Appendix A – Information Review Report

Helensburgh Coastal Flood Protection Study - Information Review Report

Final Report

September 2018

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Revision history

Revision / Date	Amendments	Issued to
Draft / July 2018	-	G Whyte, Argyll & Bute Council
Final / September 2018	Updated following comments from Argyll & Bute Council, additional data becoming available and extra stretch of coastline added at Rhu.	G Whyte, Argyll & Bute Council

Contract

This report describes work commissioned by Grant Whyte on behalf of Argyll & Bute Council by Purchase Order number AB315359. Argyll & Bute Council's representative for the contract was Grant Whyte. Douglas Pender and Nicci Buckley of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

JBA thank SEPA and Argyll and Bute Council for the supply of data.

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Contents

1 Introduction

1.1 Study extent

The study area incorporates Helensburgh, Craigendoran and Rhu, and is located on the northern shore of the Firth of Clyde, approximately 30 km to the north-west of Glasgow (Figure 1-1). Helensburgh forms the main frontage, with Craigendoran located at the south-eastern extent of the study area and the village of Rhu to the north-western extent. A number of small burns discharge out through the area into the Firth.

Figure 1-1: Location plan

1.2 Project aims

In terms of flood risk management, Helensburgh is part of the Clyde and Loch Lomond (CaLL) Local Plan District (LPD), with Glasgow City Council designated the Lead Local Authority. The Clyde and Loch Lomond Local Flood Risk Management Plan (LFRMP) for 2016-2022, which supplements the local Flood Risk Management Strategy (FRMS) developed by the Scottish Environment Protection Agency (SEPA), identifies 'Helensburgh to Loch Long' as a Potentially Vulnerable Area (PVA). The Helensburgh to Loch Long PVA is designated 11/02 and is deemed to be at risk of flooding from pluvial, fluvial and coastal sources. Of concern to this study is the risk from coastal flooding to the town of Helensburgh.

The objective of this project is to deliver a flood protection study to consider options to reduce coastal flood risk within Helensburgh (Table 1-1). The study will see the development of a 'long list' of potential options to manage this risk. The long list will be screened to a 'short list' of short, medium and long-term options using multi-criteria analysis; this type of analysis allows for the consideration of more than just the engineering based pros and cons of each option, incorporating socio-economic,

environmental, built heritage, landscape and tourism issues into the mix. Benefit-cost calculations based upon the short list options will subsequently reduce the list to a preferred option.

Table 1-1: Local FRM Plan action

Action ID	Action type and objective description	Action description
110030005	**Flood Protection Study** Reduce the risk of coastal flooding to residential properties and non-residential properties in Helensburgh.	The Council plans to undertake a study to further investigate the feasibility of new and or enhanced sections of defences along the seafront of Helensburgh. This study will look to complement and enhance the proposed development along the seafront including a new swimming pool and raised car park in Helensburgh. The study will also consider the potential for natural flood management actions to help reduce coastal flooding and the maintenance of defences. Other actions may also be considered to select the most sustainable combination of actions.

2 Historical flooding

A review of historical flood events is crucial to provide context and develop an understanding of local flood mechanisms, as well as providing an evidence base for model development and calibration.

A review of coastal flood events was undertaken using data collected from:

- Argyll and Bute Council, including Biennial reports
- SEPA historical flooding database
- SNIFFER report[1]
- British Hydrological Society (BHS) Chronology of British Hydrological Events[2]
- Internet search

The coastal historical flood record for Helensburgh has been documented within Table 2-1, with a selection of photographs presented within Figure 2-1.

The events listed highlight that coastal flooding in Helensburgh results from a combination of high water levels and wave action.

Of all the historic events special consideration will be given to those of January 2014, December 2011 and January 1991 when developing the modelling method and options appraisal. These have been the most significant in recent years resulting in major flooding.

1 FRM10: Coastal Flooding in Scotland: A Scoping Study, SNIFFER, Final Report, August 2008
2 BHS Chronology of British Hydrological Events http://cbhe.hydrology.org.uk/

Table 2-1: Historical flooding events in Helensburgh

Date	Location	Details	Source
03/01/2014	Helensburgh	Flooding of pier, West Clyde Street, Rhu Road Higher and the A814.	http://www.helensburghadvertiser.co.uk/news/13978866.Helensburgh_seafront_battered_by__worst_storms_in_decades_/
		High tide swept over the town pier and esplanade and flooded a skate park.	http://www.eveningtimes.co.uk/news/13270770.Huge_tide_surge_and_heavy_rains_bring_flooding/
		Esplanade flooded and closed at various points.	https://www.bbc.co.uk/news/uk-scotland-25582344
		Wave overtopping along Rhu Road Lower	Video supplied by Argyll & Bute Council
		Flooding of gardens and properties on coast at bottom of Adelaide Street	Photographs supplied by local resident via Argyll & Bute Council
	East Clyde Street	Waves and spray surging up and crashing up over sloping masonry at Eastbay Esplanade on to footpath.	SEPA historical database[3]
	Tower Place, West Clyde Street	Waves and spray surging up and crashing over the wall.	SEPA historical database[3]
	Maitland Street	Waves and spray surging up Maitland Street on to the road.	SEPA historical database[3]
02/01/2012	Helensburgh	Flooding and damage to seafront along East and West Clyde Street.	https://bigrab.wordpress.com/tag/storms/
	East Clyde Street	Coastal waters flooded property.	SEPA historical database[3]
08/12/2011	Helensburgh	Large waves crashing along the sea front and flooding of East Clyde Street.	https://bigrab.wordpress.com/tag/storms/
		East Clyde Street flooded near Tesco.	https://www.youtube.com/watch?v=Jo2MgLdW4cM
		Pier and West Clyde Street flooded.	https://www.bbc.co.uk/news/uk-scotland-16094360
11/11/2010	Helensburgh	Storm and high tide submerged car park at Helensburgh pier and left drivers unable to get to their vehicles.	http://www.helensburghadvertiser.co.uk/news/13975818.Drivers_stranded_as_car_ park_floods/
		Overtopping of sea wall and surface water systems tide locked.	SEPA historical database[3]

Date	Location	Details	Source
Jan 2008	Helensburgh	Gale force winds, pouring rain and giant waves destroyed he walkway and seating area, leaving the beach littered with concrete blocks.	http://www.helensburghadvertiser.co.uk/news/13974492.Seafront___039_like_a_bomb_site__039_/
28/01/2002	Eastbay esplanade	High waves at Eastbay.	SEPA historical database[3]
	Helensburgh Pier	Flooding of Helensburgh pier car park. Water level up to undercarriage of cars.	SEPA historical database[3]
Nov 1999 to Nov 2001	154 East Clyde Street	Flooding of carriageway and property.	SEPA historical database[3]
Jan 1999	Helensburgh	Inundation of East Clyde Street	Photographs supplied by local resident via Argyll & Bute Council
05/01/1991	Sailing club	4.5 feet of water reported in club house. Area was raised ~2m following this event.	Verbal - sailing club member met on site visit
	A814 - Clyde Street, West Clyde Street and William Street	Highest tide since 1907 - tide was 5 meters, 1.2 meters above its expected height. Wind-savaged, very severe storms from the south west, gusts of up to 90 miles per hour.	SEPA historical database[3]
	Helensburgh and Craigendoran	Tide 1.2m above expected height. Waterfront submerged and train services suspended. Waves breaches sea wall at Craigendoran.	Sniffer report[1]
	Helensburgh	Skew surge of 1.31m at Millport. Overtopping of defences at many locations, particularly in the Firth of Clyde. Helensburgh waterfront was completely submerged and some streets flooded to a level of up to 1m.	https://www.surgewatch.org/events/1991-01-05/
16/02/1950	Helensburgh	Shops on seafront flooded.	Sniffer report[1]
26/11/1912	East and West Clyde Street	Storm isolated Helensburgh from the outside world. In additional to local road and railway closures there was flooding within the town along East and West Clyde Street. "the water lay about 18 inches deep in some of the shops in West Clyde Street, and in many dwelling houses the water surged through the lower flats. Here and there great breaches were made in the sea walls"	"Helensburgh isolated", The Scotsman (1860-1920), 28 November 1912. www.proquest.com

[3] SEPA historical flooding database, e□tracted July 2018

Date	Location	Details	Source
09/12/1912	Helensburgh and Craigendoran	A gale of considerable force passed over Helensburgh. "during the forenoon the sea was high and the waves broke over the battery walls and across the piers at Helensburgh and Craigendoran."	"Steamers unable to call at Dunoon", The Scotsman (1860-1920), 10 December 1912
1907	Helensburgh	Flooded waterfront at Helensburgh. 5m+ high tide.	Sniffer report[1]
unknown	Glenoran Burn	Letter from resident of Dalmore Crescent reporting that under high tide conditions and with the burn in spate, water backs up at the culvert beneath the A814 and exits via the main entrance to Dalmore Crescent and flows down to the sailing club.	Letter provided by Argyll & Bute Council

Figure 2-1: Example photographs of historical flooding

3 January 2014

(a) Flooding over the esplanade at the Henry Bell monument

http://www.helensburghadvertiser.co.uk/news/13978897.Call_for_funds_to_tackle_floods/

(b) Flooding of the pier

http://www.helensburghadvertiser.co.uk/news/13978866.Helensburgh_seafront_battered_by__worst_storms_in_decades_/

(c) Wave overtopping along Rhu road Lower

Still taken from video supplied by Argyll & Bute Council.

