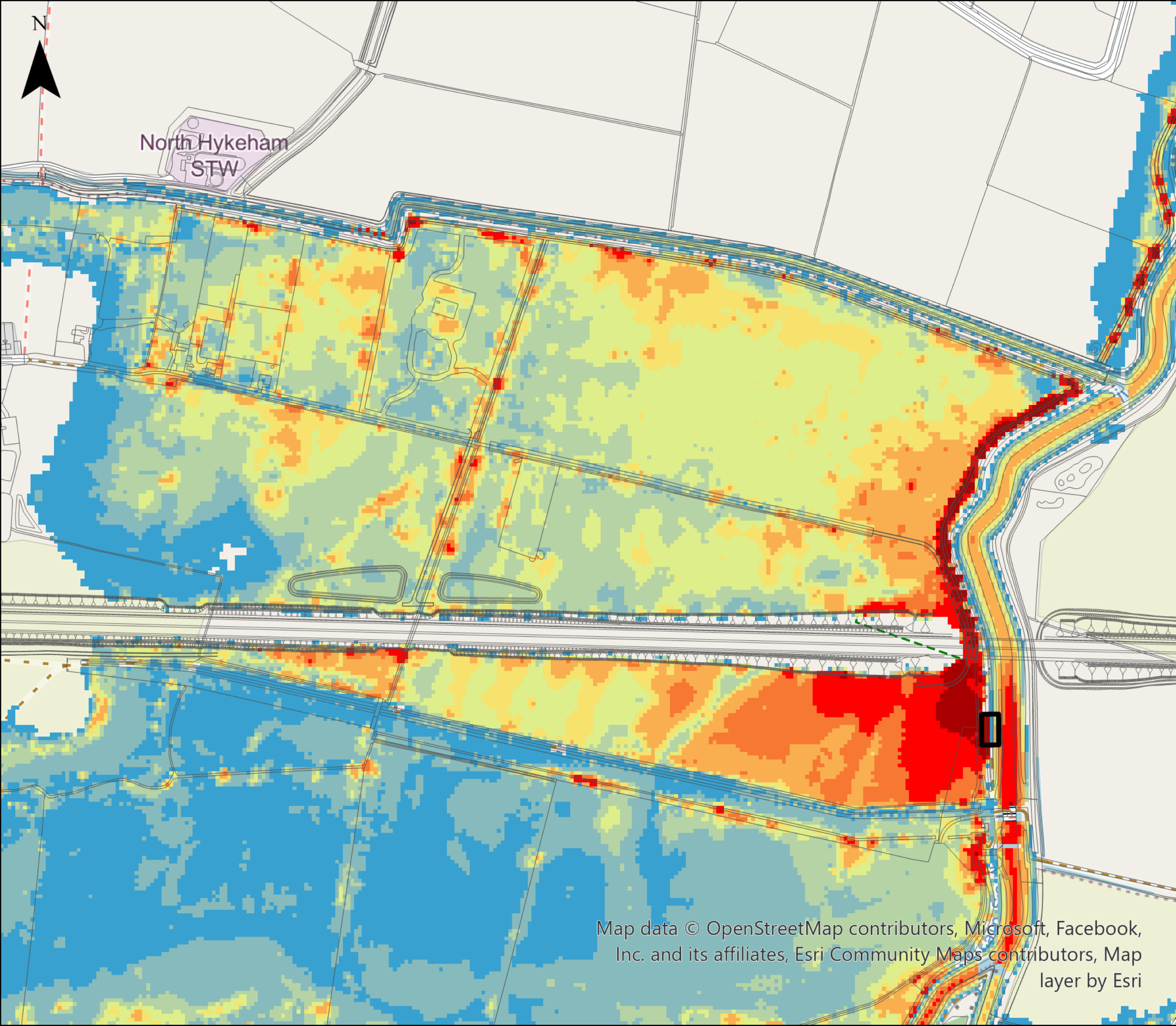


Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 100-year Climate Change (2080 Higher)

