Oban Flood Study
Report 2C: Surface Water Management Plan

December 2019

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EXECUTIVE SUMMARY

The Surface Water Management Plan (SWMP) for Oban is part of the overall Flood Risk Management Plan for Oban. The SWMP aims to identify and quantify flood risks from pluvial sources within the town. It will also identify potential solutions to reduce the risk from pluvial flooding.

To facilitate the assessment, the Oban surface water catchment was separated into 12 zones based on catchment characteristics. The surface flood probability in each zone was assessed by using data from a variety of sources, including an S16 hydraulic model of the sewer network, stakeholder and community consultation, GIS analysis of pluvial flow paths, and field visits to identify potential flow paths. The zones were also assessed on their vulnerability to flooding based on the *SEPA Flood Risk and Land Use Vulnerability Guidance.*

Three of the zones were identified as *Target Areas;* Lochavullin; Glenshellach; and, Soroba. Lochavullin has a history of significant flooding, which has regularly damaged buildings and businesses. Glenshellach has a large number of residential properties at risk of flooding. Glenshellach also has a history of flooding. Soroba was identified as the most vulnerable zone, the Scottish Water S16 model shows there is the potential for flooding from the network causing overland flow.

Twenty-eight solutions were considered, which aim to manage *everyday rain*, *more rain*, and/or *extreme rain*. They include property level interventions, local interventions, sub-catchment scale interventions, surface water network interventions, and watercourse engineering.

Multi-criteria compatibility analysis was used to score the appropriateness of each solution for resolving the primary flooding mechanism(s) in each zone, producing a ranking of solutions by zone. Detailed design is still required to develop the most appropriate individual or combination of solutions.

The discussion with stakeholders, including the community and Argyll & Bute Council, identified three priority target areas, while recognising that Scottish Water do not identify any properties in Oban as being at risk of internal flooding due to combined or foul sewer flooding for their required level of service (which is the 1 in 30 year event). The three target areas identified were Lochavullin, Soroba, and, Glenshellach. Works packages were developed for these areas. The works packages provide a variety of solutions, which in combination will reduce flood risk in these areas.

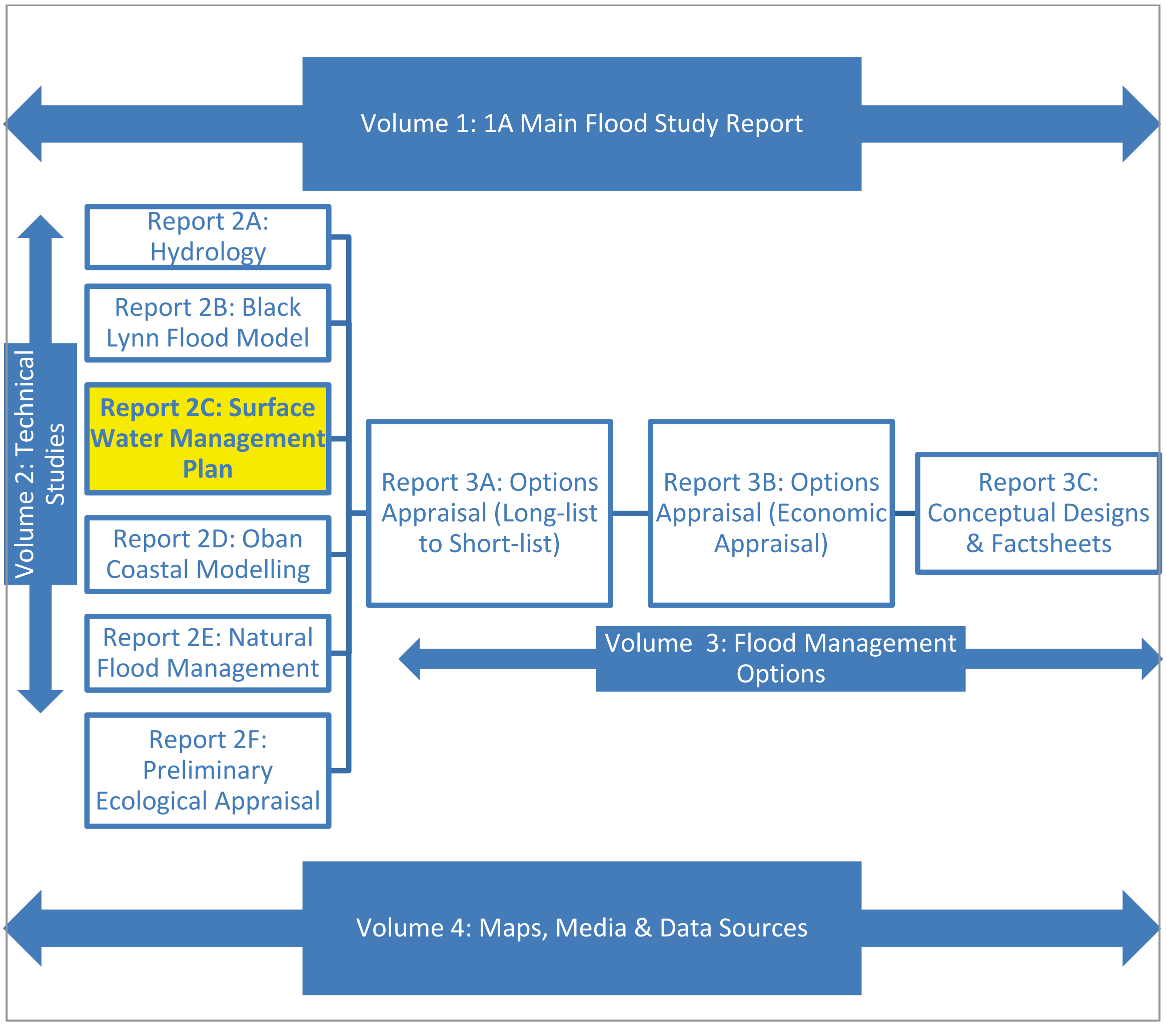
A works package was also for created for maintenance across the catchment which highlighted the need to make the best use of existing structures. Unblocking gullies, repairing pumps, and removing sediment were all highlighted as necessary maintenance tasks.

Detailed design of the solutions has not been progressed. Further assessment, design, and consultation is required to develop the solutions further and to integrate them with fluvial and coastal solutions. Consideration is also required for future climate change scenarios which will lead to more frequent and intense storms in the future.

The potential solution discussed within the SWMP can be included in future planning and development proposals. Much of the catchment would benefit from appropriate sustainable drainage systems (SuDS) which can be integrated easily into new developments (and are required for almost all new developments in Scotland) and provide additional benefits which can improve water quality or provide the community an amenity value beyond reducing flood risk.

OBAN FLOOD STUDY REPORT MAP

The context of the current report within the wider Oban Flood Study is highlighted in yellow as shown below.



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1 INTRODUCTION

1.1 Terms of Reference

EnviroCentre Limited was commissioned by Argyll & Bute Council to undertake a surface water management plan (SWMP) and flood management study for the town of Oban. This technical report contributes to the surface water management plan requirement of the study.

1.2 Definition of Surface Water Flooding

Surface water flooding is a combination of *pluvial flooding* and *surface water sewer* flooding. Surface Water Management Planning Guidance (Scottish Advisory and Implementation Forum for Flooding, 2018) defines surface water flooding as the flooding which occurs when a rainfall event causes surface water to flow and pond on the ground and when sewers and artificial drainage systems exceed their capacity It does not include flooding directly caused by fluvial or coastal flooding, although, due to complex interactions of many flooding sources, the root cause of the flooding is not always distinct.

Pluvial flooding is flooding arising from rainfall runoff ponding or flowing over the ground before entering a watercourse or drainage system, or when it cannot enter a drainage system due to the drainage system being already at full capacity.

Flooding from *surface water sewers* can occur due to inlet limitations (i.e. when the rate of water arriving at entry points such as road gullies exceeds the throughput of these inlets, especially due to debris blockage or inadequate gully density), network conveyance limitations (i.e. when the size and gradient of network pipes is inadequate to drain received water under gravity or assisted by pumps) or due to discharge limitations (inadequate pumping for pumped sewers, or high water levels in receiving watercourses or systems for gravitational sewers).

1.3 Principles of Surface Water Management

Managing surface water cannot be done in isolation and decisions regarding surface water inevitably impacts other stakeholders and the community. The Surface Water Management Planning Guidance (2018) presents the principals of sustainable surface water management to guide decision making and to maximise benefit as:

1) Manage rainfall and surface water in a way that protects and enhances both the built and natural environments.
2) Manage rainfall and surface water safely above ground.
3) Avoid increasing the amount (volume or peak rate) of surface water in sewers, and where possible reduce the amount of surface water in sewers.
4) Manage everyday rainfall at source, and heavy and extreme rainfall by collecting, delaying and conveying excess flows safely to watercourses following natural topography.
5) Where possible, multifunctional solutions should be considered which maximise all benefits; these include benefits for people, water quality and biodiversity.
6) Help the urban environment adapt to climate change and mitigate the loss of green space.
7) Coordinate with other stakeholders to maximise benefits.

1.4 Stakeholders

Managing flooding is complex and requires the active input and co-operation of a range of stakeholders to be effective. The stakeholders involved in managing flood risk include:

- Local Authorities (in exercising their powers to manage flood risk);
- Local Authorities (as roads authorities);
- Local Authorities (as planning authorities);
- Local Authorities (in applying building standards);
- Scottish Water (in compliance with their duties under the Sewerage (Scotland) Act 1968);
- SEPA (in exercising their various responsibilities to oversee flood risk management); and,
- Individual homeowners and landowners (responsible for managing rainfall and surface water on the land they own).

1.5 Scope of Report

This report is a surface water management plan (SWMP) for the town of Oban within Argyll and Bute. This report is part of the Oban Study which addresses all sources of flood risk, including coastal flood risk and fluvial flood risk.

The extent of the study area for this surface water management plan is considered to be the local catchment area draining through Oban as shown in Figure 1.1**.** The aim of a SWMP is to reduce the risk of surface water flooding in the most sustainable way, as required under the Flood Risk Management (Scotland) Act 2009.

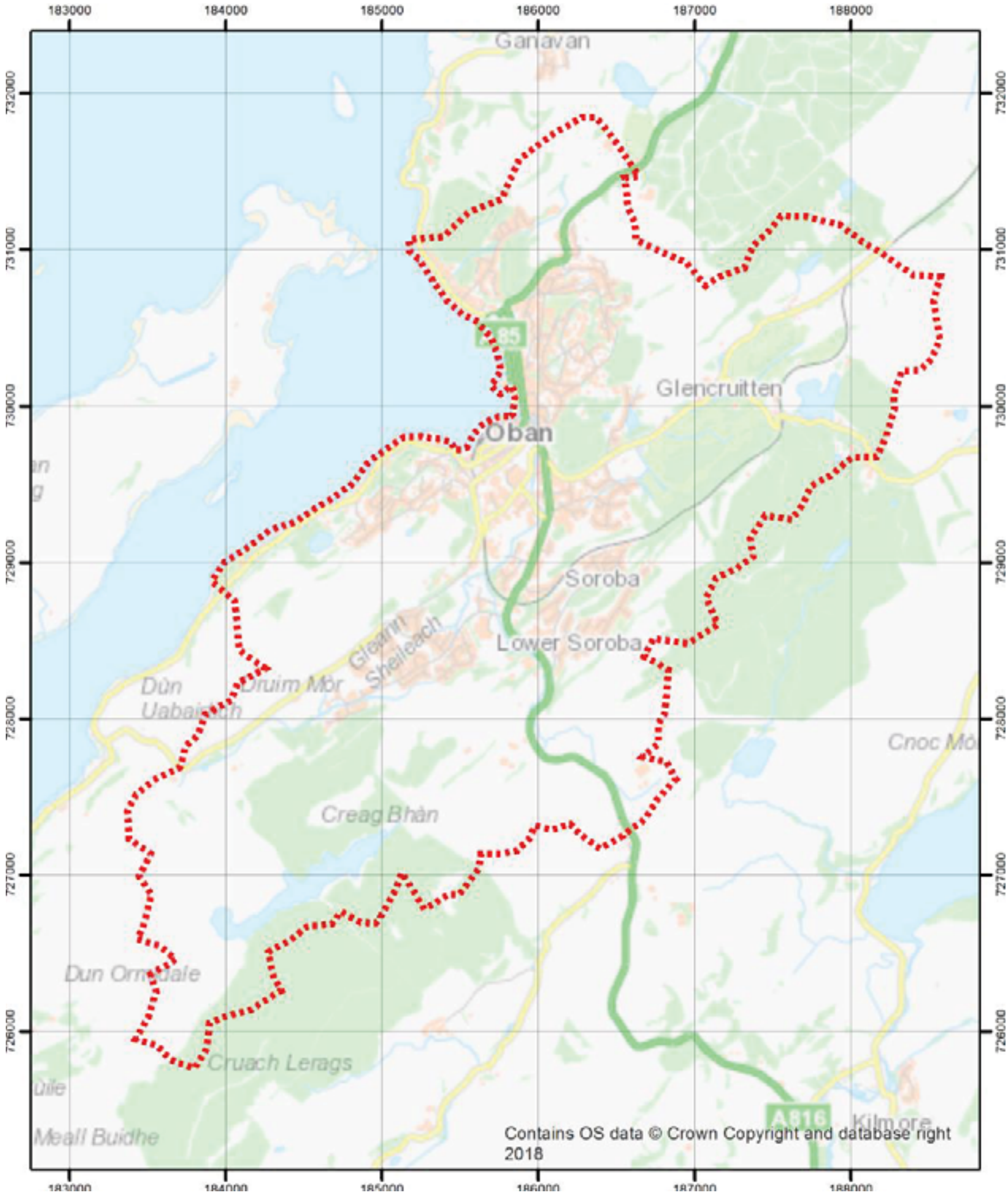
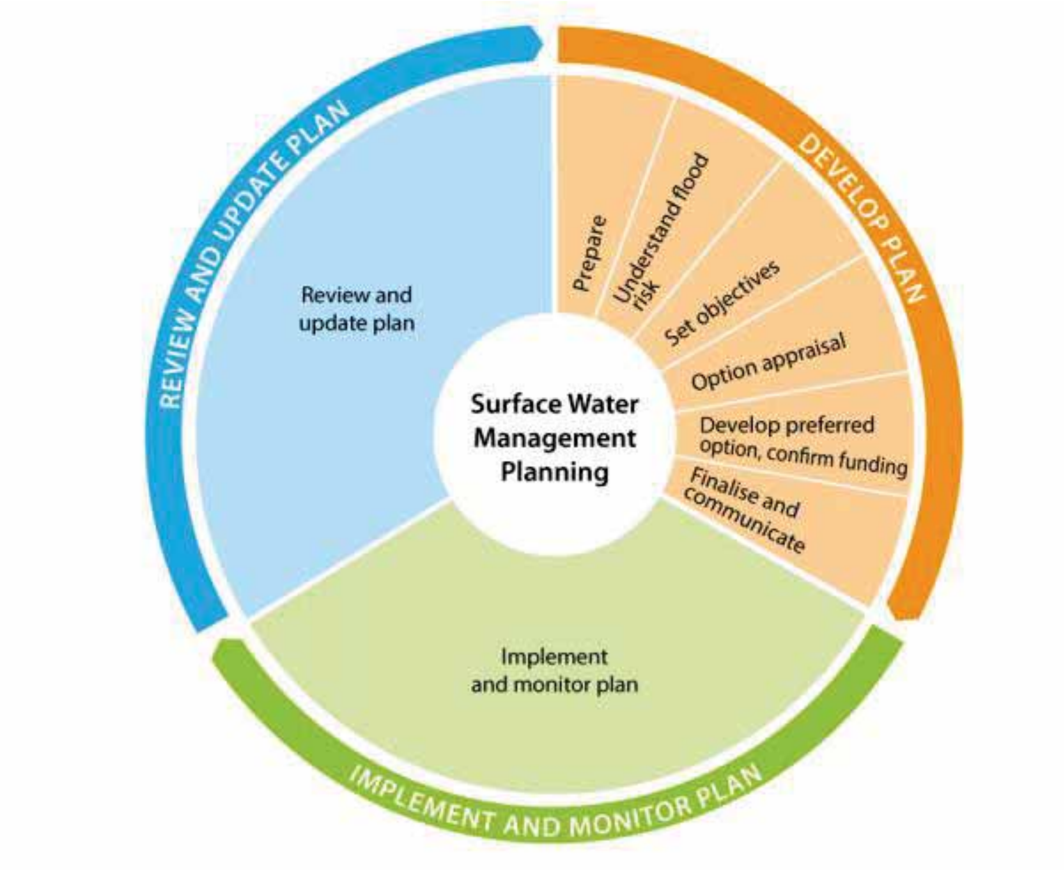


Figure 1.1: Oban Surface Water Catchment

The Surface Water Planning Guidance (Scottish Advisory and Implementation Forum for Flooding, 2018) details the approach that should be taken to developing SWMP. It sets out the principles of Surface Water Management Planning, which includes:

- Range of sustainable actions; the plan will include a range of different actions. The actions should be the most sustainable combination of actions required to manage flood risk.
- Long-term iterative approach; the SWMP should have a long term vision and should be monitored, reviewed and updated.
- Risk based; investment should be directed toward areas at greatest risk of surface water flooding.

The guidance identifies the stages of the surface water management planning process which includes developing the plan; implementing and monitoring the plan; and, reviewing and updating the plan, presented in Figure 1.2. This report will focus on the "Develop Plan" stage of Surface Water Management Planning. In particular, it will contribute to understanding the flood risk and option appraisal.



Source: Scottish Advisory and Implementation Forum for Flooding, 2018

Figure 1.2: Stages of surface water management planning; reproduced from Surface Water Management Planning Guidance

2 DATA COLLECTION

2.1 Overview

Several different sources of information were consulted in order to gain the most comprehensive understanding of the risk of surface water flooding in Oban. These included:

- Desk study and investigation, including GIS analysis and a comprehensive review of Scottish Water's S16 modelling (including their InfoWorks ICM model of the combined sewer catchment);
- Review of SEPA flood maps;
- Field work such as site visits, details of which are provided separately;
- Public consultation events held in Oban; and
- Stakeholder engagement sessions.

2.2 Drawings

Table 2.1 presents a list of the drawings used and referenced within this report. The drawings are presented in Appendix A.

Table 2.1: List of drawings used and referenced in the report

Drawing Number	Title
170506-036	S16 Model Details and Predicted Flood Depths from S16 Model
170506-037	Overland Flow Paths and Predicted Flood Depths from S16
170506-102	Predicted Flood Depths from the S16 Model for the 1 in 30 year Flood
170506-103	Predicted Flood Depths from the S16 Model for the 1 in 200 year Flood
170506-104	Predicted Flood Depths from the S16 Model for the 1 in 200 year plus Climate Change Flood

2.3 Desk Study

Argyll & Bute Council provided a significant amount of information on the geography of the catchment and the recent flooding history (Table 2.2).

Table 2.2: Data received from Argyll & Bute Council

Type	Description
Photos	Site visits, flood events in 2001, 2014 & 2018
Flood Reports	Biennial Flood reports from 2003, 2005, 2007 & 2009
Model	Scottish Water InfoWorks model with outputs and report
Shapefiles	Buildings locations and sizes
Mapping	Ordnance Survey Mapping for the study area, and SEPA's Flood Risk Mapping
Reported flood	Communication from the community and stakeholders who affected by flooding during historic events
Drainage Layout	Record Drawing of the drainage arrangement for Dalintart, and drainage arrangement plans for Lochavullin, including the Pumping Station

2.3.1 Historical Events

Historical flooding is one of the drivers for the project. A desk study was conducted to identify the location of historical flooding and possible causes of the flooding. This was supplemented with information provided by Argyll & Bute Council regarding previous flooding, including witness communication, photographs and news reports. Table 2.3 presents a summary of recent significant surface water flooding events in the study area. A comprehensive list of flooding from all sources is provided in the main Oban Flood Study report.

Table 2.3: Summary of significant surface water flooding events

Date	Flooding Type	Description
30/10/2001 & 01/11/2001	Fluvial and Surface Water	The wastewater network around Lochavullin was surcharged and caused some flooding in the supermarket carpark. Link to Photo Link to Photo 
28/10/2014	Fluvial and Surface Water	Lochavullin carpark was inundated to depths greater than a metre, destroying many cars. The car park was inundated due to the Black Lynn overtopping its banks. Link to YouTube Video 
09/10/2018 - 11/10/2018	Fluvial and Surface Water	The Black Lynn inundated the carpark affecting many parked cars and local businesses. A residential property to the east of the river, upstream of Lynn Road, has been inundated multiple times, most notably in this event. Link to the Oban Times Article Link to the Daily Record Article Link to BBC Article Link to the Northern Echo Article 

2.3.2 GIS Analysis

Geographical Information System (GIS) analysis of the Oban area was performed using the computer application ArcGIS. The outputs of the analysis were used to understand the catchment characteristics, locate areas of high vulnerability, and to identify areas at risk of flooding.

2.3.3 Hydraulic Model

Flood risk associated with the sewer network was assessed using the latest available network model provided by Scottish Water (*network STW000559:NEEDS:EXISTING:APRIL2015*, created in InfoWorks ICM 7.0). The original network model was built in 2004. According to the report supplied by Scottish Water, the confidence in the original model version was low to medium-low. The report states that the reason for the low confidence is the lack of supporting data to allow any audit trail to be followed. Model maintenance and revision was performed in 2014 and 2015 by Mouchel and in 2016 by ARC, noting that the model used for this study does not include 2016 revisions. Due to the maintenance, the model confidence has improved to acceptable. It is therefore considered suitable for use here in predicting sewer network flooding behavior.

Table 2.4 presents model inputs used in simulations considered in this report.

Table 2.4: InfoWorks inputs

Software	InfoWorks ICM Viewer
Version	7.0
Model Network	STW000559:NEEDS:EXISTING:APRIL2015
Scenario	Base
Waste Water Profile	CIRIA_1DWF Waste water profile -1hr + wk/end update
Ground Infiltration	RES01
Trade waste Profile	Trade Waste with Commercial profile 15 v2
Tide Level	Oban Sea and River Levels Design

The sewer network model has multiple discharges to the coast (Oban Bay) and to watercourses. All of the discharges are modelled as freely discharging, effectively assuming that coastal and watercourse water levels remain at or below the downstream invert level of all discharge pipes for the duration of all modelled events. It should be noted that this assumption is optimistic in terms of sewer flood risk; where water levels are above discharge pipe invert levels for some or all of the modelled extreme event, the risk of sewer flooding will be greater than predicted due to impaired discharge relative to model assumptions. Noting that the invert levels of some discharge pipes are below even baseflow water levels (e.g. NM85299705, which discharges to the Black Lynn in Lochavullin and has a downstream invert level of 2.07 m above Ordnance Datum (AOD) compared to baseflow water levels in the adjacent reach of the river of around 2.45 mAOD), it can be concluded that the sewer network model is likely to under-predict sewer flood risk.

Scottish Water provided a model build and verification report, STW000559_S3_MBV (Scottish Water, 2017). The accuracy of the model verification was not commented on as the verification audit had not been completed.

Drawing 170506-036 presents details from the hydraulic model.

2.3.4 Hydraulic Model Setup

The Scottish Water S16 model was assessed as suitable to use to identify flooding sources within the catchment. The model simulation parameters were compared to the InfoWorks ICM's default parameters, with the model using a lower (0.025 instead of the default 0.05) baseflow factor, which is a model stability parameter for low-flow conditions; this is not expected to impact model predictions of peak flow or flooding.

Table 2.5 presents total counts of model elements for each system type (either stormwater sewer, foul sewer or combined sewer containing stormwater and foul water). This summary indicates that the majority of the modelled sewer network is combined, but there are a significant number of surface water outfalls. Other assets identified in the Scottish Water network are shown in Table 2.6.

Model run data for the 1 in 5 year return period events have been provided by Scottish Water. Due to license agreements, model predictions for higher return period events were not made available for analysis as part of this study. The rainfall hyetograph of the 1 in 5-year return period, 60-minute duration event is shown in Figure 2.1.