(d) Flooding of property at bottom of Adelaide Street

Photograph supplied by local resident via Argyll & Bute Council

(e) Flooding to property on Maitland Street

Photograph supplied by local resident via Argyll & Bute Council

(f) Inundation up to properties

https://www.bbc.co.uk/news/uk-scotland-south-scotland-25593461

2 January 2012

(a) Flooding of the pier and skatepark

Photograph supplied by local resident via Argyll & Bute Council

(b) flooding along East Clyde Street

https://bigrab.wordpress.com/tag/storms/

(c) aftermath along West Clyde Street

https://bigrab.wordpress.com/tag/storms/

8 December 2011

(a) looking east towards Queens Court, East Clyde Street

https://bigrab.wordpress.com/tag/storms/

(b) 'Cromalt' at 148 East Clyde Street

https://bigrab.wordpress.com/tag/storms/

(c) along East Clyde Street https://bigrab.wordpress.com/tag/storms/

(d) waves crashing over at West Clyde Street

https://www.bbc.co.uk/news/uk-scotland-16094360

November 2010

Car park at Helensburgh pier submerged.

http://www.helensburghadvertiser.co.uk/news/13975818.Drivers_stranded_as_car_park_floods/

January 1999

Flooding along East Clyde Street

Photograph supplied by local resident via Argyll & Bute Council

5 January 1991

Inundation of Helensburgh Sailing Club

Photograph supplied by Argyll & Bute Council

3 Flood Mechanisms

3.1 Coastal flooding

The current SEPA coastal mapping (Figures 3-1 to 3-3) was produced by GIS projection modelling of still water levels alone (tidal levels plus storm surge), and as such does not include the potential risk due to wave overtopping. The current mapping suggests that there are areas around Rhu village, the sailing club, the pier, and along East and West Clyde Street that are at risk from coastal flooding. This ties in well with the areas for which historical events are documented. However, the flood record also highlights how the risk from still water levels is exacerbated by wave overtopping.

SEPA are currently updating the coastal flood mapping in phases, with the inclusion of wave overtopping being a key component of the updates.

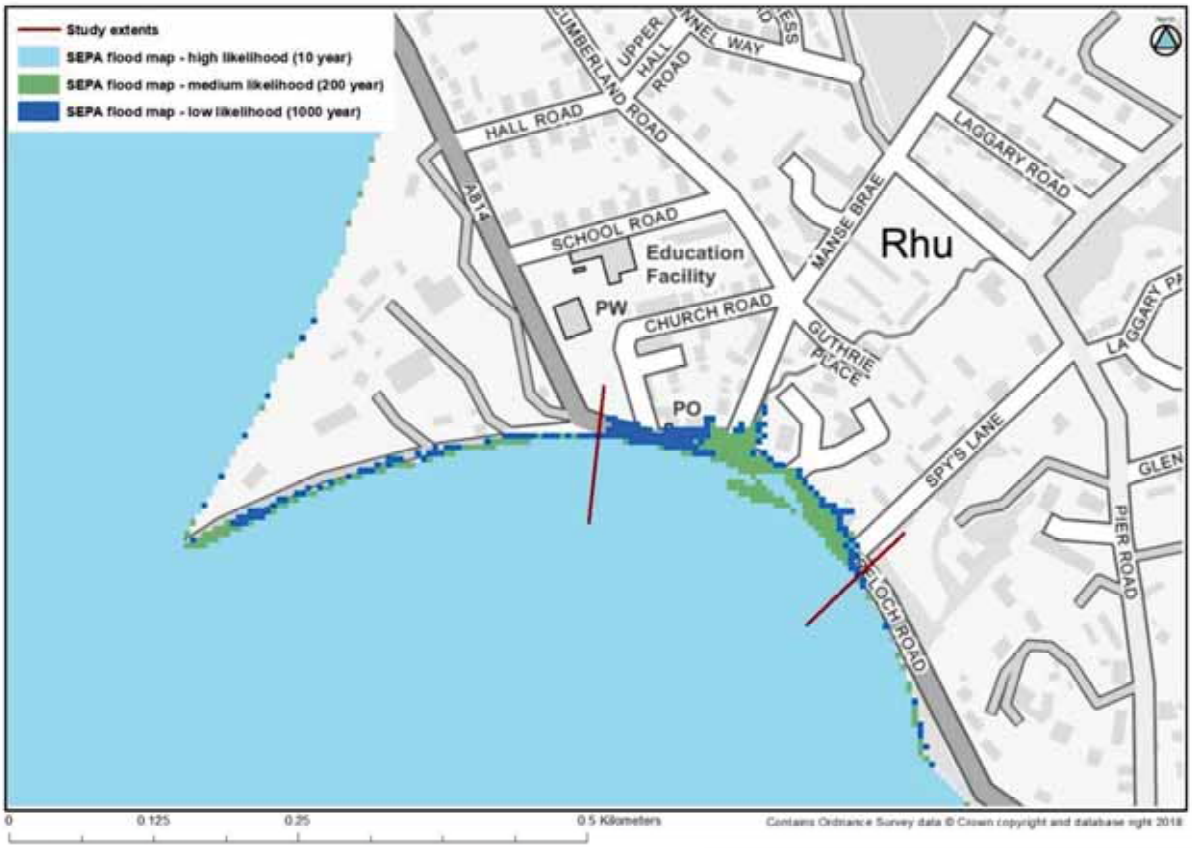

Figure 3-1: SEPA coastal flood extents (Rhu)

Figure 3-2: SEPA coastal flood extents (Helensburgh west)

Figure 3-3: SEPA coastal flood extents (Helensburgh east and Craigendoran)

3.2 Surface water (pluvial) flooding

Although surface water flooding is not the focus of this study, the potential impacts of options on surface water flood risk need to be considered. SEPA's existing pluvial flood extents are presented within Figures 3-4 to 3-6.

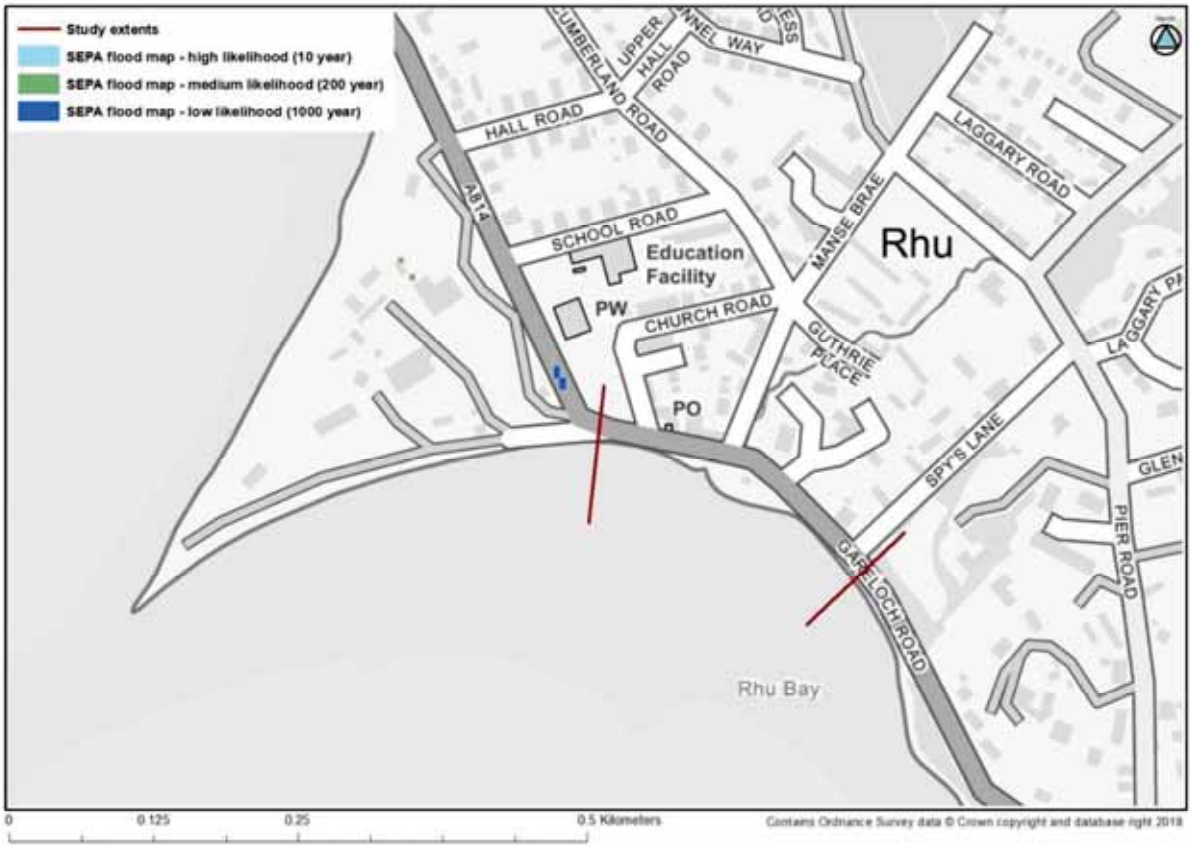

Figure 3-4: SEPA pluvial flood extents (Rhu)

Figure 3-5: SEPA pluvial flood extents (Helensburgh west)