Velocity (m/s)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title

NHRR Hydraulic Modelling Flood Velocities

Project Name

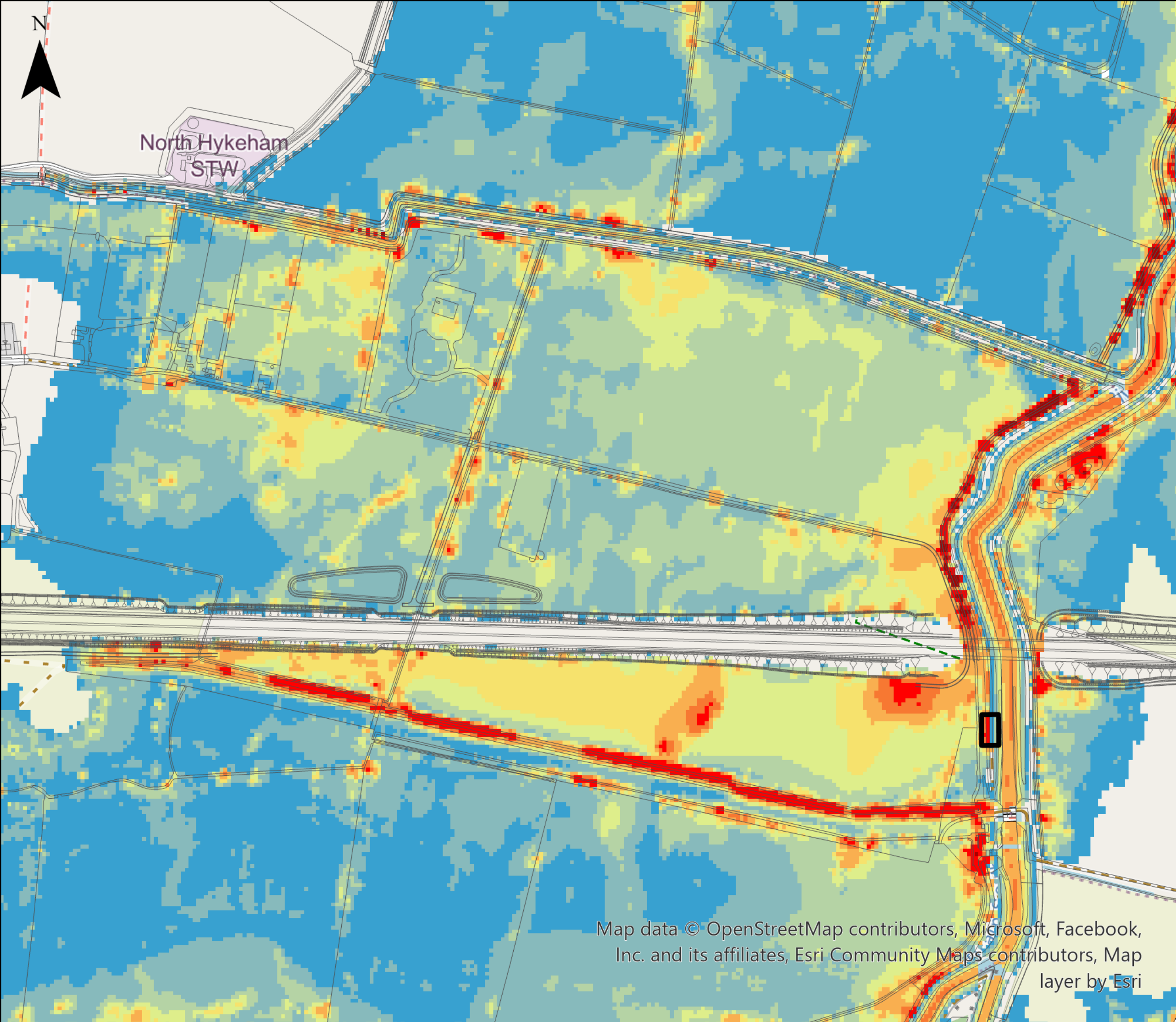
North Hykeham Relief Road

Project Number	Issue
1620013942	1
Date	Prepared By
June 2023	HN

Client

Balfour Beatty

RAMBØLL



Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 1000-year

Velocity (m/s)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title

NHRR Hydraulic Modelling Flood Velocities

Project Name

North Hykeham Relief Road

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1620013942	1

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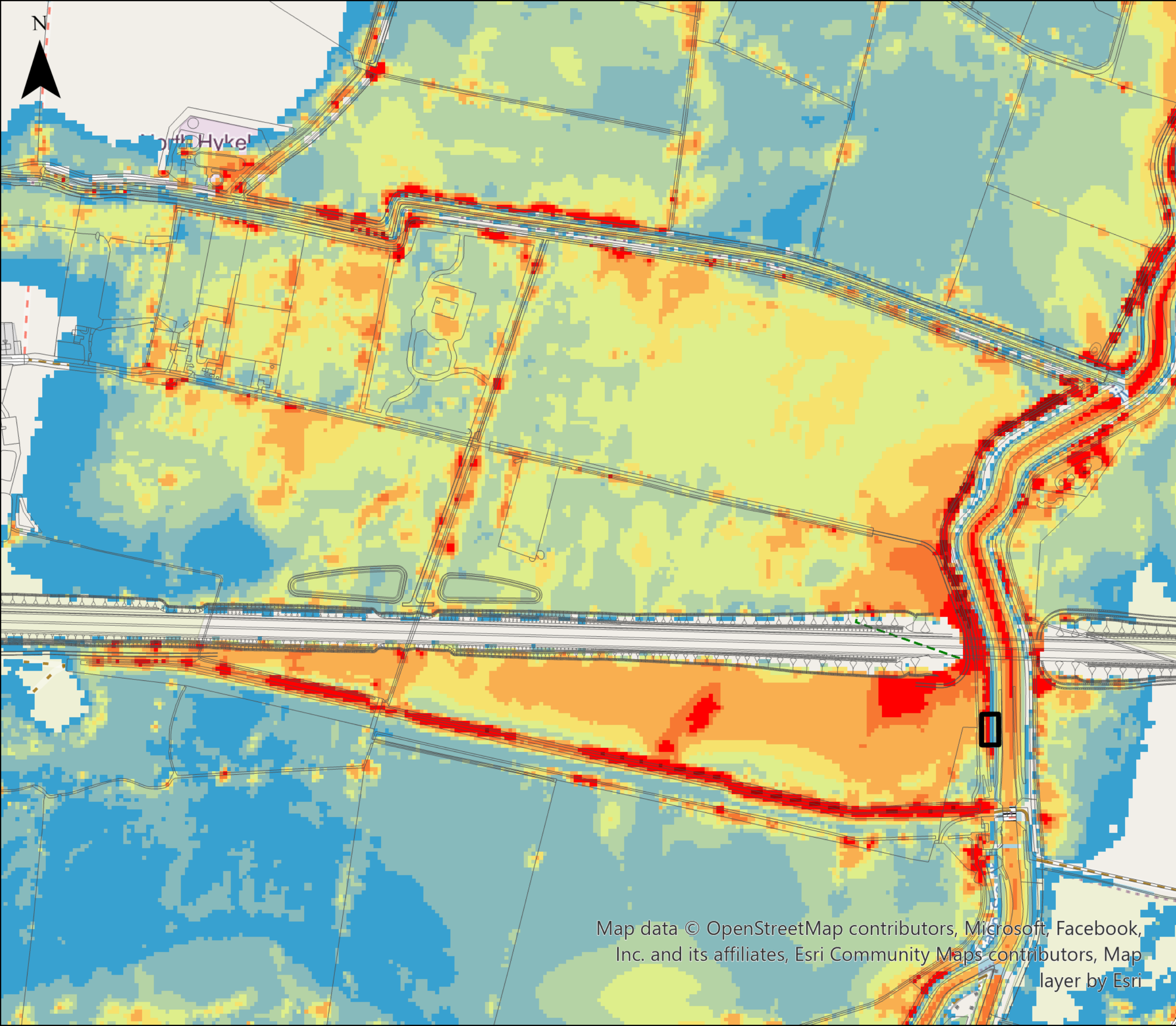

Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 1000-year Climate Change (2080 Higher)

Velocity (m/s)

- < 0.1
- 0.1 - 0.2
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- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title

NHRR Hydraulic Modelling Flood Velocities

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1

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Client

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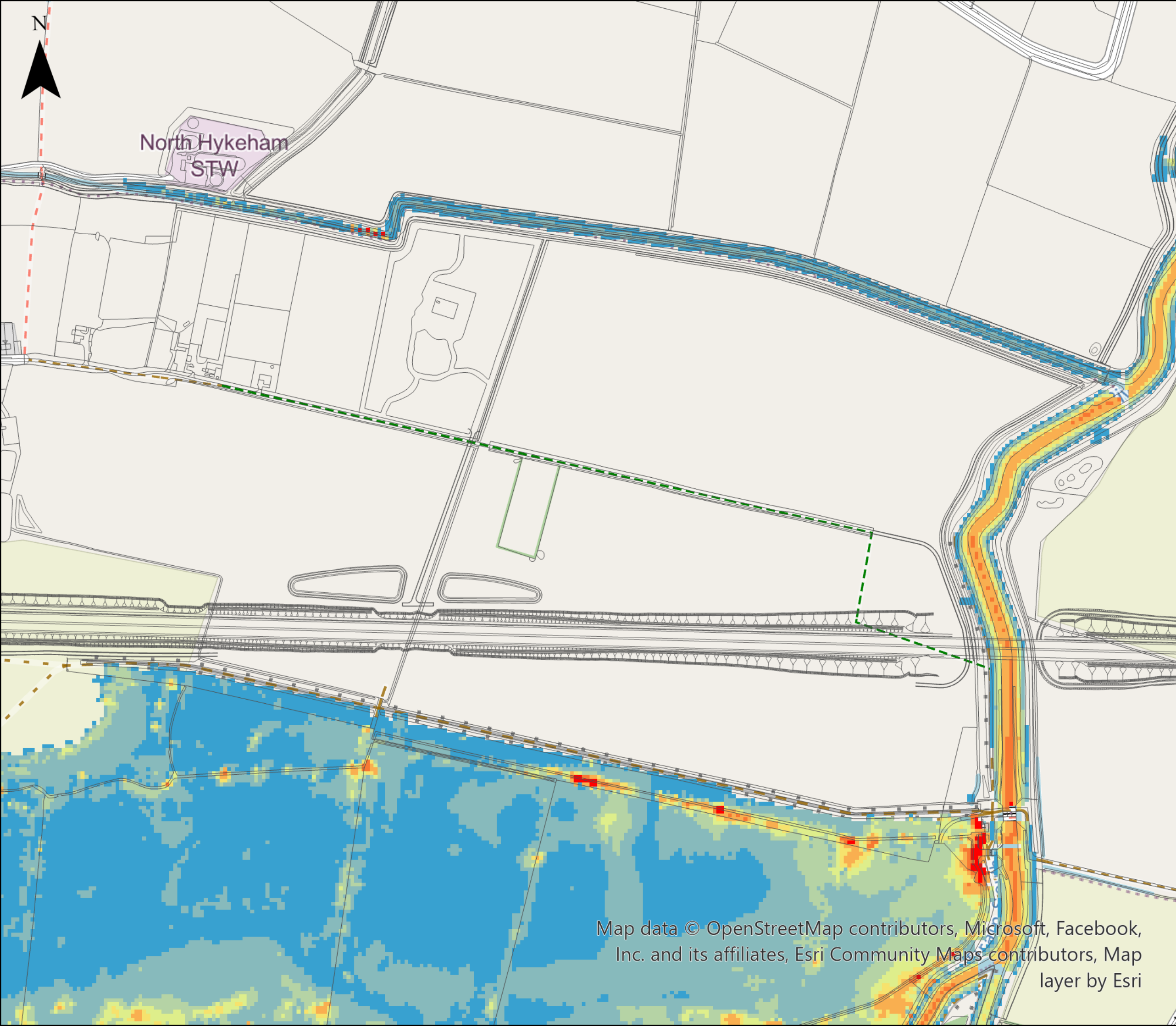

