APPENDIX A

Historic Flood Photos

1977 Flood Photos

The following photos, taken during the flood event of 31 October 1977, were provided by Mr. R. Harling, resident of 10 George Street, Langholm. Note that the photos are believed to have been taken some time after peak river levels had been reached.

A: Looking upstream from Telford Road bridge

B: Looking upstream from George street

C: Looking downstream from Telford Road bridge

D: Looking downstream from George Street

E: Looking downstream from George Street

F: Looking downstream from George Street

G: Looking upstream from steps near 10 George Street

H: Looking west from steps near 10 George Street

2015 Flood Photos

The following photos were taken during the flood event of 5 December 2015 and were provided by Dumfries and Galloway Council. The photos were taken throughout the day.

A – Looking upstream, confluence of River Esk and Ewes Water

B – River steps on George Street

C – River steps on George Street

D – Looking upstream on River Esk from George Street

E – Looking upstream on River Esk from Waterside

F – Looking downstream on River Esk from Waterside

G – Looking upstream on River Esk from George Street

H – Looking downstream on River Esk from George Street

I – Looking upstream on Wauchope Water from George Street

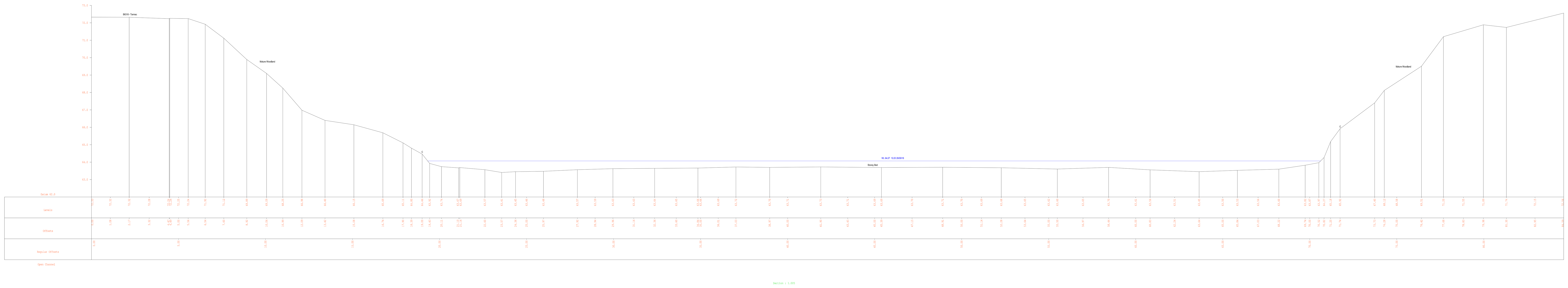
J – Flood gates installed on residential properties on George Street

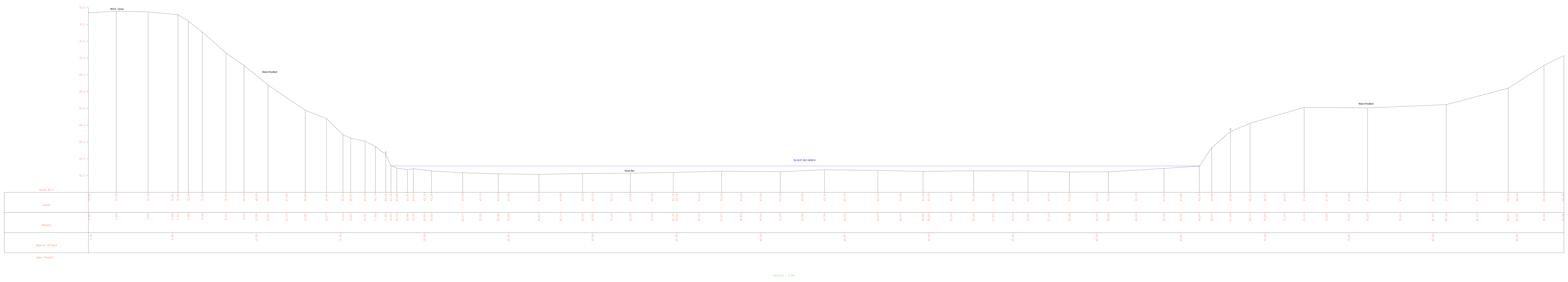
K – Looking downstream on Wauchope Water from Caroline Street

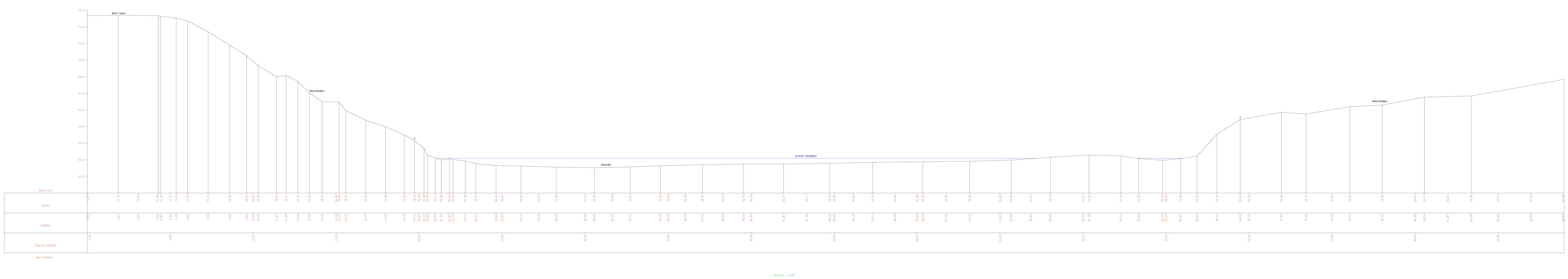
APPENDIX B

Survey Information

Six West Survey: Sept 18







Notes

Elevations in metres to Ordnance Datum (Newlyn)

No.	Revision	Drg by	Chk by

Drg by LW | Chk by PMcC | App by PMcC

Dumfries & Galloway Council

Langholm Flood Protection Scheme

Cross Sections - Sheet 2

SixWest

info@six-west.com www.six-west.com T 028 9073 1917

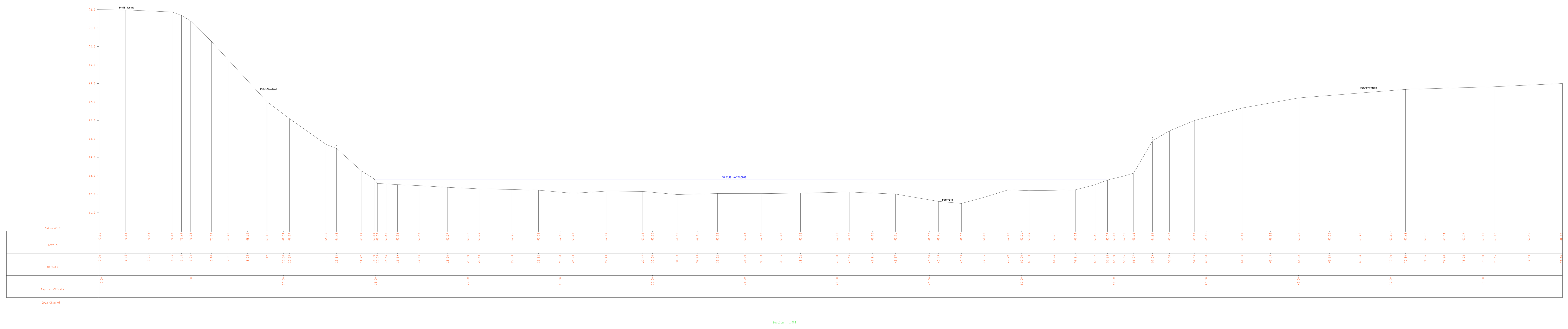
Scale 1:100 (A0) | Date September 25th, 2018

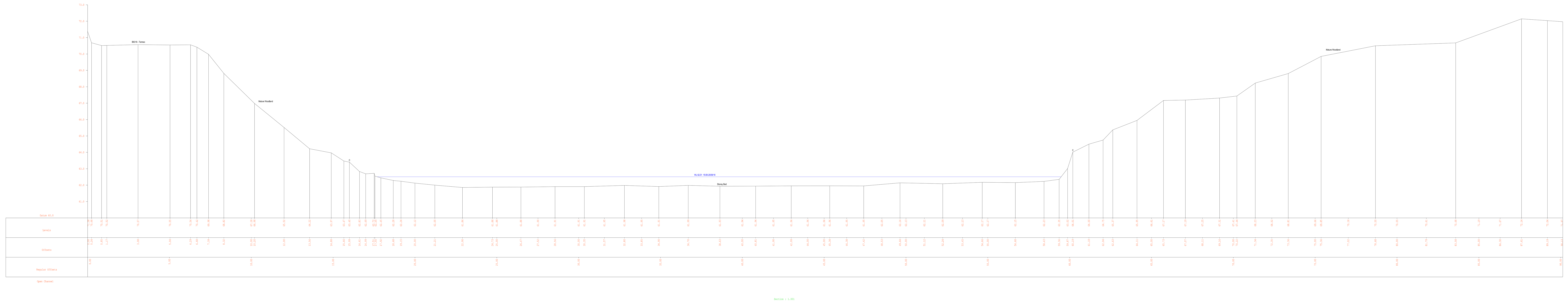
Drawing No. RL180925/Cross Sections - Sheet 2

Revision

Notes

Elevations in metres to Ordnance Datum (Newlyn)





No.	Revision	Drg by	Chk by

Drg by LW | Chk by PMcC | App by PMcC

Dumfries & Galloway Council

Langholm Flood Protection Scheme

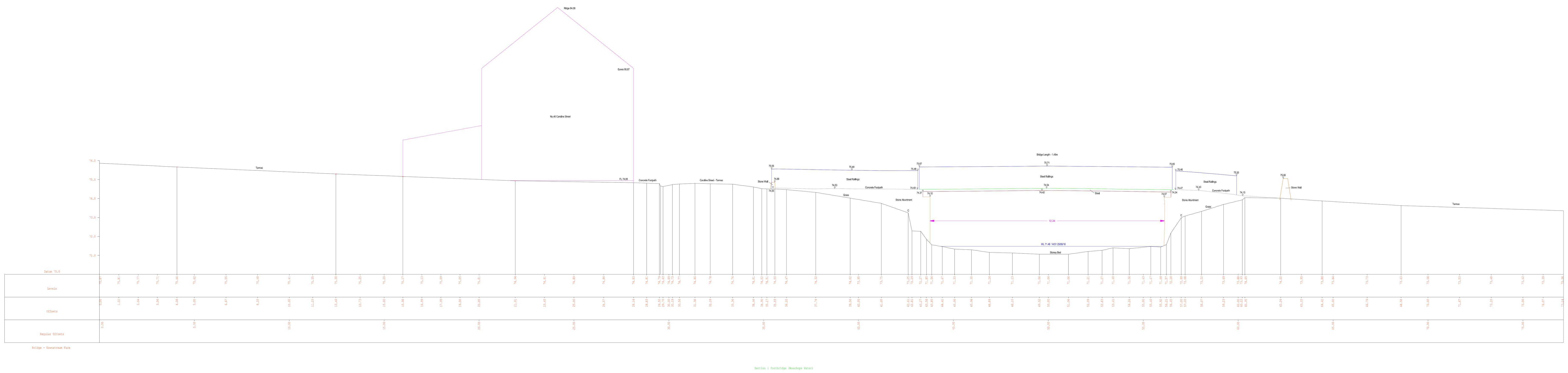
Cross Sections - Sheet 3

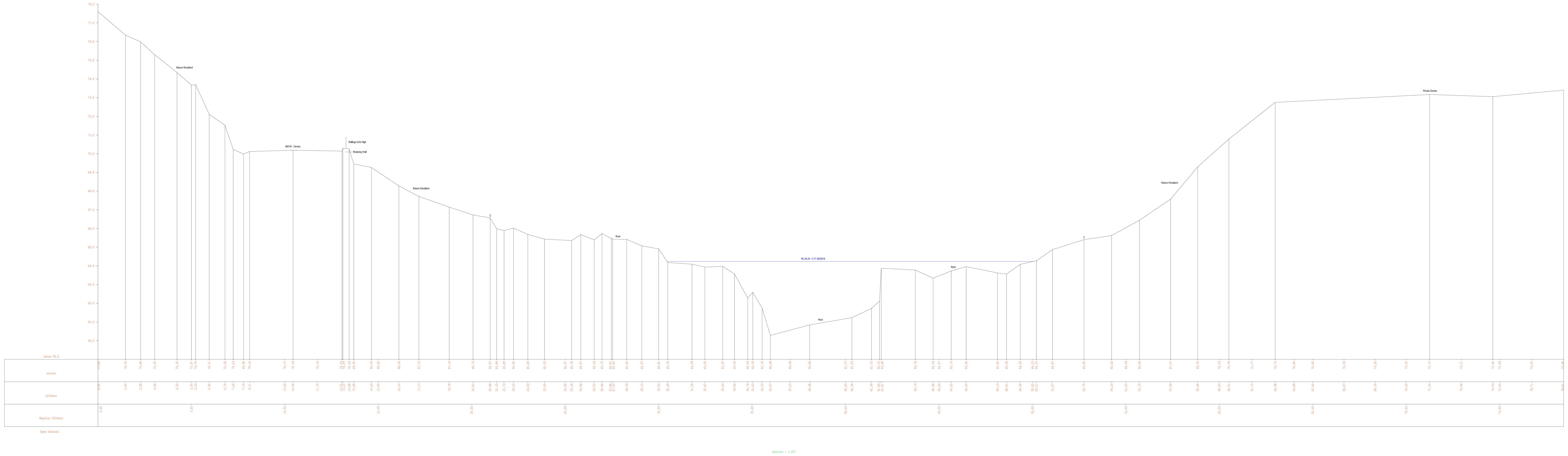
info@six-west.com www.six-west.com T 028 9073 1917

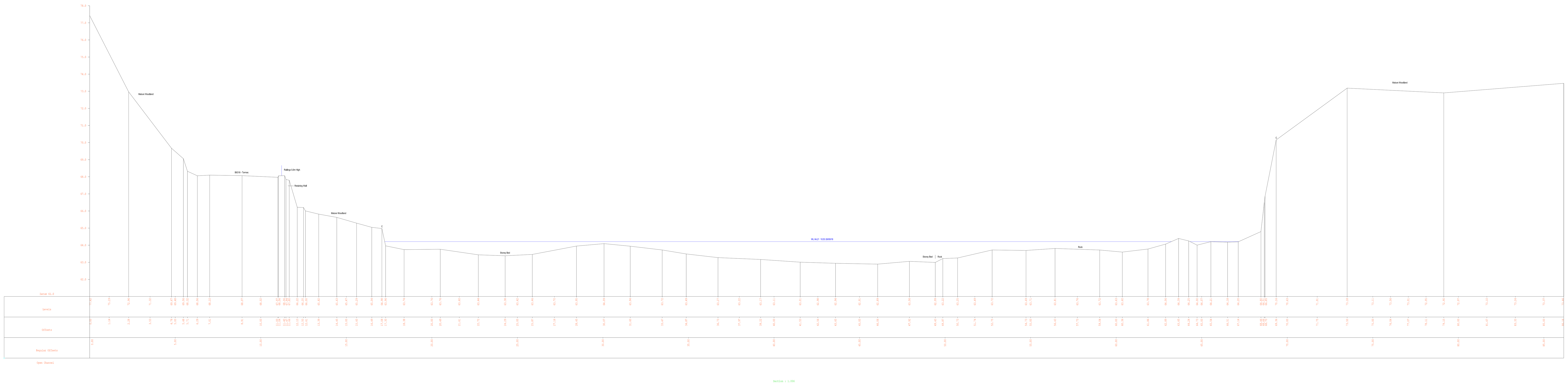
Scale 1:100 (A0) | Date September 25th, 2018

Drawing No. RL180925/Cross Sections - Sheet 3

Revision







Notes

Elevations in metres to Ordnance Datum (Newlyn)

No.	Revision	Drg by	Chk by

Drg by LW | Chk by PMcC | App by PMcC

Dumfries & Galloway Council

Langholm Flood Protection Scheme

Cross Sections - Sheet 1

SixWest

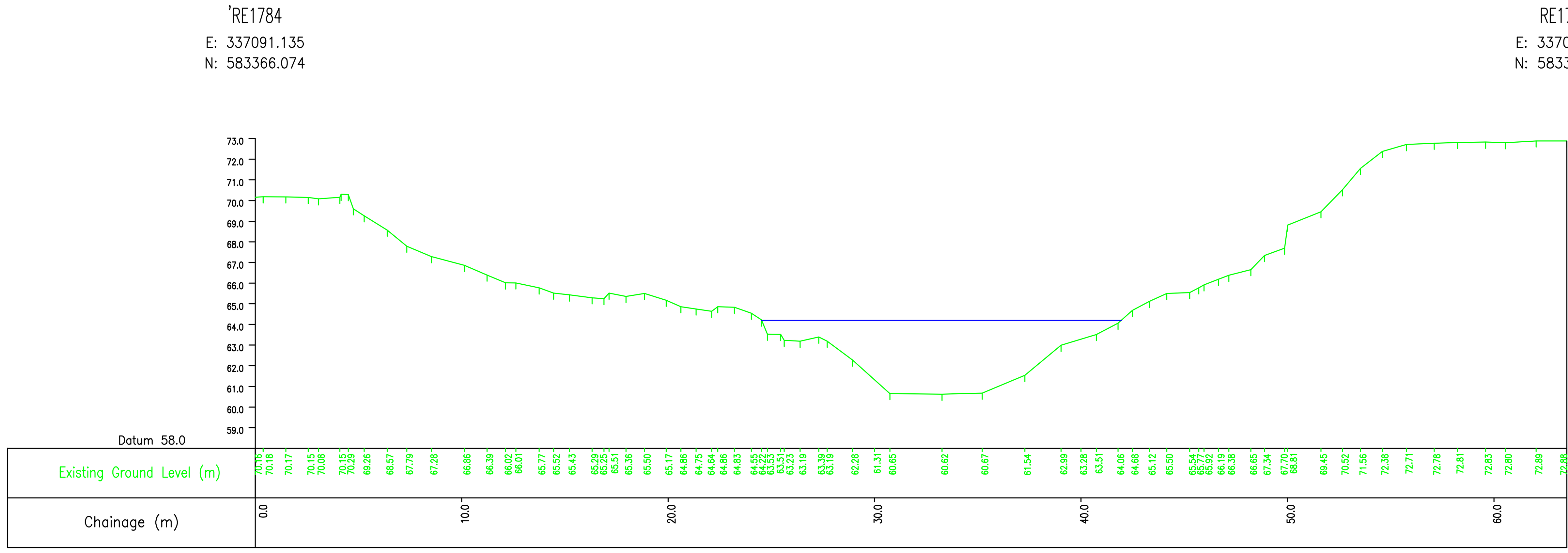
info@six-west.com www.six-west.com T 028 9073 1917