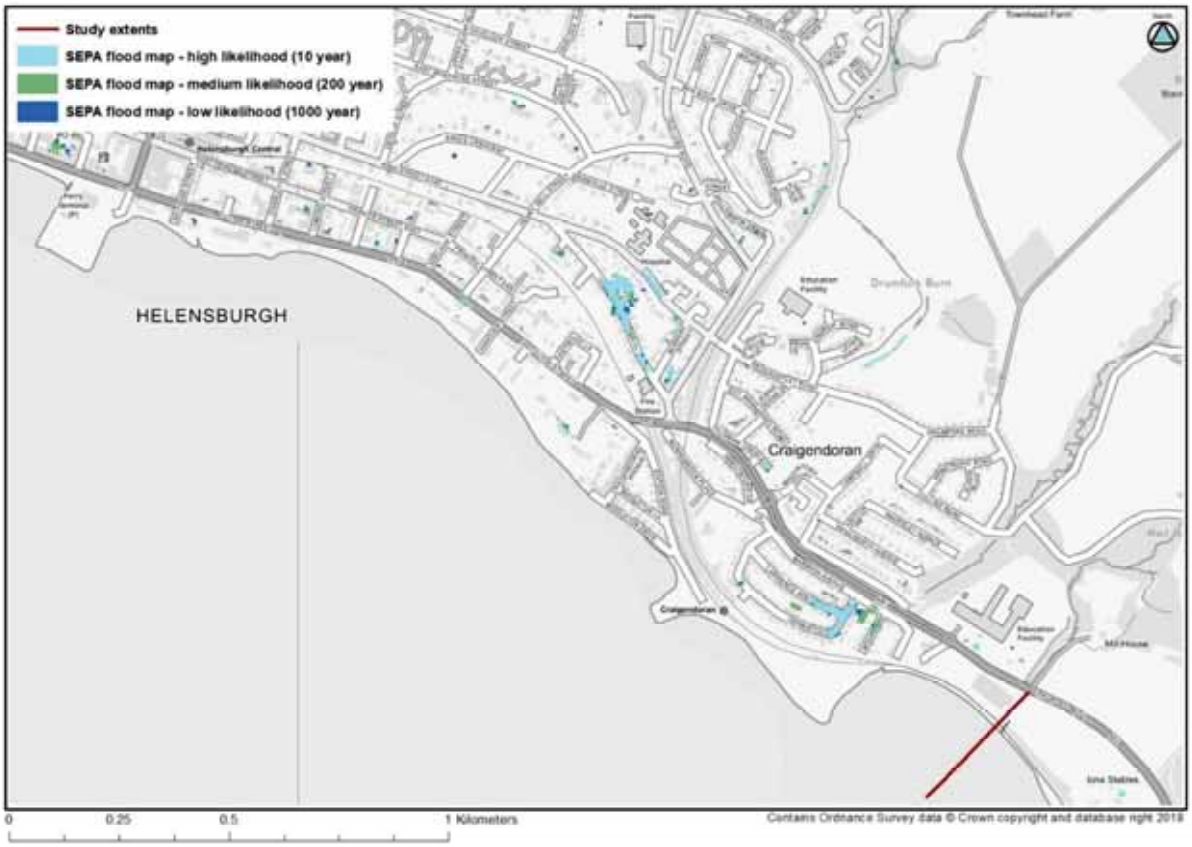

Figure 3-6: SEPA pluvial flood extents (Helensburgh east and Craigendoran)

3.3 Fluvial flooding

A number of small burns run down through Rhu, Helensburgh and Craigendoran and discharge to the Firth of Clyde within the study extent. The burns are all culverted prior to discharging onto the foreshore, with the length of these culverts varying from approximately 10 m for the Rhu Burn to approximately 350 m for the Glennan and Milligs Burns.

Grant Whyte of Argyll & Bute Council notes that there has been a previous record of flooding to the lodge located on the right bank of the Glenoran Burn, just upstream of the culvert beneath Gareloch Road, and that this is believed to have had some tidal influence.

Although fluvial flooding is not the primary focus of this study, the potential impacts of climate change of sea levels will be considered as part of the project.

SEPA's existing fluvial flood extents are presented within Figures 3-7 to 3-9. The only burn represented in the mapping is the Red Burn, with the other watercourses too small in terms of catchment area to have been included.

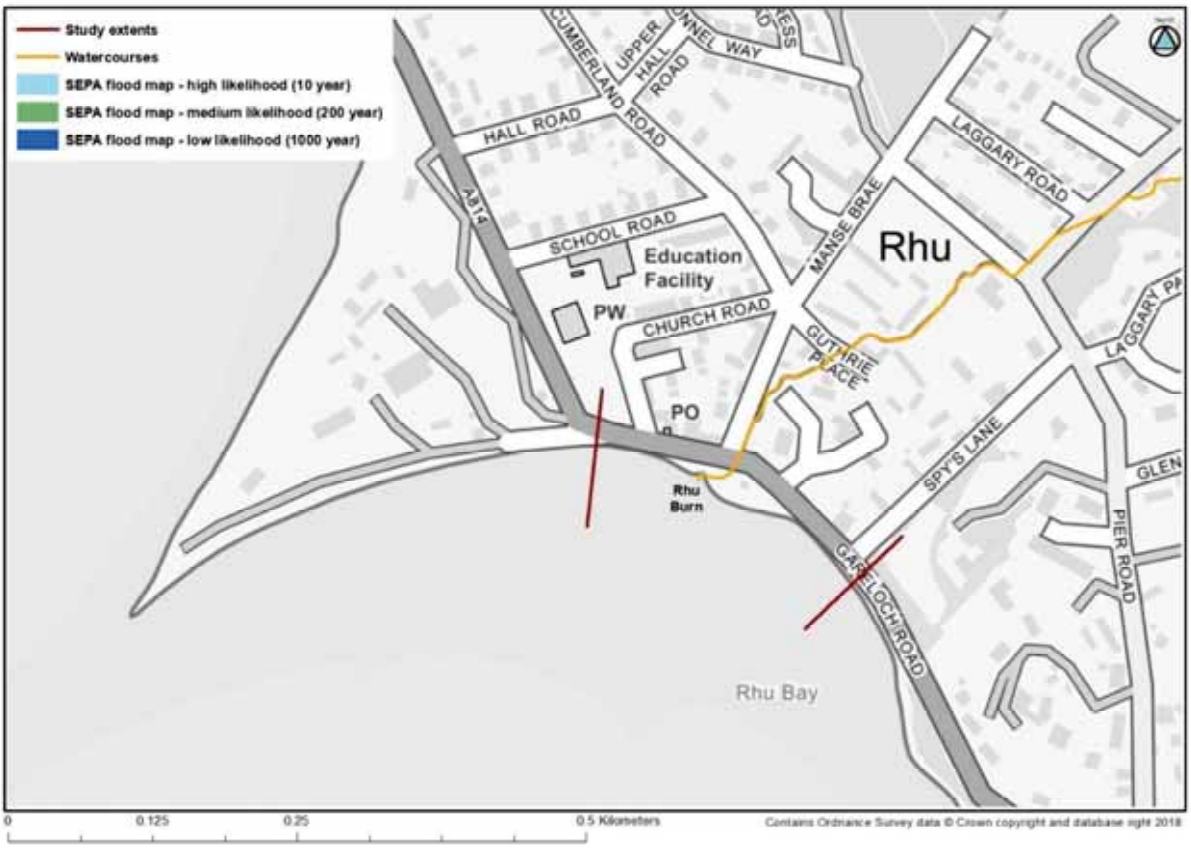

Figure 3-7: SEPA fluvial flood extents (Rhu)

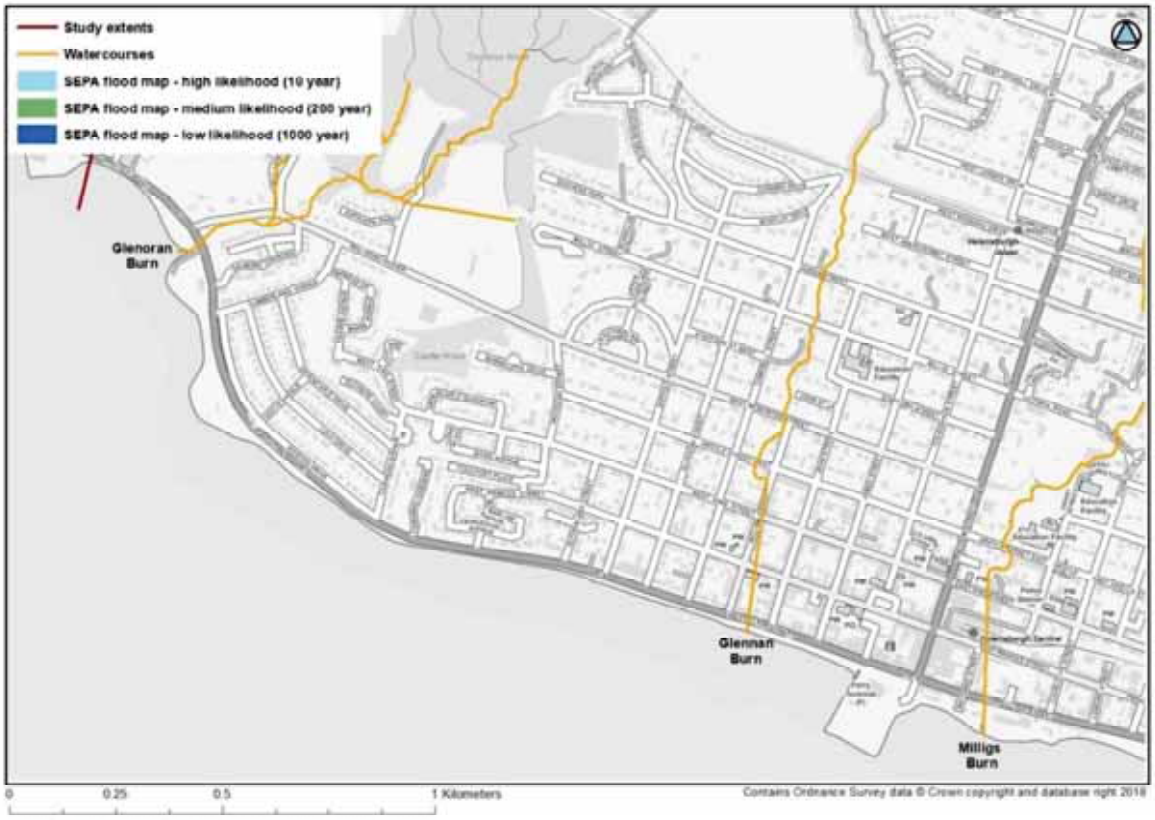

Figure 3-8: SEPA fluvial flood extents (Helensburgh west)