Table 2.5: System type for nodes, links and sub-catchments

Model	Combined	Foul	Storm
Manhole	1,474	504	629
Outfall	5	2	61
Storage	2	0	1
Total Nodes	1,481	506	691
Links	1,420	488	625
Total Link Length (m)	33,084	14,565	20,226
Sub-catchments	542	433	339
Total Subcatchment Area (ha)	139.1	96.7	100.9

Table 2.6: Other assets in the sewer network

Structure	Count
Flap Valve	12
Orifice	48
Pump	19
Screen	5
Sluice	4
Weir	131

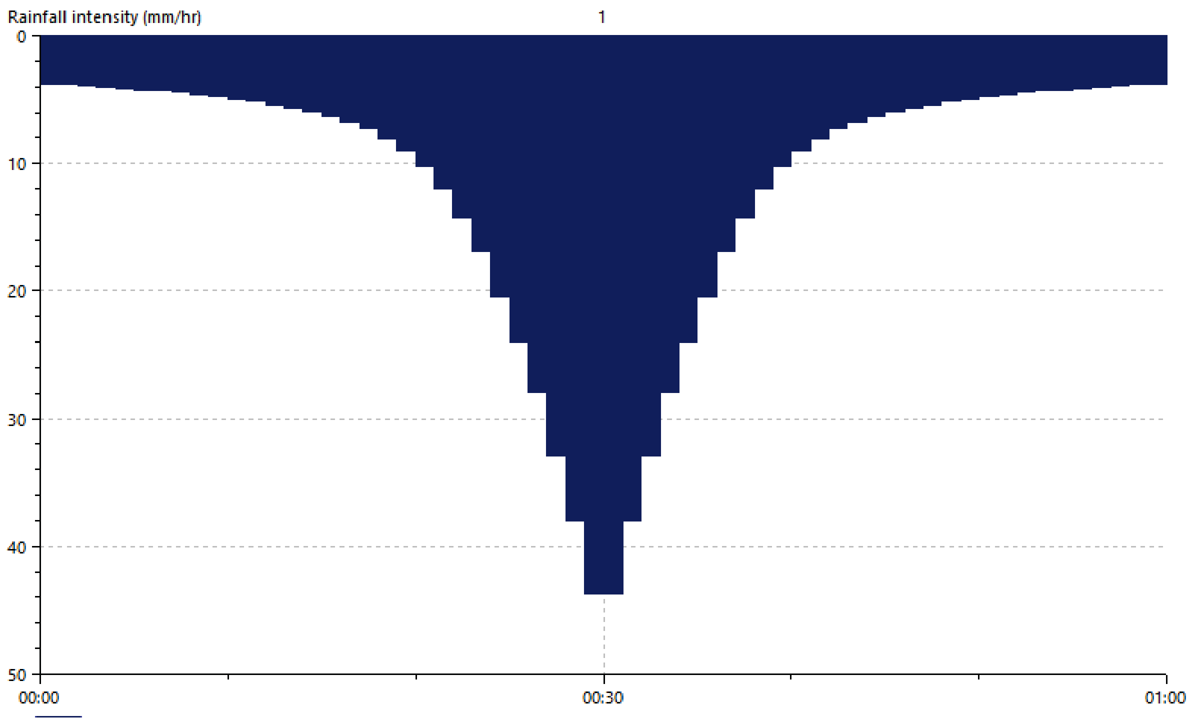


Figure 2.1: 1 in 5 year, 60 minute duration rainfall hyetograph

2.4 Field Work

A number of ground truthing site visits have been undertaken (Table 2.7). For each site visit a Site Visit Report was produced containing information including observations, future areas of investigation and early potential solutions. During these visits the following objectives were considered:

- Assessment of topography local to the forecast flooding;
- Ground truthing flow paths identified in the ICM model and LIDAR – GIS analysis;
- Identification of any potential disruption to these flow paths;
- Superficial assessment of current condition of sewer inlets;
- Identification of opportunities for mitigation;
- Identification of constraints; and
- Inspection, where practical, of drainage system outfalls to the natural water environment.

Table 2.7: Site visits

Date	Zones Visited
15/01/2019	Lochavullin, Glenshellach and Glencruitten/Mossfield
25/01/2019	Soroba
21/02/2019 - 22/02/2019	Longsdale North, Longsdale South, Town Centre North and Corran

2.5 SWMP Stakeholder Workshops

2.5.1 Workshop 1

Members of Scottish Water and Argyll & Bute Council were invited to EnviroCentre Ltd's Glasgow office on the 21st February 2019 to participate in a Surface Water Management workshop and discuss various elements of the study, including;

- Informing Scottish Water about the works to date and the progression of the Surface Water Management Plan;
- Following an extensive review, discussion of the S16 model provided by Scottish Water in October 2018. This included flagging gaps in information, general assumptions and overall confidence in the model;
- The development of the 12 Surface Water Management Zones for the town of Oban, and how they were derived;
- The pluvial pressures that have been identified for each area following various site walkovers, public consultation;
- Any potential solutions that could be implemented, and Scottish Water's opinion on each;
- Any future works that Scottish Water are planning to do in the town of Oban, and if there is potential for any collaboration with regards to flooding solutions;
- If existing Scottish Water assets can be used to divert surface water from the "hot spots" and into the coastal waters to the north;
- Overall responsibility for any potential overland and underground solutions; and
- The next steps in progressing the SWMP.

It was confirmed at the workshop that Scottish Water do not identify any properties in Oban as being at risk of internal flooding due to sewer flooding for their required level of service (which is the 1 in 30 year event).

2.5.2 Workshop 2

Members of Scottish Water and Argyll & Bute Council were invited to participate in the second Surface Water Management workshop. The workshop took place in EnviroCentre Ltd's Glasgow office on the 11th April 2019. The workshop provided an opportunity to discuss:

- The methodology of the zone and solution compatibility analysis. Examples of the long lists for each zone.
- Potential opportunities and solutions were presented for different areas in the catchment, which facilitated a discussion about their viability and whether there were practical limitations to the implementation. Surface Water Options for the following SWMP zones were considered:
    - Dunollie;
    - Corran;
    - Glencruitten;
    - Glenshellach;
    - Soroba;
    - Soroba Lower;
    - Town Centre (North);
    - Lochavullin.
- The next steps in progressing the SWMP.

Ensuring that Scottish Water are engaged throughout the development of the Surface Water Management Plan is vital to the overall feasibility of the study and can also provide additional benefits including identifying any solutions that can reduce the volume of peak rate of surface water entering sewers or which reduce the frequency and volume of spill of foul-containing drainage from combined sewer overflows (CSOs).

3 SURFACE WATER MANAGEMENT PLANNING ZONES

3.1 Overview and Derivation

The review of available baseline information along with field visits enabled 12 different Surface Water Management Planning (SWMP) Zones to be derived for the Oban surface water catchment, and these are shown in Figure 3.1 and Table 3.1.

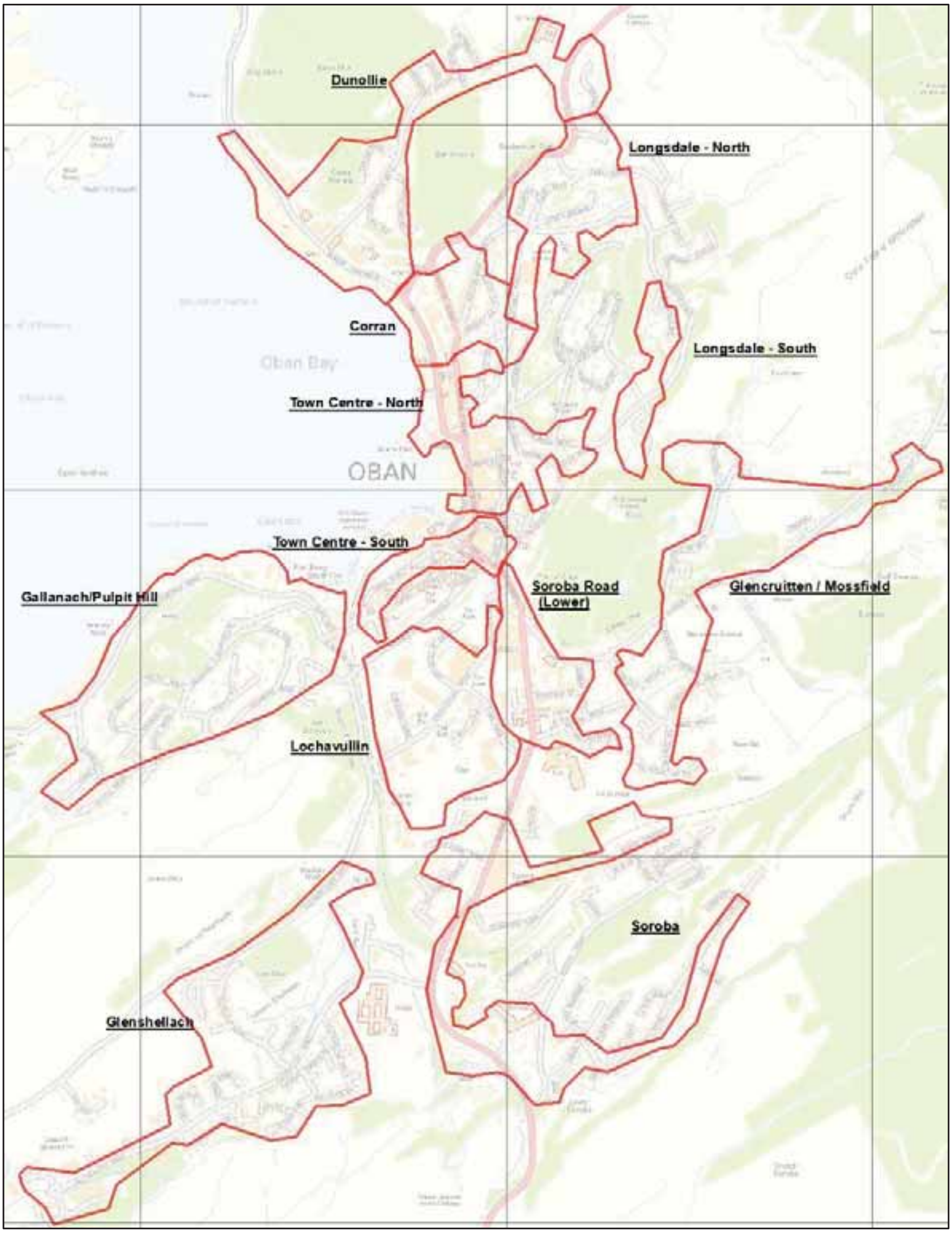


Figure 3.1: Surface Water Management Planning Zones

Table 3.1: Surface Water Management Planning Zones

SWMP Zones
Dunollie
Longsdale - North
Corran
Town Centre - North
Longsdale - South
Town Centre - South
Soroba Road (Lower)
Glencruitten / Mossfield
Gallanach/Pulpit Hill
Lochavullin
Glenshellach
Soroba

These 12 zones were defined based on the following criteria:

- Where the greatest impacts of surface water flooding occur, based on both the S16 ICM modelling, and information gathered during the desk study and public consultation events;
- The sewer catchment boundaries and urban boundaries (e.g. major roads and railway lines);
- Contributing surface water catchments; and,
- “Priority zones”.

Areas out with the 12 zones may have localised pluvial flooding but have not been considered further.

4 FLOOD RISK FINDINGS

This chapter highlights the key findings from the sources of information identified in Section 2 of this report.

4.1 GIS Analysis

Extensive analysis was conducted using ArcGIS using the methodology and data as outlined in Section 2.3.2 and detailed in Table 4.1. A list of the GIS output drawings is provided in Table 4.2, with all drawings contained in Appendix F. This allowed the categorisation of anticipated flooding from the Scottish Water pipe network. Much of this analysis was subsequently ground-truthed during extensive walk-over surveys of the 12 SWM Zones, (see Section 3.1).

Table 4.1: GIS analyses

Type	Description
Overland Flow Analysis	1m Lidar data imported and processed to derive a map of overland flow routes of surface water based upon topography only (but not considering local obstructions/deflections (walls etc.)).
Ground Slope	Lidar data was used to derive ground slope.
Flood Area Delineation	Output polygons showing flooding from Scottish Water S16 model output for a range of return periods, storm durations and inundation depths were overlain on Ordnance Survey mapping to enable the development of an understanding of the areal extent of Scottish Water network flooding. Additional mapping of the extent of the flooding around Lochavullin, reported by Argyll and Bute Council on Tuesday 09 October 2019 was added to the S16 modelled flood extents, for comparison. The flooding was likely a combination of fluvial and pluvial flooding. The observed flood extent was a similar extent as the 1 in 100 year 180min pluvial flood extent. Both had significant flooding within the car park in Lochavullin, and flooding along Lochavullin Road, Lochavullin Drive and Lynn Road, as well as flooding in the Lidl car park.
Asset Vulnerability Analysis	Polygons delineating assets (such as buildings, roads etc.), with appended usage was processed to indicate their vulnerability class. Additional analysis isolated assets liable to be impacted by Scottish Water network flooding from S16 model.

Surface Water Management Zone (SWM Zone) Definition	SWM Zones were derived using GIS:
	• Consideration was given to the flood extent polygons for 1 in 200 year return period flooding up to and above 0.1m flood depth.
	• Approximately 50 areas of interest were identified.
	• The 50 areas of interest were merged to create 12 SWM Zones based upon:
	  o Scottish Water drainage network catchments;
	  o Topographical aspects (consideration of watercourses and embankments as 'natural' boundaries;
	  o Overland flow path connectivity; and
	  o Neighbourhood identity.
	• Where the above points raised contradictions, best judgement was used to develop zones of manageable area.

S16 model analysis	S16 model data was imported from an ICM model export. This data was interrogated to show the following • Pipe diameters, invert level • Pipe slope; low gradients, high gradients; • Pipe sedimentation; • Outfall locations.

Table 4.2: GIS Outputs

Drawing Number	Title(s)	Description/Findings
170506-036	Scottish Water S16 ICM model data and Scottish Water GIS Asset Data	Overview of Scottish Water pipe and manhole network with information extracted from the Scottish Water S16 InfoWorks ICM model. It includes surcharged lengths and pipes with sediment. Surface water flooding for 1 in 200 year and 1 in 30 year events are also included.
170506-037	Overland flow paths	Overland flow paths are created using a GIS analysis.

4.2 Sewer Network Model Predictions

Predicted flooding extents from Scottish Water's sewer network model for the 1 in 30 year return period event, 1 in 200 year return period event, and 1 in 200 year return period plus climate change event, are presented in drawings 170506-102, 170506-103, and 170506-104, respectively.

The sewer network model was used to identify potential sewer flood risk mechanisms and locations. Some local factors were found to exacerbate local flood risk, but overall flood risk is primarily associated with two factors:

1. Surcharge in the trunk sewer and;
2. The combined network is required to carry high volumes of surface water relatively long distances.

The trunk sewer is surcharged due to several reasons:

1. The low pass forward flow of the Corran pumping station. According to the notes within the model, the maximum flow the Wastewater Treatment Works (WwTW) can receive is 160l/s. It is not clear if that is dictated by the pump capacity or the receiving capacity.

2. There is an orifice limiting flow to the Corran Pumping Station (PS). The modelled pump arrangement is quite complex, and results in the top water level (TWL) upstream of the orifice being greater than downstream. This suggests that there is flooding in the upstream network before the storage tank, which has a capacity of approximately 3,800m^3, is full, which is not an optimal arrangement and may indicate that the model setup is incorrect.

3. The trunk sewer has an extremely shallow gradient. This is due to the low topographic gradient and it is unlikely to be resolved without significant cost and disruption, so it is not necessarily a recommended solution. The low gradient, and hence low velocities, in the trunk sewer also causes sediment accumulation. The TWL in much of the network directly connected to the trunk sewer is dictated by the level in the trunk sewer, with predicted peak water levels being very similar across much of the network.

4. The majority of flow in the trunk sewer discharges to the WwTW but CSOs can provide relief by discharging some flow to the watercourse or Oban Bay. Scottish Water have confirmed there is a CSO and an emergency outfall which have not been included in the model. As these outfalls have not been modelled the model may be overpredicting surcharge in the trunk sewer.

There are also multiple minor issues in the modelled network which increase the risk of surcharge or flooding. These include, but are not limited to:

- The Lochavullin pumping station is not included in the model. This means flooding in Lochavullin may be overpredicted.
- Low gradient pipes can cause low velocity. This can limit the flow through the pipe. The upstream network has a greater flow than the maximum flow through the pipe.
- High gradient pipes can cause the flow to have a greater velocity. The flow also has high energy. This can cause a hydraulic jump as the network transitions from high gradient to low gradient, which can cause surcharge.
- Sediment deposits reducing the cross-section of the pipe limiting the flow; the sediment depth in the modelled network is either assumed or based on survey data.
- Pipe size reduction, the downstream pipe size is smaller than the pipe immediately upstream.

Note: The model can report two different types of surcharge: surcharge by flow and surcharge by depth. Surcharge by depth means the top water level is greater than the soffit of the pipe, whereas surcharged by flow means that the pipe full capacity of the pipe has been exceeded. When discussing surcharge in the following section *surcharge* refers to surcharge by flow unless otherwise stated.

4.2.1 Zone-Specific Predictions

Table 4.3 presents an assessment of clear over- or under- prediction of flooding for the 12 zones. This does not assess the models ability to replicate observed flooding, but assesses any clear discrepancies with reality which may cause over- or under-prediction of flooding.

Table 4.3: Assessment of flooding predictions

SWMP Zones	Assessment of Flooding
Dunollie	Acceptable
Longsdale - North	The combined network drains to Corran PS and is surcharged due to the backing up caused by the limited flow at the PS. This may mean there is a slight over prediction in flooding.
Corran	The model may be overpredicting surcharge in the trunk sewer. As discussed the trunk sewer is surcharged partly because an orifice is limiting flow to the storage tank and pump at Corran pumping station, which is causing flooding before the storage is fully utilised. This seems unrealistic, and further investigation may be required. This overprediction may also be causing overpredictions in other areas which drain to the trunk sewer.
Town Centre - North	Surcharge caused by Corran PS may be over predicting flooding in this zone.
Longsdale - South	Acceptable
Town Centre - South	Surcharge caused by Corran PS may be over predicting flooding in this zone.
Soroba Road (Lower)	Surcharge caused by Corran PS may be over predicting flooding in this zone.
Glencruitten / Mossfield	Acceptable
Gallanach/Pulpit Hill	Acceptable
Lochavullin	The Lochavullin pumping station is also not included which may be causing an over prediction in this area. There might also be an under prediction because the network has a free discharge to the Black Lynn but in reality, during extreme events the outfall may be drowned.
Glenshellach	The surface water network drain via a free discharge to the watercourse, so the model may be slightly underestimating the flooding. Also the foul network has sediment which has been assumed, which may be causing an over prediction of flooding.

SWMP Zones	Assessment of Flooding
Soroba	The surface water network drain via a free discharge to the watercourse, so the model may be slightly underestimating the flooding.

4.2.2 Property Flood Predictions

As the Scottish Water network model covers all of the Oban catchment, flood estimates based on sewer flooding can reasonably be used as a proxy for overall surface water flooding. Predicted flooding extents from the Scottish Water network model have been provided for a range of return periods in response to both a 1 hour and 3 hour storm event, with filtering applied to identify areas flooded above a 1 mm, 100 mm and 300 mm peak depth. Accounting for building upstand, flooding of less than 100 mm is unlikely to cause internal damage to properties. Based on network model predictions, property flood risk is slightly greater for a 1 hour storm event compared to a 3 hour event. For the 1 hour event, peak flood depths exceeding 100 mm are predicted to impact 10 properties in response to the 1 in 30 year event increasing to 22 properties for the 1 in 200 year event (Table 4.4; Figure 4.1). However, flooding may or may not actually inundate these properties depending upon their actual upstand, noting that Scottish Water do not identify any properties in Oban as being at risk of internal flooding due to sewer flooding for their required level of service (which is the 1 in 30 year event).

Table 4.4: Number of receptors predicted to be flooded by sewer flooding for a 1 hr duration event (based on a 100 mm depth threshold). Values are based on current climate conditions, except where noted.

Return Period (1 in x yrs)	Residential Receptor Count	Non-Residential Receptor Count	Total Receptor Count
1	0	0	0
2	0	0	0
5	1	0	1
10	2	2	4
10 (+50% climate change)	*8*	*5*	*13*
30	6	4	10
30 (+50% climate change)	*18*	*9*	*27*
50	8	5	13
100	11	7	18
200	13	9	22
200 (+50% climate change)	*25*	*15*	*40*

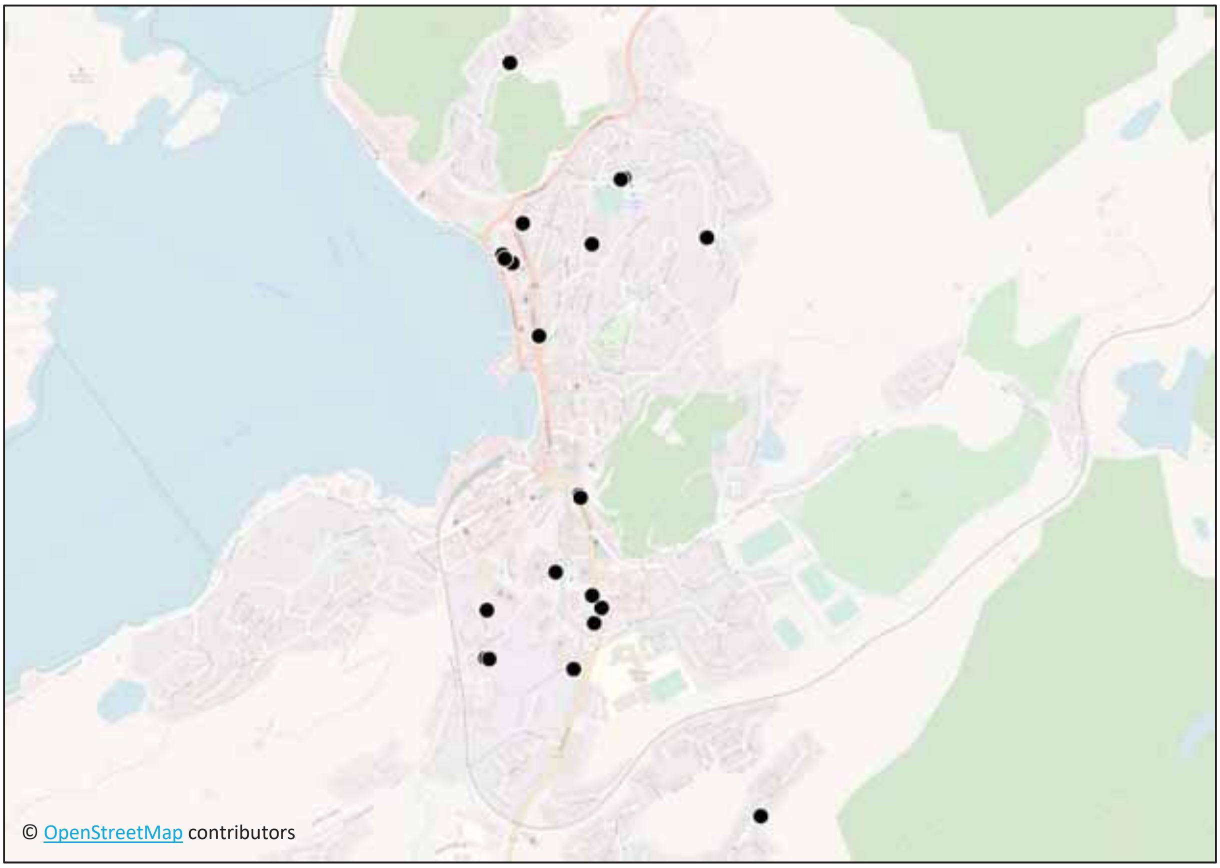


Figure 4.1 Location of properties in Oban where sewer flood depths are predicted (by Scottish Water modelling) to exceed 100 mm for a 1 in 200 year event (1 hour event duration).