Scale 1:100 (A0) | Date September 25th, 2018

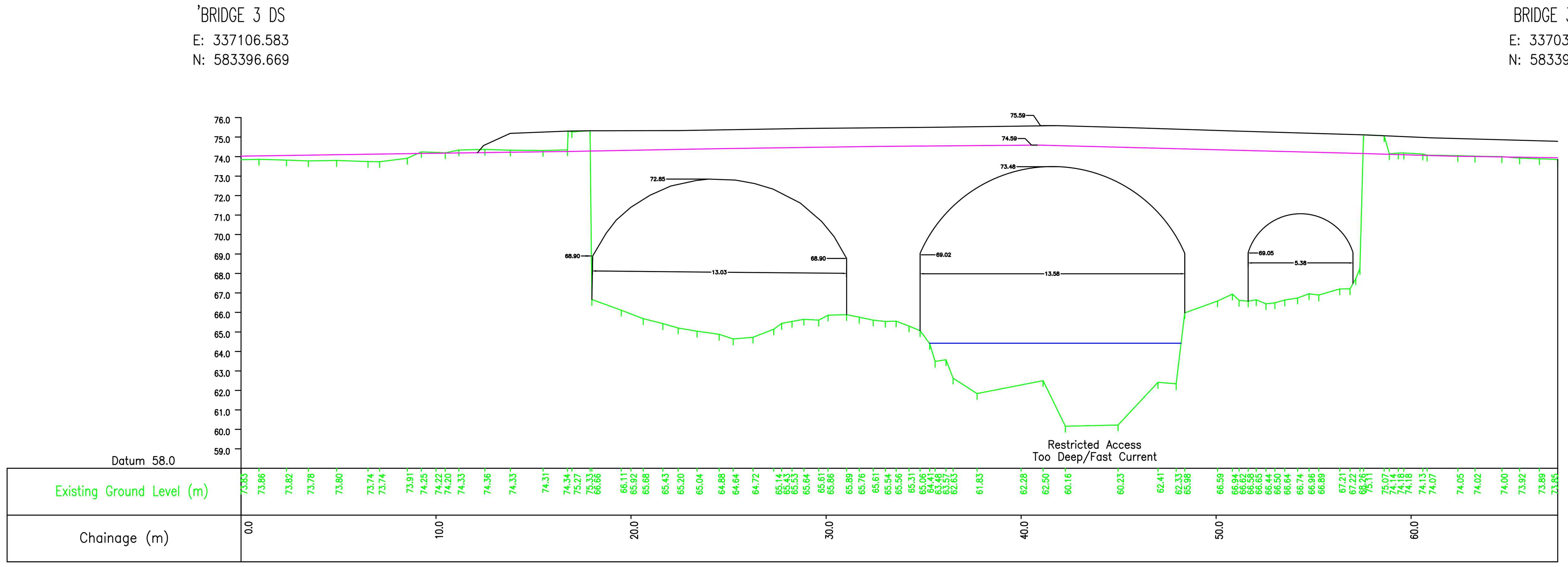
Drawing No. RL180925/Cross Sections - Sheet 1

Revision

Aspect Survey: Feb 19



Section RE1784
Horizontal Scale 1: 200
Vertical Scale 1: 200



Section BRIDGE 3 DS
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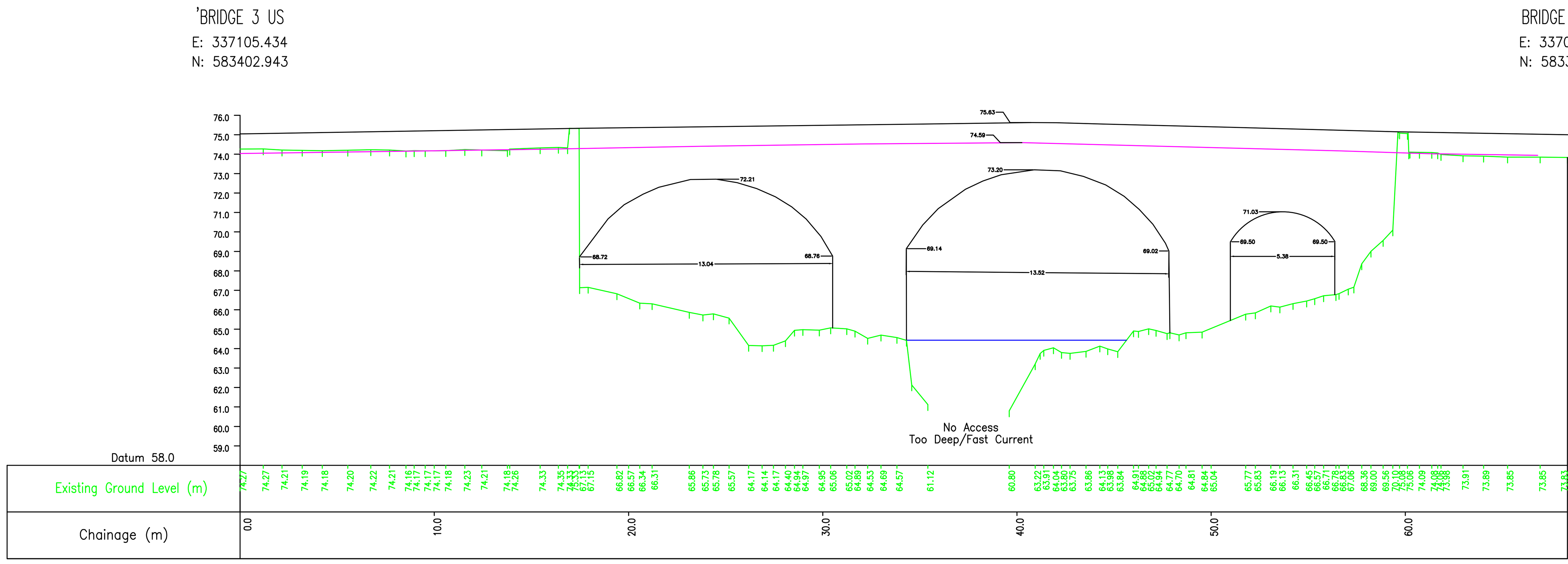
Vertical Scale 1: 200



Section BRIDGE 3 US
Horizontal Scale 1: 200
Vertical Scale 1: 200

Link Feature Legend

- Existing Ground Level
- Section Detail
- Water Level
- Wall
- Metal
- Wood
- Road
- Section Lines

Notes:

Horizontal Control points are relative to the NATIONAL GRID.

All levels are relative to ORDNANCE DATUM.

The survey was tied into the previous survey Ref No : A4914

CONTROL STATION COORDINATES

STN	EASTING	NORTHING	LEVEL

Aspect
Land + Hydrographic Surveys
CHARTERED SURVEYORS
Thornhouse Business Centre
Ballot Road
Irvine
KA12 OHW
Tel : 01294 313399
Fax : 01294 313389
E-mail: mail@aspectsurveys.com
Web: www.aspectsurveys.com

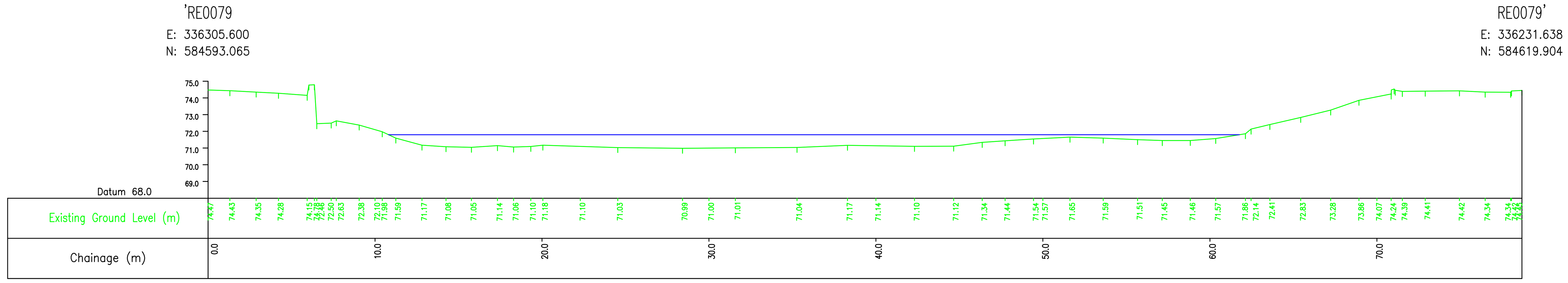
Client :

RPS
ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST
CO. ANTRIM
BT12 6RZ

Project Title :

CROSS SECTION SURVEY
RIVER ESK
LANGHOLM

Project No:	A6949	Scale :	1:500
Surveyed date :	22nd February 2019	Issued date :	27th February 2019
Surveyed by :	AS	Checked by :	RM
Sheet No. :	4 of 4	Plot Scale:	1:1 @ A1



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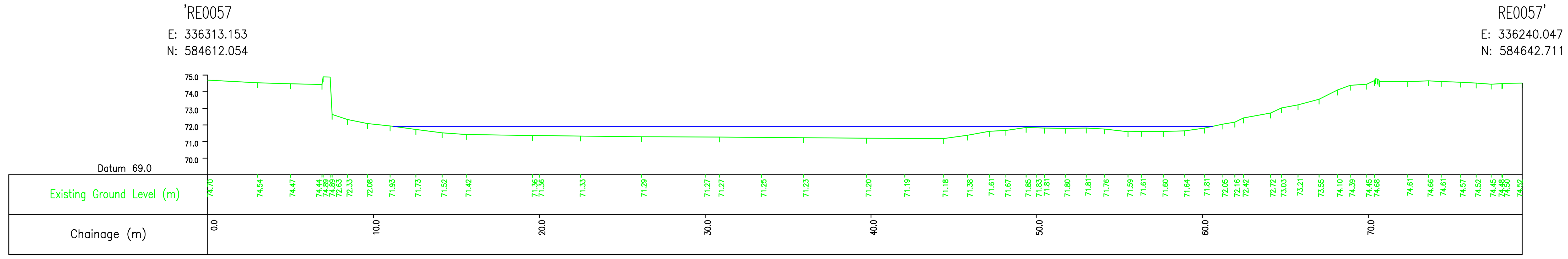
Vertical Scale 1: 200



Section RE0057
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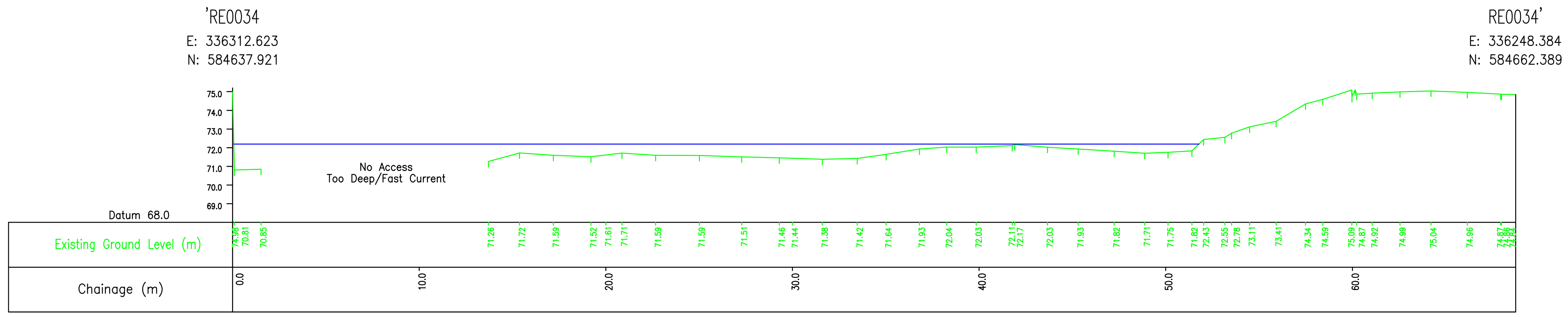

Section RE0034
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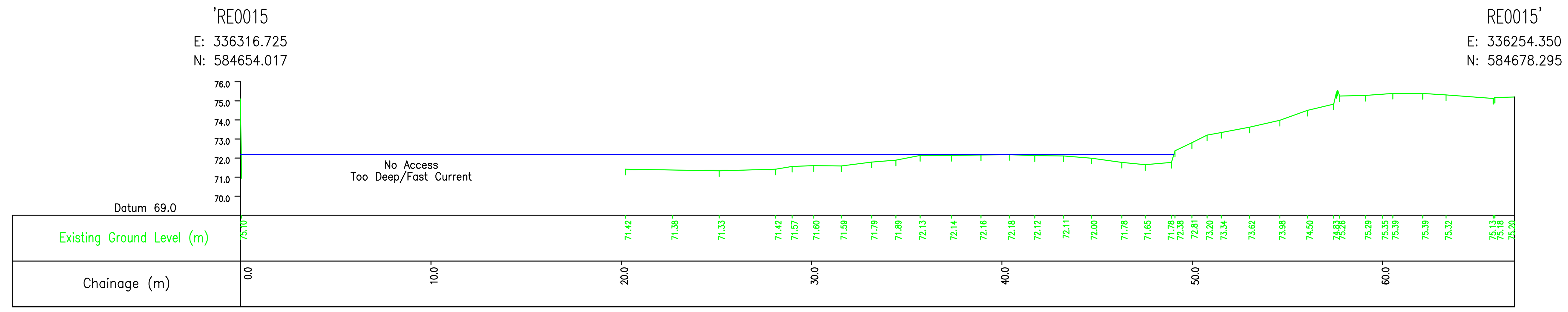
Vertical Scale 1: 200



Section RE0015
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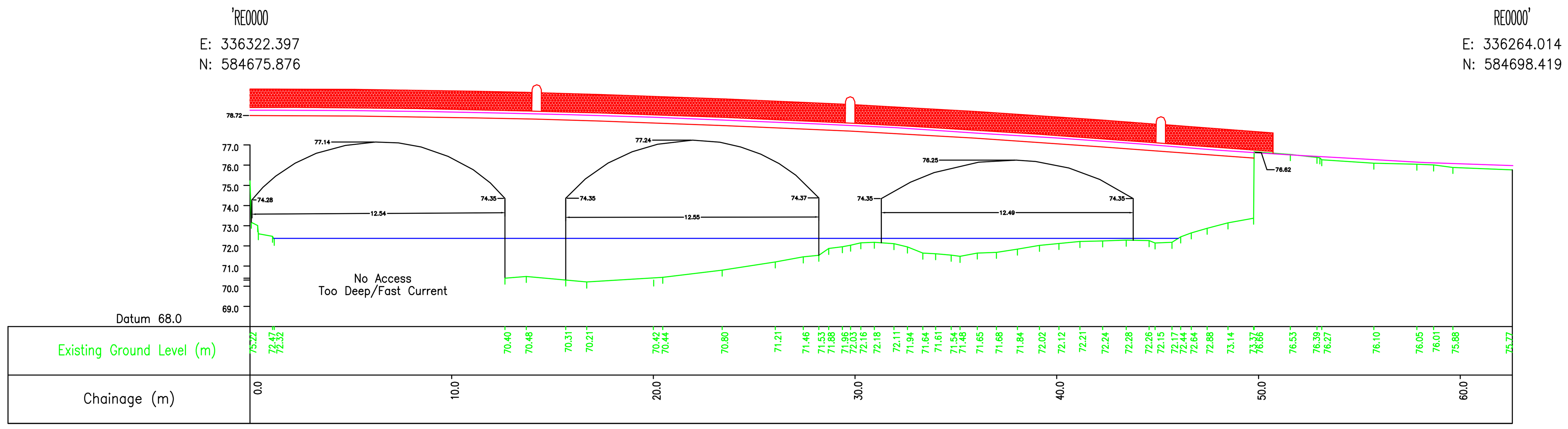
Vertical Scale 1: 200



Section RE000
Horizontal Scale 1: 200
Vertical Scale 1: 200

Link Feature Legend

- Existing Ground Level
- Section Detail
- Water Level
- Wall
- Metal
- Wood
- Road
- Section Lines

Notes:

Horizontal Control points are relative to the NATIONAL GRID.

All levels are relative to ORDNANCE DATUM.

The survey was tied into the previous survey Ref No : A4914.