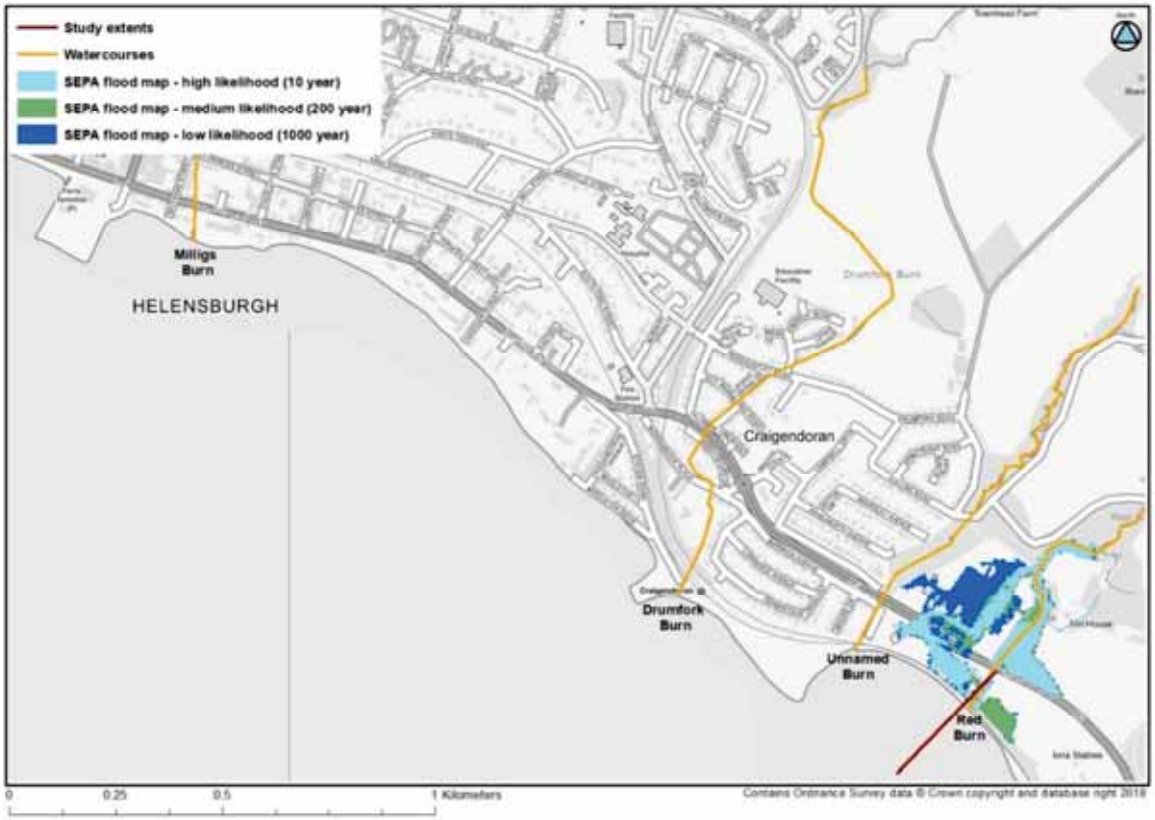

Figure 3-9: SEPA fluvial flood extents (Helensburgh east and Craigendoran)

4 Existing defences

The frontage varies through Rhu, Helensburgh and Craigendoran, with the general areas denoted within Figures 4-1 to 4-3 below.

