosystem's structure and function. The Scheme will reduce catastrophic flooding events and the associated rapid and high volume discharge of mobile sediment and, potentially, pollutants, to the Inner Clyde.

The proposed tidal walls could disconnect the channel from its surrounding floodplain and therefore increase stream powers in the channel through this section during higher flows as a result. However, as the channel where the proposed flood walls are to be placed is already confined by hard bank protection on both banks and flood walls in some areas the additional morphological impact of the new

flood wall is likely low. Furthermore the Scheme will reduce fluvial flood flows in the channel, mitigating the potential increased in stream powers.

6.6 Highways and Core Path Matters

An assessment has been undertaken to consider the following aspects which were raised in WDC's EIA screening opinion for the Scheme:

- Core path network and cycle paths;
- A82 Trunk Road; and
- Local roads and residents.

The assessment identified where the Scheme may have an adverse impact on the core paths and highways networks and set out proposals for mitigation measures such as temporary diversions, route realignment, and traffic management. High level design advice has been provided for the Core Path network based on the guidance in Cycling by Design. It is considered that the guidance provided will be suitable for typical core path users in Dumbarton.

Consultations have been undertaken with the relevant authorities for the trunk road (Transport Scotland) and the paths and highways within Dumbarton (WDC). Through this consultation it has been established that the proposals that have been set out are agreeable in principle, subject to the provision of greater detail as the Scheme progresses.

Full details are provided in the Highways and Core Path Matters report included with the documents that support the Scheme notification.

6.7 Landscape

A Landscape and Visual Statement has been provided for the Scheme by Chartered Landscape Architects (Reference GBFAS-FRH-ZZ-ZZ-RP-L-100001 included with the documents that support the Scheme notification). The report seeks to describe the baseline landscape and visual conditions of the site and surrounding area in order to assess the likely landscape and visual effects which may arise as a result of the proposals and advise mitigation measures which may reduce any potential effects.

The report has concluded that there would be no effects from the Scheme on the wider landscape character of the Glasgow and Clyde Valley, due to the small scale of the proposals within the vast extent of this landscape and varying landscape types within it. There would be changes to the site specific character, which varies significantly from each location.

There are several designated areas within Dumbarton and close to the proposals. The primary heritage designations include the scheduled monument of Dumbarton Rock and Castle and the Knoxland Square Conservation Area. It is considered that there would not be significant adverse effects on the landscape setting of these heritage features as a result of the proposals.

Mitigation recommendations are provided within the report and it is considered that these can help to reduce the potential effects on landscape and visual receptors. Recommendations include the colour and appearance of the cladding to the river walls matching the buildings of Knoxland Square as well as replacement tree and scrub planting west of the Gruggies Burn and along the coastal embankment.

It is considered that due to the scale and nature of the proposals, effects would be limited to those visual receptors within the immediate vicinity of each site as well as the site specific character of the immediate area.

6.8 Historic Environment

An assessment of the historic environment has been undertaken and is presented in a standalone report (Reference clydearc1-523259). Five historic environment assets were recorded within the area of the Scheme. These included the boundary walls of a former shipyard, a disused railway, a railway bridge and a rifle range all dating to the mid to late 19th century and considered to be of lesser value. No physical remains were visible of a 17th century stone bridge that is recorded as replacing a wooden bridge across the Gruggies Burn on Glasgow Road.

The scheduled monument of Dumbarton Rock and Castle, Knoxland Square Conservation Area and the likely extent of the medieval Burgh of Dumbarton lie immediately west of the proposed flood alleviation scheme.

The potential for buried archaeology to be present within the flood alleviation area was generally considered to be very low although more potential existed at the location of the proposed tidal defence gates on Castle Road at the base of Dumbarton Rock's cliff face.

No significant effects on the setting of historic environment assets was predicted as a result of the proposed works. Recommendations are made within the report to minimise any potential impact on the historic environment from the Scheme.

7. Conclusion

This summary report provides an overview of the proposed Scheme, including the need for the Scheme and previous work which has been undertaken. The report describes the different elements which make up the Scheme and sets out the analyses that have been undertaken to quantify the flood risk and inform the design. Information is provided on the economic appraisal and the public consultation event which was undertaken in February 2024. A summary is provided of the environmental assessments which have been undertaken and the measures which can be implemented to mitigate the potential impacts of the Scheme. Further details of all of these aspects are provided in the documents that support the Scheme notification.

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