CONTROL STATION COORDINATES			
STN	EASTING	NORTHING	LEVEL

Aspect
Land + Hydrographic Surveys
CHARTERED SURVEYORS
Thornhouse Business Centre
Ballot Road
Irvine
KA12 OHW
Tel : 01294 313399
Fax : 01294 313389
E-mail: mail@aspectsurveys.com
Web: www.aspectsurveys.com

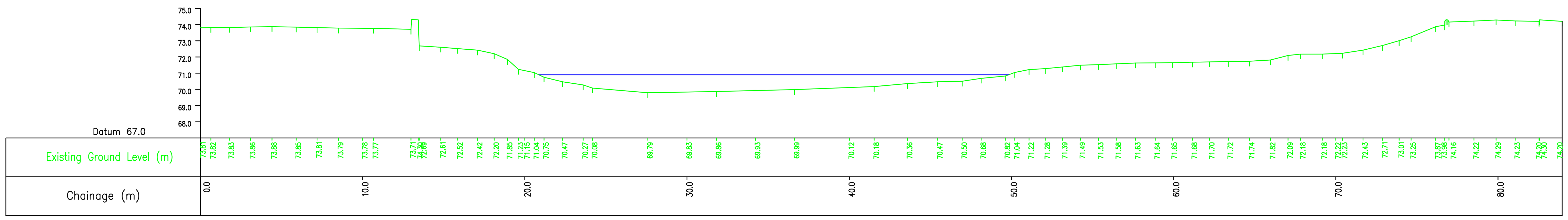
Client :
RPS
ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST
CO. ANTRIM
BT12 6RZ

Project Title :
CROSS SECTION SURVEY
RIVER ESK
LANGHOLM

Project No:	A6949	Scale :	1:200
Surveyed date :	22nd February 2019	Issued date :	27th February 2019
Surveyed by :	AS	Checked by :	RM
Sheet No. :	1 of 4	Plot Scale:	1:1 @ A1

'RE0162
E: 336278.337
N: 584512.098

RE0162'
E: 336201.763
N: 584546.488



Section RE0162
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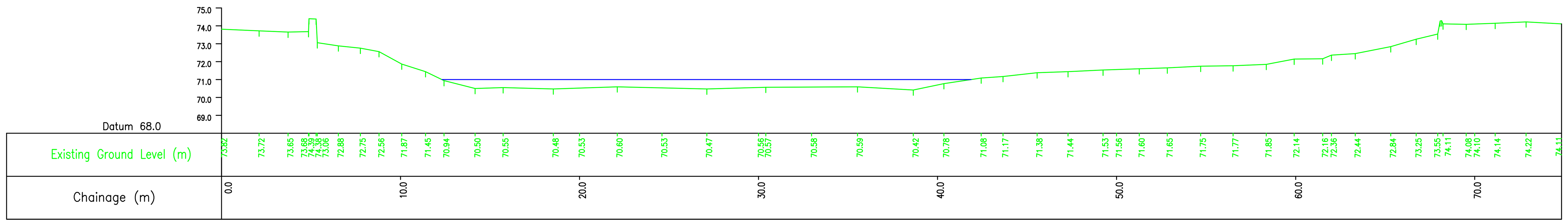
Vertical Scale 1: 200

'WEIR 1
E: 336275.608
N: 584526.266

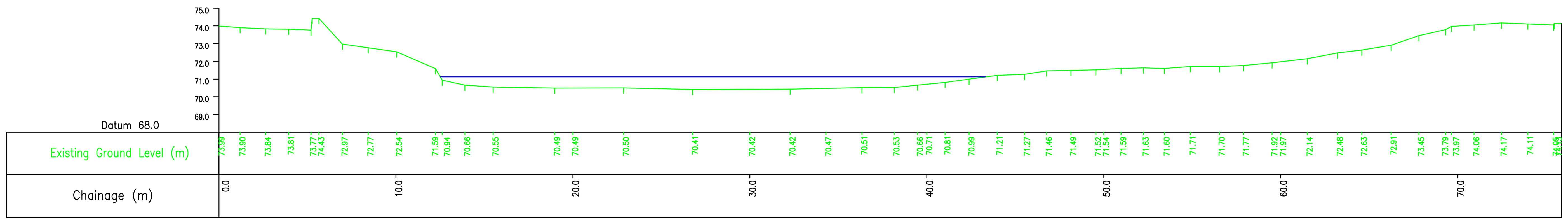
WEIR 1'
E: 336208.349
N: 584559.104



Section WEIR 1
Horizontal Scale 1: 200
Vertical Scale 1: 200

'RE0140
E: 336280.046
N: 584535.526

RE0140'
E: 336210.337
N: 584565.451



Section RE0140
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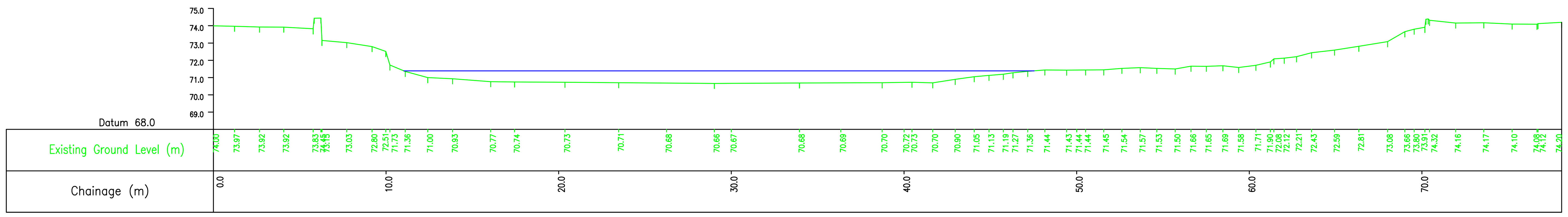
Vertical Scale 1: 200

'RE0120
E: 336288.245
N: 584553.001

RE0120'
E: 336217.309
N: 584585.647



Section RE0120
Horizontal Scale 1: 200
Vertical Scale 1: 200

'RE0100
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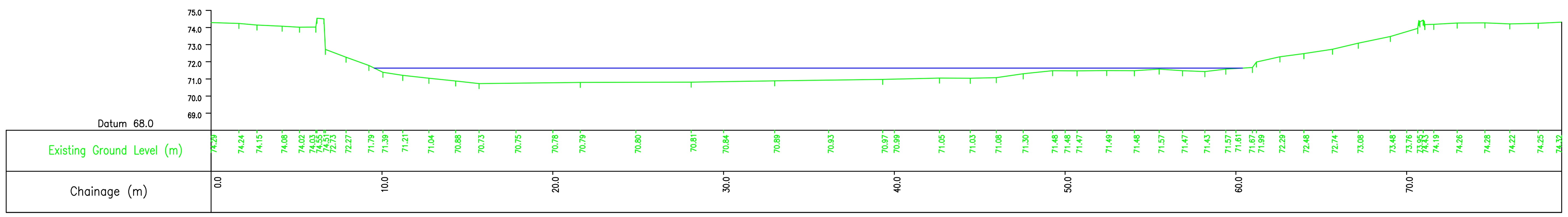
N: 584571.832

RE0100'
E: 336223.991
N: 584602.510



Section RE0100
Horizontal Scale 1: 200
Vertical Scale 1: 200

Link Feature Legend

- Existing Ground Level
- Section Detail
- Water Level
- Wall
- Metal
- Wood
- Road
- Section Lines

Notes:

Horizontal Control points are relative to the NATIONAL GRID.

All levels are relative to ORDNANCE DATUM.

The survey was tied into the previous survey Ref No : A4914.

CONTROL STATION COORDINATES

STN	EASTING	NORTHING	LEVEL

Aspect
Land + Hydrographic Surveys
CHARTERED SURVEYORS
Thornhouse Business Centre
Ballot Road
Irvine
KA12 OHW
Tel : 01294 313399
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Client :
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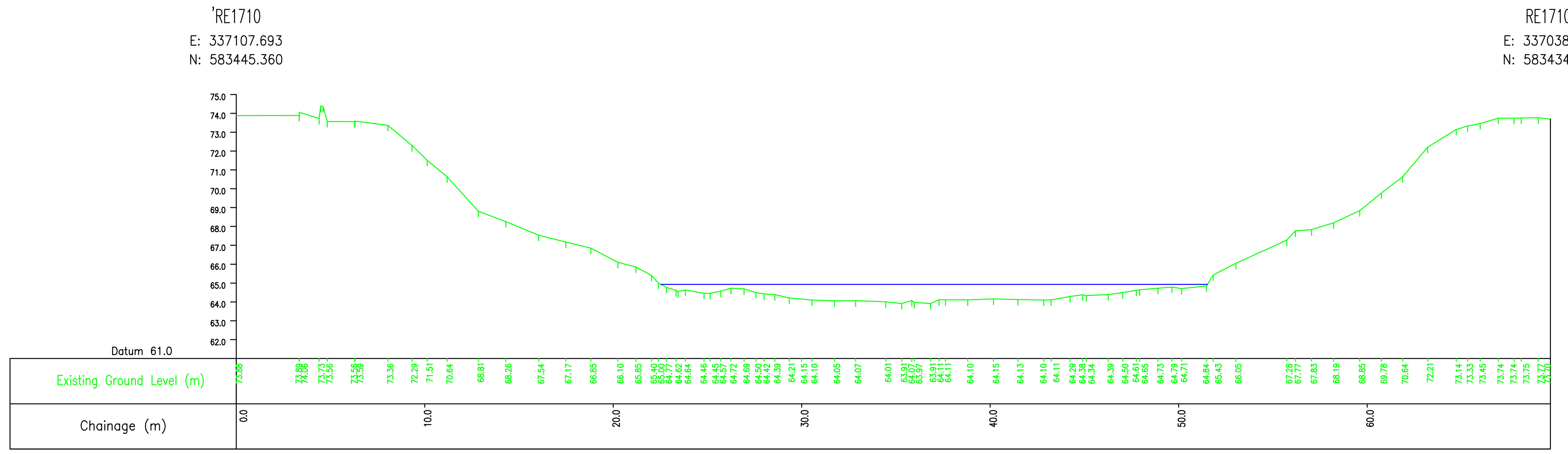
Project Title :
CROSS SECTION SURVEY
RIVER ESK
LANGHOLM

Project No:	A6949	Scale :	1:200
Surveyed date :	22nd February 2019	Issued date :	27th February 2019
Surveyed by :	AS	Checked by :	RM
Sheet No. :	2 of 4	Plot Scale:	1:1 @ A1



Section RE1710
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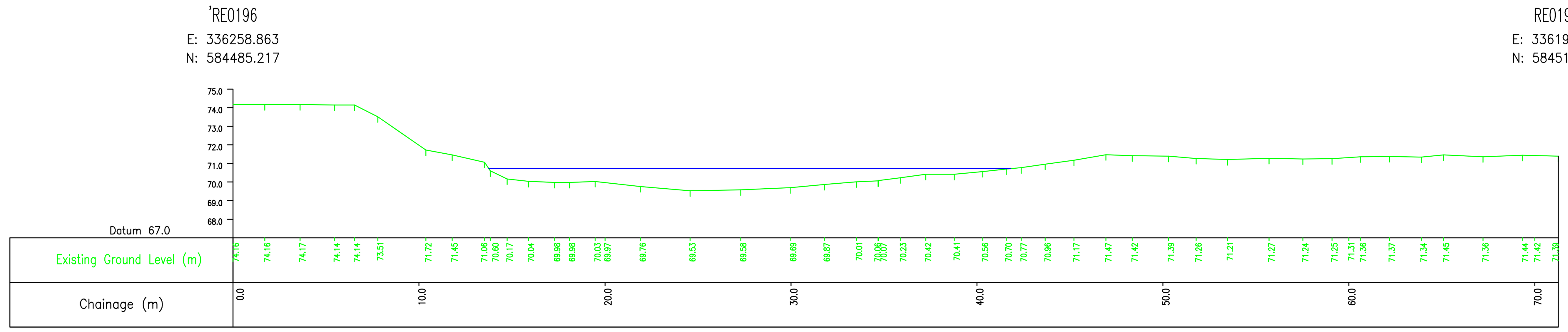
Vertical Scale 1: 200



Section RE0196
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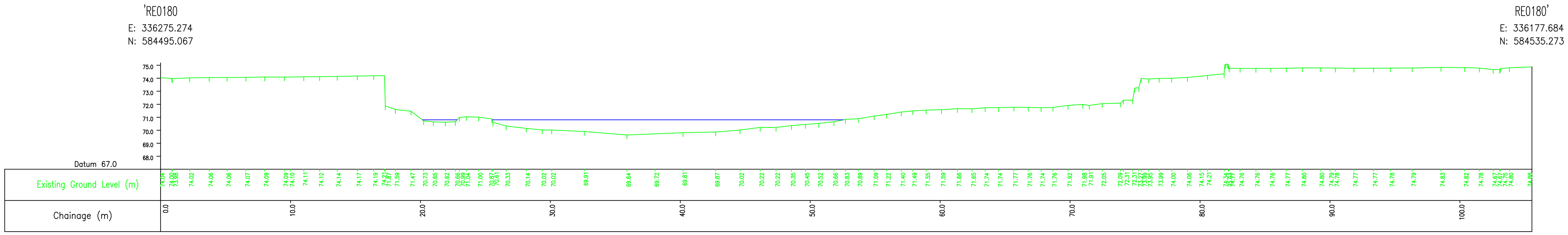
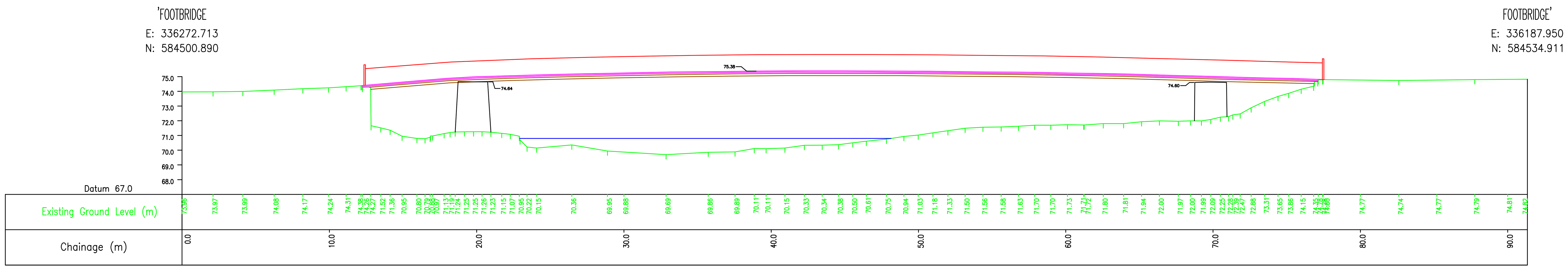
Vertical Scale 1: 200



Section RE0180
Horizontal Scale 1: 200
Vertical Scale 1: 200



Section FOOTBRIDGE
Horizontal Scale 1: 200
Vertical Scale 1: 200

Link Feature Legend

- Existing Ground Level
- Section Detail
- Water Level
- Wall
- Metal
- Wood
- Road
- Section Lines

Notes:

Horizontal Control points are relative to the NATIONAL GRID.

All levels are relative to ORDNANCE DATUM.

The survey was tied into the previous survey Ref No : A4914.

CONTROL STATION COORDINATES

STN	EASTING	NORTHING	LEVEL

Aspect
Land + Hydrographic Surveys
CHARTERED SURVEYORS
Thornhouse Business Centre
Ballot Road
Irvine
KA12 OHW
Tel : 01294 313399
Fax : 01294 313389
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RPS
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BT12 6RZ

Project Title :
CROSS SECTION SURVEY
RIVER ESK
LANGHOLM

Project No:	A6949	Scale :	1:200
Surveyed date :	22nd February 2019	Issued date :	27th February 2019
Surveyed by :	AS	Checked by :	RM
Sheet No. :	3 of 4	Plot Scale:	1:1 @ A1

APPENDIX C

Modelled Structures

RIVER	Upstream Node ID	HEIGHT (m)	LENGTH (m)	WIDTH (m)	MANNINGS n (mm)	OPENING SHAPE	SPRING HEIGHT FROM INVERT (m)
River Esk	RE_0984_US	5.861	9.9	12.279	0.0460	ARCH SPRUNG	2.997
	RE_0984_US	5.905	9.9	12.826	0.0460	ARCH SPRUNG	3.048
	RE_0984_US	4.959	9.9	12.226	0.0460	ARCH SPRUNG	3.068
River Esk	RE_1197!	6.401	1.7	3.572	0.0550	ARCH SPRUNG	6.401
	RE_1197!	6.401	1.7	46.306	0.0550	ARCH SPRUNG	6.401
	RE_1197!	6.401	1.7	2.991	0.0550	ARCH SPRUNG	6.401
River Esk	RE_2842_US	14.245	3.2	5.377	0.0800	ARCH SPRUNG	13.245
	RE_2842_US	14.245	3.1	13.503	0.0800	ARCH SPRUNG	13.245
	RE_2842_US	14.245	3.1	13.030	0.0800	ARCH SPRUNG	13.245
Ewes Water	EW_0057	6.637	2.5	16.638	0.0550	ARCH SPRUNG	3.977
Ewes Water	EW_0464	3.475	1.9	23.390	0.0550	ARCH SPRUNG	3.475
Ewes Water	EW_1101	3.060	9.0	9.392	0.0550	ARCH SPRUNG	1.557
	EW_1101	3.041	9.0	9.801	0.0550	ARCH SPRUNG	1.493
Wauchope Water	WW_BR_US	3.911	2.0	9.516	0.0550	ARCH SPRUNG	1.411
	WW_BR_US	3.911	2.0	8.341	0.0550	ARCH SPRUNG	1.411
Wauchope Water	Footbridge_u/s	3.354	1.2	12.340	0.0400	RECT	0.000

River Esk

	RE_0984_US Thomas Telford Bridge modelled with three arch sprung openings
	RE_1197! Footbridge Modelled with three archsprung openings
	RE_2842_US Skipper's Bridge road bridge over River Esk – modelled with three arch sprung openings

Ewes Water

	EW_0057 Highmill Bridge Road bridge over Ewes Water – modelled with one arch sprung opening
	EW_0464 Whitshields Bridge road bridge over Ewes Water – modelled with one arch sprung opening
	EW_1101 Ewes Bridge A7 Road bridge over Ewes Water – modelled with two arch sprung openings

Wauchope Water

	Footbridge_u/s modelled with one rectangular opening
	WW_BR_US modelled with two arch sprung openings

APPENDIX D

Model Review

MODEL REVIEW

<table>
<tr><td>Project Title: Langholm Flood Protection Scheme</td><td colspan="2">Job Number: IBE1511</td></tr>
<tr><td>Status: F01</td><td colspan="2">Reviewer comments: adjustments from D01 acceptable</td></tr>
<tr><td colspan="3">Master database location:
\\belf-eh-data-04\ICM_DB\IBE1511 - Langholm Flood Protection Scheme.sndb

Transportable database location:
L:\Section 40\Job No IBE1500 -\IBE1511 - Langholm Flood Protection Scheme\6_Hydraulic_Analysis\8_Model Issue
Software (including version):
InfoWorks ICM 8.5.2</td></tr>
<tr><td colspan="3">Project description & requirements:</td></tr>
<tr><td>Model files:

Is the naming convention appropriate?
Do you need a description for the networks/scenarios etc?</td><td>Existing Scenario

Network>Design Network> Langholm</td><td>24/09/18 FC</td></tr>
<tr><td>Events:
Climate change – applied to which events and how much?</td><td>Q2, Q5, Q10, Q30, Q50, Q100, Q200, Q1000.
As calculated during the hydrological analysis

Q200CC – CC = 44%</td><td></td></tr>
<tr><td>Scenarios:

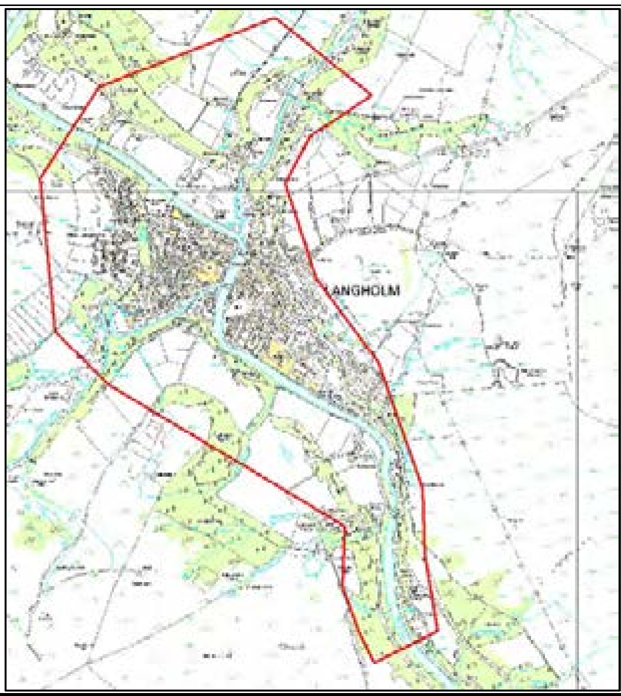
Existing/present day, sensitivity, defended/undefended, historic/options etc.</td><td>Present day for each event.