Legend

NHRR scheme

NHRR 100-year

Velocity (m/s)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title

NHRR Hydraulic Modelling Flood Velocities

Project Name

North Hykeham Relief Road

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1620013942	1
Date	**Prepared By**
June 2023	HN

Client

Balfour Beatty

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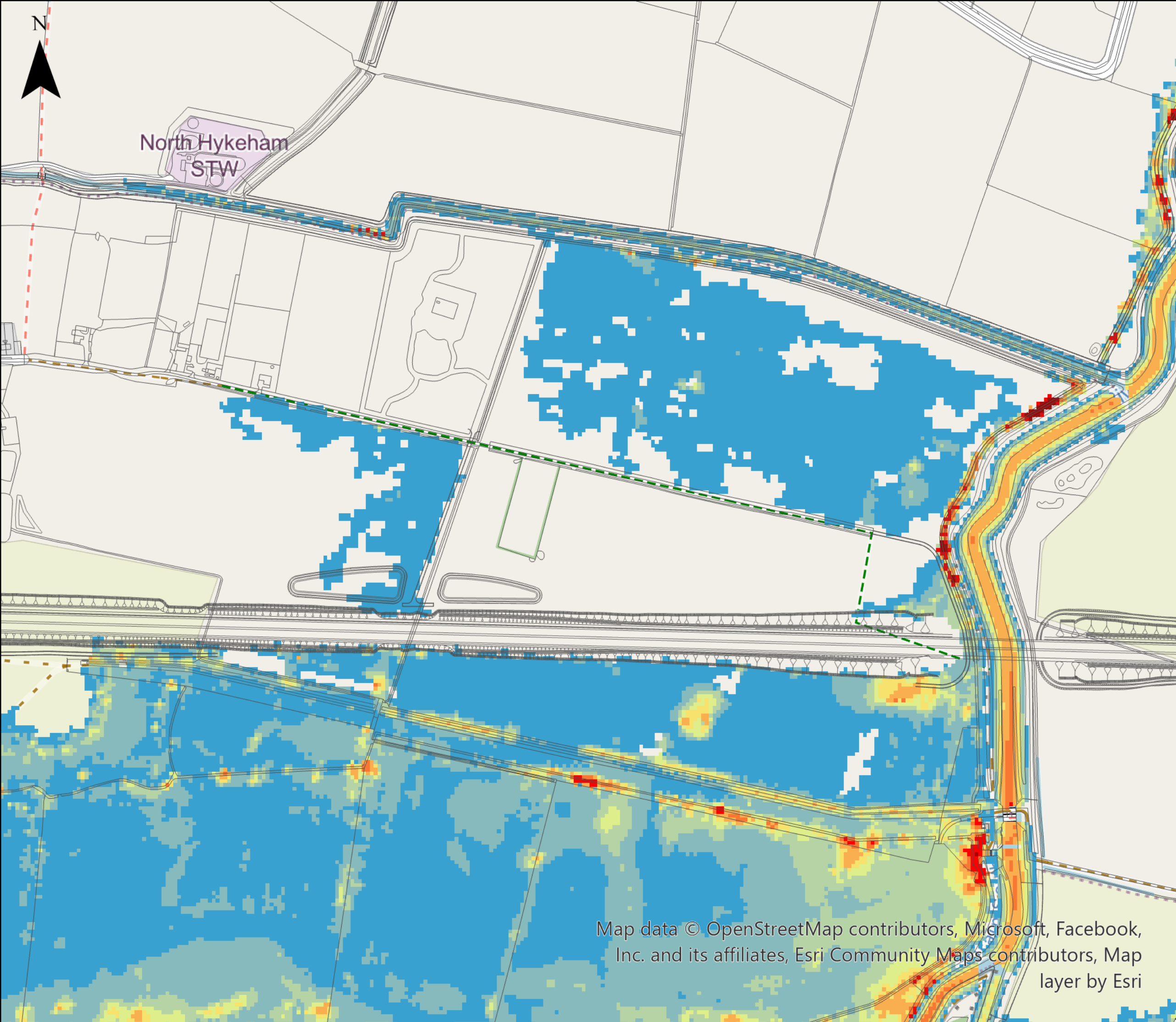

Legend

NHRR scheme

NHRR 100-year Climate Change (2080 Higher)

Velocity (m/s)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
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- 0.4 - 0.5
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- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title