A high-level economic appraisal of sewer flood damages is provided in *Report 3B: Options Appraisal (Economic Appraisal)*. It indicates that sewer flooding is a minor contributor to overall estimated flood damages in Oban for current climate conditions. However, sewer flooding may become a more significant source of overall flood risk without continuous investment in maintaining and upgrading the sewer network, and/or investment in other surface water management measures, with the number of properties at risk predicted to approximately triple at low return periods and double at moderate to high return periods due to climate change (Table 4.4). Also note that three specific limitations of network modelling may also impact upon the accuracy of flood predictions:

1. Modelling assumes free discharge at all river and coastal outfalls; it therefore does not account for elevated sewer flood risk which would result if high sewer flows occur at the same time as high water levels in the river and/or high tides.
2. Modelling does not account for mitigation to the above risk in the Lochavullin area provided by existing surface water pumps.
3. Modelling also does not account for at least one CSO and emergency outfall, which may or may not provide relief to sewer flood risk (depending upon water levels in the receiving water body).

Predictions of sewer flood risk may therefore be different if any or all of these limitations are addressed in an updated sewer model, and/or if integrated modelling is performed by dynamically linking the sewer model to a river and coastal model. However, addressing these limitations in existing model predictions of surface water flood risk is beyond the scope of the current study. Instead, the focus of this SWMP is to identify options capable of reducing surface water flood risk in isolation, especially as it may increase due to climate change, and to qualitatively assess the likely impact of predictive limitations and multi-source flood interaction upon option performance, noting:

- Candidate surface water management options which aim to reduce or attenuate inflows into the sewer network, or temporarily store excess water, will provide flood reduction benefits regardless of water level conditions at outfalls into rivers or coastal waters.
- Candidate surface water management options which aim to overcome local "bottlenecks" in the sewer network and increase the peak rate of flows passed forward in the sewer network may exacerbate flood risk in the lower sewer network during high water conditions in river/coastal waters.
- Candidate surface water management options which rely on increasing discharge to rivers or coastal waters may be ineffective during high water conditions in river/coastal waters.

Given that the contribution of sewer flooding to overall flood damages is estimated to be relatively minor, it is recommended that short-term investment is focussed on fluvial-tidal and coastal flood management, as detailed in *Report 3B*: *Economic Appraisal*. In this context, surface water management options are assessed in this report with a view to phased implementation in the medium- to long-term, rather than as part of a formal flood scheme or immediate investment.

5 VULNERABILITY AND FLOOD RISK

5.1 Vulnerability

5.1.1 Stakeholder and Community Consultation

Consultations with the community and with Argyll & Bute Council identified multiple areas requiring intervention to manage surface water flooding issues.

Lochavullin has been highlighted by Argyll & Bute Council, local business and the community as a priority area at high flood risk. The area has experienced flooding from multiple events which have been reported in the local press. It is a very flat, low lying area, such that it is difficult to drain, with drainage problems being exacerbated by high water levels in the adjacent Black Lynn river, which is tidally-impacted. As a consequence, Lochavullin is at risk from all of surface water flooding, fluvial flooding and tidal flooding. The hydraulic model broadly agrees with stakeholder and community feedback in this area.

Glenshellach was also highlighted by Argyll & Bute Council as an area that requires surface water management. There has been flooding in the gardens of some of the properties around Lon Mor. In addition, there is pluvial flooding in some of the roads around Glenshellach.

Feed back from the community notes that general maintenance is an issue within the catchment, with reports of blocked gullies and broken pipes.

Argyll & Bute Council maintain a list of gullies and screens which are regularly checked in at-risk areas. Adaptive management of this maintenance regime will be required going forward.

During the October 2018 event the pump located within Lochavullin failed. The flood history database for the local area also seems to be incomplete, indicating either that flooding issues are not being reported when they occur, or else that reports are being inadequately managed and processed.

5.1.2 SEPA Flood Risk and Land Use

The overall vulnerability of each SWMP zone was assessed based on the *SEPA Flood Risk and Land Use Vulnerability Guidance.* Buildings within the 1 in 200 year return period flood extent obtained from the S16 model were assessed for their vulnerability based on Table 5.1. Table 5.2 shows the total flood receptor count in each SWMP zone for each vulnerability classification. Water compatible uses have not been counted.

Soroba has been identified as having the highest vulnerability. There are three most vulnerable users within Soroba and 65 highly vulnerable users.

Table 5.1: Land use vulnerability

Vulnerability	Land Use
SEPA 1: Most Vulnerable Uses	Examples include emergency services; medical services; residential institutions; basement dwellings; isolated dwellings; basement dwellings; caravans and mobile homes used for permanent residence; and, installations with hazardous substance consent.
SEPA 2: Highly Vulnerable Uses	Examples include dwellings; hotels; student residence; and, landfill sites.

SEPA 3: Least Vulnerable Uses	Examples include shops; services; restaurants and takeaways; offices; bars; industry; leisure; agricultural; waste treatment.
SEPA 4: Essential Infrastructure	Includes essential transport infrastructure, essential utility infrastructure such as power stations, water and wastewater treatment, wind turbines and other energy.
SEPA 5: Water Compatible Uses	Examples include flood controls; sewage transmissions; docks and marinas; water-based recreation; and, nature conservation.

Table 5.2: Flood receptor counts for each vulnerability class and SWMP zone

Zone	SEPA 1: Most Vulnerable Uses	SEPA 2: Highly Vulnerable Uses	SEPA 3: Least Vulnerable Uses	SEPA 4: Essential Infrastructure
Dunollie	1	53	2	1
Longsdale - North	0	67	3	1
Corran	0	70	9	1
Town Centre - North	0	58	39	1
Longsdale - South	0	30	0	0
Town Centre - South	0	26	22	1
Soroba Road (Lower)	2	31	23	2
Glencruitten/ Mossfield	0	60	2	0
Gallanach/Pulpit Hill	0	33	11	1
Lochavullin	0	6	59	0
Glenshellach	1	34	9	1
Soroba	3	65	3	1
Total	7	533	182	3

5.2 Flood Risk Overview

The potential “root causes” of surface water flooding are described in Table 5.3. Each SWMP zone was assessed using the model results, stakeholder responses, information from site walkovers and historical information to determine to what degree each of these root causes is likely to contribute to surface water flood risk in the area; the outcomes of this assessment are presented in Table 5.4, adopting the following screening scale:

3 Major cause of flooding in the area. An individual root cause could flood properties.

2 Has a significant contribution to flooding in the area. Unlikely to flood properties on its own but may exacerbate flooding of major causes.

1 Has no effect or a minor impact.

Note that a scoring of 0 would be inappropriate for this analysis, since managing major causes of flooding will usually result in another cause becoming (comparatively) more significant in relation to residual flooding. Particularly for sewer networks, managing flooding is therefore usually an ongoing process of progressively identifying and resolving the “current bottleneck”, before moving on to the “next bottleneck”.

Table 5.3: Flood root cause descriptions

Root Cause	Description
Rainfall Ponding on the Ground	There is evidence that surface water ponds on the surface and cannot drain away from the site. This may be due to inadequate drainage, as well as inadequate infiltration.
Flow Accumulating and Flowing Overland	There is evidence that overland flow occurs during or following large rainfall events and substantial overland flow has been observed. This may be due to lack of drainage, as well as inadequate infiltration.
Network is Undersized Causing Surcharge	The network is surcharged if the network does not have sufficient capacity to convey the surface water. This means the maximum flow possible through the pipe is less than the incoming flow. This can be managed by reducing the inflow to the network or increasing the capacity of the local drainage network through flow diversions or upsizing the network.
Downstream Drainage Network is Surcharged	There is evidence that the downstream network is surcharged by depth. This means that the pipe full capacity of a pipe is greater than the incoming flow but a downstream restriction which is limiting flow causing backup in the local network. This can be caused due to blockages, pumping stations which are undersized, or small pipes in the downstream network for example. This root cause is identified primarily using the S16 model, supported with information gathered during the desk study, site walkovers and the public consultation events.
Outlet Drowned by the Receiving Water	If water levels in the receiving water (river or coastal) are higher than the invert level of surface water sewer outfalls, then these discharges won't be free draining. If there is inadequate hydraulic gradient to drive discharge against high water levels in the receiving water, water levels in the sewer will build up over time and may cause flooding to occur, even when sewer flowrates are below pipe capacities. This root cause is identified primarily using the fluvial model, supported with information gathered during the desk study, site walkovers and the public consultation events.

Table 5.4: Flood root cause by zone

SWMP Zone	Rainfall ponding on the surface	Flow accumulating and flowing overland	Network is Undersized Causing Surcharge	Downstream Drainage Network is Surcharged	Outlet Drowned by the Receiving Water
Dunollie	2	3	2	2	1
Longsdale - North	2	3	3	3	1
Corran	1	3	3	3	1
Town Centre - North	2	2	3	3	1
Longsdale - South	2	3	1	1	1
Town Centre - South	1	2	1	3	1
Soroba Road (Lower)	1	3	1	3	1
Glencruitten / Mossfield	3	3	3	1	1
Gallanach / Pulpit Hill	3	3	1	1	2
Lochavullin	2	1	3	1	3
Glenshellach	2	3	3	1	1
Soroba	2	3	3	1	1

5.3 SWMP Zones

The vulnerable users and potential fluvial flood risk for each SWMP zone is summarised in Table 5.5.

Table 5.5: Summary of pluvial flood risk and vulnerable users for SWMP zones

Zone	Vulnerable Users	Flood Risk Description
Dunollie	• 1 Most Vulnerable receptor (school) • 53 Highly Vulnerable receptors (mostly residential properties) • The A85 passes through the zone	This zone includes a length of trunk sewer which drains to the Corran PS, which has a low gradient and is surcharged. The zone is steep, and overland flow is possible towards the bay along Corran Brae. There are two other high risk areas in the north of the zone which are surcharged.
Longsdale - North	• 67 Highly Vulnerable receptors (mostly residential property) • The A85 passes through the zone	There are two stretches of conduits connected to the 600mm pipe leaving this zone, which are surcharged and therefore pose a flood risk. There are two flooding manholes in this area which may require further investigation. The zone is steep, and overland flow is possible.
Corran	• 70 Highly Vulnerable receptors (mostly residential property) • The A85 passes through the zone	There are multiple flooding manholes in this zone. This zone drains via a trunk sewer to the Corran PS. There are several linked conduits which are surcharged by flow and flooding manholes and pose a flood risk. The zone is steep, and overland flow towards the bay is possible.
Town Centre - North	• 58 Highly Vulnerable receptors (mostly residential property) • 39 Least Vulnerable receptors • The A85 passes through the zone	The zone drains to the Corran PS via the trunk sewer. The trunk sewer is surcharged by both flow and by depth. In addition to the risk from the trunk sewer there is also surcharged and flooding nodes in the local smaller network.
Longsdale - South	• 30 Highly Vulnerable receptors (mostly residential property)	There are some surcharged links within the zone. There are no flooding nodes. This zone is not at high flood risk from the network.
Town Centre – South	• 26 Highly Vulnerable (mostly residential properties) • The A85 and A816 both pass through the zone.	The zone drains to the Corran PS via the trunk sewer which is surcharged. There are some surcharged links but no flooding nodes. Evidence of previous flooding observed during walkover.

Zone	Vulnerable Users	Flood Risk Description
Soroba Road (Lower)	• 2 Most Vulnerable receptor (an ambulance station and a residential home) • 31 Highly Vulnerable receptors • The A816 passes through the zone	The zone drains to the Corran PS via the trunk sewer which is surcharged. There are also two surcharged lengths with flooding nodes.
Glencruitten / Mossfield	• 60 Highly Vulnerable receptors (mostly residential property)	This zone includes several areas of open space including playing fields at Mossfield Park and Oban Rugby club, which could provide relief to these surcharged assets. The zone includes several drainage assets (around the MS research centre north west of Mossfield Park and around the sub-station; these are not included in the S16 model and may require further investigation). Evidence of surface water flooding within the car park at the MS research centre and Glencruitten Court was evident during the ground truthing site visit. A lot of the zone has surcharged links. In particular the area around Mossfield Drive has multiple flooding manholes. This zone is at a high risk of flooding and the network is not providing sufficient drainage.
Gallanach	• 33 Highly Vulnerable receptors (mostly residential property)	There are two clusters of flooding manhole, one is located at the outfall to the sea, the other is in the east of the zone. This zone may need further investigation as it contains some complex pump and asset arrangements.
Lochavullin	• 6 Highly Vulnerable receptors (mostly residential property)	There are several outfalls that discharge surface water to the Black Lynn as it routes northwards and anecdotal evidence gathered during the public consultation events suggest that the majority of these outfalls are submerged during extreme tidal events. During the ground truthing site visit it was observed that some of the surface water drainage assets (including gullies and strip drains) are in poor condition and require maintenance. The network in this zone is complex. There are more flooding nodes in Lochavullin than any other zone. Multiple conduits are surcharged, however the Council operated pump station in this area is not included within the model, which when operational will drain lower lying areas. As a result, the modelled flood extents are expected to over-predict the effects of pluvial flooding in this area. There are known issues regarding the resilience of the Council pump station, which has contributed to recent flood events. The operation of the present drainage network is not considered to be providing adequate protection for this zone in the present form.

Zone	Vulnerable Users	Flood Risk Description
Glenshellach	• 1 Most Vulnerable receptor (a residential home) • 34 Highly Vulnerable receptors • The A816 passes through the zone	A number of responses received during the public consultation events have indicated that the surface water issues experienced in this area are due to the recent residential development at Catalina in the North West of the Glenshellach area, and the increase of impervious areas. There are some areas of green space that could be utilised for SuDS retrofitting, including the areas around McKelvie Road. The contribution of overland flows from the undeveloped higher ground surrounding this area flowing down onto the recent developments is a factor in the surface water issues observed in this area. The east of the zone has a number of connected links that are surcharged, and multiple flooding manholes, this poses a high risk to the community and to the hospital located adjacent to this area.
Soroba	• 3 Most Vulnerable receptors (a school, children's home and a fire station) • 65 Highly Vulnerable receptors (mostly residential property)	During the ground truthing site visit it was identified that some existing gullies around Jura Road and Shuna Terrace, and Soroba Road itself (as it passes Soroba Park Terrace) were in need of maintenance. As Soroba Road (A816) continues north passed the railway track, it falls at a steeper gradient and acts as a flow path for any overland flow routing from Dummore Road. The existing drainage network does not have the required inlet density and capacity to effectively deal with this runoff. To the south of the Fire Station there is an existing depression (approx. location 185822, 728618) which could potentially be utilised for storage. There are multiple links between the surface and foul networks. The foul network is surcharged in the east of the zone, due to the high amount of interaction between the two systems any change could exacerbate the issue. The SW network is complex, surcharged, and several nodes are flooding. The network is not sufficient to drain this area. Soroba has the highest vulnerability of any of the SWMP zones.

5.4 Interaction with the Black Lynn Watercourse

As noted, there are sewer outfalls discharging to the Black Lynn in the vicinity of Lochavullin. These outfalls are fitted with flap valves, to prevent backflow during high river water level conditions and therefore prevent the sewers from becoming a pathway for fluvial flooding. Sewer providers aim to protect against internal property flooding for events up to the 1 in 30 year return period event; for this return period (and for the critical storm event in relation to fluvial flood risk), river water levels are predicted to reach 3.9 mAOD in the Lochavullin area, causing flooding beyond both banks of the Black Lynn (Figure 5.1). High river levels will result in backup or "locking" of sewer outfalls, where there is insufficient hydraulic gradient to allow these outlets to drain into the river. In the event of bank overtopping, river floodwater will also enter sewer gullies and displace sewer storage capacity, with both effects resulting in higher sewer flood risk than predicted by Scottish Water modelling. Surface water management options which attenuate flows "upstream" of this area will provide some benefit to reducing interacting fluvial-pluvial flood risk in the Lochavullin area, whereas options relying on increasing sewer conveyance or discharge to the river may be ineffective or may further exacerbate combined fluvial-pluvial flood risk in Lochavullin.

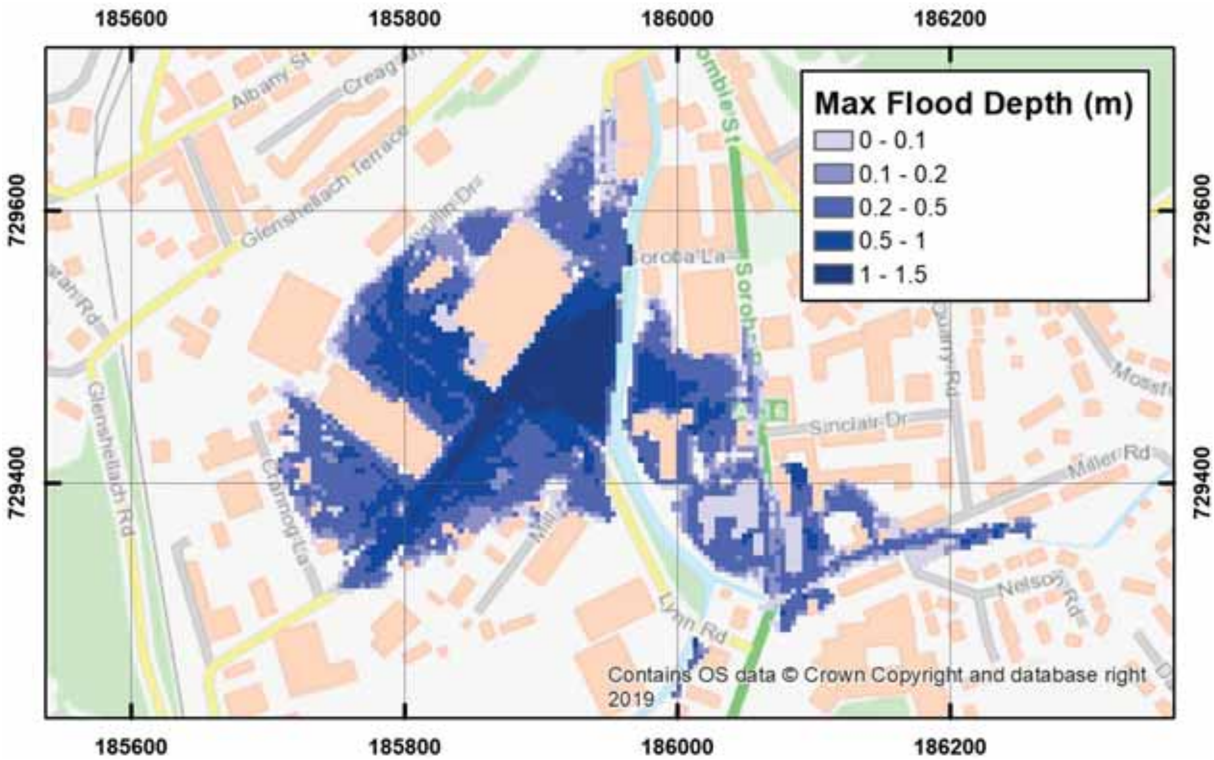


Figure 5.1: Fluvial flood extent for 1 in 30 year event

5.5 Lochavullin Pump Station

There is a pumping station located in the Lochavullin car park (Drawing No. 98047M/7), which operates as an integral part of the surface water drainage system and was installed to provide drainage when water levels in the adjacent Black Lynn Burn were too high to allow gravity drainage. The Lochavullin pump station (Drawing No. 98047M/4) has three connected sumps. The three pumps discharge through a 300mm diameter rising main, which discharges into the Black Lynn watercourse. The sumps have a storage capacity of approximately 28m^3. Each pump has an effective maximum capacity of 620m^3/hr, accounting for headloss, although they share a rising main so it is unlikely that the combined discharge is as high as 1,860m^3/hr.

The pumping station was constructed in 2001. Recently, there has been issues with the operation of the pumping station which exacerbated flooding within Lochavullin. Flash flooding in October 2018 affected the control cabinet of the pumping station, which compromised the pump automatic operation. The pump control resilience has since been improved to avoid this failure, and further pump improvements and operational safeguards are proposed by Argyll & Bute Council in the short term.

The pumping station will be effective at reducing surface water flood risk to the Lochavullin area, provided the Black Lynn is not also overtopping its banks, at which point pumping floodwaters to the river becomes ineffective. Beyond this, the pumping station may also be effective at evacuating flood waters following pluvial-fluvial flooding, to minimise the persistence of flooding and resulting flooding consequences.

5.6 Interaction with Oban Bay

The 1 in 200 year tidal level is 3.87mAOD and the 1 in 30 year tidal level is 3.48mAOD. The Corran Esplanade is above the 1 in 30 year tidal level, although five manholes on the esplanade have cover levels below the 1 in 200 year tidal level.

The Black Lynn is a transitional water body, and is affected by both high fluvial and high tidal levels. Lochavullin has 22 manholes with cover levels below the 1 in 30 year tidal level and 48 manholes with cover levels below the 1 in 200 year tidal level. As is the case with the interaction with fluvial flooding (see Section 5.4), sewer network discharge in the Lochavullin area will be reduced during extremely high tides, thereby increasing the risk of surface water flooding, exacerbated by tidal flooding whenever tidal level exceed river bank levels.

5.7 Target Areas

To support the phased approach the following target areas were identified. Discussion with stakeholders and the community and the SEPA vulnerability analysis have highlighted three key areas in Oban which surface water management planning should focus on.

Target Area 1: Lochavullin

This area was identified by the community and stakeholders as a high risk and vulnerable area. This is evidenced by previous flood events in the area. There are multiple businesses located here which would benefit from surface water management and flood risk management more generally.

Target Area 2: Soroba

From the vulnerability analysis presented in Section 5.1, Soroba is the most vulnerable area. There are three properties with a Most Vulnerable land use classification in this zone, and a large number of residential properties which are predicted to be at risk of flooding according to the sewer network model.

Target Area 3: Glenshellach

From the vulnerability analysis presented in Section 5.1, Glenshellach is one of the most vulnerable areas. This area is highly ranked in the SEPA Flood Risk Assessment. There are a large number of residential properties at risk of flooding in this zone. In addition, Argyll & Bute Council have identified this as a priority location for surface water management intervention due to historical flooding in the area.

6 SURFACE WATER MANAGEMENT OPTIONS

A range of structural and non-structural solutions will be considered to mitigate the surface water risk within the catchment. A long list of structural solution options will be created using multiple sources including SWMP Guidance and engineering judgement. This long list can be shared with stakeholders for further assessment to identify the most appropriate range of options for each SWMP zone.

Solutions will, where possible, be integrated with green infrastructure and use blue-green corridors. Where appropriate, multifunctional uses will be considered which will contribute to the amenity value of the community and provide multiple positive benefits in addition to reducing flood risk.

6.1 Surface Water Management Options Considered

6.1.1 Scale of Structural Solutions

The solutions have been grouped together according to the scale of the intervention. The groups are:

A. Property level intervention;
B. Local intervention;
C. Sub-catchment scale intervention;
D. Surface water network intervention; and,
E. Watercourse engineering.

A. Property Level Interventions

Property level interventions are small scale solutions which are usually designed to intercept flows at the property level. Two property level interventions have been considered: rainwater harvesting and green roofs. Both solutions intercept flows as they runoff from the roof and can have a positive impact on localised flooding. Their impact is very limited, especially for higher return period events, and they need to be installed on buildings across a wide area to have a significant impact on the wider catchment. Green roofs are typically difficult to retrofit onto existing buildings, due to their additional structural loading (especially when wet), but also due to a large proportion of roofs in Oban (and the UK generally) being pitches rather than flat; green roof implementation may therefore have more potential as part of future redevelopment.

B. Local Interventions

Local interventions are small scale interventions which can have a positive impact on the local network. Local interventions can retain and store flow, reduce flow velocity, convey flow, provide flow with an opportunity to drain away, or a combination of the above.

The primary objective of these interventions is to relieve flooding in the local area, but they have the potential to provide secondary flooding benefits on the downstream network. By retaining or draining flow locally, the interventions avoid passing the flow forward and therefore reduce flood risk downstream.

In order to have a catchment wide impact, a range of local interventions should be considered, and they should be implemented over a wide area.

C. Sub-Catchment Intervention

Sub-catchment scale interventions are interventions which have a major impact across the catchment. Sub-catchment scale interventions are generally designed to store a large volume of water during a flood event. They have the potential, depending on the option selected, to provide a great deal of amenity value and even biodiversity benefits.