See sensitivity section for detail

No defended scenarios

See calibration section for historic scenarios</td><td></td></tr>
<tr><td>Gauged
Are there gauges in the study area that can be used for calibration/validation</td><td>There is a gauge 12km downstream used but not within model area</td><td></td></tr>
</table>

1. Model extents

Item Checked	**Modeller Comments**	**Reviewer Comments on D02**
What is the study area described in the Brief?	River Esk from Approx. 1km US of Townsend Bridge through to Skipper's Bridge, Wauchope Water from Springhill through to the Esk, and the Ewes Water from Highmill Bridge to the Esk confluence,	24/09/18 FC
Are the model extents suitable? Contains the study area at largest event? Contains all (rainfall) contributing areas? Is there 2D flow leaving the model? Where?	The study area contains largest event.	
Is the downstream extent appropriate? Far enough from the area of interest to have an impact? Rule of thumb for backwater effect – 0.7D/S D = channel bank full depth, S = mean bed slope (mm)	Yes	
Provide a figure of model to show study area is covered.		

Upstream model extents:			
Watercourse name	**Node**	**X**	**Y**
Ewes Water	EW_0000	336905	585887
River Esk	RE_0000	335563	585262
Wauchope Water	WW_0000	335630	584179
Downstream model extent:			
Watercourse name	**Node**	**X**	**Y**
River Esk	RE_2897_out	337146	582733

2. Source of data

Data	Source	Date obtained	Appropriate for use? Reasoning	Supplied with log
River Esk, Wauchope Water & Ewes Water cross sections, structures	Procured by RPS & Topo survey undertaken DG Design and Aspect Surveys	May 2012	Yes Still appropriate for use	Yes (upon completion of project)
River Esk & f'bridge on Wauchope Water	Six West Surveys	Oct 2018	Yes	Yes (upon completion of project)
LiDAR	Supplied by DGC	May 2012	Yes Most recently flown	n/a

Item Checked	Modeller Comments	Reviewer Comments on D02
Data If data older than 5 years check for changes	No recent data to check against	

3. Boundary Conditions

<table>
<tr><th>Item Checked</th><th>Modeller Comments</th><th>Reviewer Comments on D02</th></tr>
<tr><td>Upstream boundary:</td><td>Point inflows were applied at the following nodes:
<table><tr><th>Model Node</th><th>River</th></tr><tr><td>WW_0000</td><td>Wauchope Water</td></tr><tr><td>RE_00000</td><td>River Esk</td></tr><tr><td>EW_0000</td><td>EWES Water</td></tr></table></td><td>24/09/18 FC</td></tr>
<tr><td>Rainfall / laterals:

Any runoff/infiltration rates for rainfall?

Any loss to drainage network?</td><td>Lateral flows calculated during the hydrological analysis were disaggregated between the HAPs and distributed pro-rata, based on length, and applied to each link (river reach). See the Flood Study Report hydrology chapter for further info.

Hydrograph timings will initially be based on the hydrological analysis and catchment response. The timings may then be adjusted if required to meet check flow HAPs values.

No rainfall applied</td><td></td></tr>
<tr><td>Downstream boundary:

Detail node type, level, Q/H or normal depth boundary?</td><td>Normal depth boundary condition - based on the bed gradient of the last two sections immediately upstream of the outfall. This is a function automatically applied within the modelling package.

All tributaries of the River Esk are dynamically linked to the River Esk and as such the downstream boundaries are determined by the water levels in the appropriate reach of the River Esk.</td><td></td></tr>
</table>

4. Model Construction

Item Checked	Modeller Comments	Reviewer Comments on D02
1D		
Model build history:	Reaches for River Esk, Ewes Water and Wauchope Water were built into the model using the cross section survey data procured in 2012.this was originally built in InfoWorks RS and converted to ICM. Additional sections downstream of Skippers Bridge were added in 2018 to the ICM model.	24/09/18 FC
Cross sections: Have cross sections been amended from survey? Provide figure of modelled vs surveyed cross sections. 1D-2D? Extended sections sufficient - need to check for glass walling?	Cross sections were trimmed where appropriate to exclude low points to avoid flow split and checked against the LiDAR to ensure no secondary embankments were present.	
Interpolated / copied sections: Appropriate use?	Cross sections were copied to create bridges. There are interpolated sections.	
Bank lines: How were bank lines created? Was bank level info augmented? How? Are formal/informal defences included? How? Do they tie in with the top of bank? Bankline discharge coefficient range: show examples. Modular limit range:	Bank lines were created from the end of the cross sections. The level associated with the end point of each modelled cross section was taken as the bank level at that location with intermediate elevations being interpolated from one section to the next. The bank level information was augmented with LiDAR information where it was deemed appropriate to do so. Banklines have been amended to remove any unrealistic high or low pints. The river wall on the River Esk LHB along George Street has not been included as it is not a formal defence and has a number of gaps in it. Bankline discharge coefficient ranges from 0.6 – 0.8 depending on the nature of the bank. Examples are shown below:	25/03/19 FC

	 Wauchope Water, WW_0200 RHB discharge coefficient = 0.6  River Esk, RE_13111 RHB discharge coefficient = 0.8 Modular limits range from 0.6 – 0.8.	
2D		
Ground model: How was the dtm created?	The LIDAR data covers the entire study area. There is a 1D-2D connection along all modelled reaches, except the upstream extent of the Ewes Water. There is no 2D coverage at the upstream extent of the Ewes	

Was the dtm augmented in any way – defences/buildings/correcting Lidar? Error in Lidar – show images, how was error identified, how was it corrected?	Water for approx. 490m. The flow is confined to a linear flood plain within the 1D therefore 2D is not required For an accurate assessment of 2D flow paths the bare earth DTM data was used within the modelling package to generate the computational mesh, the mesh was then augmented to include buildings. Building footprints were defined by a GIS shape file which was extracted from the OS Master Map geodatabase	
2D zone boundary type: Any other 2D boundary lines?	Vertical wall – there was no flow reaching the edge of the 2D mesh so there was no need to change from default	
Area:	313ha	
Resolution: Mesh resolution appropriate?	2D zone: • Max triangle area 25m^2 • min element area 5m^2	25/03/19 FC
	Mesh zone: • Max triangle area 5m^2 • min element area 1m^2 Mesh zone was added to show flooding through streets in more detail, no ground level modification	25/03/19 FC
False blockages: Check simulation at roads/rail embankments etc., refine following calibration. Check small w/c in dtm, flows under bridges etc.	No false blockages were identified.	
Buildings: What element are used to represent buildings? What data was used to create buildings? Was it amended from original? How? Porosity value applied:	The building footprints were extracted from the OS Master Map geodatabase. The building footprints were imported into the model as porous polygons and designated as having a porosity of 0.01. The value used was adequate for purposes in the model	
Building threshold levels: Any FFL applied? From where, how? Raised from dtm by agreed amount?	The buildings were imported as mesh zones with the *Ground level modification* set to +300mm The church - raised by 1m (7no. steps to FFL)	

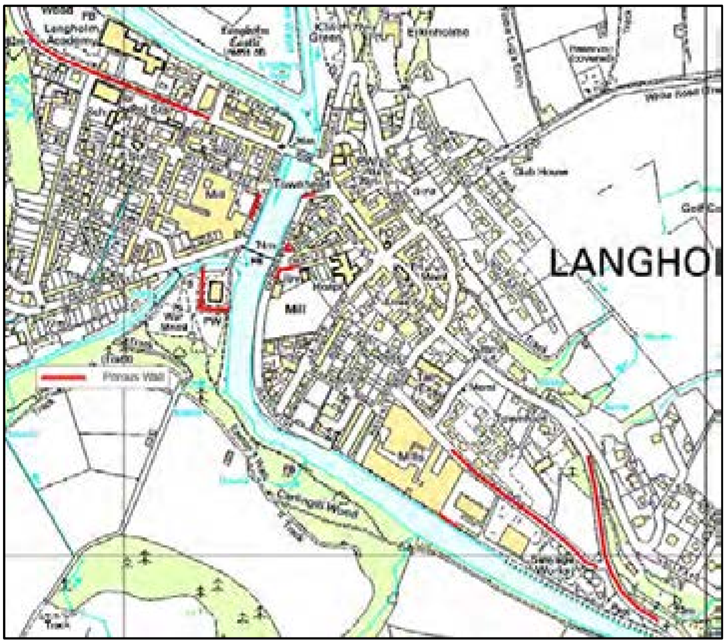
3.1 Structures

Item Checked	Modeller Comments	Reviewer Comments on D02
1D structures in channel		
What data was used? Are all structures represented? If not, why?	Bridges on the River Esk and Ewes Water were built into the model using the 2012 survey data. The footbridge on the Wauchope Water was built using the 2018 survey data. There are 8no. bridges in the model, details of which can be found in Appendix D of the Study. Not all structures where represented. Duchess Bridge & a footbridge on the River Esk have not been included as they are not thought to cause restrictions to the flow.	25/03/19 FC
Bridges: Include modelled name, location/road name, bridge and opening type, deck level and discharge coefficient (and reason if amended from default) Bridge boundary used and appropriate? Any spills around or over the structure?	The most appropriate bridge/culvert type was used was based on each structure. **EW_0057** Highmill A7 Road bridge over Ewes Water – modelled with one arch sprung opening The modelled bridge deck is set at the parapet level with discharge coefficient unchanged at 1.7. No spills over the structure **EW_0464** Milntown connect road bridge over Ewes Water – modelled with one arch sprung opening The modelled bridge deck is set at the deck level with discharge coefficient unchanged at 1.7. No spills around or over the structure **EW_1101** Ewes Water Bridge A7 Road bridge over Ewes Water – modelled with two arch sprung openings The modelled bridge deck is set at the parapet level with discharge coefficient unchanged at 1.7. No spills around or over the structure **WW_BR_US** Wauchope Bridge over Wauchope Water – modelled with two arch sprung openings The modelled bridge deck is set at the parapet level with discharge coefficient unchanged at 1.7. No bridge boundary Spills over the structure (>0.5%) **RE_0984_US** Townhead Bridge – road bridge over River Esk – modelled with three arch sprung openings The modelled bridge deck is set at the parapet level with	

	discharge coefficient unchanged at 1.7. No spills around or over the structure **RE_1197!** Foot Bridge over River Esk – modelled with three arch sprung openings The modelled bridge deck is set at the deck level with discharge coefficient unchanged at 1.7. No spills around or over the structure **RE_2842_US** Skippers Bridge - road bridge over River Esk – modelled with three arch sprung openings The modelled bridge deck is set at the parapet level with discharge coefficient unchanged at 1.7. No spills around or over the structure **Footbridge** Foot Bridge over Wauchope Water – modelled with one rectangular opening The modelled bridge deck is set at the deck level with discharge coefficient unchanged at 1.7. No bridge boundary Spills over the structure (>3.33%)	
Culverts: Include modelled name, location/road name, conduit shape, roughness and headloss (and reason if amended from default) Are culvert inlets/outlets used? Why?	No Culverts were identified	
Weirs: Include modelled name, type, discharge coefficient	On the Wauchope Water at Course Holm **WW_0360** Round nosed broad crested weir	
1D structures in 2D domain		
Formal / informal defences Review following	Porous walls have been added to represent boundary walls where they may have a substantial impact on flow paths (see diagram below). Heights were estimated from Google	25/03/19 FC

<table>
<tr>
<td>calibration – railway embankments, boundary walls etc. impact flow paths.

Type of element used, data crest level based on, assumptions on porosity

Include figure</td>
<td>Street view. Porosity values were applied as follows:
• Solid stone walls – 0.005
Porous walls, with 100% porosity, have been added as break lines along Glenesk Road, High Street and Thomas Telford Road.


Porous Wall Locations</td>
<td></td>
</tr>
<tr>
<td colspan="2">2D model structures

Terrain sensitive meshing was used to increase mesh resolution in areas where the topography varied by more than a defined limit within a mesh element.</td>
<td></td>
</tr>
<tr>
<td>Other features:

Reservoirs, control units</td>
<td>None</td>
<td></td>
</tr>
</table>

3.2 Defences

Type	Watercourse	Location	Model start	Model end	Model element type	Information source
n/a						

3.3 Roughness

Item Checked	Modeller Comments	Reviewer Comments on D02
1D: Approach used to apply – global or varying. Based on photos/walk over/CCTV? Where are panel markers used?	**Channel** In-channel roughness values have been assigned based on guidance contained in the CIRIA Culvert Design Manual which have been extracted from Chow (1973), in conjunction with modeller's judgement. **In-bank:** 0.040 - 0.080 reaches vary from clean, winding to active mountainous watercourses with rocky and cobble beds large boulders **Out-of-bank:** 0.040 - 0.08 due to the extended sections banks vary from pasture and scattered brush to medium/dense brush	25/03/19 FC
	Panel markers are used at each vertices.	25/03/19 FC

<table>
<tr>
<td>2D:

Should not be applied globally.
LCM / OSMM? Any adjustments made?</td>
<td>Out-of-bank

The 2D model domain was split into different land uses based on the OS Master Map
Roughness values were assigned to the different land uses as per the table below:

<table>
<tr><th>Class</th><th>Manning’s n</th></tr>
<tr><td>General Surface</td><td>0.040</td></tr>
<tr><td>Glasshouse</td><td>1.000</td></tr>
<tr><td>Inland Water</td><td>0.030</td></tr>
<tr><td>Landform</td><td>0.035</td></tr>
<tr><td>Natural Environment</td><td>0.100</td></tr>
<tr><td>Path</td><td>0.016</td></tr>
<tr><td>Rail</td><td>0.020</td></tr>
<tr><td>Road Or Track</td><td>0.014</td></tr>
<tr><td>Roadside</td><td>0.015</td></tr>
<tr><td>Tidal Water</td><td>0.020</td></tr>
<tr><td>Unclassified</td><td>0.050</td></tr>
<tr><td>Building</td><td>1.000</td></tr>
<tr><td>Rough Grassland</td><td>0.035</td></tr>
<tr><td>Natural Environment Scrub</td><td>0.043</td></tr>
<tr><td>Non-coniferous Trees</td><td>0.05</td></tr>
<tr><td>Non-coniferous Trees (Scattered),Rough Grassland</td><td>0.055</td></tr>
<tr><td>Natural Environment Coniferous Trees</td><td>0.08</td></tr>
<tr><td>Structure_</td><td>0.1</td></tr>
</table>
</td>
<td>FC 24/09/18</td>
</tr>
<tr>
<td>Buildings:</td>
<td>The building footprints were extracted from the OS Master Map geodatabase.
The building footprints were imported into the model as porous polygons and designated as having a porosity of 0.01.
The value used was adequate for purposes in the model</td>
<td></td>
</tr>
</table>