NHRR Hydraulic Modelling Flood Velocities

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1

Date	Prepared By
June 2023	HN

Client

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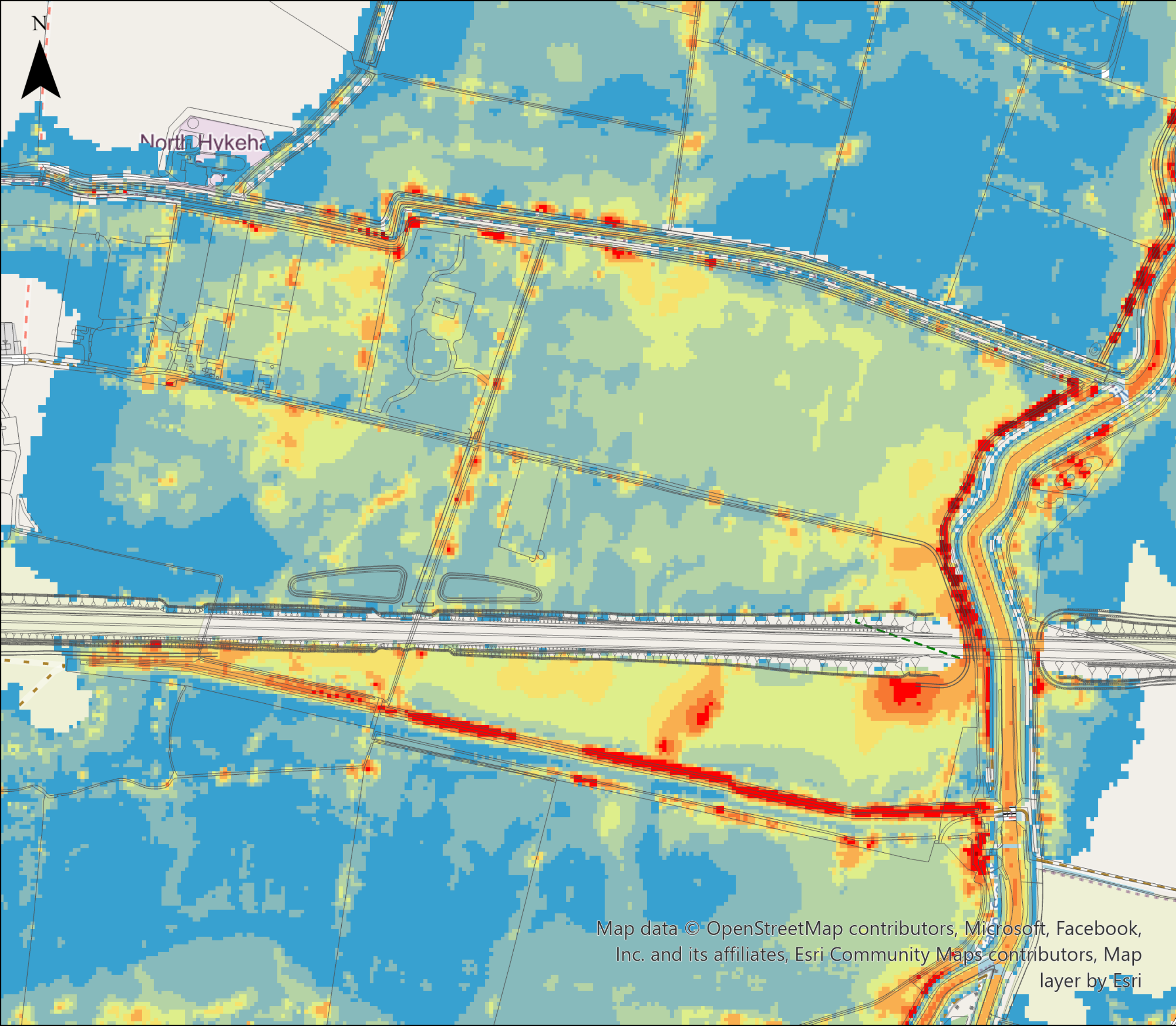


Legend

NHRR scheme

NHRR 1000-year Velocity (m/s)

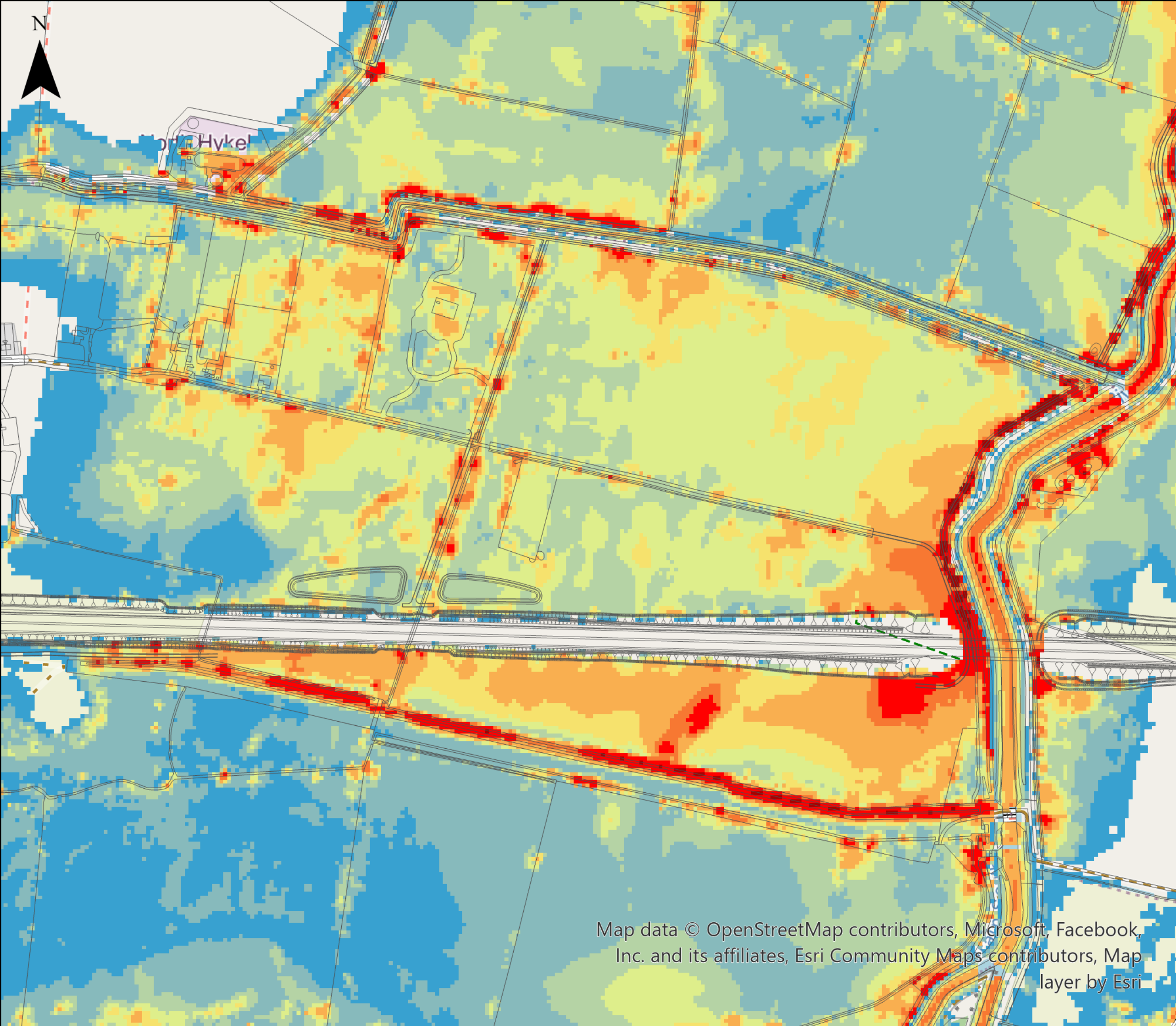
- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title	
NHRR Hydraulic Modelling Flood Velocities	
Project Name	
North Hykeham Relief Road	
Project Number: 1620013942	Issue: 1
Date: June 2023	Prepared By: HN
Client	
Balfour Beatty	