One of the major benefits of sub-catchment scale interventions is that they can be successful even when located away from locations of flooding.

To have a catchment wide impact, depending on the hydraulics and catchment specific details, only one sub-catchment scale intervention may be required. Although such options may have a larger up-front cost than diffuse solutions, they are generally less complicated to implement and cheaper to maintain, especially where these can be fully sited within publicly-own land.

D. Surface Water Network Intervention

Surface water network interventions aim to relieve surface water flooding by reducing the top water level in the surface water network.

The surface water network can also transport flooding from one area to another. Most sewer networks consist of multiple branches converging to one or a small number of trunk sewers; the resultant convergence of flow means that sewer flooding may happen in the lower reaches of the network but be caused by the contribution of flows from parts of the sewer catchment that do not themselves flood. Sewer flooding in a given location therefore cannot necessarily be resolved by local “above ground” interventions at that location, as the cause of this flooding may be regional in scale.

It is generally not feasible to implement wholesale improvements to an existing sewer network, due to the prohibitive cost and disruption of modifying pipes and manholes buried under roads, footpaths and public amenities. Instead, network-based solutions tend to be targeted at bottleneck locations, where either additional storage or conveyance, or sewer diversion, is predicted to reduce flooding at a location of interest without worsening flooding elsewhere in the network.

For surface water network interventions, the key stakeholder is Scottish Water. While Local Authorities can collaborate with Scottish Water in investigating and partially funding this type of intervention, Scottish Water are the responsible authority for implementation, monitoring and maintenance of network solution options.

E. Watercourse Engineering

There are a wide range of potential watercourse engineering solutions including, but not limited to, restoring the upstream floodplain, restoring urban watercourses, de-culverting, providing online or offline storage and construction of a flood diversion channel. By reducing river water levels, these options are capable of reducing surface water flooding caused by backup at outfall locations. However, as their primary intention and impact is to reduce fluvial flood risk, these options are assessed within the main Oban Flood Study report.

6.1.2 Rainfall Event Management

Different solutions also impact different scales of event. The rainfall events considered for option appraisal are provided in Table 6.1. For a surface water management plan to be successful, all of these will need to be managed and each will require different interventions.

Table 6.1: Management of different rainfall scales

Rainfall	Description	Management
Everyday Rain	Small rainfall events potentially occur multiple times per month. Everyday rainfall does not cause significant runoff.	Generally managed at source. Infiltration and evapotranspiration can be utilised to manage risks from this scale of rainfall event.
More Rain	Rainfall events occur multiple times a year. The rainfall causes runoff, and overland flow.	Generally managed by delaying, collecting and safely conveying overland flow to drainage networks and watercourses.
Extreme Rain	Greater than a 1 in 1 year return period. There is a significant overland flow. There is significant risk of flooding because of extreme rain.	Generally managed by delaying, storing and safely conveying overland flow to drainage networks and watercourses. Volumes are significantly greater than "more rain", so the scale of the intervention may be required to convey larger flows or store larger volumes.

6.1.3 Catchment Surface Water Management Strategies

Catchment surface water management strategies are catchment wide strategies that aim to reduce surface water risk by taking a holistic approach to management. They are typically long-term strategies that are part of future decision-making processes.

The strategies can include solutions described in Section 6.1.1 as part of the wider strategy.

In order to make these strategies work, multiple stakeholders need to be involved in particular SEPA, Scottish Water, Argyll & Bute Council, as well as smaller stakeholders involved in influencing future development.

There are three major strategies:

Run-off Reduction Strategy

A long-term strategy to convert impermeable grey surface to green permeable spaces. Green infrastructure allows more rain to infiltrate and encourages evapotranspiration. This strategy is effective for everyday and more rain rainfall events, but its impact is limited for significant rainfall events. Some of these solutions which may be implemented as part of this solution includes green roofs; tree pits; and, rain gardens.

Reducing surface water in the sewer

A long-term strategy to reduce the volume of flows in the surface water network. This can be achieved by run-off reduction as described above. This is particularly important when approving new developments. New developments will need to confirm that they are not increasing flows in the network by integrating SuDS into their designs before getting approval for the development.

Another option to reducing surface water in the sewer network is sewer separation. This is a long term strategy to replace combined sewers with separate foul and surface water sewers. Surface water sewers can be discharged to watercourses or the coast without the same pollution concerns as CSOs, which are strictly limited through licence in terms of discharge frequency and rate, although consideration will still need to be given to the Water Environment Controlled Activities Regulation, and a CAR licence may be required. Sewer separation reduces the volume of water that needs to be conveyed to the WwTW for treatment. It is, however, a disruptive and expensive solution, as large parts of the road network would be affected to construct the separate sewers.

Scottish Water is responsible for the sewer network and is therefore a key stakeholder in reducing surface water in the network.

Land Management

Land management strategies are long-term. They aim to reduce or attenuate runoff by altering either the land use type and/or improving the management of a given category of land use in order to reduce runoff rate and volumes. Re-naturalisation/restoration of riparian agricultural land into functioning floodplains can improve attenuation of flows within watercourses. Alterations to soil management, landscaping and land drainage features can reduce the rate and volume of runoff from agricultural land into watercourses.

Successful land management requires careful engagement of landowners, to ensure proposed changes are implemented and maintained.

6.2 Compatibility Screening

The objective of the compatibility screening is to remove any obviously unviable options from the long-list of options. The screening is completed by assessing the requirements and limitations of each zone and the capabilities and limitation of each solution.

As this is a first stage screening, some important parameters are not assessed as they would require site specific information or other detailed information to make a reasonable assessment. One important omission that should be noted is that the solutions were not assessed in terms of hydraulic feasibility. This will be a key parameter in the final design and some of the solutions still considered at this stage may not be hydraulically feasible in practice.

6.2.1 Stages of Screening

Stage 1: Long List to Shortlist for Each Zone

Stage 1 is to reduce the long list of options into a more manageable list that resolves one of the main causes of flooding in each SWMP zone, as presented in Table 5.5. Any solution which does not resolve one or more of the root flooding causes of a given zone will be discounted for that zone. This stage is not scored but divides the long list into options which potentially resolve the root cause and should be considered further and those options which do not and therefore should be discounted from further consideration for that zone.

Stage 2: Zone and Solution Compatibility

Stage 2 is to assess the list from Stage 1 against the zone characteristics. Each zone is assessed on varying characteristics which may inform which solutions is appropriate, and each solution is assessed on how it will respond to those characteristics. This is to assess how practically viable each solution is in each zone. This is a scored assessment and will contribute to the final score of each solution in each zone.

Stage 3: Solution Specific Viability

Stage 3 is a solution specific score. Through discussions with the stakeholders, certain characteristics of the solutions have been highlighted as important considerations in making the solution viable. These broad categories will be assessed to identify solutions which are likely to have a significant impact on flooding. This is a scored assessment and will contribute to the final score of each solution in each zone.

The final assessment of recommended solutions for each zone will be based on these stages. The long list will be reduced to a shortlist and a score for each of these solutions will be presented based on the Zone and Solution Compatibility and Solution Specific Viability.

6.2.2 Zone Compatibility

<u>Stage 1: Zone Flood Type</u>

The flooding root cause in each catchment was identified and described in Section 5.2.

<u>Stage 2: Zone Descriptors</u>

Catchment Gradient

The catchment is classified based on its overall gradient. Classification was based on GIS analysis, along with engineering judgement examining potential flooding flow paths within the zone.

A The zone generally has a very steep gradient
B The zone generally has a steep gradient.
C The zone generally has a low gradient.

Green Space

Areas which are undeveloped and unpaved, including natural areas as well as managed parks and grassed areas, are considered to be green spaces. These offer the best opportunity for placement of above-ground surface water management features, for capturing, storing, draining and/or conveying water. Some forms of green infrastructure (such as rain gardens, ponds and wetlands) may also provide other benefits (including aesthetic, amenity and recreation, water quality treatment) in addition to surface water management.

A No green space is available.
B Some green space is available.
C A significant area of green space is available.

Utilised Space

Developed non-road and non-building areas, including car parks, play parks and sporting fields, may have some potential for repurposing as part of above-ground surface water management measures, and may also be suitable for siting of below-ground water management measures, such as geocellular storage and tank storage.

A No utilised space is available.
B Some utilised space may be available.
C A significant area of utilised space may be available.

Density of Buildings

The density of buildings within an area can be used as a measure of the available space for implementing small-scale interventions and general flexibility to retrofitting surface water management measures either above- or below-ground. Constructing ponds or wetlands too close to existing buildings may damage foundations, so high building density is likely to be prohibitive to large water storage solutions, or high infiltration solutions.

A Dense buildings.
B Medium density buildings.
C Sparse buildings.

Density of Transport Infrastructure

The implementation of surface water management measures in the vicinity of public roads may require traffic management, and may otherwise cause traffic disruption, with this being an important consideration for arterial roads. Each zone was therefore assessed in terms of the presence of major transport lines.

A Minimal services.
B One of the major roads pass through the zone.
C A dense area and one of the major roads pass through the zone.

6.2.3 Solution Compatibility

<u>Stage 1: Flood Type</u>

This corresponds to the flooding root cause in each zone identified in Section 5.2.

Reduces Ponding
Directly linked with *Rainfall Ponding on the Surface*

A major everyday flooding source is overland ponding. This is caused by rainfall accumulating on the surface and being unable to drain away. If a solution intercepts the flow before it can pond or if it allows flow to drain away it will reduce ponding.

Reduces Overland Flow
Directly linked with *Flow Accumulating and Flowing Overland*

Uncontrolled overland flow has the potential to intrude into properties and make roads impassable. If the solution reduces the volume of runoff, provides a safe conveyance for the flow, or provides a way of draining excess flow it will reduce the risks associated with overland. Managing overland flow includes safely conveying it away to drainage network or to a watercourse or reducing the velocity of the flow.

Increases Local Network Capacity
Directly linked with *Network is Undersized Causing Surcharge*

The local network is surcharged by flow, meaning that the surface water network does not have enough capacity to deal with the surface water. This can be managed by reducing the inflow to the network or increasing the capacity of the local drainage network, noting that the latter may increase flood risk further downstream in the network.

Reduces Downstream Network Surcharge
Directly linked with *Downstream Drainage network is Surcharged*

If there is no downstream capacity in the surface water drainage network the surface water network will back up and may then flood. Solutions which either increase downstream flow capacity, create an additional onward flow path, or else that store water that backs up to prevent it from flooding will reduce flooding by this mechanism.

Reduces Level of the Receiving Water
Directly linked with *Outlet Drowned by the Receiving Water*

If water levels in the receiving water body are very high at the point(s) where surface water networks discharge, the rate of discharge may be significantly reduced, and cause backup flooding. Solutions which reduce water levels in receiving water bodies will reduce flood risk due to this mechanism.

<u>Stage 2: Catchment Requirements</u>

Required Gradient
Directly linked with *Catchment Gradient.*

The functionality and feasibility of a given solution can be significantly impacted by gradient. Flat or gently-sloping ground is ideal for placement of large structures, such as wetlands and other storage solutions, while avoiding excessive earthworks and finished slopes, and also ensures that velocities are manageable for conveyance features. Conversely, steep ground is generally unsuitable for the placement of large structures and may also create erosion problems for green conveyance measures such as swales.

A Can be constructed on any gradient, low to very steep.
B Can be constructed on most gradients except very steep.
C Can only be constructed on low gradients.

Required Land Take
Directly linked with *Green Space.*

The solution has been assessed on land take requirement. This is based on one installation, so a solution which would require multiple installations may still be considered as having a low land take requirement.

A The solution has low land take requirement.
B The solution has a medium land take requirement.
C The solution has a high land take requirement.

Conflict with Existing Uses
Directly linked with *Utilised Space.*

Some solutions can be constructed on sites that are already being utilised for another use. Underground solutions can be installed and the existing use restored. Also, some solutions can be retrofitted without changing the current usage of the site.

A Can be constructed on utilised land; existing infrastructure can be maintained or restored.
B Can be constructed on utilised land, following consultation from the land owners, but would require a change to land use.
C Implementation would be incompatible with existing features and infrastructure.

Proximity to Building Foundations
Directly linked with *Density of Buildings*

Solutions which rely on deep storage or infiltration can risk damage to buildings foundations. These solutions would not generally be appropriate in zones with a high building density.

A The solution can be located close to or on a building.
B The solution must consider adjacent buildings but is not expected to pose a high risk.
C The solution would put adjacent buildings at risk and must be located at a safe distance.

Disruption to Transport Infrastructure
Directly linked with *Density of Transport Infrastructure*

The implementation of some solutions, especially during the construction phase but also possibly during their operation, has the potential of causing significant disruption. Potential disruption includes traffic disruption and services disruption. An extremely disruptive solution may be prohibitive if it is in an area with vital transport links or services.

A Not disruptive, only minor impacts to transport.
B Some disruption possible.
C Extremely disruptive, potentially affecting services for a significant length of time.

Stage 3: Solution Specific Viability

During stakeholder meetings, three factors were highlighted as being key to identifying the most suitable surface water management measures:

- produces a high magnitude of flooding reduction impact;
- has a low complexity of implementation, particular in relation to the need to engage with Scottish Water and work within their requirements; and,
- provides multiple benefits.

Each solution is scored in relation to these three factors, as follows:

Magnitude of Impact
The solution is scored on its magnitude of impacts. A solution which has a major impact on reducing flooding from extreme events will score 2. A solution which contributes to resolving flooding for an extreme event or resolves flooding for a more rain event will score 1. A solution which does not have a major impact or only assists in resolving everyday rain will score 0.

Challenges Relating to Implementation
This score will give a qualitative indication of how difficult it may be to get community and stakeholder backing to the intervention, without which it may be more difficult or impossible to progress a given option.

A score of 2 is given if the solution does not have major foreseeable challenges and the community is likely to back the proposal. A score of 1 indicates that the proposed solution will likely have some challenges, but it should be possible to resolve these through community engagement or working with stakeholders. A score of 0 is given if there are major challenges, for example solutions that may increase inflows to the sewer network (and therefore be objected to by Scottish Water) or would otherwise impact upon third party owned assets.

Multifunctional Uses
Solutions that provide multiple benefits and provide amenity value to the community will score 2. A solution that has limited benefits outside of resolving flooding will score 1. Solutions that provide no additional benefits, for example buried solutions, score 0.

6.3 Scoring

For each zone every solution is assessed and is scored based on its compatibility to the one characteristics and its viability in terms of impact, implementation challenges and additional benefits.

Table 6.2 presents the scoring system against which each solution is scored. The calculation is shown in Figure 6.1 and is out of a possible 11, with higher scores being better. Appendix F presents a worked example for Glenshellach. The worked example shows the steps from long list to shortlist and how a score was applied to each solution.

Table 6.2: Compatibility scoring system

Stage 1: Long List to Shortlist for Each Zone

Flooding Root Cause	Solution Compatibility	
	Compatible	Not Compatible
Rainfall ponding on the surface	Provides a contribution to resolving this.	Does not impact this flooding root cause.
Flow accumulating and flowing overland	Provides a contribution to resolving this.	Does not impact this flooding root cause.
Network is Undersized Causing Surcharge	Provides a contribution to resolving this.	Does not impact this flooding root cause.
Downstream Drainage Network is Surcharged	Provides a contribution to resolving this.	Does not impact this flooding root cause.
Outlet Drowned by the Receiving Water	Provides a contribution to resolving this.	Does not impact this flooding root cause.

Stage 2: Zone and Solution Compatibility

Compatibility	Compatible	Not Compatible
Score	1	0
Gradient	A solution requiring a gradient which is compatible with the typical catchment gradient	A solution which is not compatible, i.e. the gradient is too steep for the solution to be viable
Green Space / Land Take	A solution which would have space to be constructed on a green space	A solution which is not compatible, i.e. the solution requires space that is not available
Utilised Space / Land Use Conflicts	A solution which would have space to be constructed on utilised land	A solution which is not compatible, i.e. the solution requires space that is not available
Density of / Proximity to Buildings	A solution which would not pose a risk to existing buildings (either due to adequate space around building, or because the solution type doesn't pose a risk)	A solution which is not compatible, i.e. the solution cannot be constructed near existing buildings but the zone is very dense.
Density/Disruption of Transport Infrastructure	A solution which would not conflict with existing services and cause disruption.	A solution is not compatible, i.e. the zone provides important transport links that may be disrupted.

Stage 3: Solution Specific Viability

Score	0	1	2
Magnitude of Impact	Has a small or negligible impact on an extreme event.	Has a significant impact or is part of a wider solution to resolve flooding during a major event	Has a major impact on resolving flooding during an extreme event.
Challenges Relating to Implementation	Very challenging to implement	Implementation challenges that will be overcome	Few foreseeable implementation challenges
Multifunctional Uses	No additional amenity value	Medium additional amenity value, one or two additional benefits	High additional amenity value, multiple other uses or benefits

Compatibility Score	=	Gradient Score	+	Green Space Score	+	Utilised Space Score	+	Density of Buildings Score	+	Density of Important Services Score	+	Magnitude of Impact Score	+	Challenges Relating to Implementation Score	+	Multifunctional Uses Score
Compatibility Score	=	1	+	1	+	1	+	1	+	1	+	2	+	2	+	2

Figure 6.1: Calculation of solution score for each zone

6.4 Screening Results

The results of the compatibility screening are presented in Table 6.3. The options which provide a solution to flooding root cause have been ranked from 1 to 3, to provide some focus on which options might be most suitable. Appendix E shows the scoring results for each solution in each zone.

Table 6.3: Solution rankings according to zone

	Glenshellach (Target Area)	Soroba (Target Area)	Gallanach	Lochavullin (Target Area)	Glencruitten / Mossfield	Soroba Road (Lower)	Town Centre - South	Dunollie	Longsdale - North	Longsdale - South	Corran	Town Centre - North
A.1 Rainwater Harvesting			2		3							
A.2 Green Roofs			2		3							
B.3 Rain Garden			1		2							
B.4 Bioretention Systems			1		2							
B.5 Proprietary Cellular Tree Pits			1		2							
B.6 Evapotranspiration			1		2							
B.7 Overland Conveyance	1	2	2		3	2		2	2	2	2	
B.8 Grass Filter Strip			3		3							
B.9 Filter Drains	2	3	3		3	3		3	3	3	3	
B.10 Additional Sewer Inlets	3	2	2	3	3	2		2	2	2	2	2
B.11 Enhanced Gully Pots	3	1	2	2	3	1		2	2	2	1	2
B.12 Permeable paving			3		3							
B.13 Enhanced Underground Void Space	2	2		3	3				2		3	2
B.14 Infiltration Basin			3		3							
B.15 Swale	1	1	1	3	2	2		1	1	1	1	2
C.17 Wetland	1	1		1	1				1		1	2
C.18 Pond	1	1		1	1				1		1	2
C.19 Attenuation Basin	2	2		2	2				2		1	2
C.20 Extended Detention Basin	1	1		1	1				1		1	1
D.22 Pipe Resizing	2	1		3	2				2		2	2
D.23 Upstream Attenuation Tank	3	2		3	3	2	1		3		3	3
D.24 In-line Attenuation Tanks	3	2		3	3	2	1		3		3	3
D.25 Drainage Network Offline Storage	2	1		3	2	2	1		2		2	2
D.26 Sewer Separation	2	1		3	2	2	1		2		2	2
D.27 New Outfall to Watercourse	1	1		3	2				1		2	2
D.28 WWTW Upgrade						2	1		2		2	2
E.29 Re-engineering Existing Watercourses				2								

Table 6.4: Commentary on appropriate measures for management zones

Zone	Commentary on Appropriate Outcomes
Town Centre - South	Due to the lack of space in this zone, SuDS are not a likely option. Therefore, improving the drainage network may be the best option.
Dunollie	Intercepting overland flow and improving the density and capacity of sewer inlets may be a priority for this zone. In addition, due to network surcharge, upgrading of the network may help alleviate some of the surface water issues.
Longsdale - North	Overland flow needs to be improved in this zone. The recommendations for this zone include improving the density and capacity of sewer inlets and utilising capacity in the network. Safely conveying flow overland should also be considered.
Longsdale - South	Safely conveying flow overland should be considered and option for this zone.
Corran	Overland flow needs to be improved in this zone. There is no capacity in the drainage network, therefore safely conveying flow overland should also be considered. Improving the drainage network could also be an option.
Town Centre - North	There is very little space in this zone, so many of the SuDS types are unlikely to be viable. Improving the drainage network may be the best option to improve flooding in this zone.
Glenshellach	Due to the flooding root cause in this zone the solutions that should be considered focus on local or property level interventions such as rainwater harvesting. For extreme events, additional outfalls to the watercourses could be considered.
Soroba	Due to the flooding root cause in this zone, rainfall ponding on the surface, the solutions that should be considered focus on local or property level interventions such as evapotranspiration or rain gardens. A swale may be an appropriate intervention, but the gradient may be too steep for this to be acceptable. There were no appropriate locations to install storage which could deal with extreme rain in this zone. A wider catchment approach may be required to identify a site for extreme rain interventions.
Gallanach	Property or local interventions may be considered appropriate for this zone. This would include rain gardens and swales.
Lochavullin	In terms of structural solutions, additional sewer inlets (to improve the inflow capacity of the sewer network) and storage devices along with swales have been highlighted as possible solutions. General maintenance and local upgrades to the drainage network may also be considered. Lochavullin is also affected by fluvial flooding, which will have a greater potential impact during larger events. Provision of non-return valves is included within the design options recommended in the main Oban Flood Study report. The forward strategy for targeting and sizing on-going upgrades will be informed by the updated Scottish Water model when it includes the Council pump station.
Glencruitten / Mossfield	Smaller property or local interventions are the most viable options for this zone. Intercepting the source rainfall and infiltrating flow would manage much of the everyday risk.
Soroba Road (Lower)	There are multiple recommendations for this zone. Improving sewer inlet density and capacity and overland flow routes would be considered the preferred option.

7 OPTIONS

7.1 Target Area Options

There were three target areas which were further investigation to develop baseline solutions as discussed in Section 5.7. The shortlist for each solution is presented in a table with the score out of 11, as discussed in Section 6.3. Further investigation was carried out to identify potential location for the solutions in the relevant zone. A comment is made as to whether or not there is an opportunity that could be pursued. The scores were used to develop works packages presented in Appendix G.