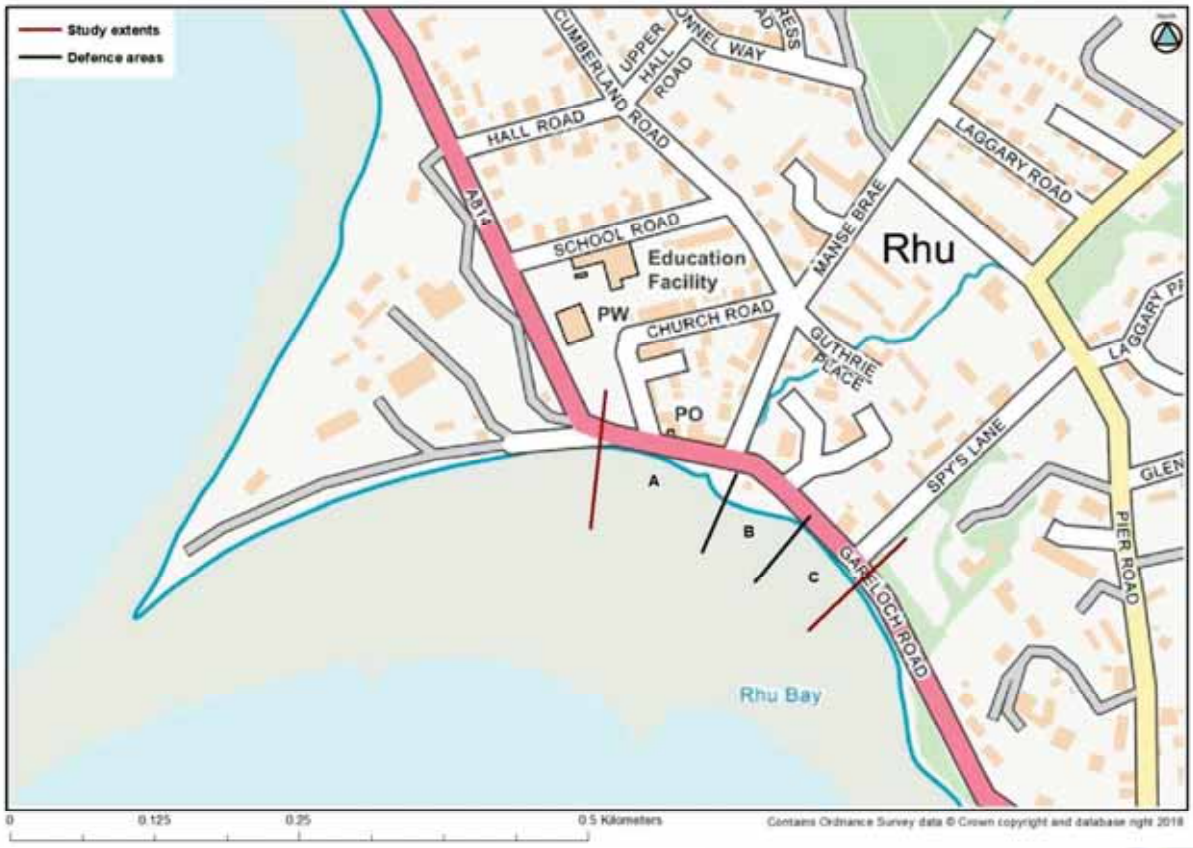

Figure 4-1: Defence sections within Rhu

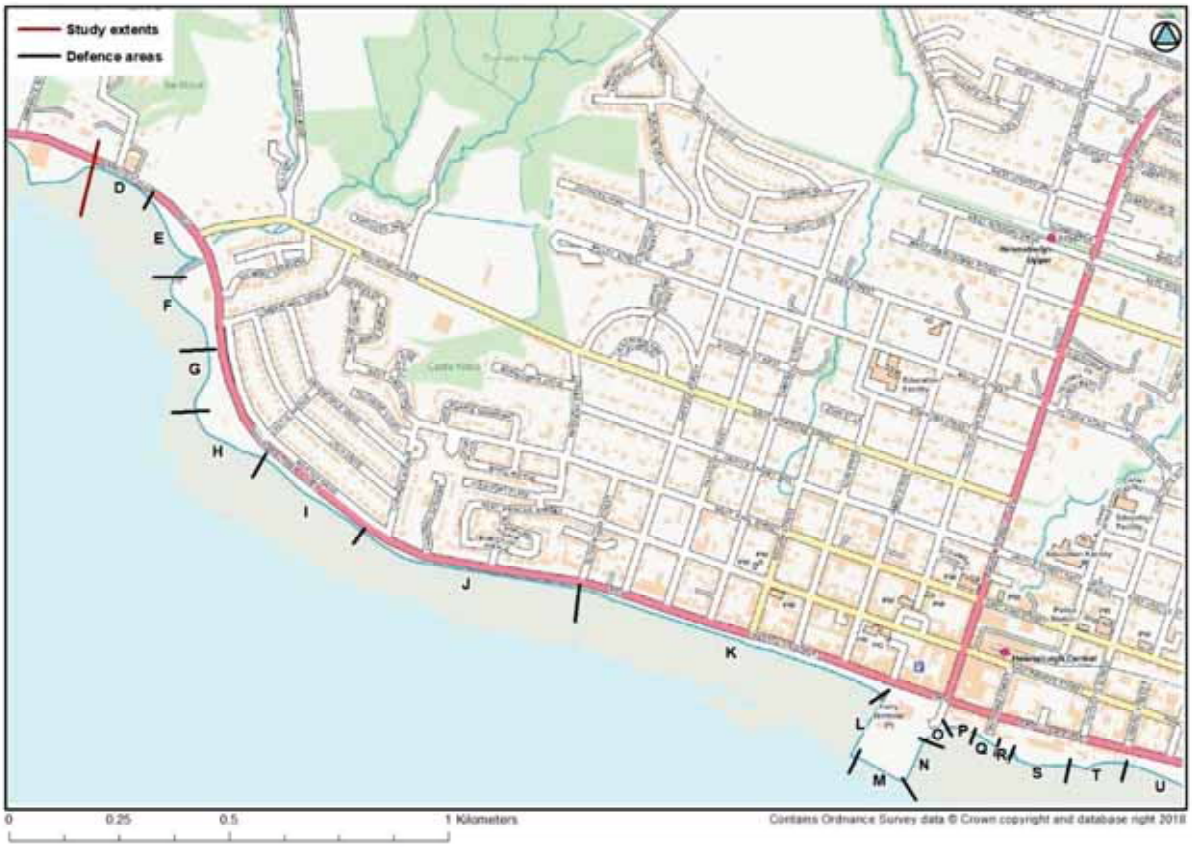

Figure 4-2: Defence sections within Helensburgh west

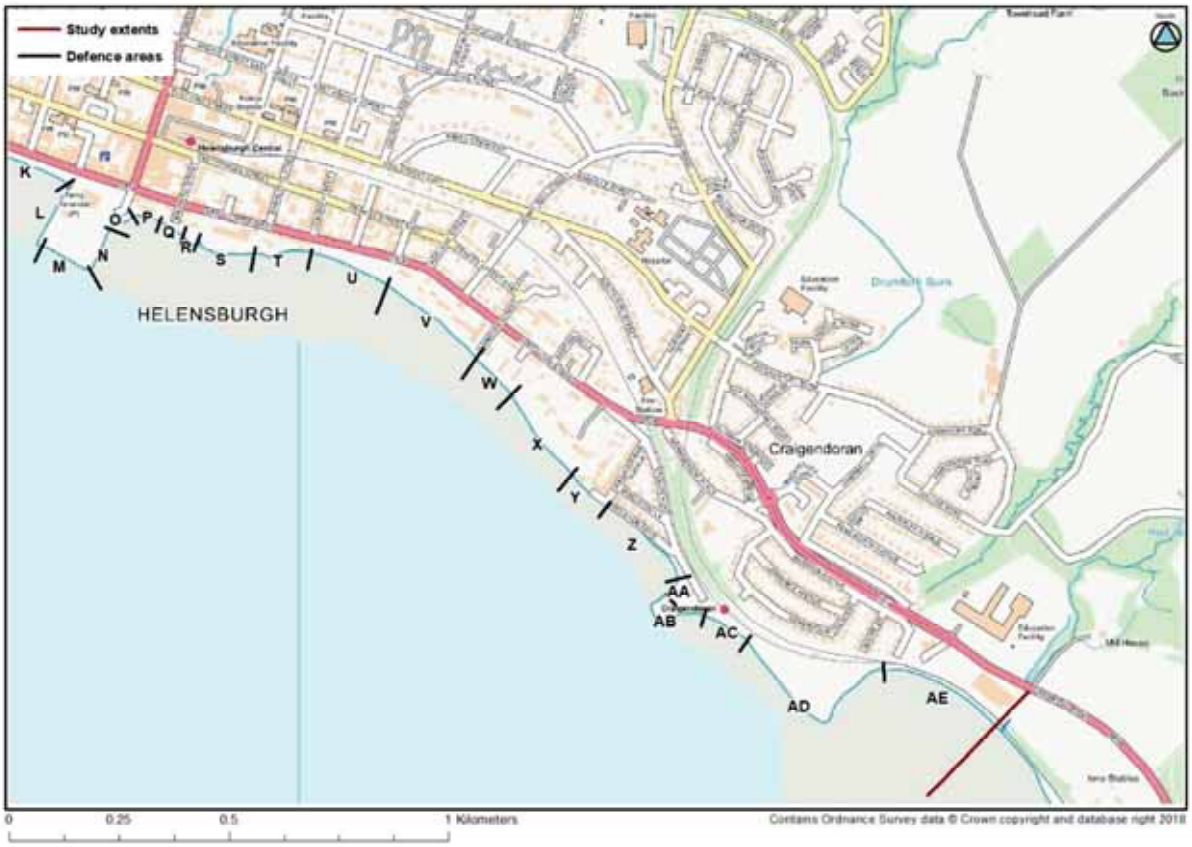

Figure 4-3: Defence sections within Helensburgh east and Craigendoran

Each of these areas/defence types is summarised below, running from west to east. These have been labelled alphabetically, and where available, Argyll & Bute's naming conventions for the defences have also been referenced.

Argyll & Bute Council's records and the Scottish Flood Defence Asset Database (SFDAD) website were checked for details of any of the defences.

Section A – masonry wall

Section A consist of a grass bank backed by a masonry wall. The A814 sits directly behind the masonry wall.

Argyll & Bute Council ref: A814 120 W10

Figure 4-4: Photograph of defence within section A

Figure 4-5: Aerial image of section A

Section B – gabion baskets

Section B consist of a grass bank backed by gabion baskets.

Argyll & Bute Council ref: A814 110 W97

Figure 4-6: Photograph of defence within section B

Figure 4-7: Aerial image of section B

Section C – rock armour revetment

Section C consist of a rock armour revetment and low masonry wall. The A814 is located directly behind the defence.

Argyll & Bute Council ref: A814 110 W89

Figure 4-8: Photograph of defence within section C

Figure 4-9: Aerial image of section C

Section D – concrete revetment with recurve wall and railing

Section D consists of a small concrete revetment topped by a concrete wave return wall, which is relatively consistent along its length. The vegetation at the toe indicates that the western end is more exposed to direct wave attack.

No drawings are available.

Figure 4-10: Photograph of defence within section D

Figure 4-11: Aerial image of section D

Section E – shingle and grass embankment

Section E lies to either side of the Glenoran Burn, that discharges beside the sailing club. No formalised defence structures exist, with the shoreline consisting of a shingle and grass embankment.

Figure 4-12: Photograph of defence within section E

Figure 4-13: Aerial image of section E

Section F – rock armour embankment

Section F is the main section of defence protecting the sailing club. It primarily consists of a rock armour embankment on top of a shingle beach. Visual inspection indicates that the sizing is irregular, suggesting that this may not be a formal structure.

No drawings are available.

Figure 4-14: Photograph of defence within section F

Figure 4-15: Aerial image of section F

Section G – shingle beach and concrete wall

Section G protrudes into the firth and consists of a shingle beach topped with a small concrete wall. The land behind rises sharply with no risk of flooding to any properties or infrastructure from overtopping.

No drawings are available.

Figure 4-16: Photograph of defence within section G

Figure 4-17: Aerial image of section G

Section H – shingle beach and sloped concrete wall

Section H forms the defence in front of the park area. The land behind rises sharply with no risk of flooding to any properties or infrastructure from overtopping.

Argyll & Bute Council ref: A814 100 W79

Figure 4-18: Photograph of defence within section H

Figure 4-19: Aerial image of section H

Section I – masonry revetment

Section I forms the first section of defences at the western end of Lower Rhu Road (A814). The defence consists of a sloping masonry revetment at the top of the shingle beach.

Argyll & Bute Council ref: A814 100 W65

Figure 4-20: Photograph of defence within section I

Figure 4-21: Aerial image of section I

Section J – concrete wave return wall

Section J is considered as the primary coastal defence along Lower Rhu Road (A814). It consists of a large concrete wave return wall at the top of the shingle beach.