RAMBOLL



Legend

NHRR scheme

NHRR 1000-year Climate Change (2080 Higher)

Velocity (m/s)

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- 0.1 - 0.2
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- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 <

Scale

0 0.05 0.1 0.2 km

Figure Title

NHRR Hydraulic Modelling Flood Velocities

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1

Date	Prepared By
June 2023	HN

Client

Balfour Beatty

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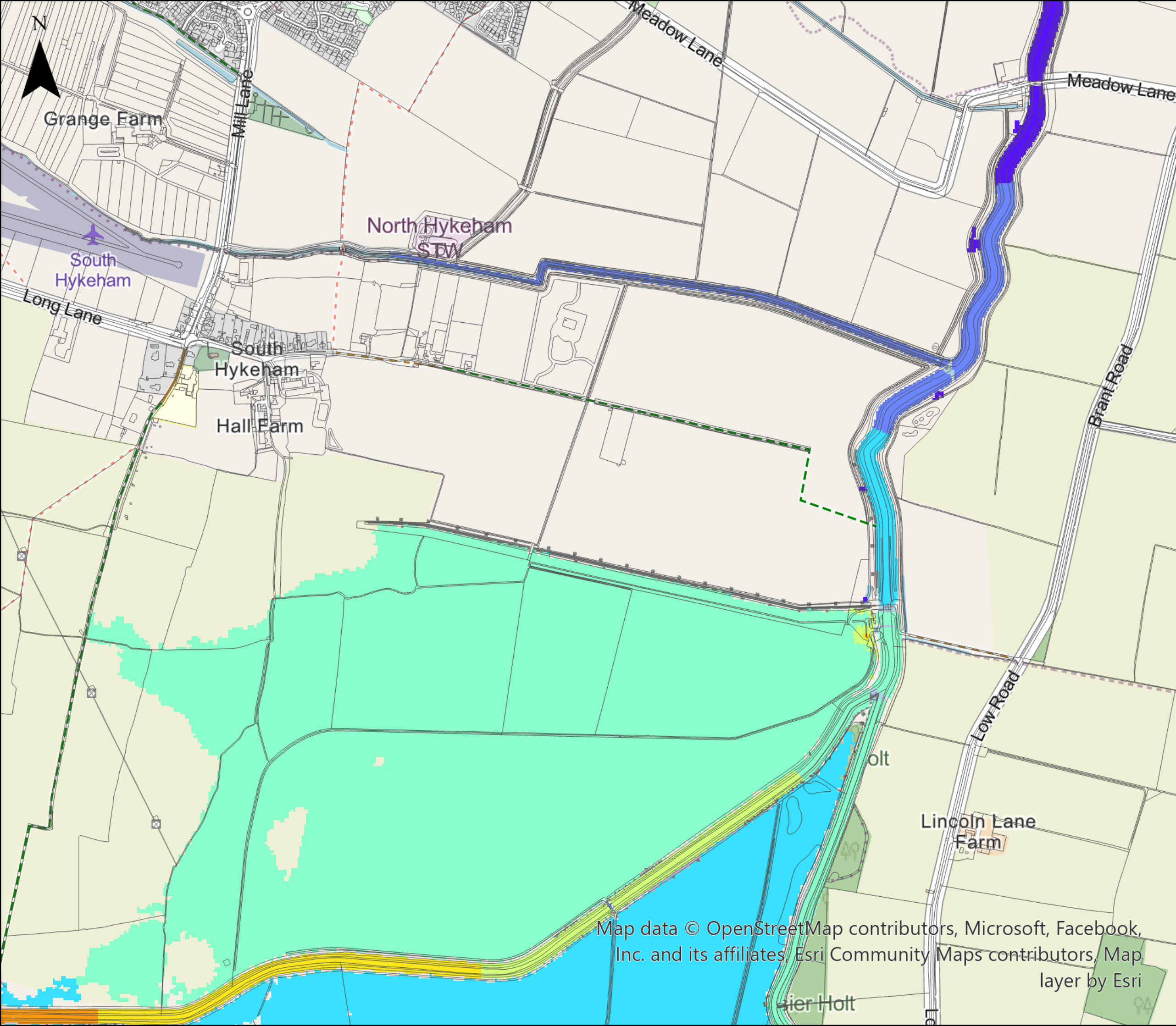

Legend

Baseline 100-year Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
- 7.0 - 7.2
- 7.2 - 7.4
- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1

Date	Prepared By
June 2023	HN

Client

Balfour Beatty

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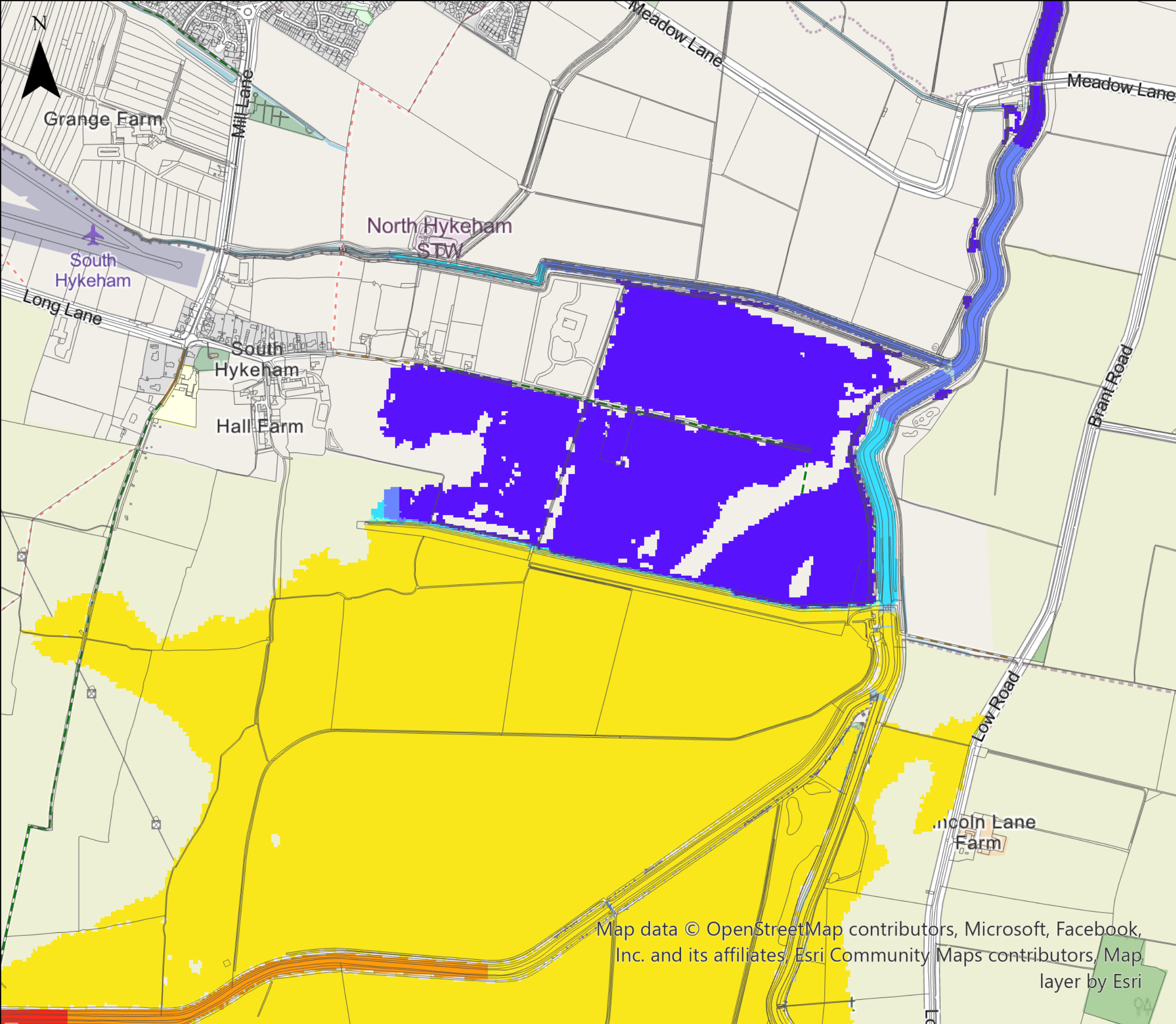