3.4 Model Boundary Conditions

Item Checked	Modeller Comments	Reviewer Comments on D02
Initial conditions: Initialising without issue?	No initial conditions. 2D parameters – 1d & 2d calcs are linked at minor time step	FC 24/09/18
Simulation Parameters: Any changes to space steps,	Simulation Parameter Drowned bank linearisation	

drown bank linearisation etc.?	threshold (m) changed from 0.01 to 0.1	

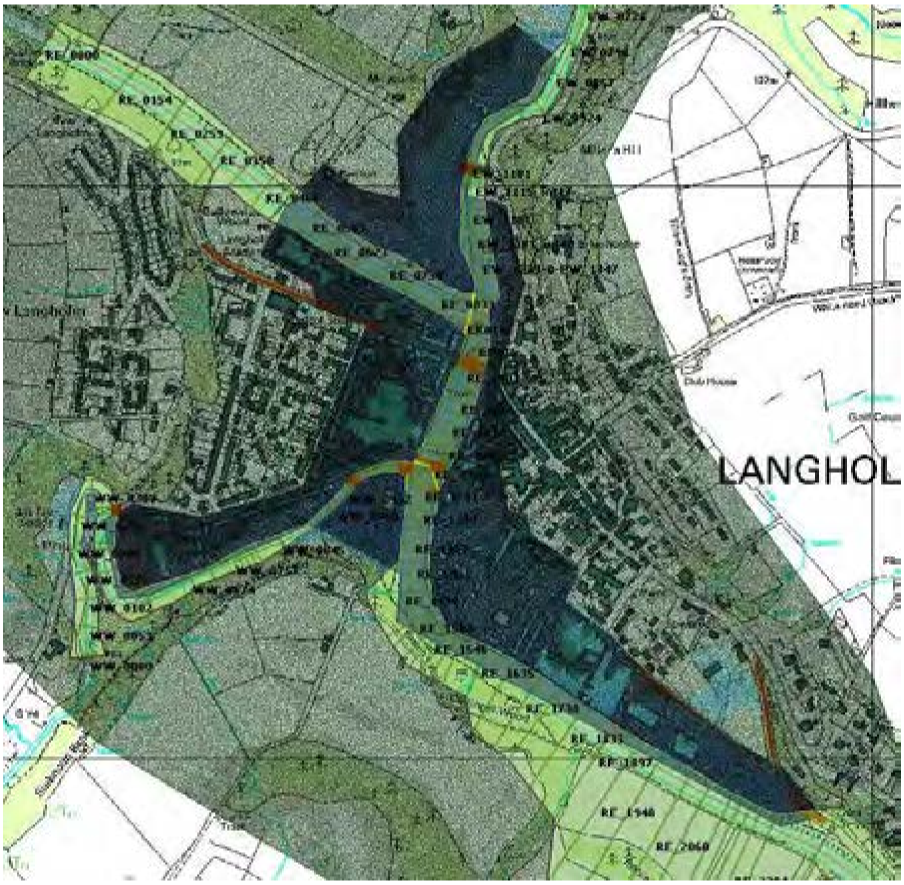
3.5 Model stability

Item Checked	Modeller Comments	Reviewer Comments on D02
Errors/warnings	Warnings - Level of bank below adjacent elements The messages are highlighting where the bank levels were lower than adjacent elements and have been changed. Bank levels can never be below the adjacent element ground level, therefore the default in the Run 2D Parameters is to adjust the bank levels based on adjacent element ground levels. These messages are unavoidable unless the terrain slopes away from the reach. - More than one profile There are two inflow profiles where a reach has a point inflow and a lateral inflow. It is right that they should both be added and used - Depth exceeding section height Innovyze support has confirmed that as long as the reaches are connected to the 2d zone these warnings can be ignored. - Flow reversals It is not always possible to completely remove flow reversals particularly if flows are significantly out of bank. Everything reasonable has been done to minimise them.	
Froude number: Check if >1 anywhere? Why?	The Froude number is not >1 in any location.	25/03/19 FC
Volume balance error: 0.5%AEP = 0.1838%		

3.6 Outputs & mapping of results

Run time:	35hours The model has past the peak of the River Esk as well as each of the tributaries. The worst case flooding is within the model run time	
Timestep:	1D timestep = 1 second 2D timestep = dynamic	

<table>
<tr>
<td>2D extents:

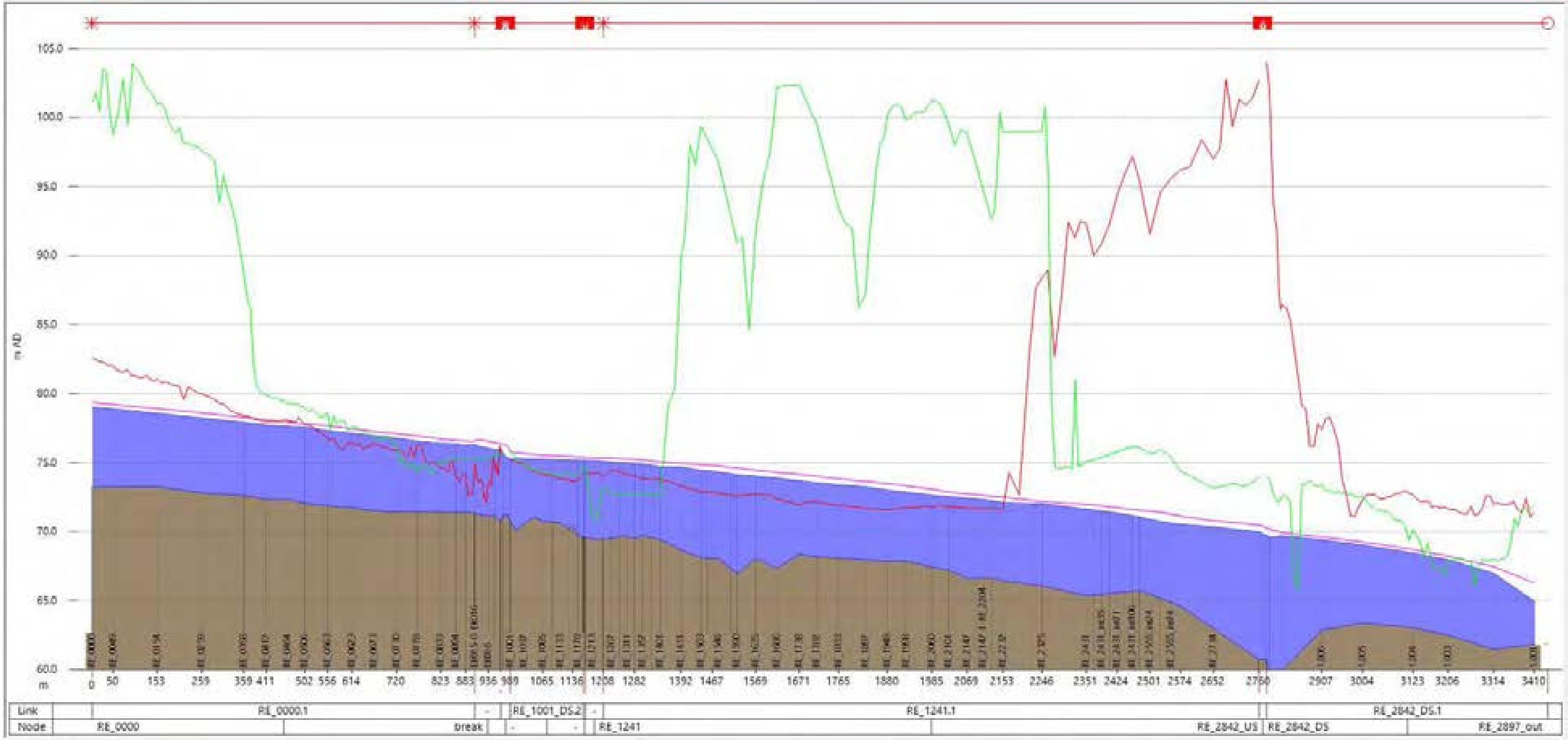
Do extents look sensible? Check extents increase with event.</td>
<td>
</td>
<td></td>
</tr>
<tr>
<td>Flood depths greater than 3m:</td>
<td>The only area where the 2D flood depths are greater than 3m are on the left bank at the confluence of the River Esk and Ewes Water, as shown below.


This is within the river channel and is therefore realistic.</td>
<td></td>
</tr>
</table>

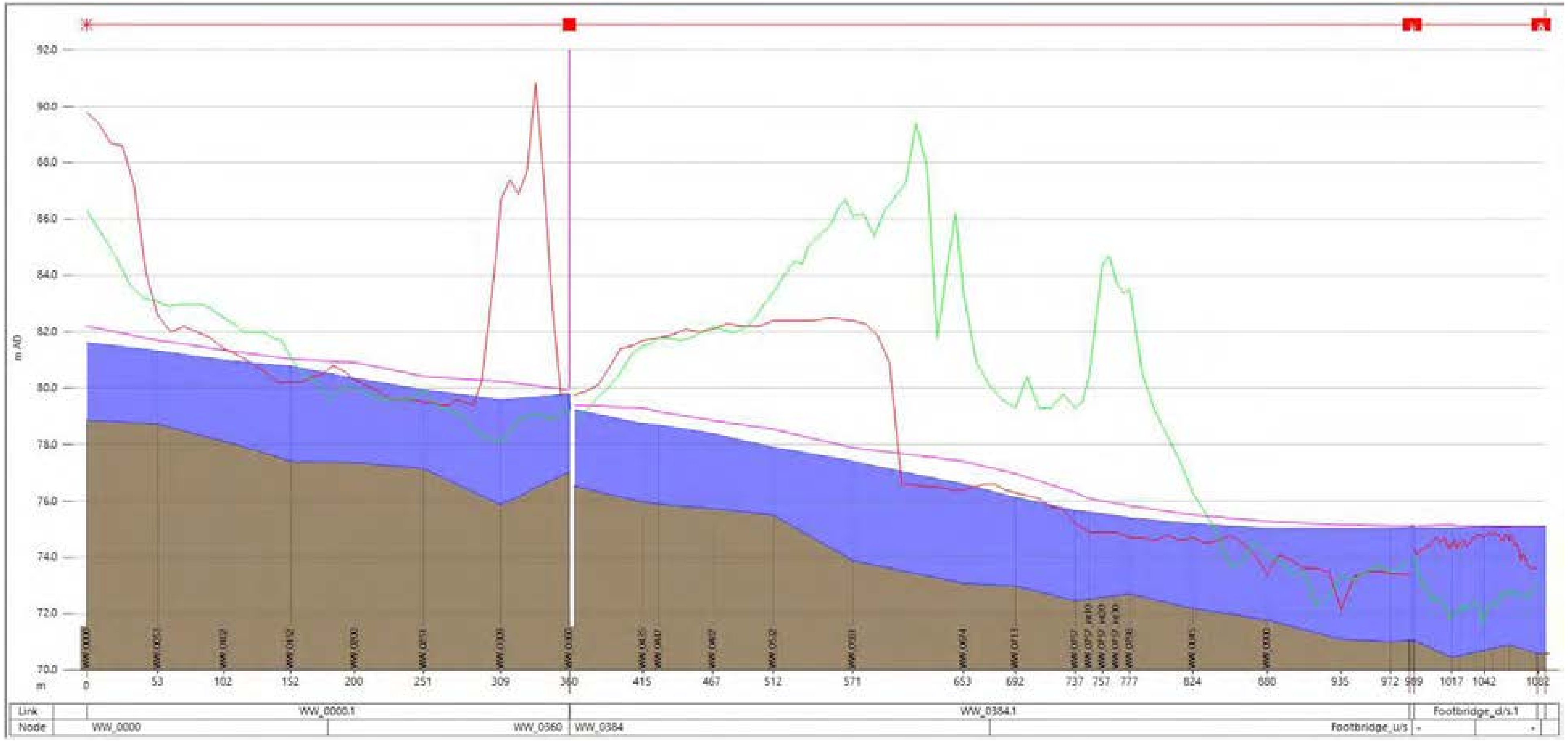
Check for oscillations…

Animations

Long sections – head difference



River Esk



Wauchope Water

Ewes Water

Simulation result files contained within transportable model Pdf flood extent / depth maps issued	yes

5. Calibration

3.7 Storm Desmond 5th December 2015

The most recent significant flood event in Langholm occurred on 5th December 2015. This event is the fifth largest on record at the Canonbie gauging station 12km downstream of Langholm. The River Esk overtopped its banks and homes in George Street were evacuated. A basement in Caroline Street and one in Laird's Entry were flooded, the Fire and Rescue Service pumped them out.

SEPA have a level gauge adjacent to the Thomas Telford Bridge, which has been used to calibrate the model. The extent of the flooding was not recorded and there are no recorded flood markers from this event. A number of timestamped photos were taken and these have been used to support the calibration. The flow gauge is a significant distance downstream from Langholm, therefore a direct correlation cannot be made between the gauge and the flooding in Langholm; neither in regard to the timing of the peak nor with the volumes between the two.

3.8 December 2015 Model Build

Through the hydrological analysis Storm Desmond has been calculated as a 1 in 12 year return period at the Canonbie gauge. An inflow file was set up for the 1 in 12 year estimated flows in all three watercourses based on the design hydrograph which has been calculated in the hydrological analysis. The model was run with this inflow file. The co-ordinates provided on the SEPA website for the gauging station indicated that it is located near the downstream face of the Thomas Telford Bridge, however onsite inspection located the gauge approximately 65m downstream of the bridge. The closest cross section within the model is RE_1017. The peak modelled water level at RE_1017 was compared to the peak level recorded for this event. The modelled flood extents were then compared to the photos taken during the event.

The river wall along George Street was built into the model with the gap at the steps. A number of existing boundary walls throughout the town which may have an impact on the flow paths were added as porous walls. See *Section 3.1 Structures, 1D structures in 2D domain* for further information on the porous walls.

The peak level recorded was at 18.15 on 05/12/15 and was 2.89m. With a gauge datum of 71.33mAOD this gives a peak recorded water level as 74.22mAOD. The maximum water level at the gauge location (RE_1017) exported from the model is 74.479m. This is a level difference of 259mm. Given that this model is to be used to develop an outline Scheme this accuracy is adequate.

There were a number of photographs taken throughout the day timestamped from 13.37 – 17.52. The peak at the gauge, 12km downstream, was at approx. 18.45.

The photos and the simulated results were compared:

Time – 14.10

Photo taken at 14.10 from Thomas Telford Bridge in Langholm on 05/12/15

Model output at corresponding time superimposed onto Google Earth

Time – 17.12

Photo taken at 17.12 at Waterside in Langholm on 05/12/15

Model output at corresponding time superimposed onto Google Earth

The reported flooding of the basement is not shown in the model. This recorded flooding of the basements may very possibly have been caused by surface water flooding or more likely by drains backing up, not being able to discharge due to high water levels in the watercourses.

3.9 31st October 1977

The most significant flood event recorded in Langholm occurred on 31st October 1977. This event is the third largest on record at the Canonbie gauging station 12km downstream of Langholm. The River Esk overtopped its banks.

The SEPA level gauge started recording data in June 2015; therefore there is no recorded level data at Thomas Telford Bridge for this event. The extent of the flooding was not recorded and there are no recorded flood markers from this event. A number of photos were taken however they are not timestamped. Therefore, as the photos carry significant uncertainty, they will be used more as a guide than calibration data. The photos can be seen in Appendix A.

3.10 31st October 1977 Model Build

Through the hydrological analysis this event has been calculated as a 1 in 21 year return period at the Canonbie gauge. An inflow file was set up for the 1 in 21 year estimated flows in all three watercourses based on the design hydrograph which has been calculated in the hydrological analysis. The model was run with this inflow file and the modelled extents and water extents in the area were compared to the photos.

The river wall along George Street was built into the model with the gap at the steps. A number of existing boundary walls throughout the town which may have an impact on the flow paths were added as porous walls. See *Section 3.1 Structures, 1D structures in 2D domain* for further information on the porous walls.

Using the topographic survey and the photos the water level is estimated to be approximately 74.291m at the steps on George Street and 74.420m upstream of the footbridge. Note the photos are believed to have been taken some time after peak river levels had been reached.

The maximum simulated water level at the steps on George Street (Section RE_1085) = 74.594m and upstream of the footbridge (Section RE_1133) = 74.527m. As both these water levels are recorded during the peak, the difference between the levels estimated from the 1977 photographs, (after the peak) and the modelled level (during the peak), is considered acceptable.

Model output at corresponding time superimposed onto Google Earth - Looking upstream from Thomas Telford Bridge

Model output at corresponding time superimposed onto Google Earth - Looking downstream from George Street

3.11 Calibration Conclusion

For the December 2015 event, an approximate 1 in 12 year return period, there is a difference of 259mm between the peak recorded and modelled water levels. This is supported by the anecdotal evidence which shows the modelled flood extents similar to those in the observed in the photos. Given that this model is to be used to develop an outline Scheme this accuracy is adequate.

While there is little confidence in the information available for the 1977 event, the modelled flood extents are similar to those observed in the photos which would further increase the confidence in the model.