7.1.1 Target Area 1: Glenshellach

	Score	Opportunity	Opportunity Exists
Extended Detention Basin	9	There are opportunities within the zone to install an extended detention basin.	Yes
Overland Conveyance	8	Due to the lack of opportunities to store flow on the slopes of the zone, overland conveyance can be used to safely convey flows to the watercourse or storage elsewhere in the zone.	Yes
Swale	8	Due to the lack of opportunities to store flow on the slopes of the zone a swale may be used to convey flow to watercourses or storage elsewhere in the zone. Swales are particularly beneficial because they will remove pollutants.	Yes
Wetland	8	There may be an opportunity within greenspace near the watercourse for placing a wetland, although the impact of this upon river flooding behaviour needs to be determined to ensure this option doesn't cause fluvial flood risk detriment.	Yes
Pond	8	There may be an opportunity within greenspace near the watercourse for placing a pond, although the impact of this upon river flooding behaviour needs to be determined to ensure this option doesn't cause fluvial flood risk detriment.	Yes
New Outfall to Watercourse	8	The surcharge in the network is located near to the watercourse so additional outfalls may reduce this surcharge.	Yes
Filter Drains	7	Filter drains will help infiltrate flow, reducing flows to the sewer system and to watercourses. They are effective at reducing flood risk for smaller events, but provide limited benefit for extreme events.	Yes
Enhanced Underground Void Space	7	Due to the vicinity to the watercourse and the lack of large areas of utilised space such as car parks, this is not considered a viable option.	No
Attenuation Basin	7	There may be an opportunity within greenspace near the watercourse for placing an attenuation basin, although the impact of this upon river flooding behaviour needs to be determined to ensure this option doesn't cause fluvial flood risk detriment.	Yes
Pipe Resizing	7	Improving flow to the watercourse may be required to reduce surcharge. There may be some areas where pipe resizing is the only option although generally above-ground conveyance is preferred.	Yes
Drainage Network Offline Storage	7	Offline storage is very expensive. It is preferred to discharge flow to the watercourse rather than storing but this may be reconsidered based on the fluvial model investigation.	No
Sewer Separation	7	The sewer system in this area is already separate.	No
Additional Sewer Inlets	6	The problems in the catchment are not due to lack of sewer inlet density/capacity. Scottish Water would also be reluctant to further increase inflow into the surface water network.	No
Enhanced Gully Pots	6	Enhanced gully pots have a positive environmental benefit but do little to resolve flooding.	No

Upstream Attenuation Tank	6	Glenshellach is already high in the catchment. Upstream attenuation won't retain a lot of flow away from the zone.	No
In-line Attenuation Tanks	6	It is preferred to discharge flow to the watercourse rather than storing but this may be reconsidered based on the fluvial model investigation.	No

7.1.2 Target Area 2: Lochavullin

	Score	Opportunity	Opportunity Exists
Extended Detention Basin	8	Lochavullin has very little space and is low lying. No over ground storage option would be viable.	No
Wetland	7	Lochavullin has very little space and is low lying. No over ground storage option would be viable.	No
Pond	7	Lochavullin has very little space and is low lying. No over ground storage option would be viable.	No
Enhanced Gully Pots	6	Enhanced gully pots have a positive environmental benefit but do little to resolve flooding.	No
Attenuation Basin	6	Lochavullin has very little space and is low lying. No over ground storage option would be viable.	No
Re-engineering Existing Watercourses	6	Reengineering the water course is further investigated in the main Oban Flood Study report.	Yes
Additional Sewer Inlets	5	The problems in the catchment are not due to lack of sewer inlet density/capacity. Scottish Water would also be reluctant to further increase inflow into the surface water network.	No
Swale	5	There are locations on the periphery of the zone where a swale could be installed.	Yes
Pipe Resizing	5	Pipe resizing would not solve the pluvial issues in this zone. Solutions which store water underground may require sewer upsizing to convey flow underground; detailed design is needed to understand if pipe upsizing is required.	Yes
Upstream Attenuation Tank	5	The pluvial catchment in this area does not have a significant upstream contribution. Upstream attenuation would not reduce the water levels in the zone significantly.	No
In-line Attenuation Tanks	5	The zone is very low lying and the network has a very low gradient. Additional inline storage would require a significant upsizing of the network to store flow. There may not be enough ground cover for a solution of this type to work, although additional investigation may be required.	Yes
Drainage Network Offline Storage	5	Offline storage could be installed under one of the car parks without creating too much disruption. Although it is an expensive option it may be necessary to hydraulically separate the Lochavullin during flood events, which would require additional storage.	Yes
Sewer Separation	5	The system in this area is separate so large scale separation is not required. There is a high level pipe which connects the two systems in Lochavullin Road. During extreme events flow from one network can discharge into the other network. From the model, during the 1 in 5year 600min event, 360m3 of surface water flow discharges into the foul network. Removing this connection pipe may reduce the volume of flow transfer into the foul sewer and thereby reduce flood risk for the foul sewer, but may worsen flood risk in the surface water sewer. Additional storage within the surface water sewer (or else at source) may therefore be required to ensure no net increase in flood risk if this connection was removed.	Yes
New Outfall to Watercourse	5	There are multiple outfalls to the watercourse in this area. The watercourse is part of the flooding issues in this zone, so it is unlikely that additional outfalls would resolve the issues.	No

Enhanced Underground Void Space	4	This can be considered but due to the scale of the flooding problems it is unlikely to provide enough storage to resolve the flooding issues.	Yes

7.1.3 Target Area 3: Soroba

	Soroba	Opportunity	Opportunity Exists
Extended Detention Basin	8	There are opportunities within the zone to install an extended detention basin.	Yes
Enhanced Gully Pots	6	Enhanced gully pots have a positive environmental benefit but do little to resolve flooding.	No
Swale	6	Due to the nature of the zone a swale is ideal, where possible, to convey flow to watercourses. Swales are particularly beneficial because they will remove pollutants before discharging to the watercourse.	Yes
Wetland	6	There are opportunities in the within the zone to install a wetland. This solution may not be prioritised in this zone.	Yes
Pond	6	There are opportunities in the within the zone to install a pond. This solution may not be prioritised in this zone.	Yes
Pipe Resizing	6	Improving flow to the watercourse may be required to reduce surcharge. This is not preferred compared to over ground conveyance but some short increases may be required.	No
Drainage Network Offline Storage	6	Offline storage is very expensive. It is preferred to discharge flow to the watercourse rather than storing but this may be reconsidered on the basis of the fluvial model investigation.	No
Sewer Separation	6	The system in this area is separate, although there are multiple locations where one network can discharge into the other over a weir.	No
New Outfall to Watercourse	6	The surcharge in the network is located near to the watercourse so additional outfalls may reduce this surcharge.	Yes
Overland Conveyance	5	Due to the nature of the zone overland conveyance is ideal, where possible, to convey flow to watercourses.	Yes
Additional Sewer Inlets	5	The problems in the catchment are not due to lack of sewer inlet density/capacity. Scottish Water would also be reluctant to further increase inflow into the surface water network.	No
Enhanced Underground Void Space	5	Due to the vicinity to the watercourse this is not considered a prioritised option.	No
Attenuation Basin	5	There are opportunities in the within the community to install an extended detention basin.	No
Upstream Attenuation Tank	5	Soroba is already high in the catchment. Upstream attenuation won't retain a lot of flow away from the zone.	No
In-line Attenuation Tanks	5	It is preferred to discharge flow to the watercourse rather than storing but this may be reconsidered on the basis of the fluvial model investigation.	No
Filter Drains	4	Filter drains are a possibility in the catchment. Filter drains will help infiltrate flow, reducing contributing to the watercourse. They do not have a major impact on flooding.	No

7.2 Works Packages

Five possible work packages or baseline solution to resolves pluvial flooding in Oban are presented in detail in Appendix G. There are three works packages that focus on the target areas, one that focuses on maintenance, and an area that requires further investigation which will improve confidence in the model.

Some of the options redirect flows from the drainage system into the water environments, and the watercourses. These solutions may need to be modelled in the fluvial model in order to assess their impacts. This will need to be done during the detailed design phase, and is not required at this stage.

7.3 Integration with Fluvial and Coastal Solutions

As discussed in Sections 5.4 to 5.6, there are multiple interactions between pluvial, fluvial and coastal flooding. Where appropriate, these have been considered within the outline design options being considered within the wider Oban Flood Study. These should be integrated into the detailed designs to provide integrated flood management solutions to reduce pluvial flood risk.

8 CONCLUSIONS

Surface water flooding poses a risk to people and property in Oban with there being historically multiple records of flooding events as a result of pluvial flooding, however Scottish Water do not identify any properties in Oban as being at risk of internal flooding due to sewer flooding for their required level of service (which is the 1 in 30 year event).

The pluvial issues in Oban are related to the topology of the ground, which is typically either steep or has a relatively shallow gradient. Where the ground is steep, overland flow occurs and where the ground has a shallow gradient, this flow accumulates and ponds.

To facilitate option identification and development, the surface water catchment area draining Oban has been separated into zones. The zones were assessed based on catchment characteristics. A long list of surface water options were identified. Each solution was assessed based on characteristics which corresponded with a catchment characteristic. This allowed the identification of options which were appropriate for each zone to be considered further.

Stakeholders within the community were consulted to develop an understanding of flood risk within the town. The consultations identified two target areas which have suffered from pluvial flooding; Glenshellach and Lochavullin.

A S16 hydraulic model developed by Scottish Water was used to understand the surface water drainage network and identify risks associated with the network. From this it was recognised that the network had some limitations, including the omission of the Council operated pump station at Lochavullin.

Three areas were identified as target areas; Glenshellach; Lochavullin; and, Soroba. Works packages have been developed for these zones based on the findings of the compatibility analysis.

Lochavullin is an area that was identified as being at high risk of pluvial flooding. The area is low lying, and the model shows there is flooding from the surface water network due to surcharge. This area also floods from fluvial sources during more extreme events and some pluvial flood risk reduction measures including provision of non-return valves are included within the fluvial flood protection measures proposed in this area. The works package proposed in this area includes improving the resilience of the pumping arrangement already present, provision of additional attenuation and storage of flows, and ongoing inspection, maintenance and repair of the piped drainage network.

The community in Glenshellach has reported surface water flooding. The hydraulic model showed several surcharged pipes and some flooding in the roads. The works package proposes increasing the density and capacity of sewer inlets and attenuation of overland flows, along with improving the routing of these flows through the urban areas to the nearby watercourse. The wider fluvial flood risk measures include improving the functioning of the Lon Mor floodplain to attenuate downstream flows, to avoid causing detriment to the flooding in the watercourse downstream.

Soroba is the most vulnerable SWMP zone, there are three most vulnerable users in this zone. The zone has a relatively high ground slope, which risks causing overland flow. The works package proposes improving overland conveyance and intercepting overland flow paths along with the provision of an attenuation basin prior to discharge back to the adjacent watercourse.

In addition to solution works packages there is also a works package related to maintenance of the network. Through field visits and stakeholder meetings it has been noted there has been some issues with maintenance across the town. It is recommended that Argyll & Bute Council collaborate with Scottish Water to improve communication to effectively maintain the surface water assets.

Finally, the hydraulic model shows that the trunk sewer is surcharged and flooding for a 1 in 5 year 60 minute event. There were multiple unknowns related to the trunk sewer, so further investigation is recommended. The results of this investigation may suggest upsizing the network is beneficial, or that additional storage is required, or that the model is overestimating flooding and no further investment is required. Scottish Water may need to upgrade their hydraulic model to remove some of these uncertainties.

In addition to these works packages SuDS can be integrated more effectively into future developments through the increased consideration of hillslope flows generated outwith the site being safely routed through developments without increasing flood risk elsewhere. This may avoid some of the present issued being experience in areas such as Glenshellach. There may be future opportunities to further improve the management of the undeveloped upslope areas to better attenuate overland flows in the vicinity of more sensitive receptors.

Climate change adaption should also be considered part of any solution. Rain storms are expected to become more frequent and more intense which is likely to increase pressure on existing infrastructure. Therefore, solutions should be designed to cope with future climate change scenarios. Many of the solutions proposed in the works packages require close collaboration with Scottish Water. Argyll & Bute Council should work with Scottish Water to optimise designs and develop solutions that benefit the community and do not have detrimental impacts on Scottish Water Infrastructure.

There are many opportunities to reduce surface water flood risk in Oban. The solutions require collaboration with multiple stakeholders within the community. In addition, the designs should be developed in conjunction with fluvial and tidal solutions where required.

REFERENCES

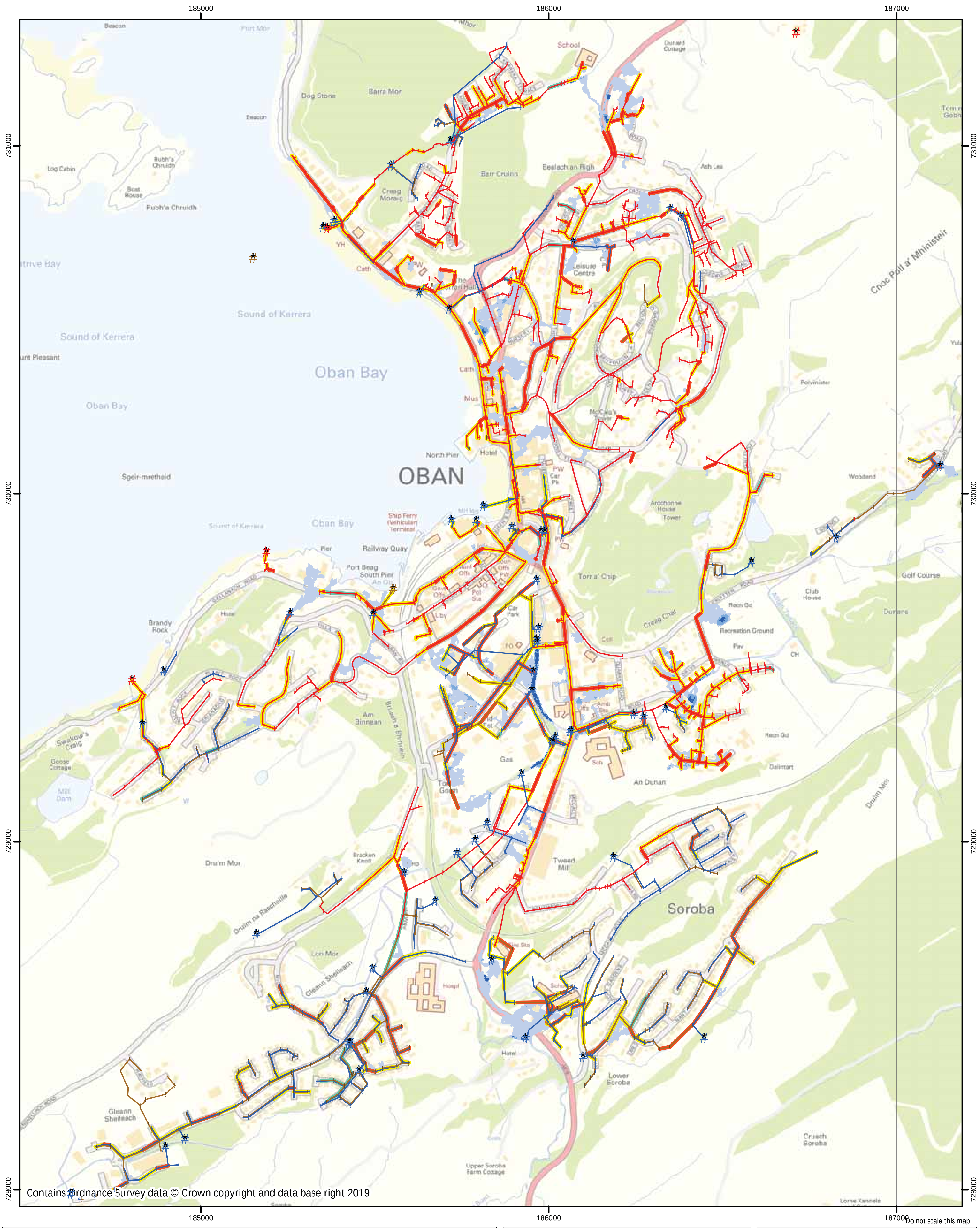
Oban Times. (2018, October 11). Swamped. pp. 1-2.

Scottish Advisory and Implementation Forum for Flooding. (2018). *Surface Water Management Planning Guidance* (Second ed.).

Scottish Water. (2017). *Drainage Area Planning Project - MBV Stage.*

APPENDICES

A DRAWINGS



Do not scale this map

Legend

systemtype	systemtype	Surcharge
Storm	Storm	Surcharged by Depth in the 1 in 5 year 60min event
Combined	Combined	Surcharged by Flow and Depth in the 1 in 5 year 60min event
Foul	Foul	Pipe Containing Sediment

systemtype	Lable
Storm	<100mm
Combined	100mm - 300mm
Foul	>300mm

Flood depths created using Scottish Water S16 hydraulic model and the LiDAR data. Results shown are for a 3 hour duration event.

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: S16 Model Details and Predicted Flood Depths from S16 Model

Status: FINAL

Drawing No.: 170506-036

Revision:

Scale: 1:10,000 A3

Date: 17 Dec 2019

Drawn: JP | Checked: EM | Approved: ITS

EnviroCentre
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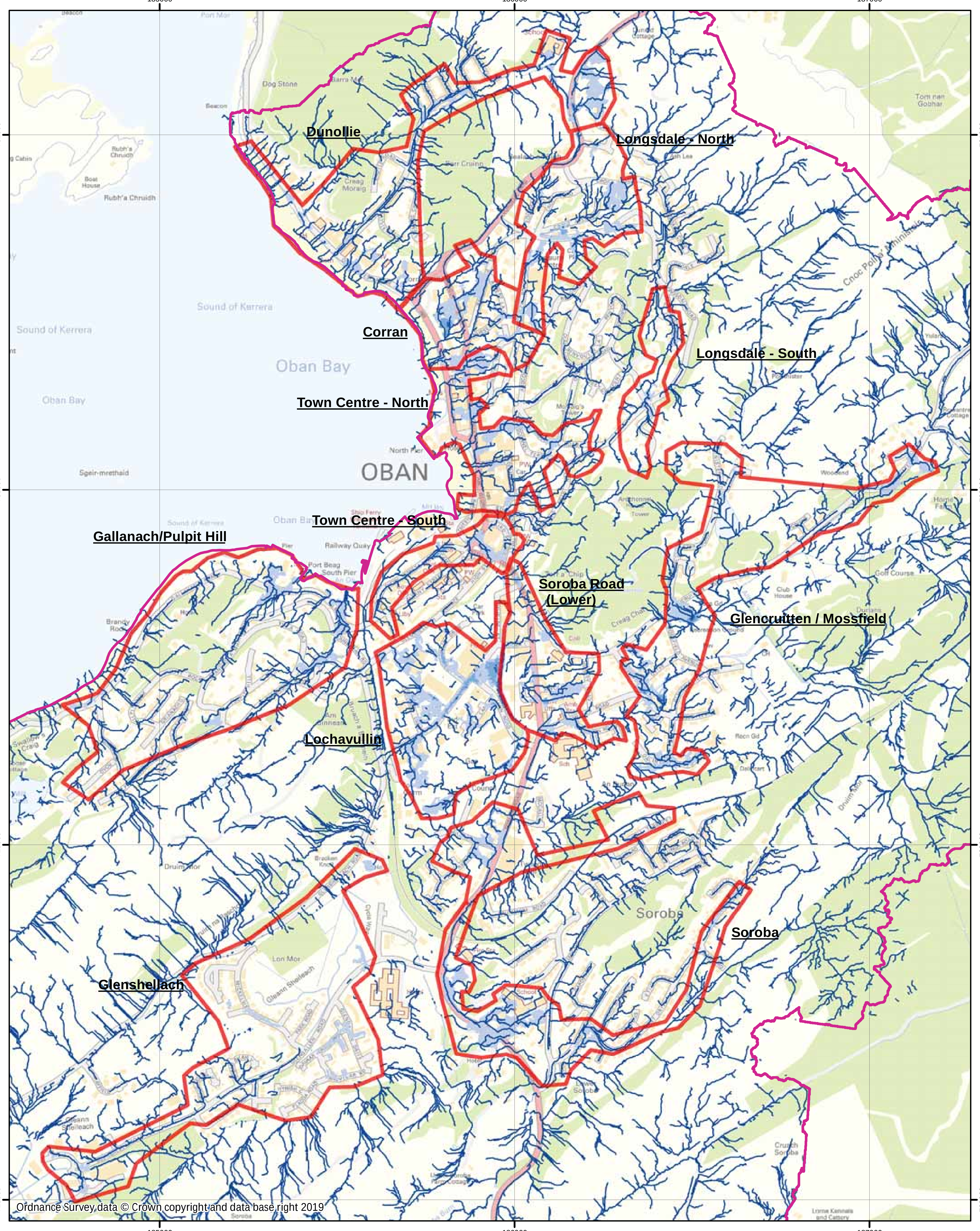

Do not scale this map

Legend

- Study Area
- Surface Water Management Zones
- Overland Flow Routes

1 in 30yr Flood Depth

- <100mm
- 100mm - 300mm
- >300mm

Flood depths created using Scottish Water S16 hydraulic model and the LiDAR data. Results shown are for the 3 hour duration event.
The overland flow paths were derived using a topographic analysis of the LiDAR digital terrain model.

Client	Argyll and Bute Council
Project	Oban Flood Study
Title	Overland Flow Paths and Predicted Flood Depths from S16 Model
Status	FINAL
Drawing No.	170506-037
Revision	B
Scale	1:10,000 A3
Date	17 Dec 2019
Drawn	JP
Checked	EM
Approved	ITS

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Legend

- Study Area
- Surface Water Management Zones

1 in 30yr Surface Water Flood Depth

- >300mm
- 100-300mm
- <100mm

Note:
Flood depths created using Scottish Water S16 hydraulic model and the LiDAR data.
Results are the 1 in 30 year event.
The duration of the event was 180 minutes.

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Predicted Flood Depths from S16 Model for the 1 in 30 Year Flood

Status	FINAL	
Drawing No. 170506-102	Revision	
Scale 1:10,000	A3	Date 13 Nov 2019
Drawn JP	Checked EM	Approved ITS

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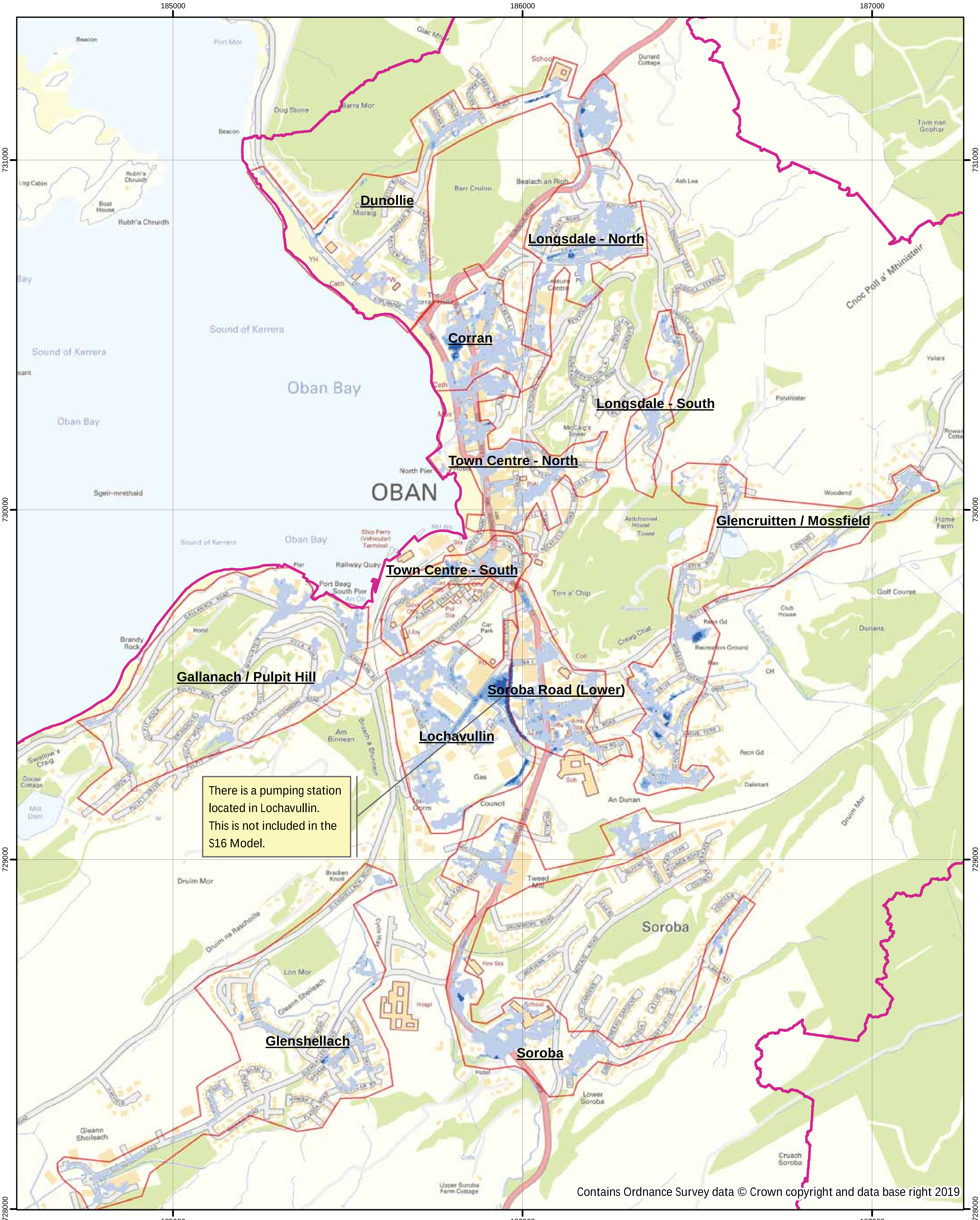

Do not scale this map

Legend

- Study Area
- Surface Water Management Zones

1 in 200yr Surface Water Flood Depth

- >300mm
- 100-300mm
- <100mm

Note:
Flood depths created using Scottish Water S16 hydraulic model and the LiDAR data.
Results are the 1 in 200 year event.
The duration of the event was 180 minutes.