Legend

Baseline 100-year Climate Change (2080 Higher)

Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
- 7.0 - 7.2
- 7.2 - 7.4
- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1

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June 2023	HN

Client

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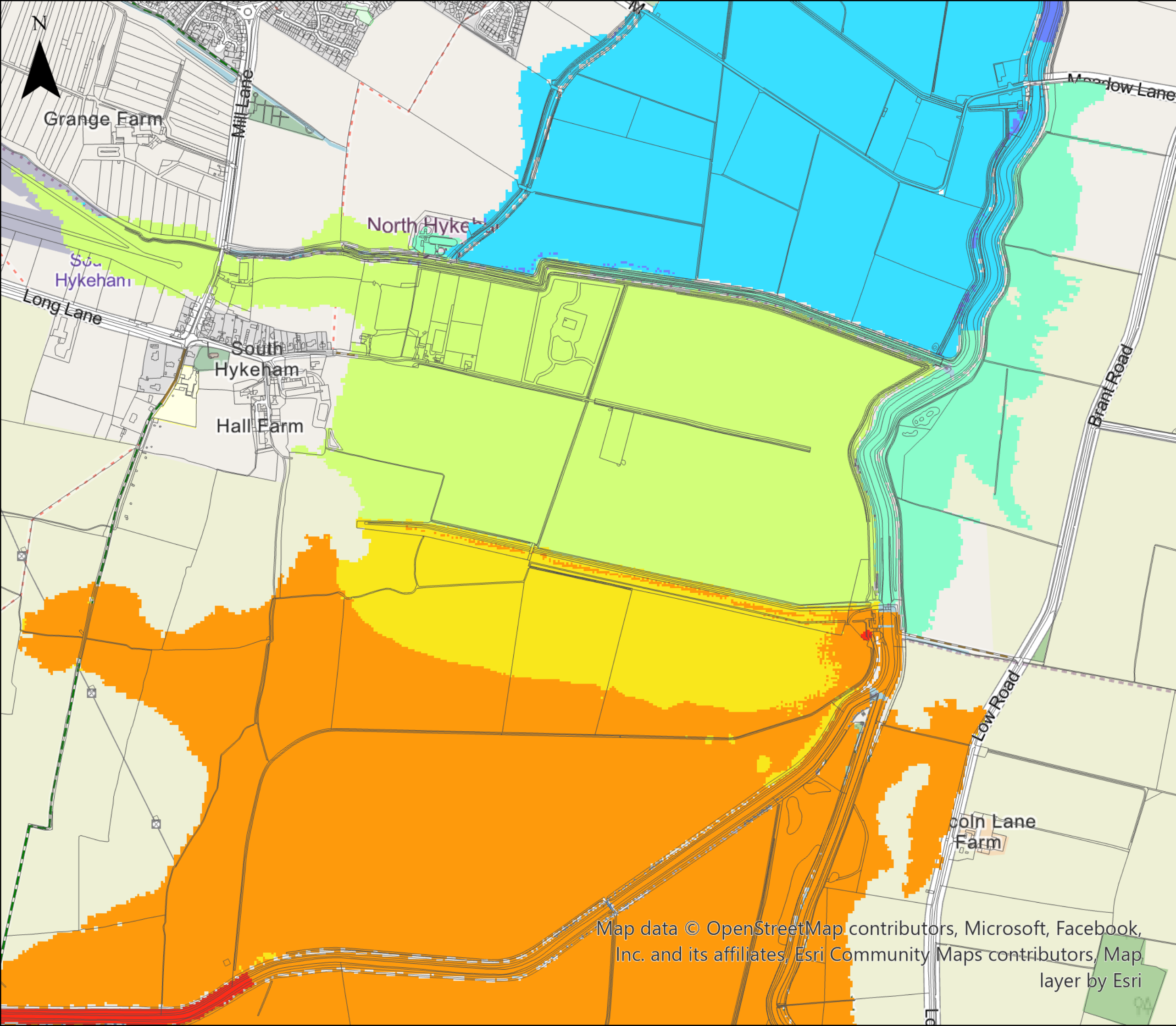

Legend

Baseline 1000-year Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
- 7.0 - 7.2
- 7.2 - 7.4
- 7.4 - 7.6
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Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1