Argyll & Bute Council ref: A814 100 W41

Figure 4-22: Photograph of defence within section J

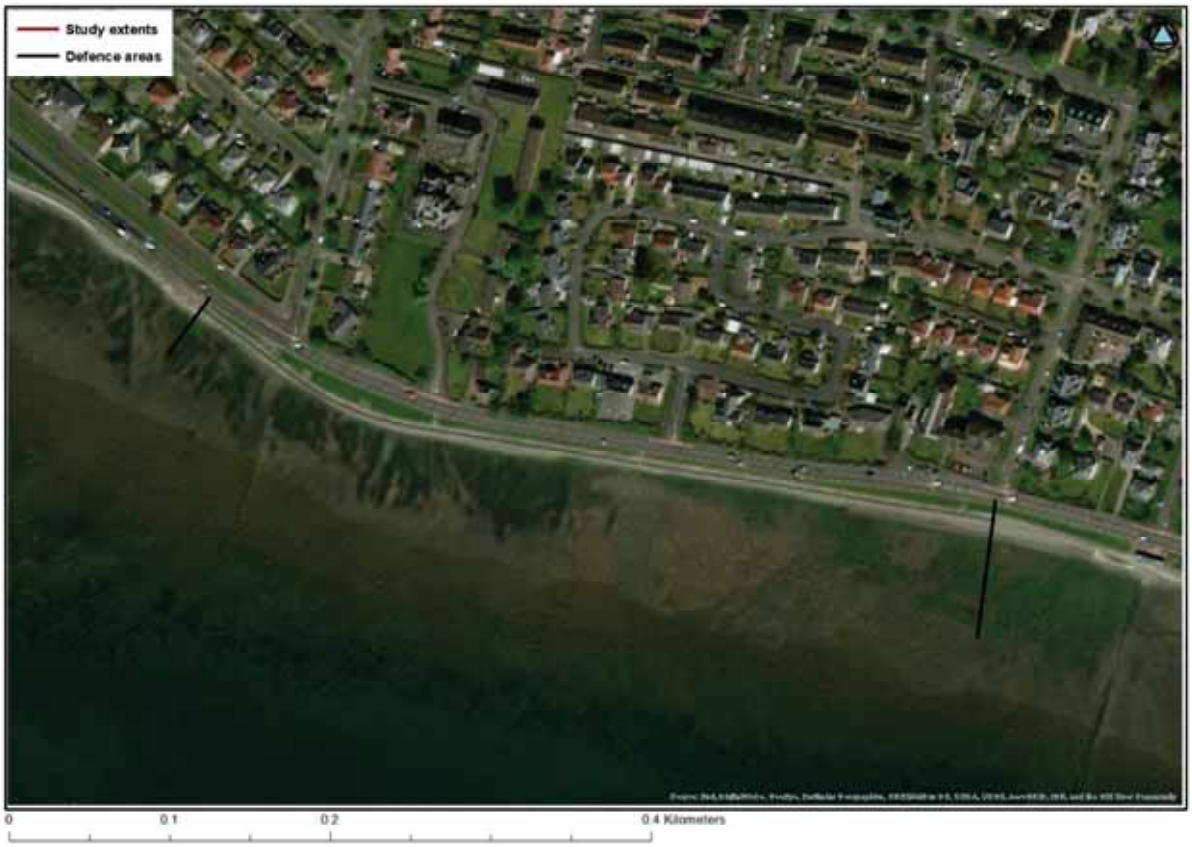

Figure 4-23: Aerial image of section J

Section K – masonry revetment

Section K is considered as the primary coastal defence along the main pedestrian frontage. It consists of a masonry revetment at the top of the shingle beach. Landward of the revetment, recent development has resulted in a small concrete wall that will potentially reduce the overtopping reaching the road and properties.

Argyll & Bute Council ref: A814 100 W04

Figure 4-24: Photograph of defence within section K

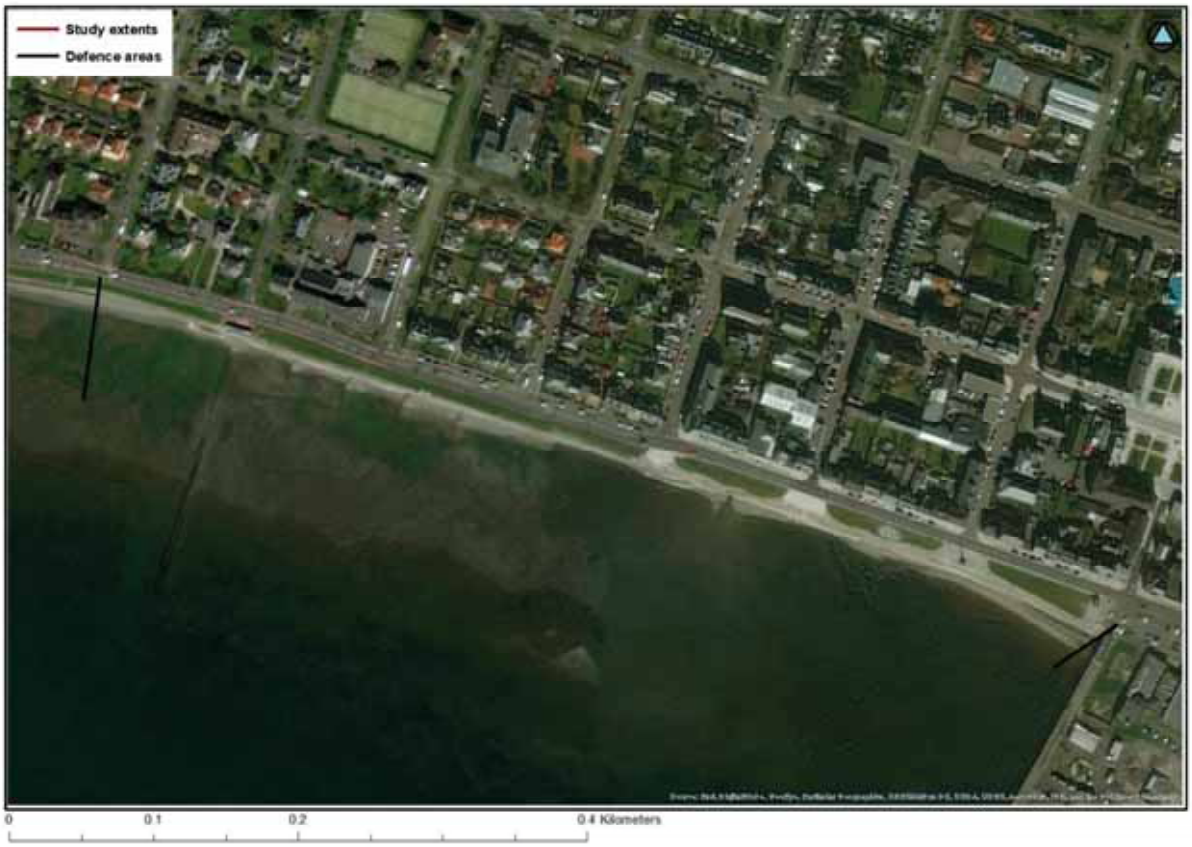

Figure 4-25: Aerial image of section K

Section L – masonry wall

Section L consists of a masonry wall on the western side of the main pier. It extends directly into the firth from the beach and is consistent in construction and orientation along the entire length.

No drawings are available.

Figure 4-26: Photograph of defence within section L

Figure 4-27: Aerial image of section L

Section M – rock armour

Section M is rock armour revetment placed along the southern side of the main pier. Tide marks show that at least half of the structure is submerged during high waters, meaning that overtopping is likely significant during extreme events.

Argyll & Bute Council ref: A814 090 W45

Figure 4-28: Photograph of defence within section M

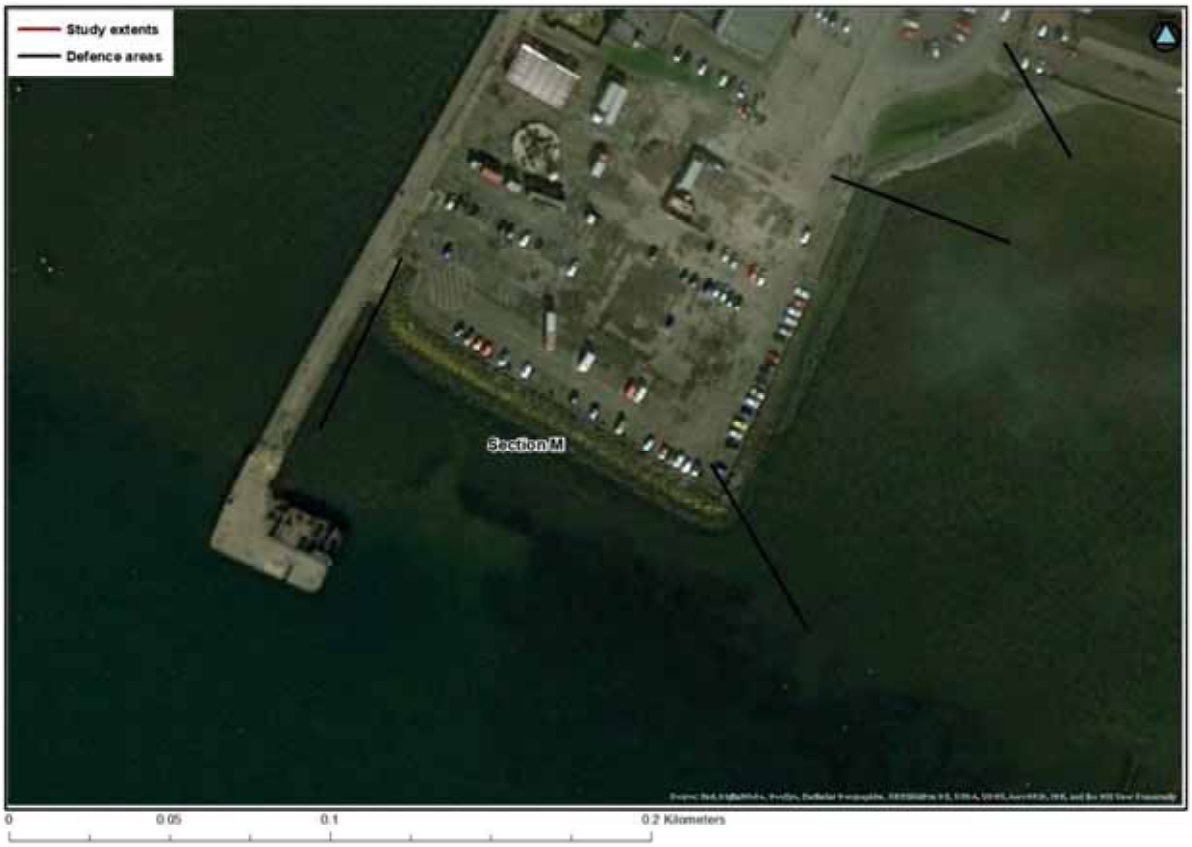

Figure 4-29: Aerial image of section M

Section N – masonry revetment and gabions

Section N forms the eastern side of the main pier. It consists of a masonry revetment topped by gabions filled with small stones.

Argyll & Bute Council ref: A814 090 W33

Figure 4-30: Photograph of defence within section N

Figure 4-31: Aerial image of section N

Section O – rock armour revetment

Section O forms the final section of coastal defence on the eastern side of the pier. It consists of a rock armour revetment placed in a near vertical profile.

No drawings are available.

Figure 4-32: Photograph of defence within section O

Figure 4-33: Aerial image of section O

Section P – masonry wall

Section P consists of a masonry boundary wall to properties that back onto the beach.

Argyll & Bute Council ref: A814 090 W22

Figure 4-34: Photograph of defence within section P

Figure 4-35: Aerial image of section P

Section Q – concrete wall

Section Q consists of a concrete boundary wall to properties that back onto the beach.