Client	Argyll and Bute Council
Project	Oban Flood Study
Title	Predicted Flood Depths from S16 Model for the 1 in 200 year Flood

Status	FINAL		
Drawing No.	170506-103	Revision	
Scale	1:10,000	A3	Date 13 Nov 2019
Drawn JP	Checked EM	Approved ITS	

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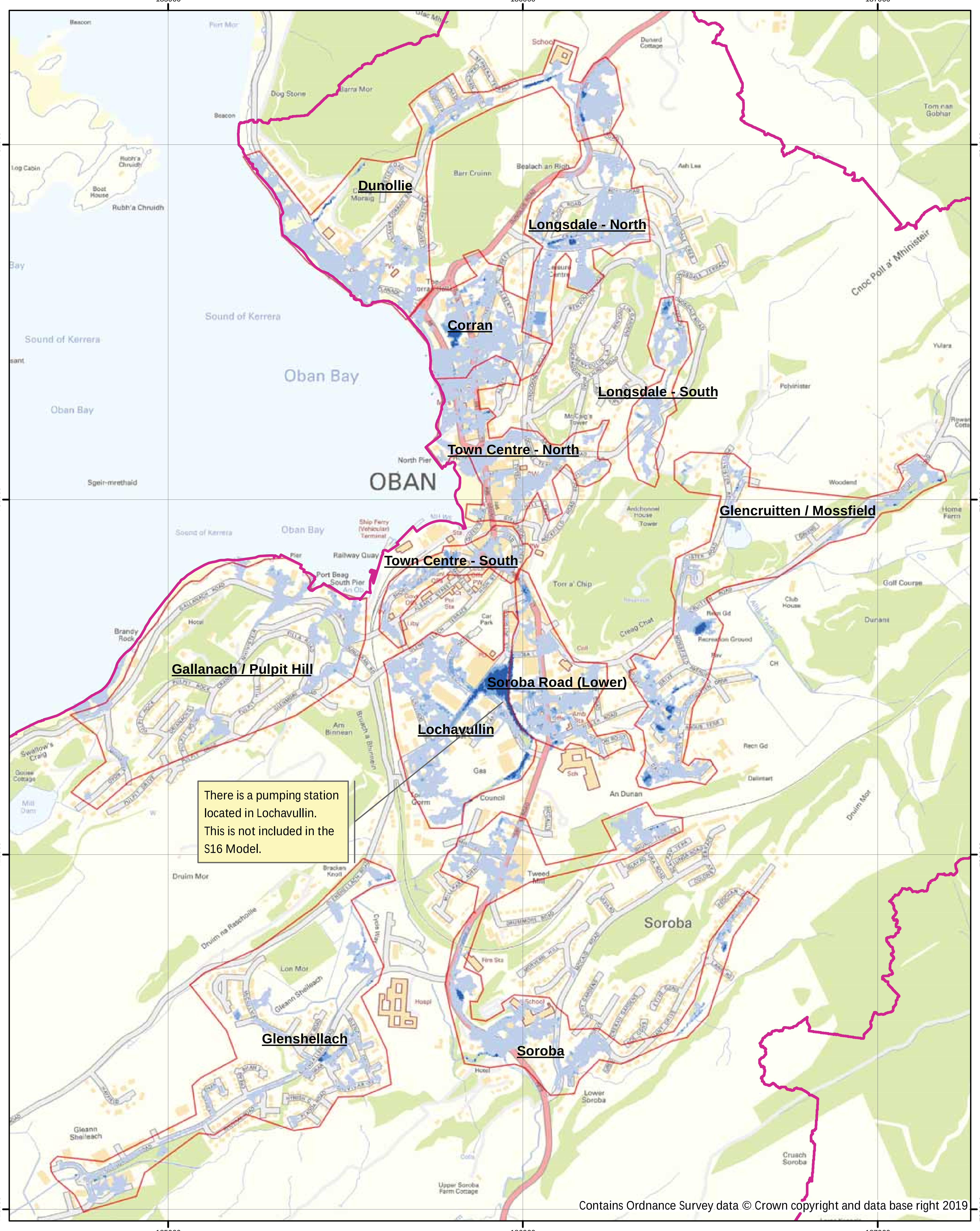

Do not scale this map

Legend

- Study Area
- Surface Water Management Zones

1 in 200yr Plus Climate Change Surface Water Flood Depth

- >300mm
- 100-300mm
- <100mm

Note:
Flood depths created using Scottish Water S16 hydraulic model and the LiDAR data.
Results are the 1 in 200 year event plus Climate Change.
The duration of the event was 180 minutes.

Client	Argyll and Bute Council
Project	Oban Flood Study
Title	Predicted Flood Depths from S16 Model for the 1 in 200 year+ CC Flood

Status			
FINAL			
Drawing No.	170506-104	Revision	
Scale	1:10,000	A3	Date: 13 Nov 2019
Drawn: JP	Checked: EM	Approved: ITS	

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B SOLUTIONS

Non-Structural Solutions

Land use planning policy - adhere to existing
Land use planning policy - implement more stringent policies where required
Clarify responsibilities for new surface water management infrastructure
Clarify responsibilities for existing surface water management infrastructure (including SUDS)
Emergency response plans
Study - improve understanding
Study - option appraisal and design
Study - improve information on surface water flood events
Self-help - business continuity planning
Self-help - community flood action groups and resilient community plans
Self-help - flood insurance
Self-help - awareness- raising
Self-help - property-level protection
Self-help - property-level resilience (retrofit)
Flood forecasting and warning
Asset management and maintenance
Watercourse management and maintenance
Relocation

Structural Solutions

Description	Advantages	Disadvantages
A.1 Rainwater Harvesting		
Rainwater is intercepted, usually from impervious surfaces, for later use as 'grey – non potable water'. Interception, conveyance and storage tank required.	Source control of flow	Rainwater can't be used for drinking, bathing
	Reduce demand for mains water for toilets, vehicle washing, horticulture etc.	Difficult to retrofit
	Effective for larger buildings with high non potable water demand	Less cost effective for smaller buildings
		Requirement for pumping, unless unsightly above ground tank used
		Complex costly systems
		Not so beneficial in areas of high rainfall
A.2 Green Roofs		
Drought resistant vegetation on top of buildings detains water within the growing medium and reservoir layer, slowly releasing runoff by	Source control of flow	High roof loadings due to growing medium
	Biodiversity	Comparative high cost
	Amenity (if access possible)	Difficult to retrofit
	Heat and sound insulation potential	Not suitable to retrofit on smaller residential building.
		Requires flat or low pitch roof

Description	Advantages	Disadvantages
evapotranspiration or via drainage layer.	No extra land take	Vegetation might require maintenance
B.3 Rain Garden		
Smaller scale engineered shallow depression with water tolerant deep rooted vegetation. Installed in relatively flat ground. Discharge through slow (24 hour) infiltration. Usually connected to single property/curtilage.	Source control of flow	Requires sufficient soil infiltration potential
	Low cost	Pre-treatment required
	Easy retrofit	sufficient soil depth required
	Ease of maintenance	Small, limited impact on volume/flow reduction
	Natural infiltration	
	Amenity	
	Biodiversity	
B.4 Bioretention Systems		
Similar to rain gardens. Diverse, small flexible vegetated water management features that form part of a larger SuDS. Discharges via infiltration and/or to an underdrain system. Can be designed bespoke or bought and installed as off the shelf proprietary units.	Source control of flow	Requires sufficient space
	Allows infiltration	Installation within urban environment may be disruptive
	Potential for place-making in urban environment	Pre-treatment required
	Amenity	Sufficient soil depth required
	Biodiversity	
B.5 Proprietary Cellular Tree Pits		
Proprietary system comprising of soil cells, grilles, guards and selected trees grown specifically for robust urban growth. Soil cells may cover extensive linear reaches under pedestrian and cycle pavements.	Source control of flow	Requires sufficient space
	Proven reliability	Installation within urban environment may be disruptive
	Manufacturer support in design and installation	Higher cost
	Can be retrofitted in constrained space	Pre-treatment required
	Potential for place-making in urban environment	Sufficient soil depth required
	Amenity	
	Biodiversity	
B.6 Evapotranspiration		
For managing 'every day rain' – maximise the use of plants to allow rain to evaporate into the atmosphere where it lands (at source), creating little or no surface water run-off.	Good amenity value	Low impact
	Cost	
	Easy to retrofit	
B.7 Overland Conveyance		
Collect, delay and convey rainfall and resultant surface water above ground to watercourses using green infrastructure techniques	Amenity	Cost
	Biodiversity	Land take
	Additional conveyance	Dependent upon levels
B.8 Grass Filter Strip		
	Reduces pollutants	Low impact

Description	Advantages	Disadvantages
Grass strips intercepting runoff from roads and urban areas before entering watercourses or the drainage network.	Slows flow	
	Cheap	
	Easy to retrofit	
B.9 Filter Drains		
Shallow trench drains with stone/gravel. Lateral interception from adjoining impermeable surface. May allow infiltration, if a geotextile used, or may be lined with geomembrane.	Easy incorporation beside roads	Pollutant build up and clogging not visible
	Fits well into landscaping scheme	Small sub-catchment
		Good installation and maintenance crucial
B.10 Additional Sewer Inlets		
Additional gully pots and strip drains will allow greater inflow to the sewer and reduce the risk of inlet exceedance.	Location specific	May lead to increased downstream flow
	Removes surface water	
B.11 Enhanced Gully Pots		
Enhanced gully pots, especially in steep areas, to allow interception of coarser sediment that would otherwise be deposited downstream when low gradients are encountered	Simple Solution	Increased maintenance required
	Prevents downstream capacity loss	
B.12 Permeable Paving		
Can include porous asphalt, permeable blockwork and reinforces grass/gravel. May rely. Conveyance, by infiltration, of run-off to drainage and/or underground attenuation systems.	Allows dual use of space	Susceptible to clogging – can't be used where high % of solids in run-off (issues with winter gritting)
	Reduces flow to drainage network	Cyclical maintenance required
	Reduces need for pipe excavations	Higher cost than conventional pavement
	Water quality treatment,	Heavy axle loads may lead to failure
	Achieves sediment removal from runoff	
	Reduces ponding and formation of ice	
B.13 Enhanced Underground Void Space		
Base course under, typically, car parks with permeable paving cap. Enhanced porosity can be achieved by using high void foundation stone, or proprietary geocellular sub-base. Discharges via infiltration and/or to an underdrain system.	Source control of flow	Limit to bearing capacity on surface
	Large storage potential achievable	Disruptive to retrofit
	Can be combined with tree pits/other bioretention systems	
	Treatment provided within permeable paving	
B.14 Infiltration Basin		
	Cost-effective	low impact

Description	Advantages	Disadvantages
Infiltration basins are vegetated depressions designed to store runoff on the surface and infiltrate it to the ground. They are usually dry except in periods of heavy rainfall.	Reduces pollutants	Requires high infiltration soil
	Small land take	Requires a large, flat area
B.15 Swale		
Shallow vegetated channels with, typically, low gradient side slopes and flat bottom, however different profiles and planting may be incorporated. Commonly used for roadside drainage. Steeper flows may require check dams. Attenuation storage and infiltration is facilitated	Run-off flow reduction	Land take
	Low cost	Difficult to retrofit in urban/ suburban areas
	Ease of construction	Maintenance (litter pick and grass cutting) essential
	Visual amenity	Unsuitable for extremely steep areas
	Water quality treatment	Incompatible with roadside parking or tree planting
	Lower cost	
C.17 Wetland		
Well vegetated shallow permanent pool with attenuation capacity above permanent storage level. Extensive shallow benching encourages sustainable aquatic planting. Outfall to drainage network. Storage may be enhanced using floating wetlands.	Source control of flow	High land take
	Water quality treatment	Maintenance essential
	High biodiversity benefits	Specialist construction skills required
	High amenity/education benefits	Pre-treatment required
	Eases river flooding	Requires engineering to intercept run-off before entering network
		Requires baseflow
		Potential for adverse nutrient release
C.18 Pond		
Vegetated deeper permanent pool and greater attenuation capacity than wetland. Smaller marginal aquatic planting area. Lower amenity/ biodiversity benefit, but simpler maintenance, than wetland. Pre-treatment not required. Outfall to drainage network.	Source control of flow	High land take
	Manages both high and low flows	Maintenance essential (especially to avoid colonisation by invasive species)
	Pollutant removal	Regular inflow required
	Biodiversity	Not suitable for steep locations
	Amenity	Perceived safety issue
	Eases river flooding	
C.19 Attenuation Basin		
Vegetated dry pond that has an unrestricted inlet and restricted outlet that detains run-off water during storm conditions and releases water to the combined or storm sewer network when flows reduce. Lower amenity/ biodiversity benefit, but simpler maintenance, than both	Source control of flow	High land take (if dual use not possible)
	Manages both high and low flows	Maintenance essential
	Amenity space	Pre-treatment required
	Eases river flooding	Performance dependant on inlet/ outlet levels
	Simple design and construction	
	Proven track record	

Description	Advantages	Disadvantages
pond and wetland. Pre-treatment required.		
C.20 Extended Detention Basin		
An extended detention basin is a facility constructed through filling and/or excavation that provides temporary storage of stormwater runoff. It has an outlet structure that detains and attenuates runoff inflows and promotes the settlement of pollutants.	High impact	Major cost
	Can be dual use for example car park or playground	Land take
	Manages extreme flows	Performance dependant on inlet/ outlet levels
D.22 Pipe Resizing		
Increase conveyance capacity by increasing diameter of existing pipes at locations that affect known/modelled surcharging.	Topical pipe capacity increase	Cost
	High impact to local network	Potential for significant disruption
		Complicated to design
		Must be well designed to not increase downstream risk
D.23 Upstream Attenuation Tank		
Underground attenuation tank with flow control at network connection. Inflow from surface water interception (new engineering). Includes geocellular proprietary products or oversized concrete pipe for example	Dual land use	No amenity / biodiversity value
	Source control of flow	Pre-treatment required
	Very high void ratios	Sufficient depth and cover required
	Manages high flow events	Difficult maintenance
	Eases river flooding	
	Long term stability	
D.24 In-line Attenuation Tanks		
Attenuation capacity provided for storm or combined sewerage in underground tanks. Inflow from dual manhole weir. Outflow from flow control device or by pumping.	In line storage	Cost
	Suitable for combined and storm sewers	Disruption
	Reduces downstream peak flows that are liable to surcharging	Land required
		Design must allow for ease of maintenance
D.25 Drainage Network Offline Storage		
Divert surface water to storage tanks or by providing storage in the existing drainage / flood management network.	High impact	Major cost
	Can be constructed away from significant roadways	Services disruption
		Maintenance required
D.26 Sewer Separation		
Remove storm water inflow from combined sewer network. Create new small storm sewer networks with separate discharges to watercourses. This work may necessitate provision of	Reduced flow to combined sewer	Major cost
	Reduces entrained sediment load received by combined sewer	Acute disruption to property owners and road users
	Subsequent increased foul water capacity in network will enable future urban development in line with the Local Plan	Significant work is required to have a major impact

Description	Advantages	Disadvantages
additional treatment of run-off before discharge to the natural water environment.		
D.27 New Outfall to Watercourse		
Increase capacity or build new underground pipes for surface water.	High impact	Potential for major disruption
		Difficult to site new outfalls to be hydraulically effective
D.28 WWTW Upgrade		
Increase Wastewater Treatment Works capacity to enable increased capacity in the trunk combined sewer	Increased combined sewer capacity	Major cost
	Increased potential for urban expansion	Major disruption to combined water treatment
E.29 Re-engineering Existing Watercourses		
Put in place, for example, storage (on-line or off-line storage), embankments, walls or flood diversion channels in urban burns, all of which can reduce flood risk from the watercourse itself. Also restoring the upstream flood plain and removing culverts could reduce downstream water levels.	Storage	Major cost
	Conveyance	Existing land use issues
	Flood protection	
	Amenity	
	Biodiversity	
	Additional conveyance	

C ZONE COMPATIBILITY ANALYSIS

		Rainfall ponding on the surface	Flow accumulating and flowing overland	Network is Undersized Causing Surcharge	Downstream Drainage Network is Surcharged	Outlet Drowned by the Receiving Water		Gradient	Green Space	Utilised Space	Density of Buildings	Density of Transport Infrastructure
	1	No effect/ minor impact	No effect/ minor impact	No effect/ minor impact	No effect/ minor impact	No effect/ minor impact	A	The zone generally has a very steep gradient	No green space is available.	No utilised space is available.	Dense buildings	A dense area and one of the major roads pass through the zone
	2	Contributor	Contributor	Contributor	Contributor	Contributor	B	The zone generally has a steep gradient	Some green space is available	Some utilised space may be available	Medium density buildings	One of the major roads pass through the zone.
	3	Major Cause	Major Cause	Major Cause	Major Cause	Major Cause	C	The zone generally has a low gradient	A significant area of green space is available	A significant area of utilised space may be available	Sparse buildings	Minimal Services
Glenshellach		2	3	3	1	1		B	C	B	C	C
Soroba		2	3	3	1	1		B	C	B	B	A
Gallanach		3	3	1	1	2		A	C	A	C	C
Lochavullin		1	2	3	1	3		C	A	C	A	A
Glencruitten / Mossfield		3	3	3	1	1		B	C	C	C	C
Soroba Road (Lower)		1	3	1	3	1		C	A	B	A	A
Town Centre - South		1	2	1	3	1		C	A	A	A	A
Dunollie		2	3	2	2	1		A	B	B	B	B
Longsdale - North		2	3	3	3	1		B	C	C	B	B
Longsdale - South		2	3	1	1	1		A	B	A	B	C
Corran		1	3	3	3	1		B	B	C	A	A
Town Centre - North		2	2	3	3	1		B	A	B	A	A

D SOLUTION COMPATIBILITY ANALYSIS

Option		Reduces Ponding	Reduces Overland Flow	Increases Local Network Capacity	Reduces Downstream Network Surcharge	Reduces Level of the Receiving Water		Gradient	Land Take	Conflict with Existing Uses	Proximity to Building Foundations	Disruption		Magnitude of Impact	Challenges Relating to Implementation	Multifunctional Uses
	1	Does not have an impact	Does not have an impact	Does not have an impact	Does not have an impact	Does not have an impact	A	Can be constructed on any gradient, low to very steep	The solution has low space requirement	Can be constructed on already utilised land, existing infrastructure can be maintained or restored	The solution can be located close to or on a building	Not disruptive, only minor impacts to transport	0	Small scale of Impact (Everyday)	Very challenging to implement	No additional amenity value
	2	Has minor impact	Has minor impact	Has minor impact	Has minor impact	Has minor impact	B	Can be constructed on most gradients except very steep	The solution has a medium space requirement		The solution must consider the foundations in the design but it wont expose the building to a high risk.	Some disruption possible	1	Some impact (More Rain)	Implementation challenges that will be overcome	Medium additional amenity value, one or two additional benefits
	3	Has significant impact	Has significant impact	Has significant impact	Has significant impact	Has significant impact	C	Can only be constructed on low gradients	The solution has a high space requirement	Construction will eliminate existing features and infrastructure	The solution would put adjacent buildings at risk and must be located at a safe distance	Extremely disruptive, potentially affecting services for a significant length of time	2	Significant Impact (Extreme Event)	Few foreseeable implementation challenges	High additional amenity value, multiple other uses or benefits
A.1 Rainwater Harvesting		3	2	2	1	1		A	A	A	A	A		0	2	1
A.2 Green Roofs		3	2	2	1	1		A	A	A	A	A		0	2	1
B.3 Rain Garden		3	2	2	1	1		A	A	A	A	B		1	2	1
B.4 Bioretention Systems		3	2	2	1	1		A	A	A	A	B		1	2	1
B.5 Proprietary Cellular Tree Pits		3	2	2	1	1		A	A	A	A	A		1	2	1
B.6 Evapotranspiration		3	2	2	1	1		A	C	A	C	A		0	1	2
B.7 Overland Conveyance		2	3	2	1	1		A	A	A	A	B		1	2	0
B.8 Grass Filter Strip		3	2	2	1	1		A	A	A	A	A		0	2	0
B.9 Filter Drains		3	3	2	1	1		A	A	A	B	B		0	2	0
B.10 Additional Sewer Inlets		1	3	3	1	1		A	A	A	A	B		1	0	0
B.11 Enhanced Gully Pots		1	3	3	1	1		A	A	A	A	A		1	0	0
B.12 Permeable Paving		3	2	2	1	1		A	A	A	A	B		0	2	0
B.13 Enhanced Underground Void Space		1	1	3	2	1		B	A	A	B	B		1	1	0
B.14 Infiltration Basin		3	2	2	1	1		C	A	A	B	A		1	1	0
B.15 Swale		2	3	3	1	1		A	B	A	A	B		1	1	1
C.17 Wetland		1	1	3	2	2		C	C	C	C	A		2	1	2
C.18 Pond		1	1	3	2	2		C	C	C	C	A		2	1	2
C.19 Attenuation Basin		1	1	3	2	2		C	B	C	C	A		2	1	1
C.20 Extended Detention Basin		1	1	3	2	2		C	A	A	B	A		2	1	2
D.22 Pipe Resizing		1	1	3	2	1		A	A	A	B	C		2	0	0
D.23 Upstream Attenuation Tank		1	1	3	3	1		C	A	A	B	C		2	0	0
D.24 In-line Attenuation Tanks		1	1	3	3	1		C	A	A	B	C		2	0	0
D.25 Drainage Network Offline Storage		1	1	3	3	1		A	A	A	B	C		2	0	0
D.26 Sewer Separation		1	1	3	3	1		A	A	A	B	C		2	0	0
D.27 New Outfall to Watercourse		1	1	3	1	1		A	A	A	B	B		2	1	0
D.28 WWTW Upgrade		1	1	1	3	1		A	A	A	B	C		2	0	0
E.29 Re-engineering Existing Watercourses		1	1	1	1	3		A	B	A	B	B		2	0	2

E SCREENING RESULTS

	Glenshellach	Soroba	Gallanach	Lochavullin	Glencruitten / Mossfield	Soroba Road (Lower)	Town Centre - South	Dunollie	Longsdale - North	Longsdale - South	Corran	Town Centre - North
A.1 Rainwater Harvesting			6		6							
A.2 Green Roofs			6		6							
B.3 Rain Garden			7		7							
B.4 Bioretention Systems			7		7							
B.5 Proprietary Cellular Tree Pits			7		7							
B.6 Evapotranspiration			7		7							
B.7 Overland Conveyance	8	5	6		6	5		6	6	6	5	
B.8 Grass Filter Strip			5		5							
B.9 Filter Drains	7	4	5		5	3		5	5	5	3	
B.10 Additional Sewer Inlets	6	5	6	5	6	5		6	6	6	5	5
B.11 Enhanced Gully Pots	6	6	6	6	6	6		6	6	6	6	6
B.12 Permeable Paving			5		5							
B.13 Enhanced Underground Void Space	7	5		4	6				6		4	5
B.14 Infiltration Basin			5		5							
B.15 Swale	8	6	7	5	7	5		7	7	7	6	6
C.17 Wetland	8	6		7	8				7		6	6
C.18 Pond	8	6		7	8				7		6	6
C.19 Attenuation Basin	7	5		6	7				6		6	5
C.20 Extended Detention Basin	9	8		8	8				8		7	8
D.22 Pipe Resizing	7	6		5	7				6		5	5
D.23 Upstream Attenuation Tank	6	5		5	6	5	5		5		4	4
D.24 In-line Attenuation Tanks	6	5		5	6	5	5		5		4	4
D.25 Drainage Network Offline Storage	7	6		5	7	5	5		6		5	5
D.26 Sewer Separation	7	6		5	7	5	5		6		5	5
D.27 New Outfall to Watercourse	8	6		5	7				7		5	6
D.28 WWTW Upgrade						5	5		6		5	5
E.29 Re-engineering Existing Watercourses				6								

F WORKED EXAMPLE

The following provides a worked example of how the shortlist was achieved for the Glenshellach Zone.