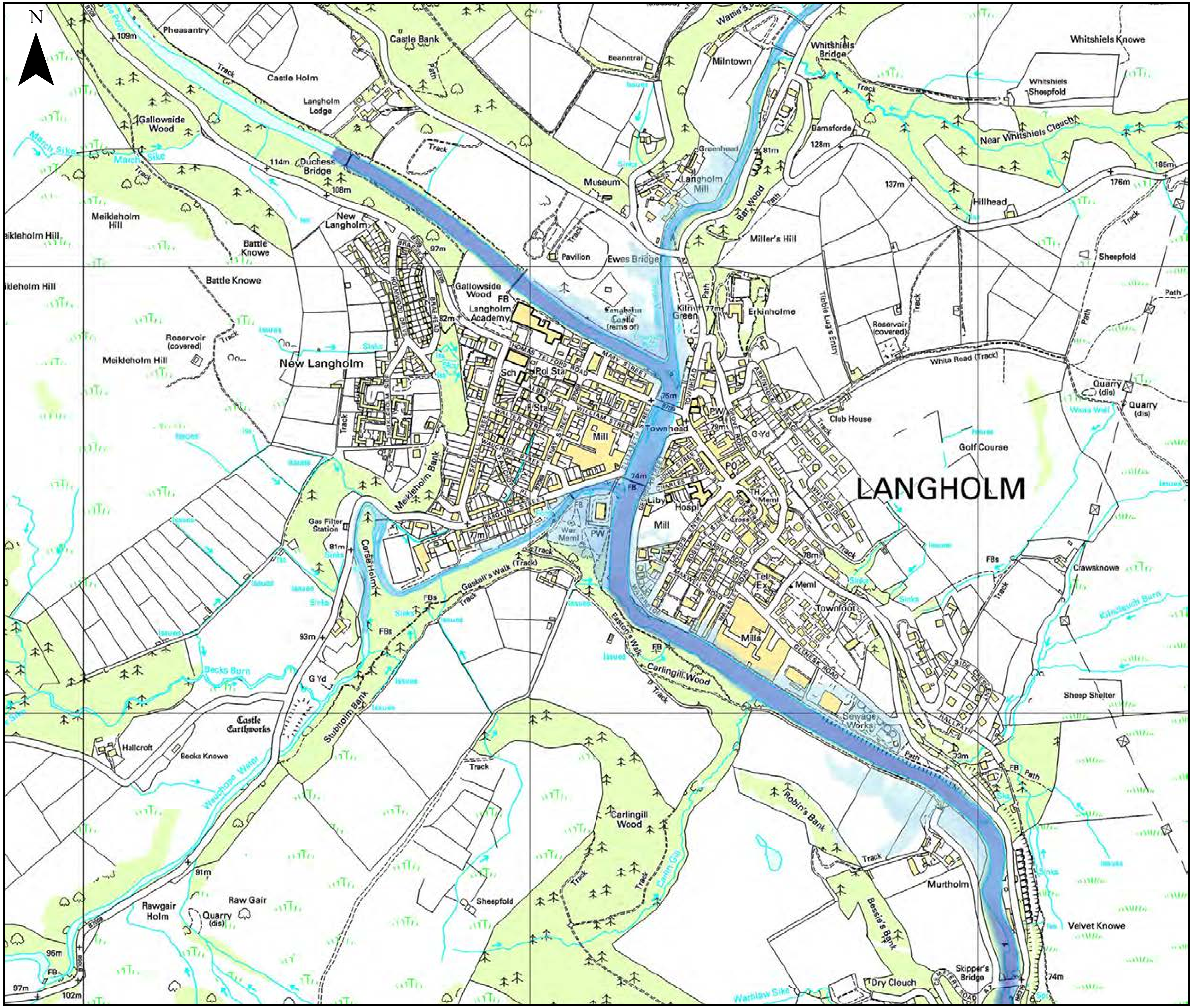
6. Sensitivity

Item Checked	Modeller Comments	Reviewer Comments
Sensitivity scenarios: Check Brief and agreed with Client	**Boundary conditions:** 20% flow increase  Increase in flood extents – sensitive to flow increase **Roughness:** 1D & 2D roughness increased by 40%  Significant increase in flood extents – very sensitive to roughness increase **Model resolution**: 2D Zone increased from max 25 to 5, and min 5 to 1. Mesh Zone increased from max5 to 2 and min 1 to 0.5.	25/03/19 FC

	 Insignificant difference in flood extent – not sensitive to model resolution.	

APPENDIX E

Flood Maps – Historic Scenarios



Legend

1977 Historic Flood Event (Q21)

Value

High : 5.6

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

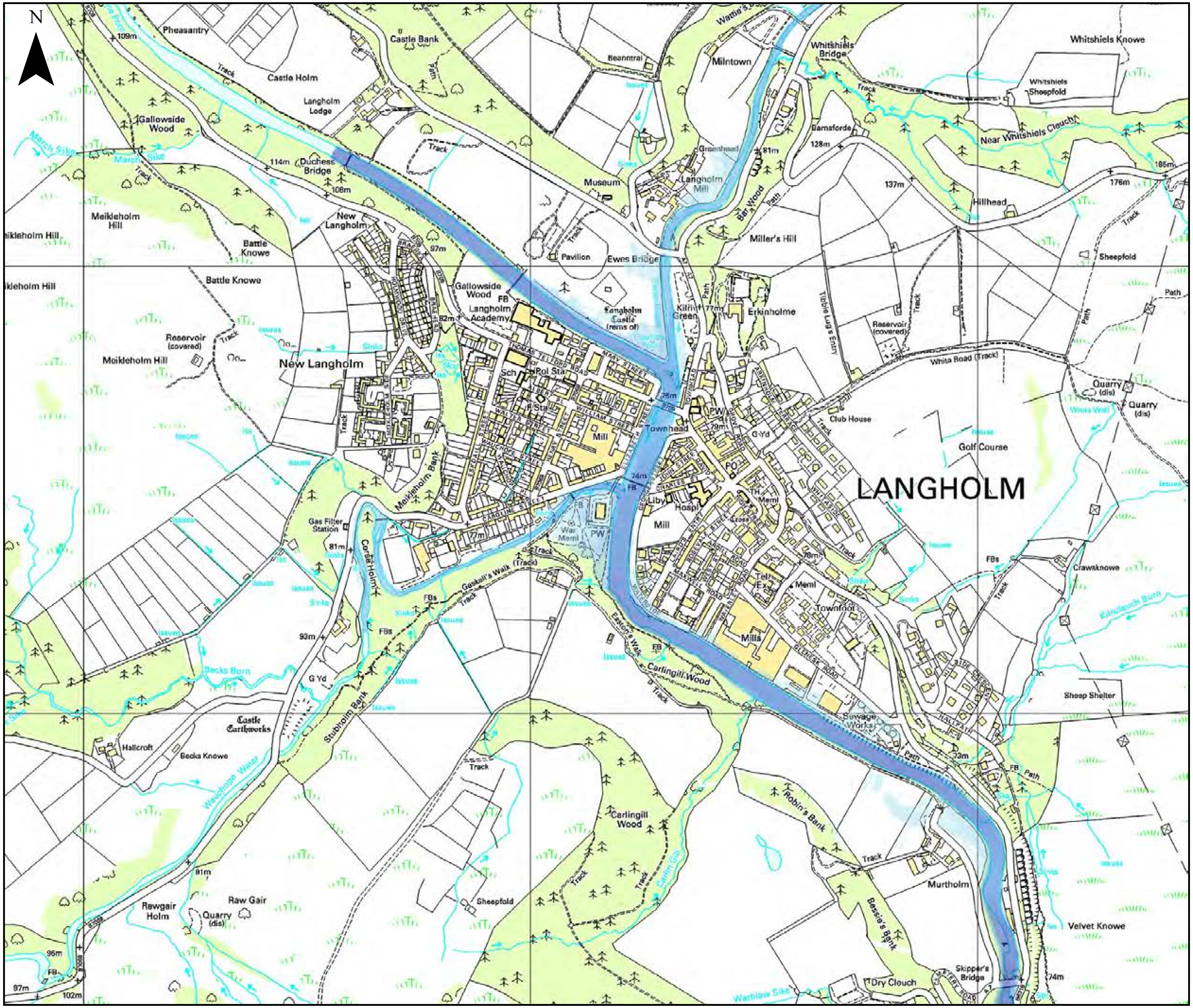
Client: Dumfries & Galloway Council

Project: LANGHOLM Flood Protection Scheme

Title:
Flood Extent Map
1977 Flood Event

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



Legend

2015 Historic Flood Event (Q12)

Value

High : 5.4

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

Client: Dumfries & Galloway Council

Project: LANGHOLM Flood Protection Scheme

Title: Flood Extent Map 2015 Flood Event

rps MAKING COMPLEX EASY

Drawn By :	GMcK
Checked By :	FC
Approved By :	FC
Date :	20/05/19
Scale :	NTS

APPENDIX F

Sensitivity Analysis Output Tables

Cross Section:	Design Level:	Flow Increase	Roughness Increase	Resolution Change
EW_0000	85.141	85.435	85.581	85.141
EW_0000_int13	85.032	85.325	85.482	85.032
EW_0000_int27	84.876	85.17	85.344	84.876
EW_0000_int41	84.706	84.992	85.165	84.706
EW_0057	84.547	84.823	84.971	84.547
EW_0064	84.427	84.695	84.939	84.427
EW_0161	83.803	84.088	84.346	83.803
EW_0161_int25	83.623	83.912	84.177	83.623
EW_0161_int51	83.455	83.747	84.019	83.455
EW_0161_int77	83.311	83.603	83.878	83.311
EW_0265	83.197	83.486	83.757	83.197
EW_0294	82.998	83.302	83.598	82.998
EW_0379	82.559	82.902	83.245	82.559
EW_0464	82.045	82.393	82.871	82.045
EW_0469	81.799	82.169	82.754	81.799
EW_0575	80.963	81.243	81.475	80.963
EW_0658	80.267	80.479	80.663	80.266
EW_0728	79.731	79.922	80.052	79.731
EW_0798	79.096	79.25	79.353	79.095
EW_0857	78.623	78.79	78.885	78.624
EW_0924	78.154	78.394	78.486	78.166
EW_0964	78.017	78.267	78.34	78.02
EW_1022	77.734	77.975	78.031	77.732
EW_1101	77.306	77.609	77.5	77.308
WW_0384	79.232	79.51	79.676	79.232
WW_0435	78.736	78.968	79.193	78.736
WW_0447	78.685	78.915	79.129	78.685
WW_0487	78.384	78.623	78.84	78.384
WW_0532	77.890	78.134	78.357	77.89
WW_0591	77.406	77.655	77.867	77.407
WW_0674	76.594	76.845	77.074	76.594
WW_0713	76.133	76.373	76.499	76.134
WW_0757	75.663	75.874	76.033	75.663
WW_0757_int10	75.610	75.829	76.014	75.611
WW_0757_int20	75.549	75.777	75.988	75.551
WW_0757_int30	75.478	75.715	75.96	75.479
WW_0798	75.399	75.66	75.933	75.4
WW_0845	75.195	75.584	75.855	75.193
WW_0900	75.020	75.482	75.766	75.021
WW_0955	75.028	75.473	75.762	75.029
WW_0992	75.024	75.471	75.76	75.024
Footbridge_u/s	75.053	75.507	75.779	75.054
WW_0000	81.613	81.847	82.065	81.613
WW_0053	81.326	81.55	81.739	81.326
WW_0102	80.989	81.22	81.409	80.989
WW_0152	80.775	81.017	81.167	80.776
WW_0200	80.343	80.555	80.694	80.345
WW_0251	79.934	80.218	80.383	79.933
WW_0309	79.588	79.854	80.054	79.589
WW_0360	79.783	80.101	80.148	79.783
RE_1197	75.147	75.567	75.838	75.147
RE_1213	75.160	75.584	75.836	75.161
RE_1241	75.103	75.532	75.791	75.103
WW_BR_DS	75.098	75.528	75.793	75.1
WW_1144	75.102	75.53	75.788	75.103
RE_1241	75.103	75.532	75.791	75.103
RE_2842_DS	69.713	70.255	70.854	69.716
RE_2848	69.597	70.128	70.74	69.6
RE_2897	69.689	70.248	70.71	69.692
1.006	69.415	69.951	70.372	69.417
1.005	69.027	69.541	69.94	69.03
1.004	68.451	68.954	69.319	68.453
1.003	67.969	68.487	68.824	67.972
1.002	66.988	67.455	67.74	66.99
1.001	64.965	65.322	64.963	64.967
Footbridge_d/s	75.047	75.509	75.782	75.047
WW_1041	75.035	75.522	75.813	75.027
WW_1041_int6	75.038	75.48	75.776	75.039
WW_1041_int12	75.056	75.537	75.809	75.057
WW_1041_int18	75.061	75.514	75.796	75.063
WW_1041_int24	75.067	75.533	75.807	75.068
WW_1041_int30	75.073	75.559	75.818	75.075
WW_1041_int36	75.078	75.533	75.805	75.081
WW_1084	75.083	75.524	75.802	75.086
WW_BR_US	75.106	75.547	75.813	75.11
RE_1241	75.103	75.532	75.791	75.103

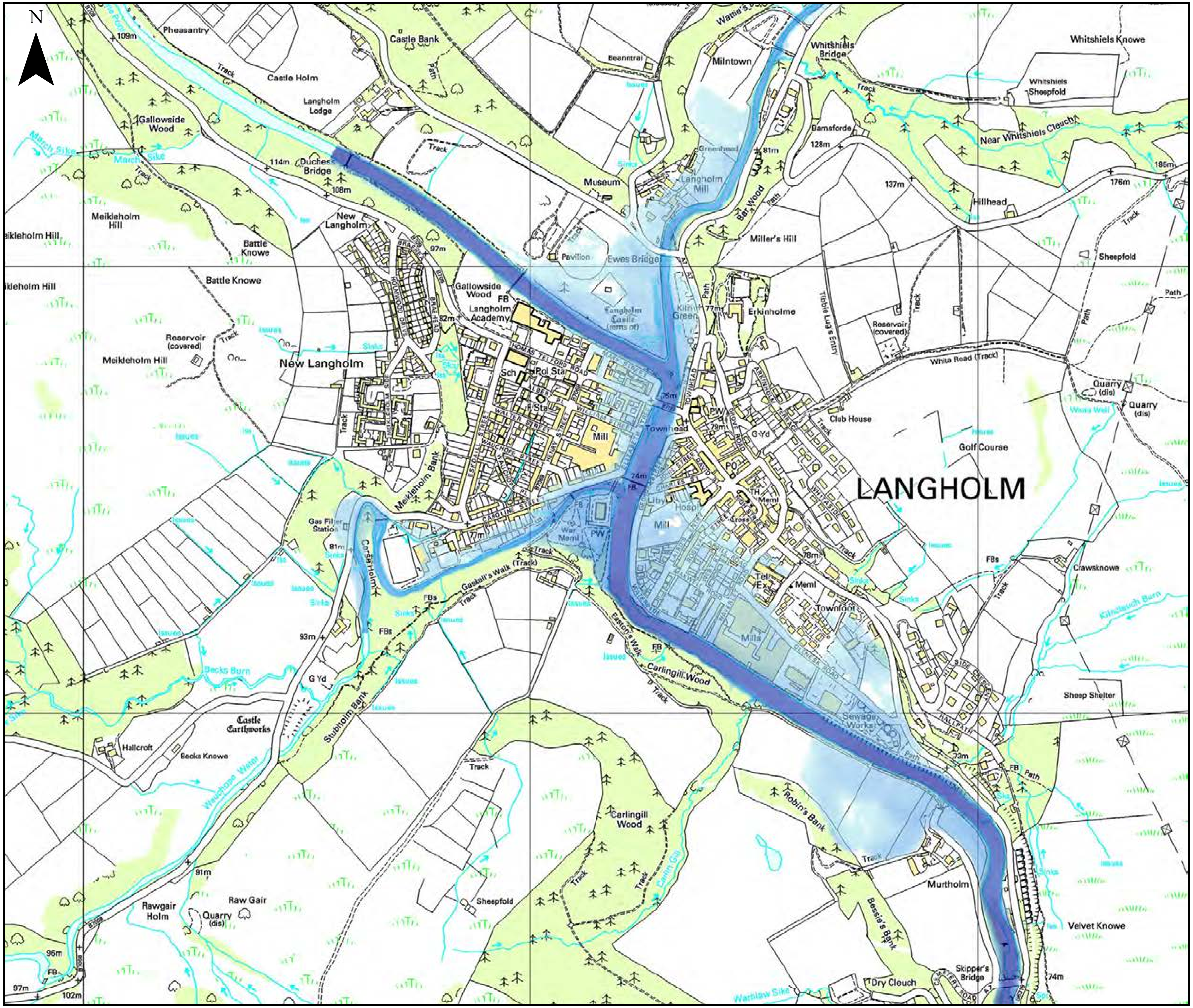
Flow Diff. (m)	Roughness Diff.	Resolution Diff.
0.294	0.440	0.000
0.293	0.450	0.000
0.294	0.468	0.000
0.286	0.459	0.000
0.276	0.424	0.000
0.268	0.512	0.000
0.285	0.543	0.000
0.289	0.554	0.000
0.292	0.564	0.000
0.292	0.567	0.000
0.289	0.560	0.000
0.304	0.600	0.000
0.343	0.686	0.000
0.348	0.826	0.000
0.370	0.955	0.000
0.280	0.512	0.000
0.212	0.396	-0.001
0.191	0.321	0.000
0.154	0.257	-0.001
0.167	0.262	0.001
0.240	0.332	0.012
0.250	0.323	0.003
0.241	0.297	-0.002
0.303	0.194	0.002
0.278	0.444	0.000
0.232	0.457	0.000
0.230	0.444	0.000
0.239	0.456	0.000
0.244	0.467	0.000
0.249	0.461	0.001
0.251	0.480	0.000
0.240	0.366	0.001
0.211	0.370	0.000
0.219	0.404	0.001
0.228	0.439	0.002
0.237	0.482	0.001
0.261	0.534	0.001
0.389	0.660	-0.002
0.462	0.746	0.001
0.445	0.734	0.001
0.447	0.736	0.000
0.454	0.726	0.001
0.234	0.452	0.000
0.224	0.413	0.000
0.231	0.420	0.000
0.242	0.392	0.001
0.212	0.351	0.002
0.284	0.449	-0.001
0.266	0.466	0.001
0.318	0.365	0.000
0.420	0.691	0.000
0.424	0.676	0.001
0.429	0.688	0.000
0.430	0.695	0.002
0.428	0.686	0.001
0.429	0.688	0.000
0.542	1.141	0.003
0.531	1.143	0.003
0.559	1.021	0.003
0.536	0.957	0.002
0.514	0.913	0.003
0.503	0.868	0.002
0.518	0.855	0.003
0.467	0.752	0.002
0.357	-0.002	0.002
0.462	0.735	0.000
0.487	0.778	-0.008
0.442	0.738	0.001
0.481	0.753	0.001
0.453	0.735	0.002
0.466	0.740	0.001
0.486	0.745	0.002
0.455	0.727	0.003
0.441	0.719	0.003
0.441	0.707	0.004
0.429	0.688	0.000