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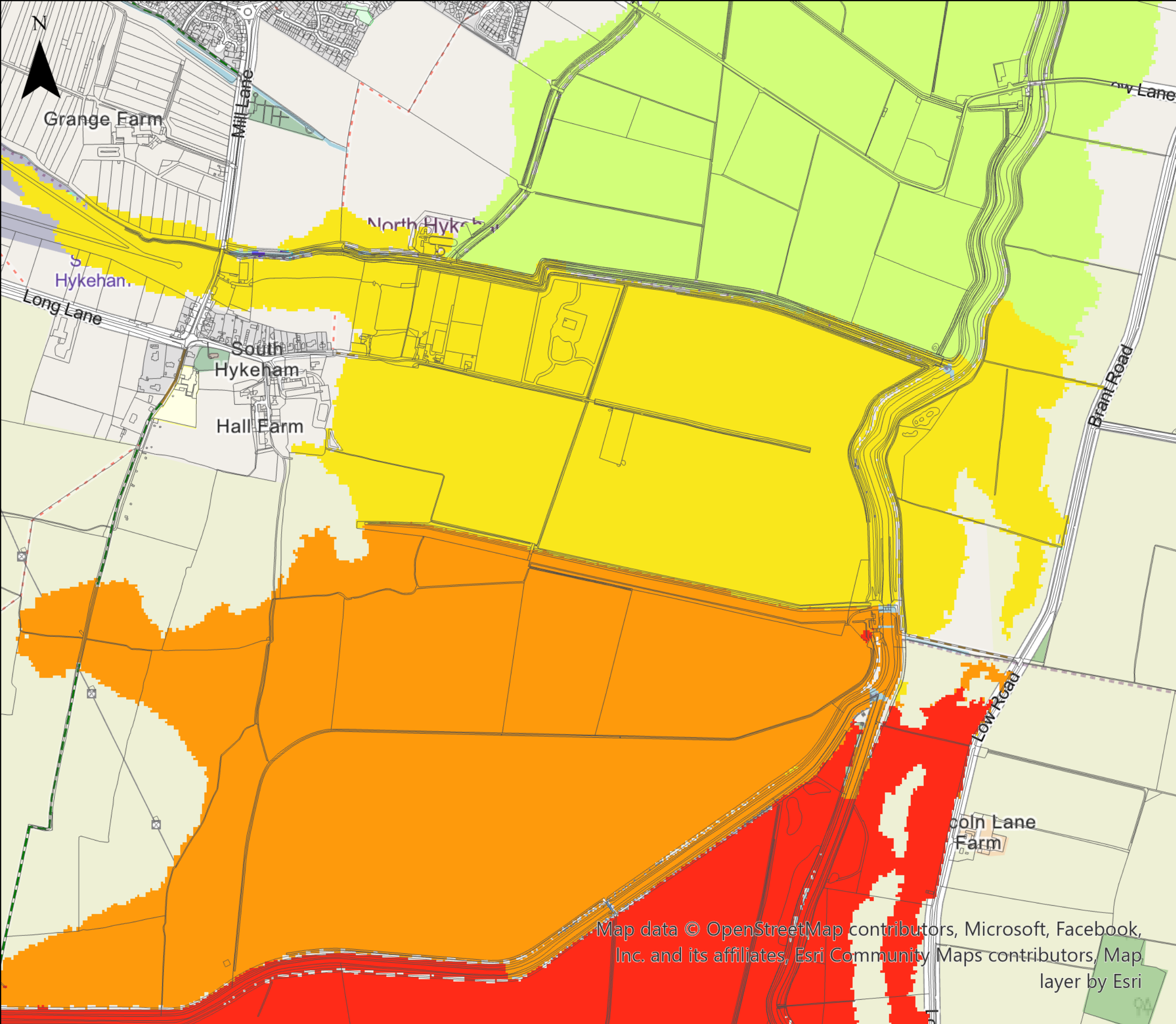

Legend

Baseline 1000-year Climate Change (2080 Higher)

Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
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- 7.2 - 7.4
- 7.4 - 7.6
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- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1
Date	Prepared By
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Client

Balfour Beatty

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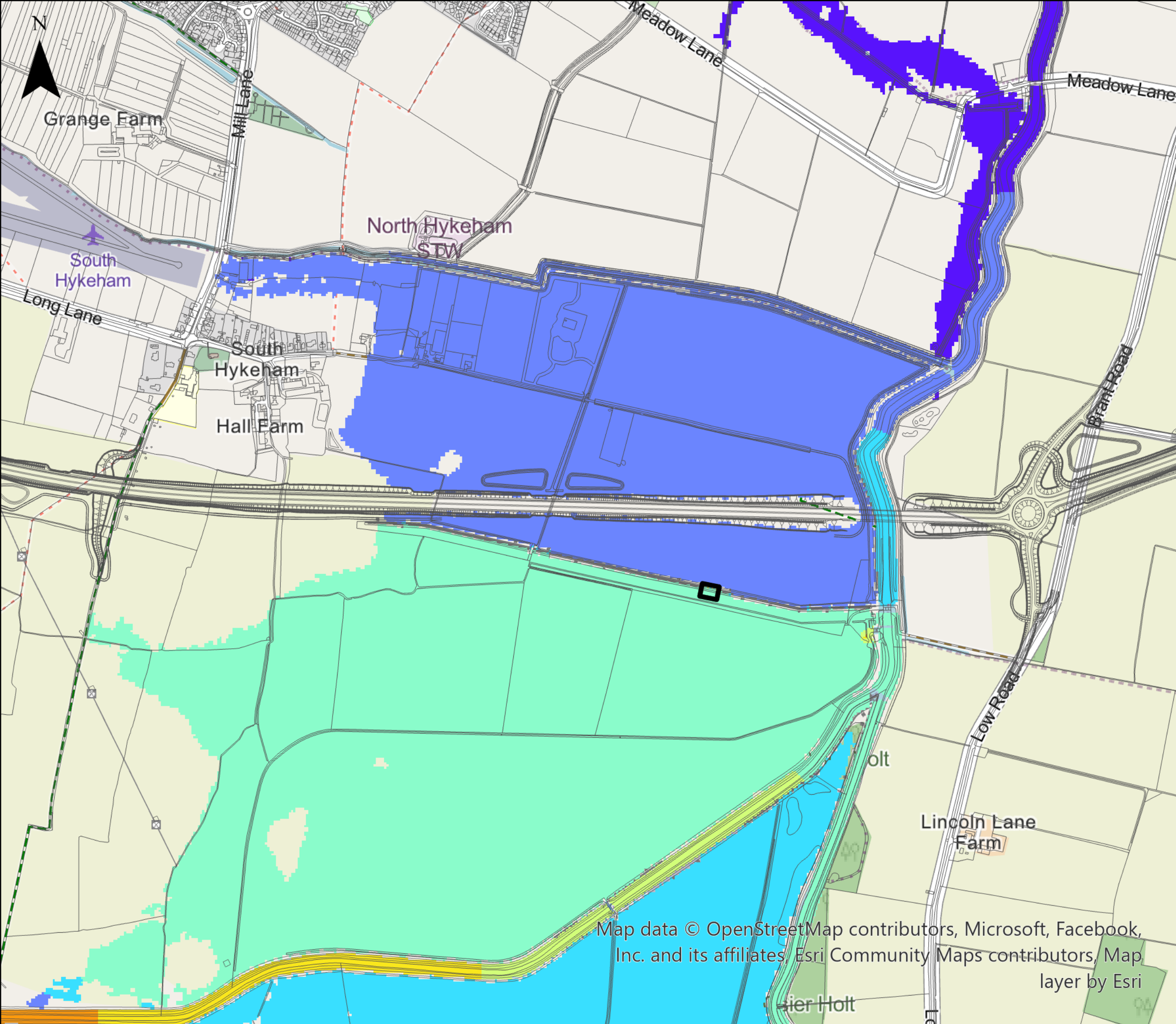