Root Cause Compatibility

The first step is to identify which of the solutions resolve one of the major root causes in Glenshellach. If a solution does not resolve a major root cause it will not be further considered.

Glenshellach has two major root causes, *Flow accumulating and flowing overland* and *Network is undersized and causing Surcharged*, shown in Table A.

Table A: Glenshellach flooding root causes

		Rainfall ponding on the surface	Flow accumulating and flowing overland	Network is Undersized Causing Surcharge	Downstream Drainage Network is Surcharged	Outlet Drowned by the Receiving Water
	1	No effect/ minor impact	No effect/ minor impact	No effect/ minor impact	No effect/ minor impact	No effect/ minor impact
	2	Contributor	Contributor	Contributor	Contributor	Contributor
	3	Major Cause	Major Cause	Major Cause	Major Cause	Major Cause
Glenshellach		2	3	3	1	1

There are 16 solutions which resolve one of these major root causes shown in Table B. These are the solutions which will be further assessed and scored.

Table B: Solutions which resolve a Glenshellach Root Cause

B.7 Overland Conveyance	C.17 Wetland	D.22 Pipe Resizing
B.9 Filter Drains	C.18 Pond	D.23 Upstream Attenuation Tank
B.10 Additional Sewer Inlets	C.19 Attenuation Basin	D.24 In-line Attenuation Tanks
B.11 Enhanced Gully Pots	C.20 Extended Detention Basin	D.25 Drainage Network Offline Storage
B.13 Enhanced Underground Void Space		D.26 Sewer Separation
B.15 Swale		D.27 New Outfall to Watercourse

Catchment Compatibility

The next step is to identify solution which are appropriate and suitable to the zone. If a solution is compatible it will receive a score of 1.

Table C: Catchment Descriptors Glenshellach

		Gradient	Green Space	Utilised Space	Density of Buildings	Density of Important Services
	A	The zone generally has a very steep gradient	No green space is available.	No utilised space is available.	Dense buildings	A dense area and one of the major roads pass through the zone
	B	The zone generally has a steep gradient	Some green space is available	Some utilised space may be available	Medium density buildings	One of the major roads pass through the zone.
	C	The zone generally has a low gradient	A significant area of green space is available	A significant area of utilised space may be available	Sparse buildings	Minimal Services
Glenshellach		B	C	B	C	C

Gradient

Glenshellach has a generally steep gradient. Solutions which can only be constructed in low gradient areas will not score for this category. For example, a wetland will not be appropriate as it will be difficult to construct on the steep slopes. On the other hand, an overland conveyance solution would be able to utilise the slopes to convey water away from where there is flooding.

Green Space

Glenshellach has a significant area of greenspace available. All solutions benefit from having a large amount greenspace and therefore all solutions would be appropriate in Glenshellach and will score for this category. Other zones, such as Lochavullin, does not have a lot of greenspace available, so some solutions such as Evapotranspiration will not score in this category in Lochavullin.

Utilised Space

Glenshellach has utilised space available, an example of this is located beside Glen Gallen Drive in a recreation field. Solutions which cannot be constructed on utilised land without removing the current use will not score in this category. For example, constructing a pond on a recreation field or carpark will completely supersede the existing use.

Density of Buildings

Glenshellach has a low density of buildings. Due to the low density of buildings every solution is appropriate for consideration in Glenshellach. Other zones such as Town Centre South have very high density of the solutions would not be appropriate. Solutions that risk the foundations of existing buildings either through infiltration of root intrusion, therefore evapotranspiration or infiltration basins would not be appropriate in the town centre south.

Density of Important Services

Glenshellach does not have important services. Therefore, every solution is appropriate for consideration as they would not disrupt existing services. Other zones such as Soroba has major roads passing through the zone. Solutions which disrupt these services, such as major underground pipe works, would not score for this category.

Compatibility Score

Based on the scoring above the following compatibility scores were achieved by each solution:

Table D: Solution compatibility score totals

Option	Gradient	Green Space	Utilised Space	Density of Buildings	Density of Important Services	Compatibility score
A.1 Rainwater Harvesting	Does not Resolve a flooding Root Cause					
A.2 Green Roofs	Does not Resolve a flooding Root Cause					
B.3 Rain Garden	Does not Resolve a flooding Root Cause					
B.4 Bioretention Systems	Does not Resolve a flooding Root Cause					
B.5 Proprietary Cellular Tree Pits	Does not Resolve a flooding Root Cause					
B.6 Evapotranspiration	Does not Resolve a flooding Root Cause					
B.7 Overland Conveyance	1	1	1	1	1	5
B.8 Grass Filter Strip	Does not Resolve a flooding Root Cause					
B.9 Filter Drains	1	1	1	1	1	5
B.10 Additional Sewer Inlets	1	1	1	1	1	5
B.11 Enhanced Gully Pots	1	1	1	1	1	5
B.12 Permeable paving	Does not Resolve a flooding Root Cause					
B.13 Enhanced Underground Void Space	1	1	1	1	1	5
B.14 Infiltration Basin	Does not Resolve a flooding Root Cause					
B.15 Swale	1	1	1	1	1	5
C.17 Wetland	0	1	0	1	1	3
C.18 Pond	0	1	0	1	1	3
C.19 Attenuation Basin	0	1	0	1	1	3
C.20 Extended Detention Basin	0	1	1	1	1	4
D.22 Pipe Resizing	1	1	1	1	1	5
D.23 Upstream Attenuation Tank	0	1	1	1	1	4
D.24 In-line Attenuation Tanks	0	1	1	1	1	4
D.25 Drainage Network Offline Storage	1	1	1	1	1	5
D.26 Sewer Separation	1	1	1	1	1	5
D.27 New Outfall to Watercourse	1	1	1	1	1	5
D.28 WWTW Upgrade	Does not Resolve a flooding Root Cause					
E.29 Re-engineering Existing Watercourses	Does not Resolve a flooding Root Cause					

Solution Viability Score

Described in section 6.2. The solution viability score is solution specific and is the total of the magnitude of impact, challenges relating to implementation and potential multiple benefits. Table E shows the totals for each solution.

Table E: Solution viability score totals

Solution	Magnitude of Impact	Challenges Relating to Implementation	Multifunctional Uses	Total Solution Viability Score
A.1 Rainwater Harvesting	0	2	1	3
A.2 Green Roofs	0	2	1	3
B.3 Rain Garden	1	2	1	4
B.4 Bioretention Systems	1	2	1	4
B.5 Proprietary Cellular Tree Pits	1	2	1	4
B.6 Evapotranspiration	0	1	2	3
B.7 Overland Conveyance	1	2	0	3
B.8 Grass Filter Strip	0	2	0	2
B.9 Filter Drains	0	2	0	2
B.10 Additional Sewer Inlets	1	0	0	1
B.11 Enhanced Gully Pots	1	0	0	1
B.12 Permeable paving	0	2	0	2
B.13 Enhanced Underground Void Space	1	1	0	2
B.14 Infiltration Basin	1	1	0	2
B.15 Swale	1	1	1	3
C.17 Wetland	2	1	2	5
C.18 Pond	2	1	2	5
C.19 Attenuation Basin	2	1	1	4
C.20 Extended Detention Basin	2	1	2	5
D.22 Pipe Resizing	2	0	0	2
D.23 Upstream Attenuation Tank	2	0	0	2
D.24 In-line Attenuation Tanks	2	0	0	2
D.25 Drainage Network Offline Storage	2	0	0	2
D.26 Sewer Separation	2	0	0	2
D.27 New Outfall to Watercourse	2	1	0	3
D.28 WWTW Upgrade	2	0	0	2
E.29 Re-engineering Existing Watercourses	2	0	2	4

Total Score

The final score is the combination of the compatibility score and the solution viability score. Only those solutions that resolve a root cause in that zone receives a score. Table F shows the total scores for solutions in Glenshellach.

Table F: Solution total scores for Glenshellach

Solution	Compatibilty Score	Viabilty Score	Total Score
A.1 Rainwater Harvesting	-	-	-
A.2 Green Roofs	-	-	-
B.3 Rain Garden	-	-	-
B.4 Bioretention Systems	-	-	-
B.5 Proprietary Cellular Tree Pits	-	-	-
B.6 Evapotranspiration	-	-	-
B.7 Overland Conveyance	5	3	8
B.8 Grass Filter Strip	-	-	-
B.9 Filter Drains	5	2	7
B.10 Additional Sewer Inlets	5	1	6
B.11 Enhanced Gully Pots	5	1	6
B.12 Permeable paving	-	-	-
B.13 Enhanced Underground Void Space	5	2	7
B.14 Infiltration Basin	-	-	-
B.15 Swale	5	3	8
C.17 Wetland	3	5	8
C.18 Pond	3	5	8
C.19 Attenuation Basin	3	4	7
C.20 Extended Detention Basin	4	5	9
D.22 Pipe Resizing	5	2	7
D.23 Upstream Attenuation Tank	4	2	6
D.24 In-line Attenuation Tanks	4	2	6
D.25 Drainage Network Offline Storage	5	2	7
D.26 Sewer Separation	5	2	7
D.27 New Outfall to Watercourse	5	3	8
D.28 WWTW Upgrade	-	-	-
E.29 Re-engineering Existing Watercourses	-	-	-

Other Zones

This methodology is repeated for all other zones to score each solution for each zone. This means different solutions will be on the shortlist in different areas, and different solutions have the potential to be scored higher.

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Maintenance

The reduce the risk of ponding on the surface and to restore the efficiency of the network a maintenance schedule is required.

Description

There is evidence that the network is not working as designed. Site walkovers have identified areas that require a regular maintenance schedule to resolve ongoing issues. During the stakeholder workshop a broken pipe was potentially identified and provides an example of

Multiple areas have been identified as requiring maintenance work. Some of this work involves a one off action such as replacing a broken pipe, but there is also a requirement for a schedule to maintain problem areas.

The following list of actions is not an exhaustive list. This has been compiled from the findings of the site walkover visits.

Solution	Location	Description	Impact
1. Identify and repair broken pipe.	Combie Street	It has been suggested that due to recent LiDL construction works, the pipe in this area may be cracked, broken or have collapsed entirely.	Simple fix to reduce the flood risk near to Lochavullin.
2. Clear gullies	Lochavullin and Soroba	Some of the gullies are completely blocked. When the gullies are blocked they are unable to drain surface water and create ponds on the surface.	Clearing the gullies will mean the network responds as designs and should reduce ponding during small events.
3. Clear pipe blockage and sediment	Lochavullin and elsewhere	The model has 129 pipes with sediment, based on survey data. Sediment and blockages restrict flow reduces the networks ability to pass the flow forward. Pipes with a low gradient are particularly at risk of sediment and the flow velocity is reduced. This sediment should be regularly cleared to make sure it cannot limit flow during extreme events, pipes with a low gradient should be a significant part of the maintenance schedule.	Removing sediment will allow pipes to operate at their maximum capacity.
4. Pump Maintenance	Lochavullin	During the October 2018 event the Lochavullin pump was compromised which exacerbated flooding in this area.	Regular pump maintenance will reduce the risk of failure during a major event in the future.

In addition to maintenance, Scottish Water have suggested that issues and flooded is not always communicated effectively with them. The community may not know who to communicate with when they have an issue, and when they do inform someone the message may not be passed on. Therefore, working with Scottish Water and improving communication with them is a priority. Promotion of how community members report their surface water issues should also be prioritised, for example a flooding hotline on the Argyll and Bute website.

Risk and Uncertainty

As stated above the problems listed are not a complete list of required maintenance in the catchment. The actual maintenance requirement is unknown and may require further investigation.

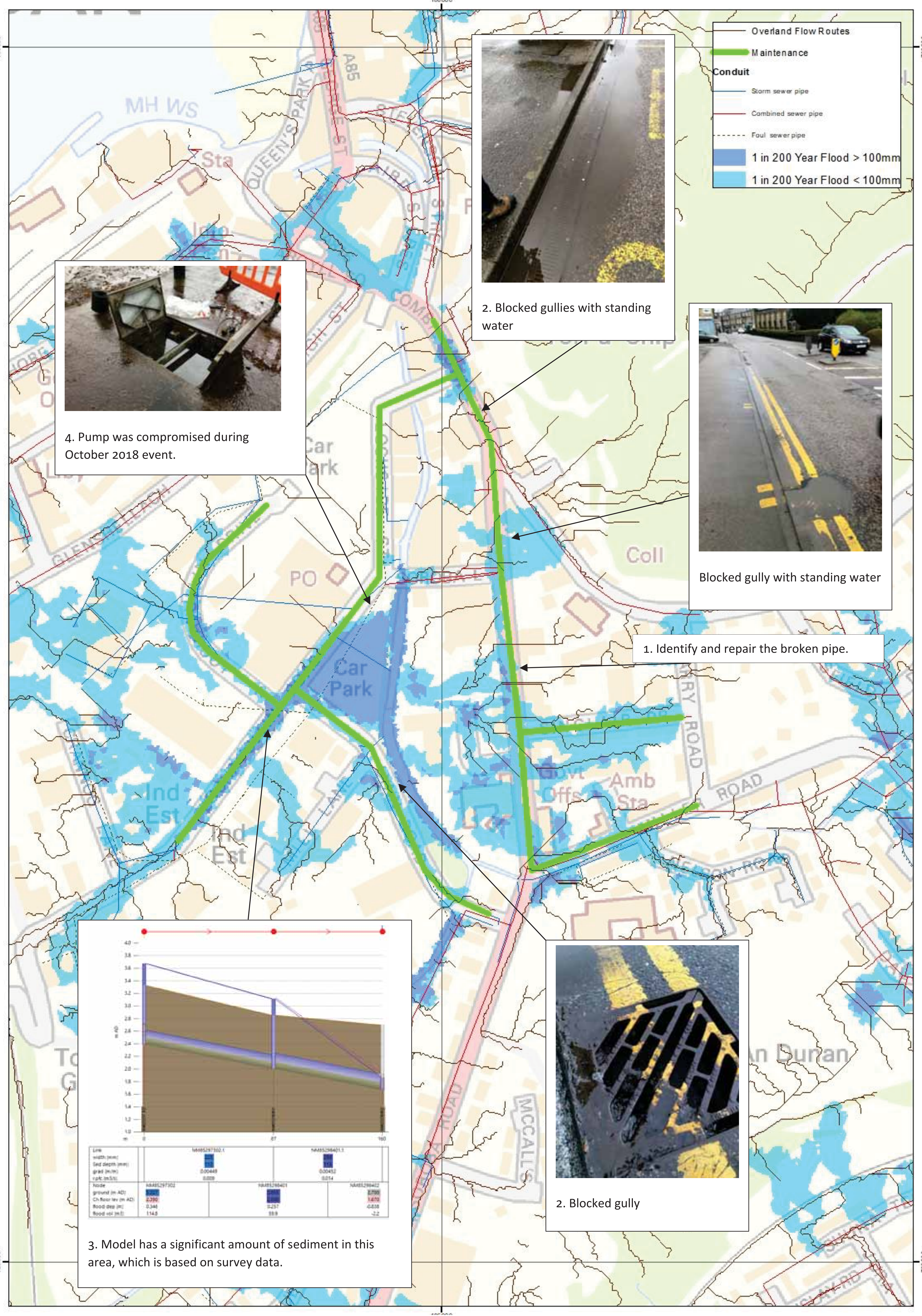
The sediment included in the model is based on survey data, areas that have not been surveyed cannot be assumed to have sediment, therefore there could be more pipes with sediment in the catchment. Also, sediment can be transitory, so it may longer be where it was surveyed.

There is a risk that improving the drainage by clearing the gullies will increase the flow in the network and potentially increase the pressures elsewhere in the network. This should be managed by formal solutions.

Further Investigation and Next Steps

A quality survey of the network is required to identify where there are existing issues and what is the current state of the network across the catchment. Once the extent of the required maintenance is understood a schedule can be developed in conjunction with Scottish Water to make sure the network is at its maximum efficiency.

INDICATIVE IMPACT (1 low - 5 high)	2	***INDICATIVE COST (1 low - 5 high)***	1
INDICATIVE RISK & UNCERTAINTY (1 low - 5 high)	1		


Overland Flow Routes
Maintenance
Conduit
Storm sewer pipe
Combined sewer pipe
Foul sewer pipe
1 in 200 Year Flood > 100mm
1 in 200 Year Flood < 100mm
2. Blocked gullies with standing water
4. Pump was compromised during October 2018 event.
Blocked gully with standing water
1. Identify and repair the broken pipe.
2. Blocked gully
3. Model has a significant amount of sediment in this area, which is based on survey data.
Car Park
PO
Coll
Ind Est
ROAD
A85
QUEEN'S PARK
186000
730000

Trunk Sewer Further Investigation

A large proportion of the surface water network drains to the Corran Pumping Station (PS), before being pumped to the Wastewater Treatment Works (WwTW). The model shows that the trunk sewer is surcharged and floods in the town centre along the A85. Upgrading the trunk sewer will improve the capacity of the network and reduce the surcharge in the network. Improving Corran PS or the WwTW could also be considered.

The model has multiple uncertainties so there may be multiple reasons for surcharge in the trunk sewer and further investigation is required before developing these solutions. Any work in this area could be extremely disruptive and expensive further investigation and developing the hydraulic model will reduce the

The trunk sewer also impacts other areas of the catchment. Much of the network drains to the WwTW via the trunk sewer. Reducing surcharge in the trunk sewer will reduce flooding and surcharge elsewhere in the network.

The Corran PS has a pump which discharges flow at the WwTW with a maximum flow of 160l/s, and two emergency pumps which discharge to the flow with a combined discharge of 160l/s. There is a storage tank of with an area of 440m^2, an invert level of -5.077 and a soffit of 4.084 and a total volume of 4 030m^3.

Solution Description

At this stage it is recommended to focus on resolving the uncertainties in the model and to invest in upgrading the model of the pumping station trunk sewer. This will increase confidence in the model at the trunk sewer and elsewhere in the network.

The trunk sewer draining the network is surcharged by depth during a 1in5yr event. Multiple options could be considered at a later stage:

Option	Description	Impact
Upsize the Trunk Sewer.	Increasing the size of the trunk sewer will allow more flow to pass through it during. The network is surcharged by depth	The trunk sewer is surcharged by depth only in the 1 in 5yr event. Upsizing the trunk sewer may not change the depth in the trunk sewer. Significant upsizing could provide additional. Upsizing the trunk sewer would have a significant disruptive impact to the town. This would also be one of the most expensive option.
Increase the pumping forward	Increasing the downstream pass forward flow at Corran PS to the WwTW. Increasing the flow will allow the This option could also include an additional storage tank at the treatment works.	This solution would have a major impact on the WwTW. There is a maximum the WwTW can receive, therefore increasing the pumping rate would require additional storage at the WwTW. It may also require upgrade to the rising main.
Removing the Pumping station orifice.	Flow is retained in the trunk sewer by an orifice. The model indicates that the storage tank located at Corran PS is not being fully utilised even though there is upstream flooding.	Removing the orifice will reduce the upstream depth and will fully utilise the storage tank. This may increase the volume of flow going into the storage tank at low return period events meaning more combined flows discharging into the sea.
Emergency Outfall	There is a pumped emergency outfall which discharges to the sea, this is limited to 160l/s. The contributing network has an approximate maximum flow of 1m^3/s therefore there is a risk that the storage tank could be full after 1.5hours, therefore the capacity of the emergency outfall could be reviewed to ensure the risk of the storage tank being full is minimised..	Increasing the emergency outfall discharge will mean more combined flows discharge to the sea.
Increase the number of outfalls	There is, potentially, a surface water sewer from the distillery which crosses the trunk sewer. The trunk sewer could discharge to this during an emergency to reduce the risk of flooding.	Increase the number outfalls will mean more combined flows discharge to the sea. The coastal levels will need to be considered for this option. If the tide levels drown the outfalls during a major event it will not reduce the surcharge in the network.

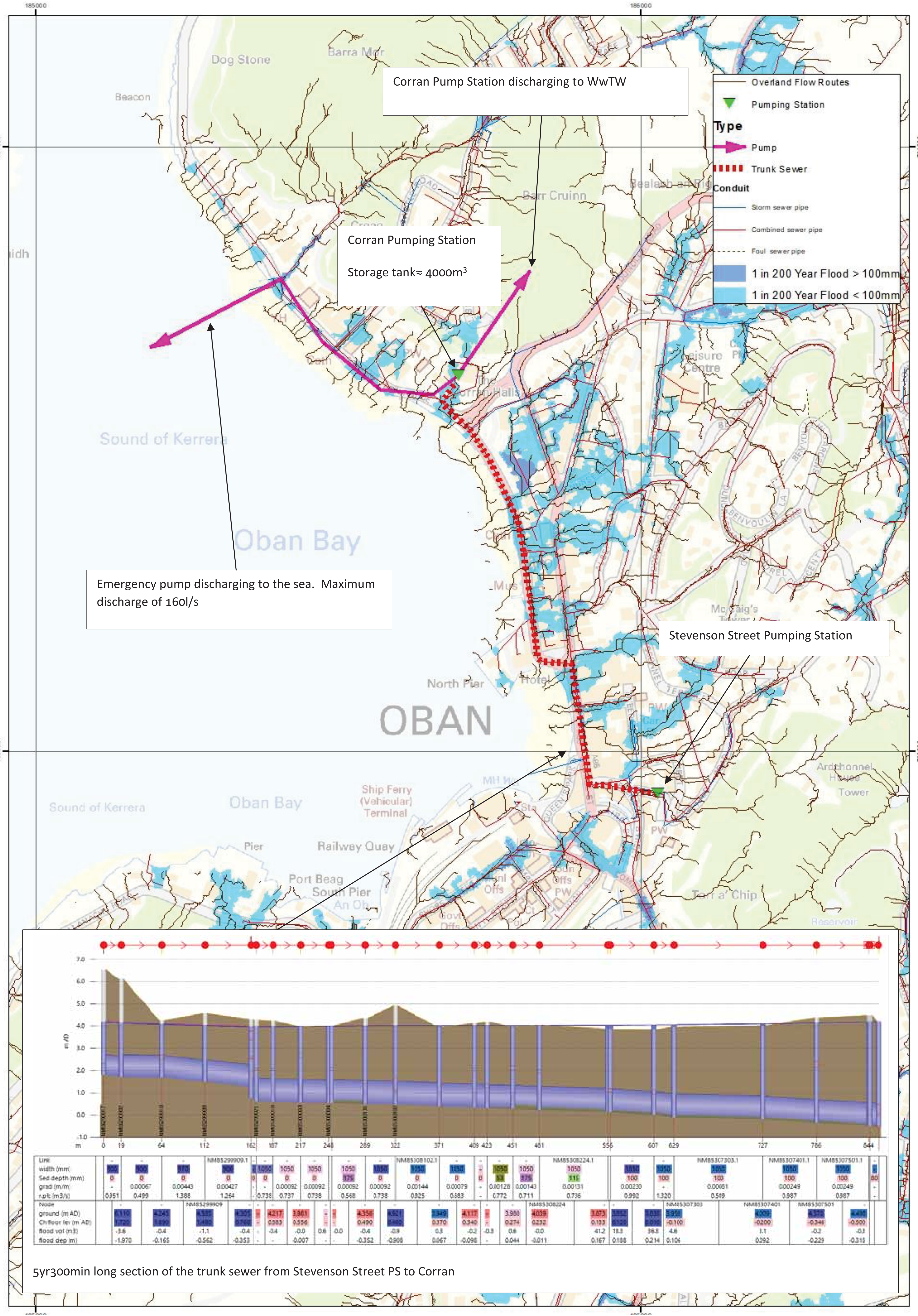
Risk and Uncertainty

Uncertainty	Description
Emergency outfall	The model has a pump which pumps flow to the sea during an extreme event. There is some uncertainty about how this is operating in the model. Th
CSO at the George Hotel.	The model does not include a CSO at the George Hotel. Scottish Water reported that there should be an outfall here which is not modelled.
Distillery Surface Water	there is potentially a Surface Water Line from the distillery with a diameter of 1050mm. It is not clear if this is a private or a SW asset. This is not currently modelled, and could potentially be conveying some of the surface water that is flowing to the Corran PS.
Pumping Station Orifice	There is a modelled orifice which retains the flow in the trunk sewer. The model shows flooding from the trunk sewer when there is still approximately 2000m^3 available in the storage tank. This is not operating correctly and therefore need to be fully reviewed.