RE_1267	75.043	75.487	75.752	75.045	0.444	0.709	0.002
RE_1290	75.005	75.456	75.721	75.005	0.451	0.716	0.000
RE_1311	74.973	75.424	75.696	74.97	0.451	0.723	-0.003
RE_1330	74.935	75.389	75.662	74.934	0.454	0.727	-0.001
RE_1357	74.891	75.346	75.615	74.89	0.455	0.724	-0.001
RE_1379	74.810	75.268	75.544	74.811	0.458	0.734	0.001
RE_1401	74.706	75.162	75.453	74.709	0.456	0.747	0.003
RE_1451	74.689	75.161	75.406	74.692	0.472	0.717	0.003
RE_1503	74.446	74.913	75.226	74.449	0.467	0.780	0.003
RE_1503-0-RE_1546	74.410	74.881	75.195	74.412	0.471	0.785	0.002
RE_1503-1-RE_1546	74.378	74.85	75.165	74.381	0.472	0.787	0.003
RE_1546	74.332	74.806	75.127	74.335	0.474	0.795	0.003
RE_1546-0-RE_1590	74.258	74.731	75.069	74.259	0.473	0.811	0.001
RE_1546-1-RE_1590	74.188	74.663	75.016	74.187	0.475	0.828	-0.001
RE_1590	74.122	74.6	74.959	74.117	0.478	0.837	-0.005
RE_1635	74.013	74.491	74.836	74.012	0.478	0.823	-0.001
RE_1686	73.878	74.331	74.659	73.877	0.453	0.781	-0.001
RE_1738	73.690	74.111	74.451	73.704	0.421	0.761	0.014
RE_1782	73.545	73.962	74.304	73.549	0.417	0.759	0.004
RE_1833	73.397	73.802	74.11	73.402	0.405	0.713	0.005
RE_1897	73.254	73.659	73.925	73.262	0.405	0.671	0.008
RE_1948	73.022	73.368	73.669	73.018	0.346	0.647	-0.004
RE_1998	72.865	73.197	73.495	72.867	0.332	0.630	0.002
RE_2060	72.649	73.002	73.334	72.651	0.353	0.685	0.002
RE_2101	72.542	72.952	73.283	72.544	0.410	0.741	0.002
RE_2147	72.435	72.868	73.201	72.437	0.433	0.766	0.002
RE_2147-0-RE_2204	72.377	72.813	73.157	72.379	0.436	0.780	0.002
RE_2147-1-RE_2204	72.322	72.755	73.108	72.324	0.433	0.786	0.002
RE_2204	72.270	72.714	73.073	72.272	0.444	0.803	0.002
RE_2232	72.108	72.591	72.983	72.111	0.483	0.875	0.003
RE_2325	72.028	72.563	72.89	72.031	0.535	0.862	0.003
RE_2431	71.639	72.177	72.589	71.642	0.538	0.950	0.003
RE_2431_int17	71.568	72.109	72.528	71.571	0.541	0.960	0.003
RE_2431_int35	71.492	72.038	72.465	71.494	0.546	0.973	0.002
RE_2431_int53	71.421	71.975	72.406	71.423	0.554	0.985	0.002
RE_2431_int71	71.349	71.913	72.347	71.351	0.564	0.998	0.002
RE_2431_int89	71.259	71.829	72.273	71.262	0.570	1.014	0.003
RE_2431_int106	71.167	71.746	72.2	71.17	0.579	1.033	0.003
RE_2555	71.086	71.682	72.141	71.089	0.596	1.055	0.003
RE_2555_int24	70.886	71.473	71.973	70.888	0.587	1.087	0.002
RE_2555_int49	70.740	71.312	71.816	70.743	0.572	1.076	0.003
RE_2555_int74	70.617	71.192	71.696	70.62	0.575	1.079	0.003
RE_2654	70.528	71.107	71.603	70.531	0.579	1.075	0.003
RE_2734	70.356	70.948	71.389	70.359	0.592	1.033	0.003
RE_2842_US	69.985	70.546	70.996	69.988	0.561	1.011	0.003
RE_0000	79.033	79.607	80.089	79.034	0.574	1.056	0.001
RE_0049	78.895	79.456	79.918	78.895	0.561	1.023	0.000
RE_0154	78.575	79.11	79.555	78.575	0.535	0.980	0.000
RE_0259	78.247	78.753	79.154	78.247	0.506	0.907	0.000
RE_0358	77.914	78.373	78.747	77.915	0.459	0.833	0.001
RE_0412	77.739	78.143	78.482	77.739	0.404	0.743	0.000
RE_0464	77.616	77.999	78.257	77.616	0.383	0.641	0.000
RE_0506	77.575	77.944	78.14	77.575	0.369	0.565	0.000
RE_0563	77.332	77.678	77.886	77.332	0.346	0.554	0.000
RE_0623	77.134	77.482	77.664	77.134	0.348	0.530	0.000
RE_0673	76.973	77.329	77.487	76.973	0.356	0.514	0.000
RE_0730	76.771	77.15	77.29	76.769	0.379	0.519	-0.002
RE_0778	76.559	76.988	77.128	76.553	0.429	0.569	-0.006
RE_0833	76.396	76.85	76.981	76.396	0.454	0.585	0.000
RE_0894	76.382	76.848	76.944	76.376	0.466	0.562	-0.006
EK015	76.268	76.725	76.841	76.268	0.457	0.573	0.000
EK015-0-EK016	76.315	76.789	76.864	76.314	0.474	0.549	-0.001
EW_1115	76.709	76.883	77.076	76.71	0.174	0.367	0.001
EW_1115_int5	76.607	76.881	77.067	76.608	0.274	0.460	0.001
EW_1115_int11	76.525	76.882	77.06	76.525	0.357	0.535	0.000
EW_1115_int17	76.471	76.885	77.055	76.47	0.414	0.584	-0.001
EW_1138	76.451	76.889	77.052	76.452	0.438	0.601	0.001
EW_1181	76.395	76.851	76.998	76.396	0.456	0.603	0.001
EW_1181_int14	76.386	76.847	76.986	76.386	0.461	0.600	0.000
EW_1181_int28	76.379	76.841	76.977	76.38	0.462	0.598	0.001
EW_1181_int43	76.375	76.836	76.967	76.375	0.461	0.592	0.000
EW_1239	76.373	76.838	76.962	76.374	0.465	0.589	0.001
EW_1239-0-EW_1347	76.352	76.823	76.943	76.354	0.471	0.591	0.002
EW_1239-1-EW_1347	76.319	76.788	76.895	76.313	0.469	0.576	-0.006
EW_1347	76.281	76.75	76.838	76.282	0.469	0.557	0.001
EK015-0-EK016	76.315	76.789	76.864	76.314	0.474	0.549	-0.001
RE_1001	75.275	75.67	76.028	75.277	0.395	0.753	0.002

RE_1017	75.321	75.72	76.045	75.322		0.399	0.724	0.001
RE_1037	75.287	75.697	76.014	75.288		0.410	0.727	0.001
RE_1063	75.265	75.684	75.989	75.265		0.419	0.724	0.000
RE_1085	75.262	75.677	75.971	75.262		0.415	0.709	0.000
RE_1111	75.244	75.663	75.947	75.244		0.419	0.703	0.000
RE_1133	75.212	75.629	75.914	75.213		0.417	0.702	0.001
RE_1151	75.189	75.606	75.884	75.189		0.417	0.695	0.000
RE_Weir	75.166	75.584	75.869	75.166		0.418	0.703	0.000
RE_1178	75.170	75.59	75.859	75.17		0.420	0.689	0.000
RE_1197!	75.156	75.577	75.844	75.157		0.421	0.688	0.001
EK015-0-EK016	76.315	76.789	76.864	76.314		0.474	0.549	-0.001
EK015-1-EK016	76.131	76.609	76.72	76.136		0.478	0.589	0.005
EK016	76.071	76.543	76.636	76.063		0.472	0.565	-0.008
EK017	75.931	76.408	76.489	75.937		0.477	0.558	0.006
RE_0984	75.991	76.466	76.485	75.993		0.475	0.494	0.002
					Max. Difference (m)	0.60	1.14	0.01

APPENDIX G

Flood Maps – Design Scenarios



Legend

0.1% AEP Design Extent

Value

High : 7

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

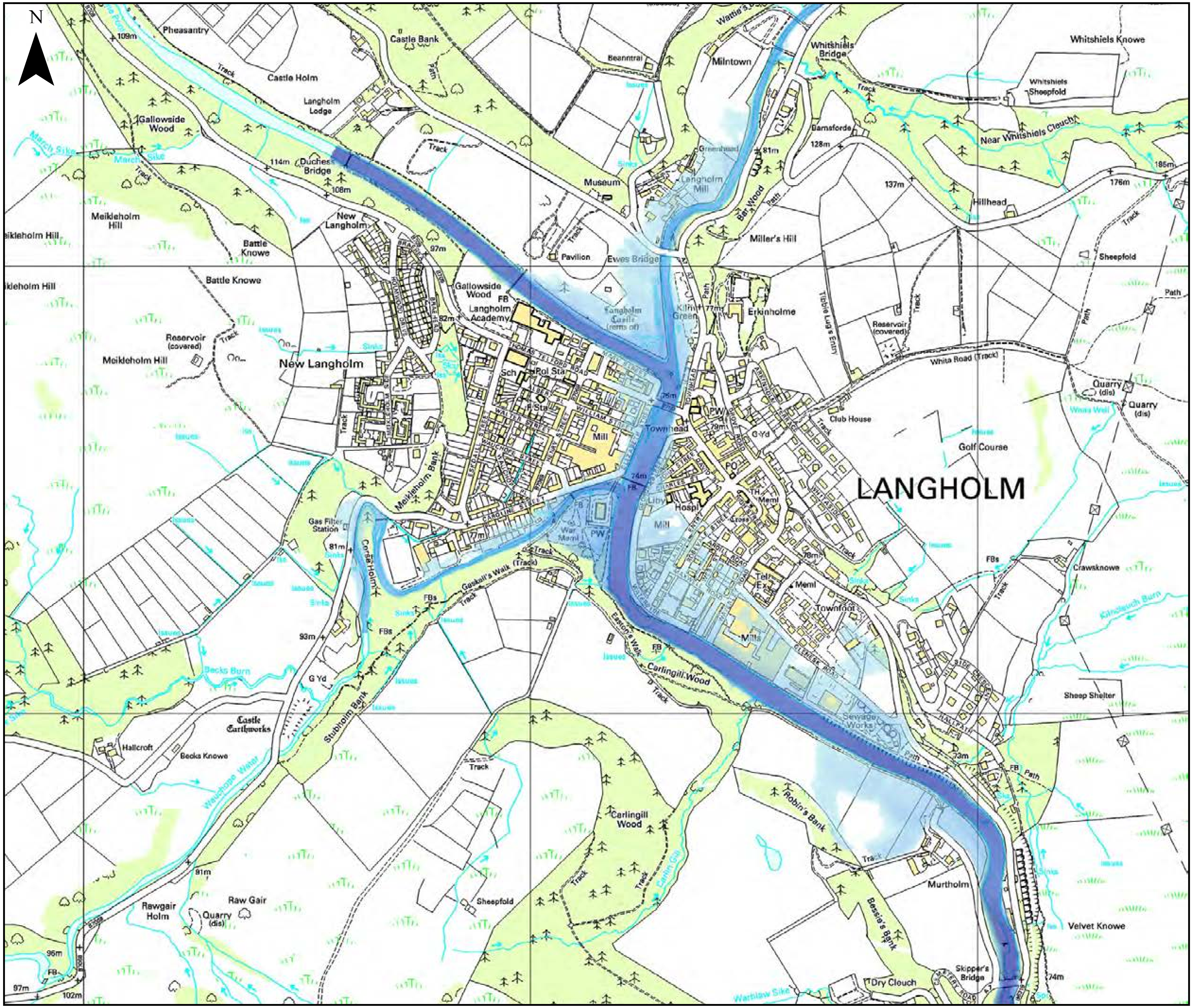
Client: Dumfries & Galloway Council

Project: LANGHOLM Flood Protection Scheme

Title:
Flood Extent Map
EXISTING SCENARIO
0.1% AEP

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



Legend

0.5% AEP Design Extent

Value

High : 6.5

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

Client:

Dumfries & Galloway

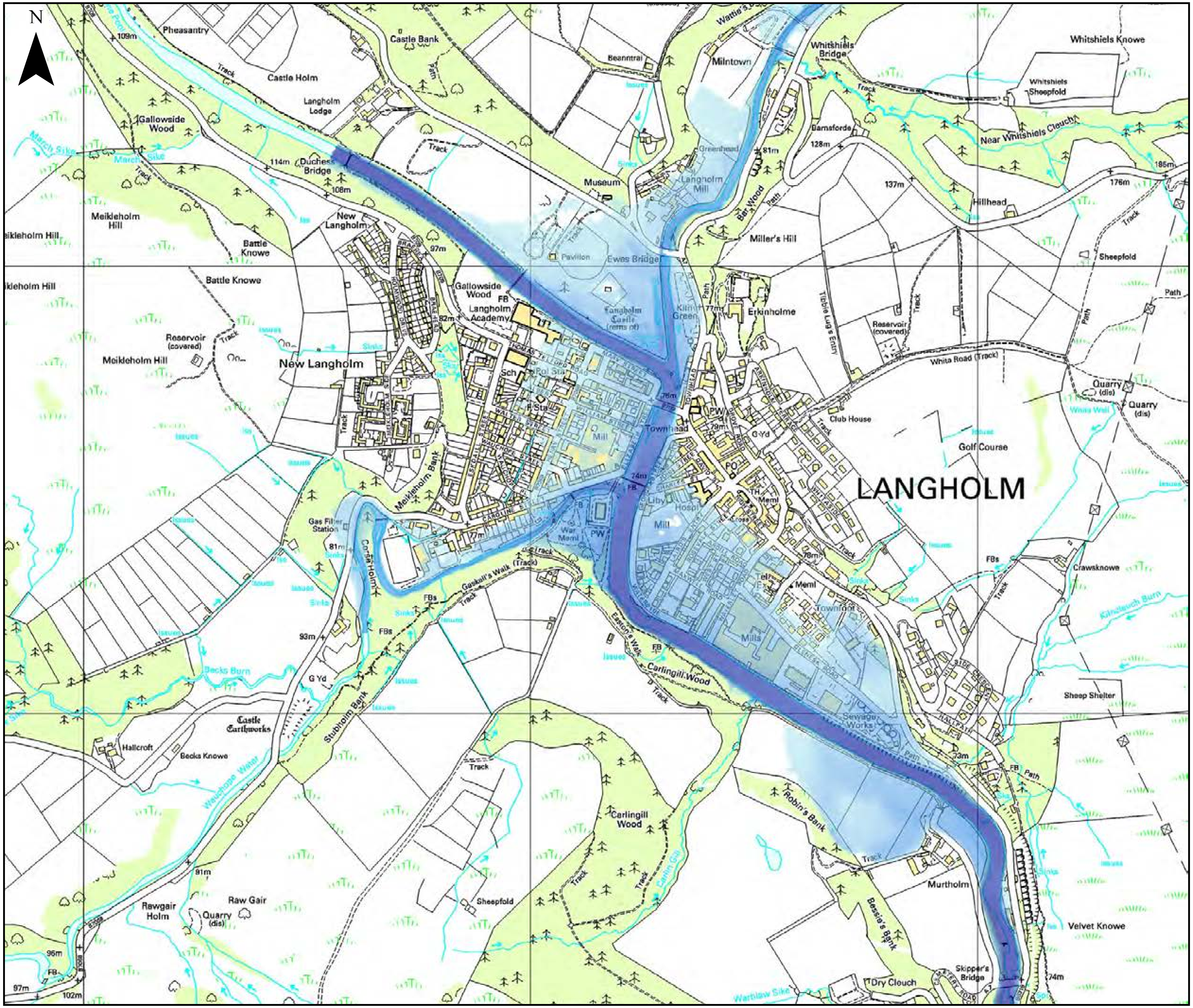
Project:

LANGHOLM
Flood Protection Scheme

Title:

Flood Extent Map
EXISTING SCENARIO
0.5% AEP

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 220/05/19
Scale : NTS



Legend

0.5%CC Design Extent

Value

High : 7.7

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

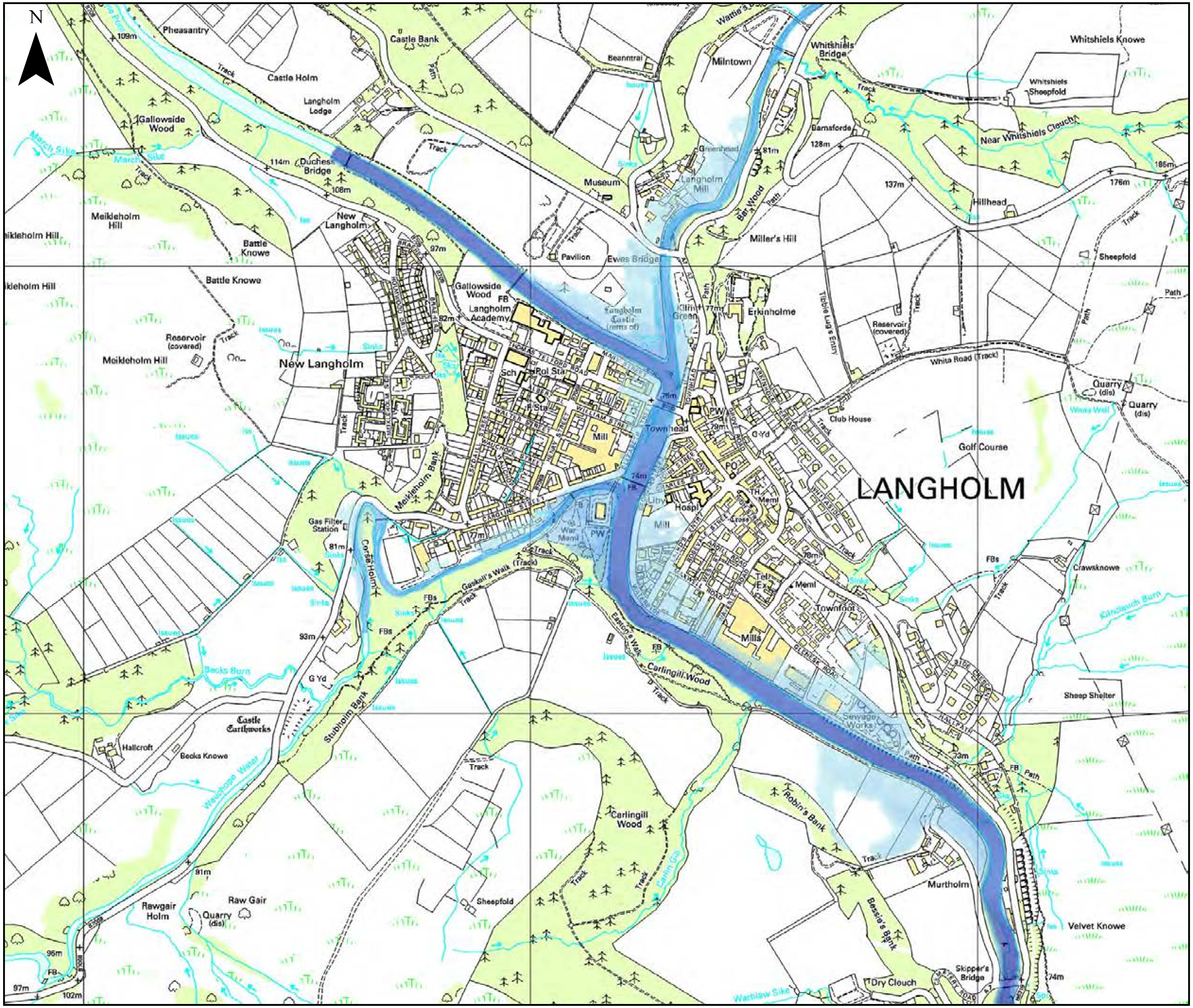
Client: Dumfries & Galloway Council

Project: LANGHOLM Flood Protection Scheme

Title:
Flood Extent Map
EXISTING SCENARIO
0.5%CC AEP

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



Legend

1% AEP Design Extent

Value

High : 6.2

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

Client:

Dumfries & Galloway Council

Project:

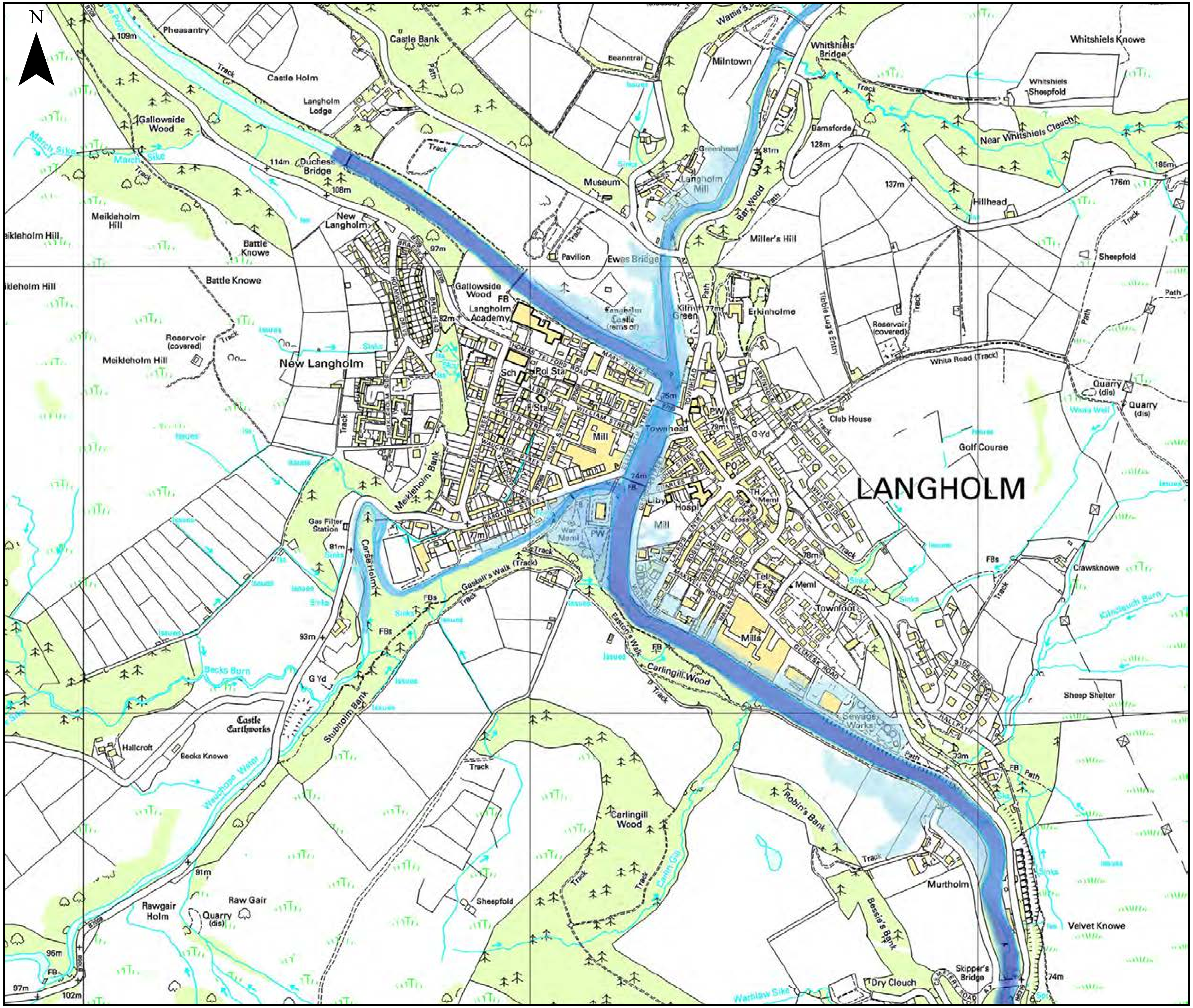
LANGHOLM
Flood Protection Scheme

Title:

Flood Extent Map
EXISTING SCENARIO
1% AEP

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



Legend

3.33% AEP Design Extent

Value

High : 5.8

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

Client:

Dumfries & Galloway Council

Project:

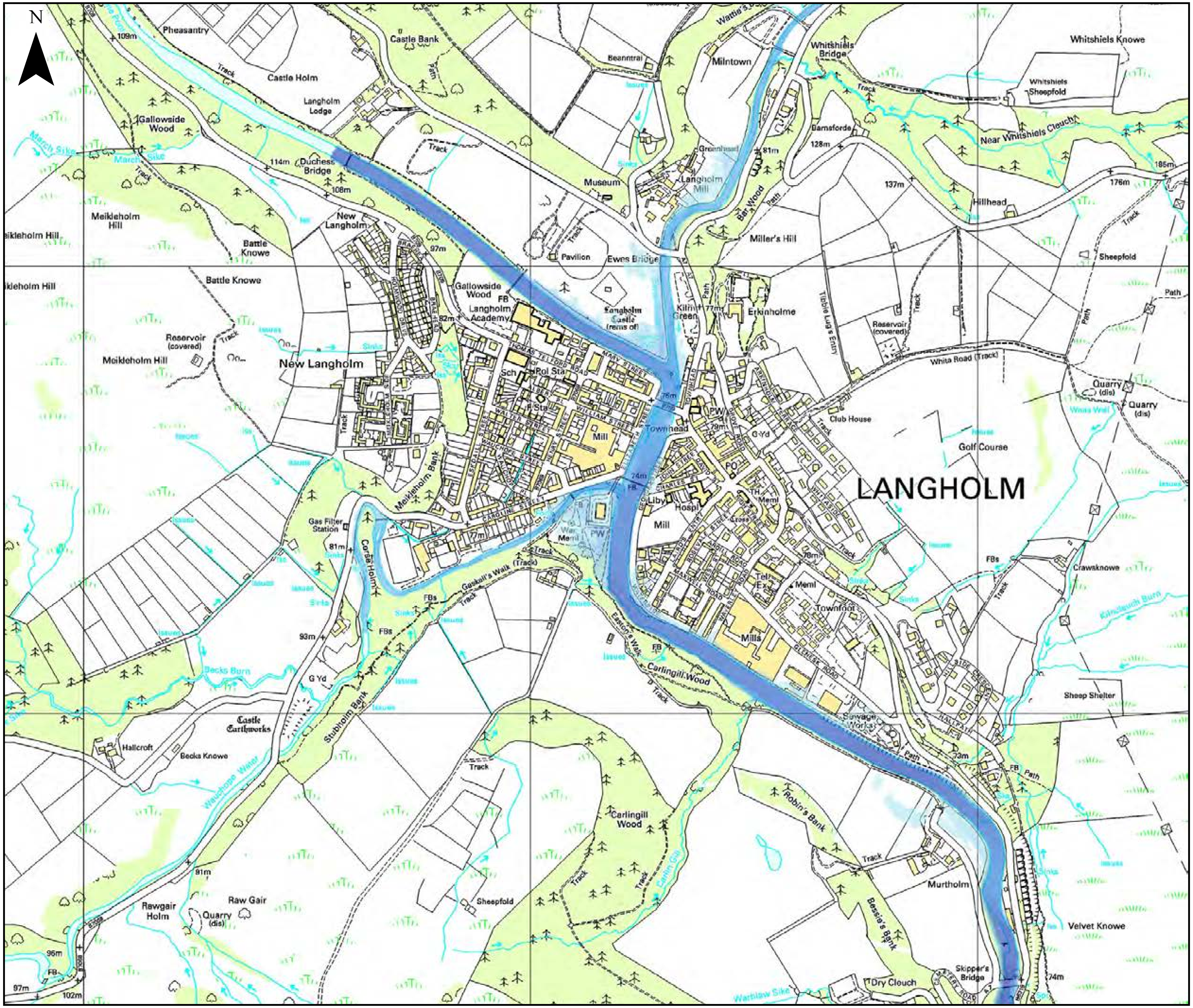
LANGHOLM
Flood Protection Scheme

Title:

Flood Extent Map
EXISTING SCENARIO
3.33% AEP

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



Legend

10% AEP Design Extent

Value

- High : 5.3
- Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

Client:

Dumfries & Galloway Council

Project:

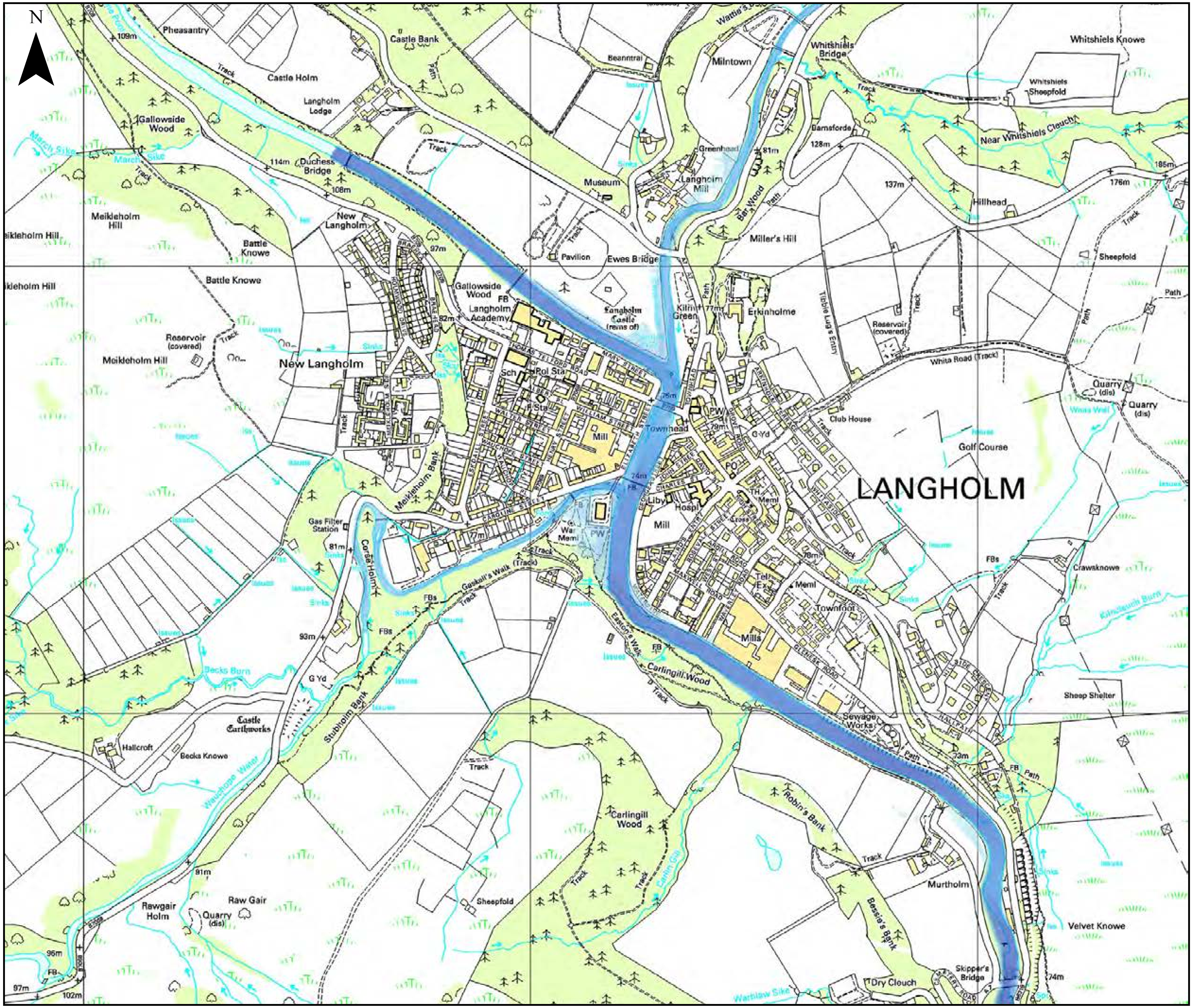
LANGHOLM
Flood Protection Scheme

Title:

Flood Extent Map
EXISTING SCENARIO
10% AEP

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



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Legend

q5

Value

High : 5

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

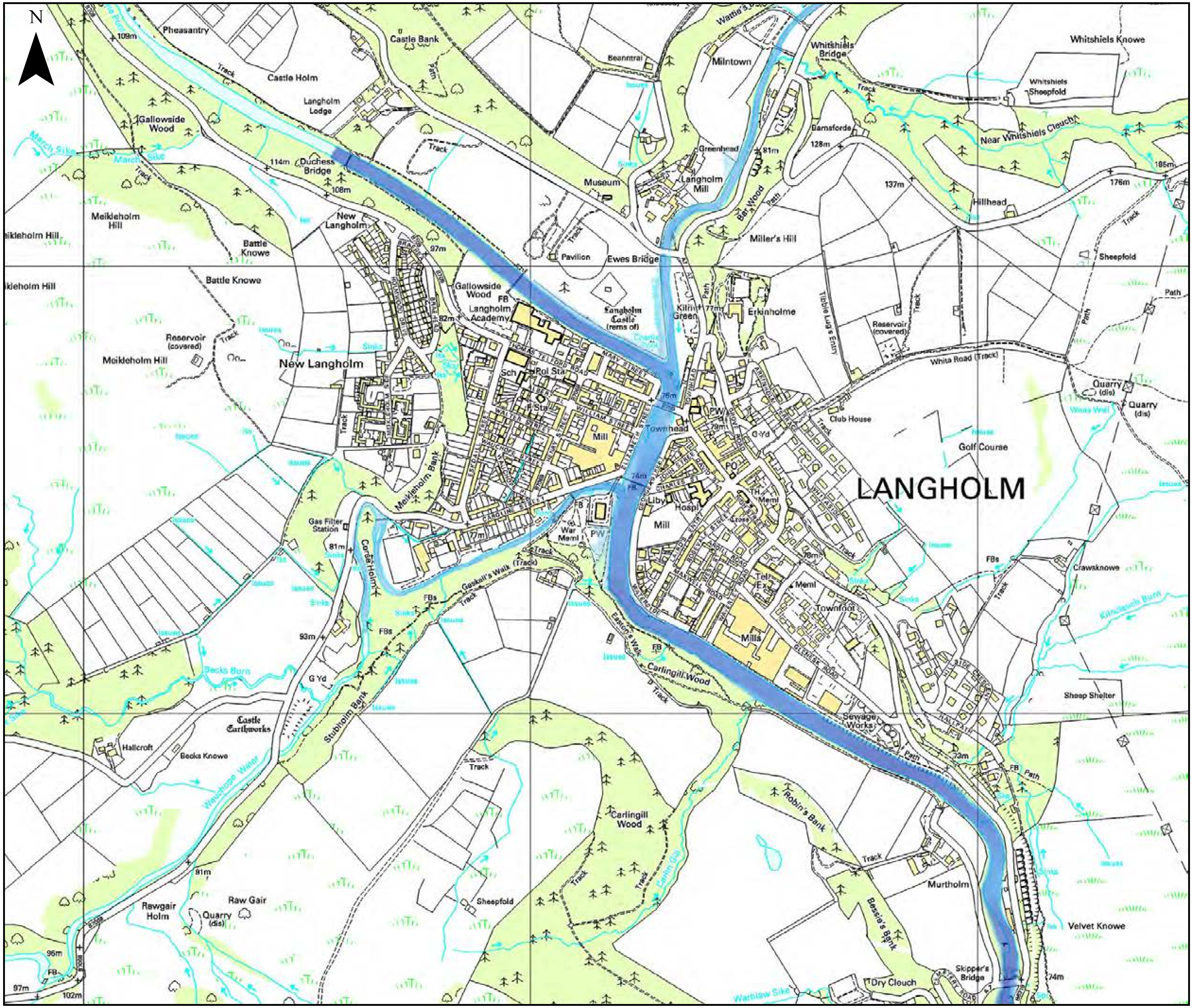
Client: Dumfries & Galloway Council

Project: LANGHOLM Flood Protection Scheme

Title: Flood Extent Map EXISTING SCENARIO 20% AEP

rps MAKING COMPLEX EASY

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS



Legend

50% AEP Design Extent

Value

High : 4.4

Low : 0

Water Depth (m)

REV:	NOTE:	DATE:

Client:

Dumfries & Galloway

Project:

LANGHOLM
Flood Protection Scheme

Title:

Flood Extent Map
EXISTING SCENARIO
50% AEP

rps

Drawn By : GMcK
Checked By : FC
Approved By : FC
Date : 20/05/19
Scale : NTS