Argyll & Bute Council ref: A814 090 W12

Figure 4-36: Photograph of defence within section Q

Figure 4-37: Aerial image of section Q

Section R – masonry wall

Section R consists of a masonry boundary wall to properties that back onto the beach.

Argyll & Bute Council ref: A814 090 W06

Figure 4-38: Photograph of defence within section R

Figure 4-39: Aerial image of section R

Section S – rock armour revetment

Section S consists of the rock armour revetment that bounds the Civic Centre. Details of the outline design are provided in the Akins 2011 design report.

Argyll & Bute Council ref: A814 080 W95

Figure 4-40: Photograph of defence within section S

Figure 4-41: Aerial image of section S

Section T – masonry walls

Section T lies to the east of the Civic Centre and consists of private property boundaries. The masonry walls vary in height along the section.

Argyll & Bute Council refs: A814 080 W86, W83, W82, W80, W77

Figure 4-42: Photograph of defences within section T

Figure 4-43: Aerial image of section T

Section U – masonry revetment

Section U consists of a masonry revetment at the top of the shingle beach. Landward of the revetment, a small concrete wall exists that will potentially reduce the overtopping reaching the road and properties during minor events. Flood history shows that this location is prone to high levels of overtopping.

Argyll & Bute Council ref: A814 080 W68

Figure 4-44: Photograph of defence within section U

Figure 4-45: Aerial image of section U

Section V – masonry walls

Section V consists of private property boundaries that border the beach. The height of the walls vary through the section.

Argyll & Bute Council refs: A814 080 W58, W 53, W49, W47, W39

Figure 4-46: Photographs of defences within section V

Figure 4-47: Aerial image of section V

Section W – masonry wall

Section W consists of a private property boundary that borders the beach.

Argyll & Bute Council ref: A814 080 W28

Figure 4-48: Photograph of defence within section W

Figure 4-49: Aerial image of section W

Section X – masonry walls

Section X consists of private property boundaries that border the beach.

Argyll & Bute Council ref: A814 080 W18, W13

Figure 4-50: Photograph of defence within section X

Figure 4-51: Aerial image of section X

Section Y – masonry wall

Section Y consists of a private property boundary that borders the beach.

Argyll & Bute Council ref: A814 080 W04

Figure 4-52: Photograph of defence within section Y

Figure 4-53: Aerial image of section Y

Section Z – concrete revetment and wall

Section Z consists of a concrete revetment that protects the private road (Middleton Drive) and properties just to the west of Craigendoran Pier, as well as a concrete wall that protects Station Road.

Argyll & Bute Council ref: A814 080 W04

Figure 4-54: Photographs of defences within section Z

Figure 4-55: Aerial image of section Z

Section AA – rocky foreshore and grass embankment

Section AA consists of a rocky foreshore and a vegetated grass embankment. Although the foreshore consists of substantial concrete blocks, these are not considered to be a formalised defence structure.

Argyll & Bute Council ref: A814 50 W74

Figure 4-56: Photograph of defence within section AA

Figure 4-57: Aerial image of section AA

Section AB – concrete walls

Section AB forms the main defences to Craigendoran Pier. and is in the form of a vertical concrete wall. Localised rock armour placements also exist.

Argyll & Bute Council ref: A814 50 W70

Figure 4-58: Photographs of defences within section AB

Figure 4-59: Aerial image of section AB

Section AC – masonry revetment and wall

Section AC lies to the east of Craigendoran Pier and consists of a masonry revetment topped, in part, by a small concrete wall. The revetment appears relatively uniform along the length, but the crest elevation of the wall varies.

Argyll & Bute Council ref: A814 050 W59

Figure 4-60: Photograph of defence within section AC

Figure 4-61: Aerial image of section AC

Section AD – rock armour and grass embankment

Section AD consists of rock armour placements that back onto a grass embankment. Localised placements of concrete and masonry are also evident suggesting that this is an ad hoc defence to prevent erosion.

No drawings are available.

Figure 4-62: Photograph of defence within section AD

Figure 4-63: Aerial image of section AD

Section AE – concrete wall

Section AE is the main coastal defence protecting the railway from wave overtopping. It consists of a uniform vertical concrete wall along the entire length. The toe of the structure is well above low water and the water marks observed suggest that little submersion occurs even at high tide.

No drawings are available.

Figure 4-64: Photograph of defence within section AE

Figure 4-65: Aerial image of section AE

Recommendation: It is recommended that a visual structural survey to classify the defences, assess their condition, record defects, assess residual life and where possible assess toe depth is undertaken.

5 Environmental background

5.1 Environmental designations and data

The study will need to consider international, national and local designated sites.

Information on local designations, Invasive Non-Native Species (INNS), previous studies and any other environmental data has been requested from Argyll & Bute Council.

Recommendation: It is recommended that a baseline ecology and environment report, including site walkover and desktop study, is undertaken in order to consider all potential environmental constraints within the optioneering.

5.2 River Basin Management Plan

Helensburgh is located within the 'Clyde Estuary – Outer' transitional water body, ID 200320. The water body has 'Moderate' overall status, and this has been consistent every year from 2007 to 2016. In 2014, this was split down into 'Moderate' for physical condition, 'High' for freedom from invasive species and 'Good' for water quality. The water body is designated as heavily modified on account of physical alterations for navigation and flood risk.

Recommendation: It is recommended that a desktop baseline report be prepared, which can be used to assess the potential options and make sure the classification of the water body would not be downgraded due to any proposed works.

5.3 Natural Flood Management

Natural Flood Management (NFM) and morphology pressures data has been requested from SEPA but was not available at the time of writing.

Recommendation: It is recommended that a baseline natural flood management desktop report be prepared; this will review the SEPA data and recommend any options that could feed into the appraisal process.

5.4 Built landscape and heritage

Tourism plays an important role in the economy of the local area, and as such it is imperative that any proposals take into account the local townscape and built heritage of the area.

Recommendation: It is recommended that built landscape and heritage baseline reports be prepared, which can be used to assess the potential options in reference to the wider built environment.

5.5 Geotechnical Investigation

The underlying geotechnical conditions are a key consideration in the selection of potential options. Existing information has been located from the development of the Helensburgh Civic Centre, and additional existing information may be available through Envirocheck.

Recommendation: It is recommended that a geotechnical engineering desk study be prepared in order to collate and review the existing information in the context of a coastal flood protection scheme.

6 Modelling

There have been several previous assessments focused along the shorefront at Rhu, Helensburgh and Craigendoran; these are summarised below along with a summary of the proposals for modelling as part of this study.

6.1 Previous assessments

A summary of previous studies is provided below, with particular consideration of the findings being used to inform the options appraisal and engineering components of the detailed study being undertaken herein.

Helensburgh Waterfront FRA – Kaya Consulting (June 2018)

Flood risk assessment for the proposed development on Helensburgh Pier. The report notes that the existing site is at risk from a 5 year event based on still water levels (SWL) alone. The report recommends finished floor levels for the development as well as for the wider car parking area. Risk from wave overtopping is also considered, with recommendations of defences presented for the western, southern and eastern sides of the pier.

Firth of Clyde Flood Forecasting System (FFS) Recalibration (November 2017)

SEPA have operated a still water level forecasting model for the Firth of Clyde since 2008. Through continued monitoring of the system, it was apparent that the model was overpredicting still water levels during high storm surge events and a performance review was required. During the project, the still water level forecasts were recalibrated to recent events and wave overtopping forecasts were added at 15 locations, including Helensburgh East Clyde Street.

New Helensburgh Swimming Pool and Leisure Facility Options Appraisal Report – Aecom (October 2015)

The report presents and assesses a range of defence options for the proposed development of Helensburgh pier. The options are assessed against a range of criteria, including flood risk, buildability, durability, length of programme and the impact on adjacent structures.

Craigendoran Pier FRA – JBA Consulting (April 2013)

Flood risk assessment for a proposed single property on Craigendoran Pier. The report considers coastal flood risk with regard to still water levels and wave overtopping to the site as well as to access and egress.

Helensburgh Coastal Defence, Options Report – Atkins (December 2011)

The report presents and assesses a range of defence options for the development of the Helensburgh Civic Centre site. The options are assessed against a range of criteria, including flood risk, buildability, durability, length of programme and the impact on adjacent structures.

Proposed Development at Helensburgh FRA – URS (November 2011)

Flood risk assessment covering the CHORD site, Helensburgh pier and the Civic Centre site. The report concludes that all 3 sites are at risk from still water levels and wave overtopping. The report recommends further overtopping analysis to adequately design defences at each site.

Scottish Water Asset Resilience FRAs – JBA Consulting (September 2011)

Flood risk assessments considering coastal, fluvial and pluvial risk to ten pumping stations located along the coast in Helensburgh and Craigendoran. The reports include a series of reactive and proactive options to improve asset resilience at each site.

6.2 Proposed modelling

The modelling proposed as part of this study includes wave calculations, joint probability assessment, wave overtopping modelling and a TUFLOW inundation model. This modelling will require a range of input data; this is summarised below.

Coastal Flood Boundary Dataset (CFBD)

The CFBD provides estimates of extreme sea levels at a 2km chainage around the entire UK coast. The levels are obtained through statistical analysis of surge residuals at A-Class and intermediate gauges throughout the UK, with areas between estimated from a combination of interpolation and hydrodynamic modelling.

These levels were first provided by Defra in 2011 but have recently been updated to make use of longer historical records. These updated values will form the SWL component of the flooding analysis and design of defence options.