Further investigation

The uncertainties described above require significant investigation before investing in the options suggested above. Improving the model may remove modelled flooding in this area altogether, and reduce flooding in other areas, this will focus investment on where it is really required and can provide the most benefits.

INDICATIVE IMPACT (1 low - 5 high)	*1*	***INDICATIVE COST (1 low - 5 high)***	*2*
INDICATIVE RISK & UNCERTAINTY (1 low - 5 high)	*1*		



5yr300min long section of the trunk sewer from Stevenson Street PS to Corran

Soroba

Soroba has two locations where there is potentially surcharge and flooding. The hydraulic model indicates that the school, a highly vulnerable user, is at risk of overland flooding.
The network in this area is mostly separate but there are multiple connections between the surface water and foul networks. The surface water does discharge into the foul and there may be foul flooding due to surface water in the foul network.

Description

The solution proposal focuses on two areas in Soroba. Millpark Road has multiple properties at risk of pluvial flooding. The hydraulic model is surcharged during a 1in5yr event. The solution in this area improves overland conveyance to discharge into the Soroba Burn, which will reduce the pressure on the network.
Rockfield Primary School is a highly vulnerable user and is at risk of pluvial flooding. The hydraulic model is surcharged near the school and there are multiple flooded nodes. The solution focuses on improving overland flow and storing the pluvial flow in an existing depression before discharging into the Soroba Burn.

Solution	Location	Description	Benefit	Dimensions
1. Overland Conveyance	Millpark Road and Millpark Avenue	The overland conveyance intercepts overland flow from properties and road. It carries flow along the edge of the Millpark Road and Millpark Avenue. There is green space along the edge of the roads which could be utilised without conflicting with the community.	Intercepts runoff from the road and properties. Conveys flow into the Watercourse	Length = 300m (this is the sum of multiple lengths of swale)
2. Flow Routing	Rockfield Primary School	The model indicates that there is surcharge and overland flow in the school grounds. This is likely to be routed overland through the grounds into the road. By routing flow overland, and not into the network the pressure on the network will be reduced. There are many options for flow routing at the school: • Rainwater harvesting. • Infiltration through school gardens • Formal overland flow paths • Swale It is recommended that precise options for the school are produced in consultation to maximise benefits. Any excess overland flow can drain overland into a swale which drains to the downstream attenuation pond.	Drains overland flow away from the school. Reduces the flow into the surface water network. Excellent opportunity to provide multiple benefits and to engage with the community.	Unknown
3. Overland Conveyance	From Rockfield Primary School to A816 Swale	The overland conveyance collects flow from the school and conveys the flow to the A816 overland conveyance.	Drains overland flow away from the school. Reduces the flow into the surface water network.	Upstream level= 38.2mAOD Downstream level= 34.7mAOD Length = 100m
4. Overland Conveyance	Adjacent to A816	The overland conveyance intercepts excess flow from the school. It carries flow along the edge of the A816 and drains to the attenuation basin.	Drains overland flow away from the school. Reduces the flow into the surface water network.	Upstream level= 36.6mAOD Downstream level= 19.0mAOD Length = 175m
5. Attenuation Basin	Corner of A816 and Fire Station	There is an existing basin at this site. This was likely created due to the construction of the A816. There is already pluvial flow that naturally collects at this location.	There is an existing basin which reduces the work required for this solution. The basin has a very large potential volume (this needs to be confirmed by survey).	Area= 1400m^2 Volume= 3750m^3
6. Drainage Pipe	Crossing the A816	A small buried pipe conveys flow from the attenuation tank, across the A816 and into the Soroba Burn. There is likely to be an interaction with the Soroba Burn.	This is a short length of pipe to drain the basin.	Upstream level= 14mAOD Downstream level= 11mAOD Length under the road = 25m Length from road to Soroba Burn = 35m

Impact

The proposed solution will have positive impacts on the properties around Millpark Road and at the school. There is an opportunity to reduce the surcharge levels in the network by utilising overland flow route, this may also reduce the level in the foul and combined system downstream, as the model indicates that the surface water discharges into the foul network as well as the watercourse. The solutions at the school provide an opportunity to engage with the community and provide additional benefits to the school, for example rain water harvesting could support a school garden. This will require coordination with the school.
In addition to reducing pluvial flood risk the solution may also have a positive impact on reducing the level in the watercourse. The attenuation basin is estimated to retain 3750m^3, and therefore reduce downstream fluvial levels.

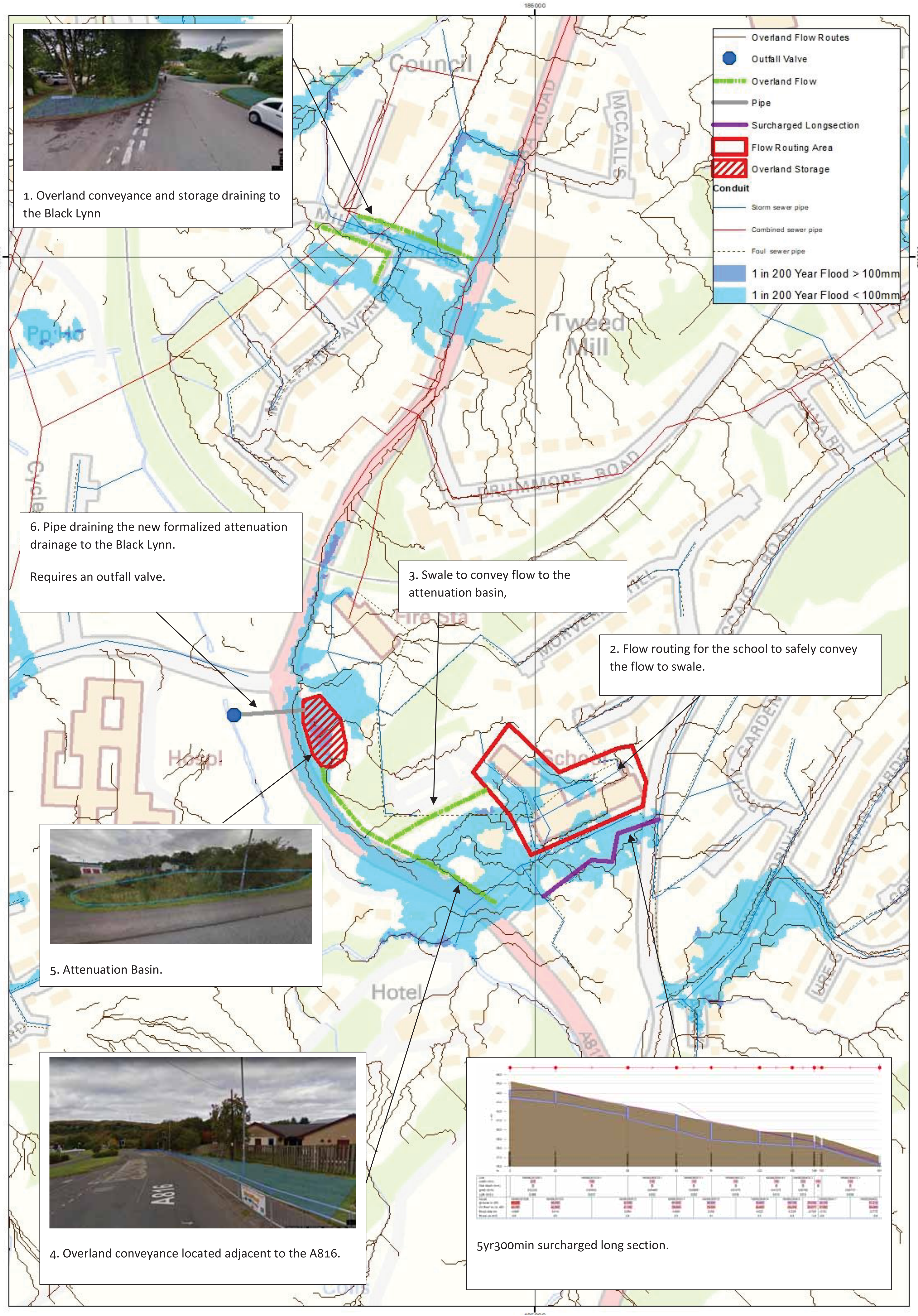
Risk and Uncertainty

The solutions ultimately discharge into the Soroba Burn, the levels in the watercourse need to be confirmed by a fluvial model before confirming their viability.
The model has an outfall which discharges in front of the fire station. This needs to be confirmed. If that is correct, this could also be connected to the attenuation basin.

Further Investigation and Next Steps

The fluvial flood levels will influence the viability of these solutions and the design will need to consider predicted fluvial level.

INDICATIVE IMPACT (1 low - 5 high)	*3*	***INDICATIVE COST (1 low - 5 high)***	*2*
INDICATIVE RISK & UNCERTAINTY (1 low - 5 high)	*3*		


186000
729000
Overland Flow Routes
Outfall Valve
Overland Flow
Pipe
Surcharged Longsection
Flow Routing Area
Overland Storage
Conduit
Storm sewer pipe
Combined sewer pipe
Foul sewer pipe
1 in 200 Year Flood > 100mm
1 in 200 Year Flood < 100mm
1. Overland conveyance and storage draining to the Black Lynn
6. Pipe draining the new formalized attenuation drainage to the Black Lynn.
Requires an outfall valve.
3. Swale to convey flow to the attenuation basin,
2. Flow routing for the school to safely convey the flow to swale.
5. Attenuation Basin.
4. Overland conveyance located adjacent to the A816.
5yr300min surcharged long section.
Council
Tweed Mill
DRUMMORE ROAD
Fire Sta
Hospl
Hotel
A816

Glenshellach

There are multiple areas in Glenshellach that have surcharged pipes or overland flooding. The west end of Glengallan Road has some businesses at risk of flooding. Around Glengallen Drive and McKelvie Road the network is surcharged, and the solution proposes routing flow into the burn and utilising two potential overland storage sites. The network in the area is separate so discharging the existing network to burns and overland storage is a possible solution. The zone also has steep sides which creates overland flow. This is the likely cause of flooding in Glenshellach Road and the properties in Balvicar Road & Fladdia Road.

Description

The solution proposal focuses on two areas in Glenshellach.

Solution	Location	Description	Benefit	Dimensions
1. Overland Conveyance	Glengallen Road	There is a space on the edge of the road. the overland conveyance discharges into the watercourse. The model shows there is overland flow in this area.	This is considered a low priority. It will reduce the risk of overland flow impacting local businesses.	Length= 50m Upstream Level= 22.9mAOD Downstream Level= 19.0mAOD
2. Pipe discharging to Burn	Glengallen Road	The network running parallel to the burn in this area is surcharged as shown in the plan. A small pipe discharging the excess flow into the burn to reduce surcharge in the upstream network.	It will reduce the surcharge in the network	Length= 16m
3. Attenuation Basin	Recreation field Glengallen Drive	There is an existing recreation field currently used as a football field. The level of the basin is currently approximately 9.2mAOD but this level could be reduced to increase storage at this site. The network would discharge to the field and return to the network through the same pipe.	The basin already partially exists but is not directly connected to the network. The basin can still be used as a football recreation field or can be developed for other compatible uses such as a playground.	Area= 1000m² Approximate volume = 500m³
4. Pipe	Glengallen Drive or Craighouse Ave	There are two options for discharging flow into the attenuation basin shown on the plan. Modelling is required to confirm which solution is appropriate and removes pluvial flooding in the area.	By discharging the network directly into the attenuation basin, the level in the network can be significantly reduced and controlled during the peak of a storm event.	Length= 42m
5. Pipe discharging to the culvert	Stacair Crescent	The surface water pipe in Stacair Crescent runs parallel to the Glenshellach Burn culvert. The surface water network is surcharged potentially causing a flood risk to the properties.	By discharging the surface water network into the culvert at this point reduces surcharge downstream, in turn reducing the risk of flooding.	Length= 7m
6. Pipe discharging to flood plain	McKelvie Road	The upstream network has a diameter of 225mm. A new pipe could directly discharge the flow into the flood plain. This will reduce surcharge in the downstream catchment and reduce fluvial flood. The flow from this network already discharges into the floodplain. By creating the shortcut to the floodplain the surcharge in the network will be reduced. There is a SuDS pond which has not been vested by Scottish Water nearby.	It will reduce the surcharge in the network by discharging to the floodplain further upstream the network.	Diameter= 150mm Length= 45m
7. Overland Storage	Watercourse Flood Plain	The burn flows through a wide floodplain. The flood plain provided a large potential storage if it could be properly formalised and managed.	Low benefit to pluvial flooding. This will provide a benefit to fluvial flooding.	Area= 74 000m²
8. Overland Interception and Swale	Glenshellach Road	This zone is located in a valley. Flows travel overland down the steep slopes and into Glenshellach Road. This is causing flooding in the road. A swale located beside the road can intercept flows, attenuate them, and convey them safely to Lon Mor.	This solution will reduce flooding in Glenshellach Road.	Length= 500m
9. Overland Interception	Balvicar Road & Fladdia Road	Overland flow is discharging down the steep slopes and flooding the gardens of properties. Interception of this flow and conveying it either to the watercourse or the drainage network is required. There may be challenges with where to construct a solution as the land is privately owned. It is therefore proposed as a longer-term solution.	By intercepting flow it will reduce flooding in to the properties.	Length= 350m

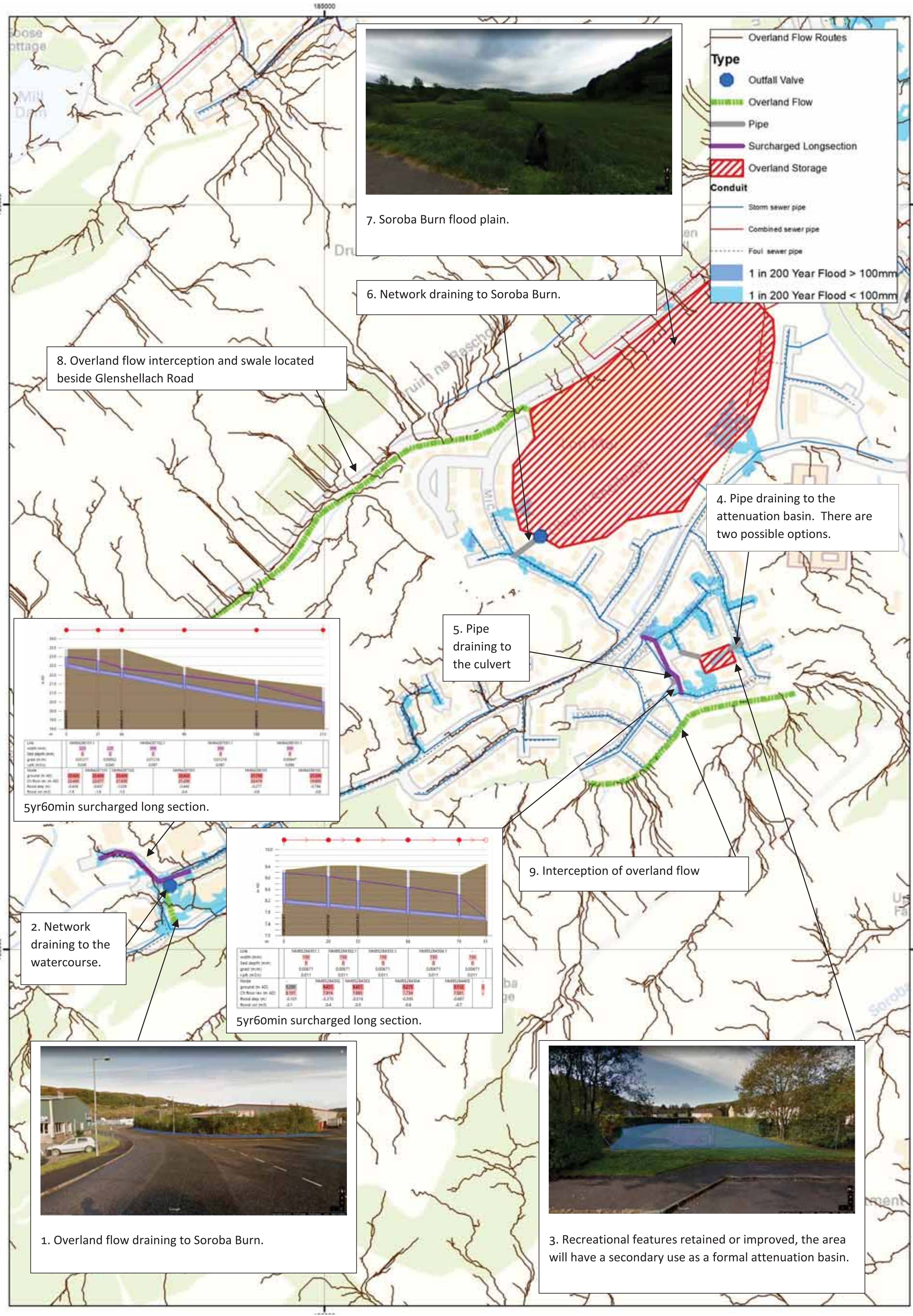
Risk and Uncertainty

- The solutions ultimately discharge into the Black Lynn, the levels in the watercourse need to be confirmed by a fluvial model before confirming their viability.
- The culvert located under Fladda Road has some uncertainty about how it is modelled. It currently discharges on the upstream side of Glengallen but is more likely to discharge into the burn downstream of Glengallan Road. Also, there is a surface water network pipe that discharges into the road, but this should be linked into the culvert.

Further Investigation and Next Steps

The fluvial flood levels will influence the viability of these solutions and the design will need to consider predicted fluvial level.

INDICATIVE IMPACT (1 low - 5 high)	*3*	***INDICATIVE COST (1 low - 5 high)***	*2*
INDICATIVE RISK & UNCERTAINTY (1 low - 5 high)	*2*		


185000
Overland Flow Routes
Type
Outfall Valve
Overland Flow
Pipe
Surcharged Longsection
Overland Storage
Conduit
Storm sewer pipe
Combined sewer pipe
Foul sewer pipe
1 in 200 Year Flood > 100mm
1 in 200 Year Flood < 100mm
7. Soroba Burn flood plain.
6. Network draining to Soroba Burn.
8. Overland flow interception and swale located beside Glenshellach Road
4. Pipe draining to the attenuation basin. There are two possible options.
5. Pipe draining to the culvert
5yr60min surcharged long section.
9. Interception of overland flow
2. Network draining to the watercourse.
5yr60min surcharged long section.
1. Overland flow draining to Soroba Burn.
3. Recreational features retained or improved, the area will have a secondary use as a formal attenuation basin.

Lochavullin

Lochavullin has been flooded multiple times in recent history. Lochavullin is a low point in the catchment and is located on the bank of the Black Lynn. During major events there can be extensive fluvial and pluvial flooding, due to this interaction it is difficult to confirm the extent of the pluvial flooding.

The surface water network in the model has a free discharge into the Black Lynn but, during high water levels it is likely that the downstream end of the network would be drowned, and pluvial flooding would be unable to discharge. This would mean that the network will "store" flow. During extreme events the network would not have enough capacity, and there would be surface water flooding.

The network in this area is mostly separate, although there is a pipe connecting the surface water network and the foul network which discharges approximately 360m^3 of surface water flow into the downstream combined sewer during a 1 in 5yr 600min event. The surface water network is also entirely within the zone, so there are no upstream areas which could retain surface water further up the catchment.

Description

First Stage

The priority is to improve the efficiency of the existing infrastructure. This will include improving the existing pump station, improving the discharge to the watercourse, and improving retention upstream in the catchment.

Solution	Location	Description	Benefit
Pump Resilience	Lochavullin PS	The pump station has had some maintenance issues. Improving the maintenance schedule, upgrading the pump and protection of the control panel if required, and improving the pump alert/activation system, will improve the functionality of the pump station in alleviating flood risk.	Improving the existing asset is a low cost solution to reduce the risk of pluvial flow in Lochavullin.
Non-return valves to the Black Lynn	Outfalls to the Black Lynn	Improved non-return valves will make sure there is no back flow from the water course into the surface water network.	The provision of existing non-return valves is not consistent and one of the main cast iron flap valves may not be working as intended due to corrosion.
SuDS storage	Lochavullin PS	Retrofitting overland/underground storage to retain more flow upstream in the zone will reduce runoff volume entering the drainage network. The suggested locations are open areas, which can be easily retrofitted with over/under ground storage.	Reduces the volume of flow in the network by storing over ground. This will reduce surcharge in the network and reduce the risk of pluvial flooding.

Second Stage

The Hydraulic model does not include the existing Lochavullin PS. This means that surcharge and flooding in the area may be overpredicted. Scottish Water have committed to upgrading the model to include the Lochavullin PS. This would assist in sizing the future retro-fitting of SuDS measures if required in support of the pumping arrangement.

Due to the low level of this zone and the challenge of discharging to the Black Lynn when the river is in flood, provision of additional surface water storage will provide additional resilience to flood risk within this area. Runoff from buildings, car parks or within the surface water network and could be routed and stored in underground storage. There are three extensive car parking areas which provide a combined utilised area of approximately 18,000m^2. This space is currently used for the shops and businesses in the area. It is unlikely that this space could be sacrificed for above ground water storage, so underground storage should be considered. Underground storage does not provide additional amenity value to the community, however other solutions were considered but there is not enough space, or their effect would be low due to them being hydraulically isolated from the pluvial issues they have not been considered.

Three underground storage methods have been considered:

Solution	Description	Benefit	Risk
Cellular Storage	There is a wide area available for a large volume of cellular storage.	Does not require deep excavations.	Requires a large area. May require a pump to discharge the flow to the Black Lynn.
Online attenuation	Online attenuation requires an upsize of the existing network. This is unlikely to be a viable solution due to the low	Will drain under and gravity and won't require a pump.	Some parts of the network only have ground cover of 0.9m, a significant upsize won't be possible in this area.
Offline Attenuation	Requires a small area This solution would require a pump to return the flow to the network	Easy to drain the network from a problem area away to a tank, potentially located some distance away. One tank could drain flow from both longsections in the network.	Will require a deep excavation. Will require a pump to return flow to the Black Lynn

In addition to the storage tanks other features may be required:

Solution	Location	Description	Benefit	Dimensions
Pipe	See Plan	Pipe can be located to drain the network at pinch points. These lengths may be quite long to route the flow from the pinch point to the car park which has been agreed for storage.	Hydraulically the best solution drains the flow at the pinch point.	Approximate Length= 200m – 400m
Remove Pipe	Crannog Lane	Installing the storage may be a good opportunity to take account for the surface water flow discharging to the foul network. This will reduce pressure on the downstream combined network. This may require additional storage to deal with the increased flow in the surface water network.	Potentially an easy additional win as part of a wider solution.	

Risk and Uncertainty

- There are uncertainties in the accuracy of the hydraulic model of the surface water drainage network of the area. The two main areas of uncertainty are the absence of the Council pumping station and assumption of a free draining discharge. These will be addressed in the model update provided by Scottish Water.
- There is interaction between pluvial and fluvial flooding in this area and the proposed measures aim to remove this by dealing with the know areas of connection. The presence of any older connections not identified may require to be addressed should they be detected at a later date.
- The proposed fluvial flood risk management measures in this area detailed in the main Oban Flood Study report include measures to reduce the frequency of fluvial overtopping into this zone, and provision of non-return valves to prevent reverse flows into this zone.
- The effective operation of the existing pump station with resilience measures in place, should also consider the effects of temporary reductions in pump capacity or downtime on projected flood extents.

Further Investigation and Next Steps

It is recommended that the updated hydraulic model is used to investigate the above options and identify the most effective solution or combination of solutions. Hydraulically there are multiple variables, so the final option may require multiple additional features to optimise its effectiveness.

This work will be potentially expensive and disruptive to the businesses but will provide flood relief so there should be community and business support. It can be progressed with a progressive and retro-fitting approach as an integral component of re-developments within this zone.

INDICATIVE IMPACT (1 low - 5 high)	*4*	*INDICATIVE COST (1 low - 5 high)*	*4*
INDICATIVE RISK & UNCERTAINTY (1 low - 5 high)	*2*