Wave analysis

Waves responsible for overtopping will predominantly be fetch limited and generated within the firth. Extreme waves will be estimated for each overtopping location based on fetch length for a range of exposure windows. Wind data will be requested for local stations (e.g. Rhu Marina and Glasgow Airport) and extreme value modelling undertaken. These will be compared to the wind data from the WaveWatch III hindcast and the most appropriate (based on record length and quality) used within the final calcuations.

Climate change

The UK Climate Projections (UKCP) provides the relative sea level rise scenarios that will be used in the study. The current datasets were released in 2009 (UKCP09) and new estimates are scheduled to be released in November 2018 (UCKP18). The appropriate dataset (and emissions scenarios) will be confirmed through consultation with SEPA as it is important to ensure a nationally consistent approach across all coastal flood studies that are to be considered during the July 2019 prioritisation exercise. Should SEPA advise on the use of the UKCP18 data, this could lead to a delay in delivery.

Should the UKPC09 dataset be used to inform the options appraisal, the Council should be aware that they will need to run models again for the new climate change predictions as part of any detailed design process.

Topographic data

The 1D SWAN wave transformation models will require bathymetry data to represent the offshore bathymetry of the firth. This data has been purchased from OceanWise.

SEPA's Phase 1 LiDAR covers the full extent of Rhu, Helensburgh and Craigendoran (Figure 6-1) and is at 1m resolution. The water surface present within the dataset has been removed ready for use within the modelling; the LiDAR appears to have been flown at low tide, thus maximising the extent of the foreshore that is present within the dataset.

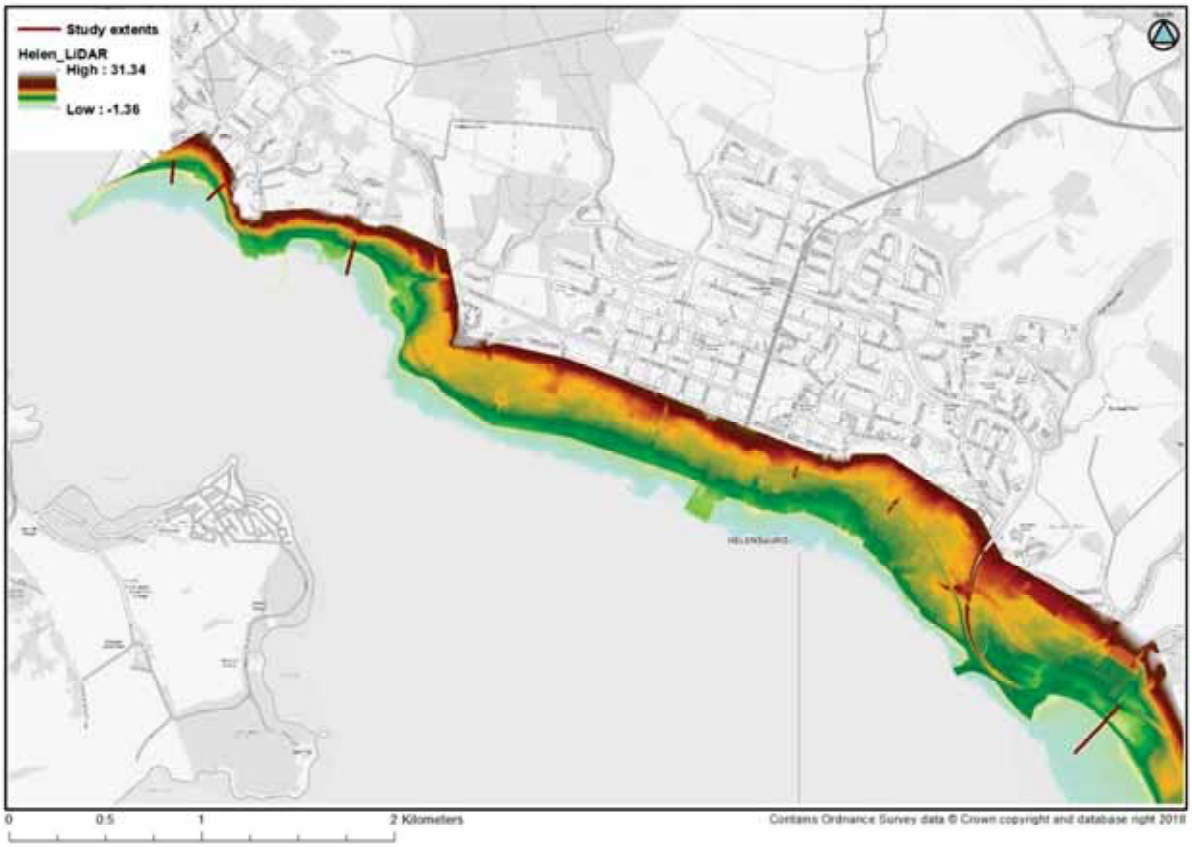

Figure 6-1: SEPA Phase 1 LiDAR

A number of previous topographic surveys have been undertaken along the shorefront; these are focused on Helensburgh pier as well as East and West Clyde Street. Argyll & Bute Council combined these different topographic surveys, with the data presented within Figure 6-2. Two cross sectional profiles through the defences were surveyed by JBA Consulting for the development of the overtopping element of the Clyde coastal Flood Forecasting System (FFS); the extent of the FFS survey is presented within Figure 6-3. It is understood that there are no existing threshold levels for the area.

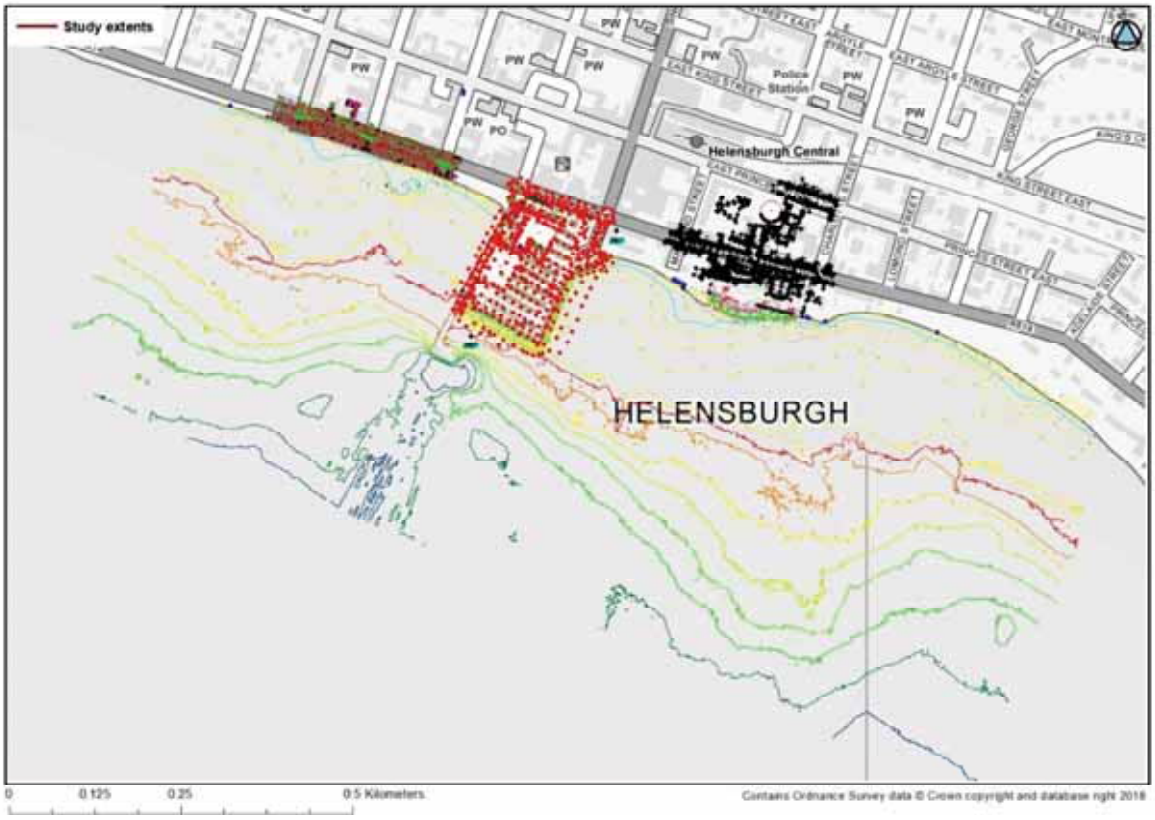

Figure 6-2: Extent of the topographic survey data

Figure 6-3: Extent of the Flood Forecasting System survey

Recommendation: It is recommended that a topographic survey of the full frontage be undertaken; this would be best achieved through the use of a 3D scanner to ensure that all structures are picked up and would provide a 3D model for use within the design process and for stakeholder engagement. Following the inundation modelling, it is recommended that a threshold survey of properties is undertaken; leaving this phase of the survey until after the modelling has been completed will ensure that all the necessary properties are picked up without additional expenditure on properties that are not required for the economic analysis.

7 Summary of recommendations/requirements

7.1 Recommendations

Table 7-1: Recommendations for further studies

Recommendations	Currently programmed
Structural survey including visual inspection of all coastal defences.	Yes
Baseline ecology survey including site walkover	Yes
Baseline RBMP and NFM study	Yes
Built landscape and heritage baseline assessments	Yes
Desktop geotechnical desk study	Yes
Topographic survey of shorefront and defences	Yes

7.2 Datasets

Table 7-2: Outstanding datasets

Dataset	Source
Updated CFB dataset	SEPA
UKCP18	SEPA/UKCP
INNS (invasive non-native species) data	ABC
Historical mapping	ABC

Offices at

Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Isle of Man
Limerick
Newcastle upon Tyne
Newport
Peterborough
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

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