Legend

NHRR scheme

BREACH FSA

NHRR BREACH FSA 100-year Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
- 7.0 - 7.2
- 7.2 - 7.4
- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1
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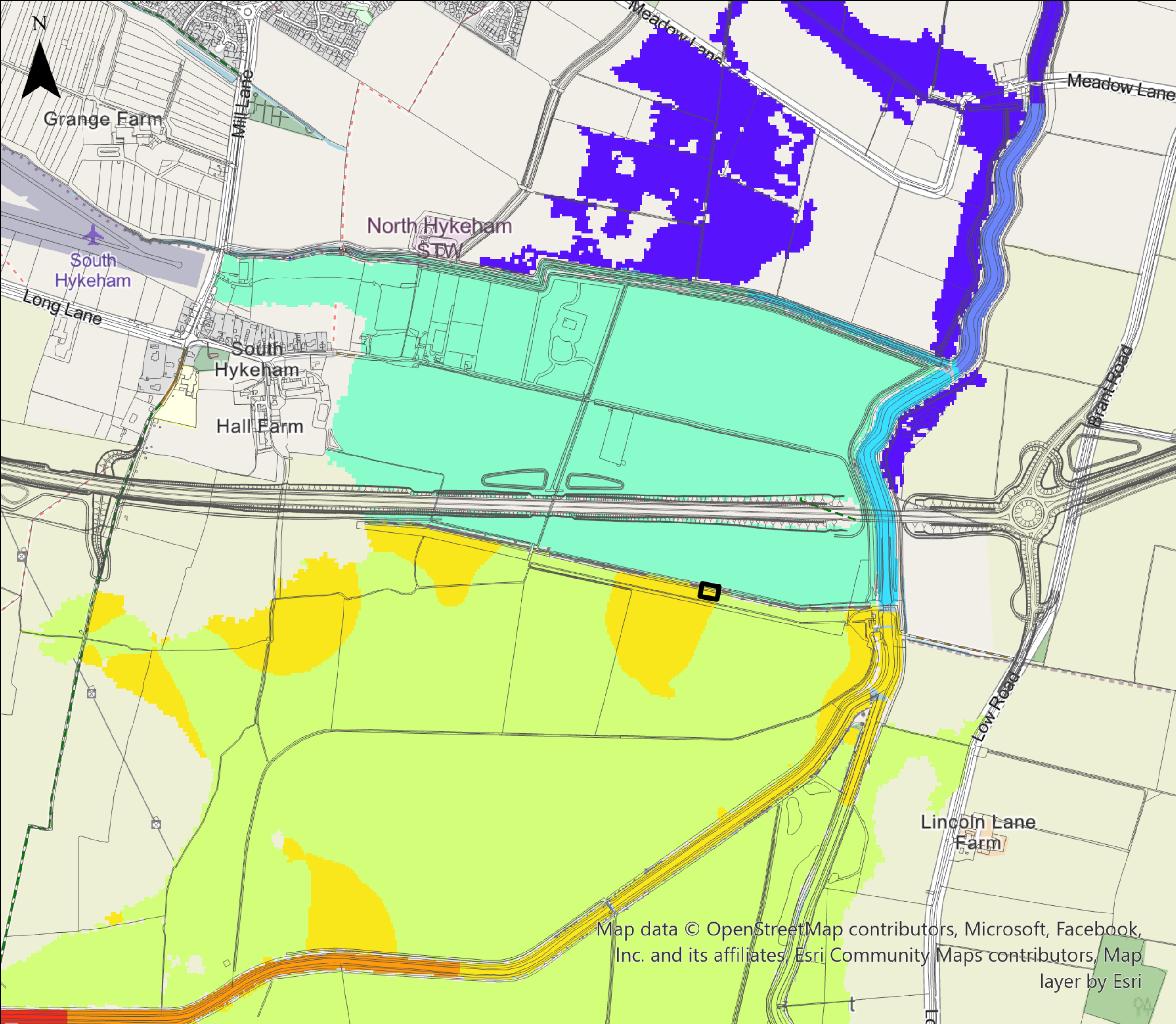

Legend

NHRR scheme

BREACH FSA

NHRR BREACH FSA 100-year Climate Change (2080 Higher)

Water Level (m AOD)

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- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

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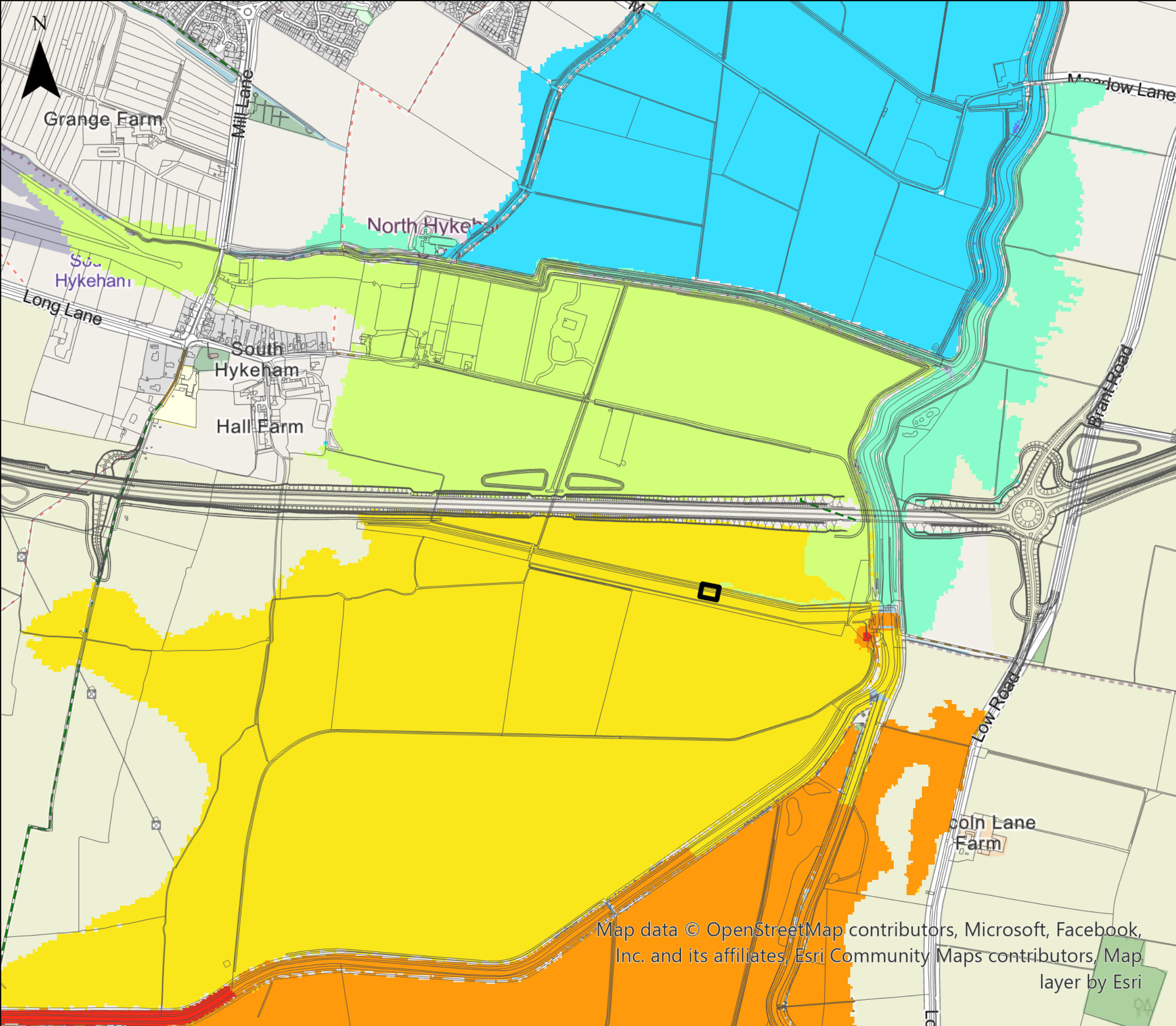

Legend

- NHRR scheme
- BREACH FSA

NHRR BREACH FSA 1000-year Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
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- 7.2 - 7.4
- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1
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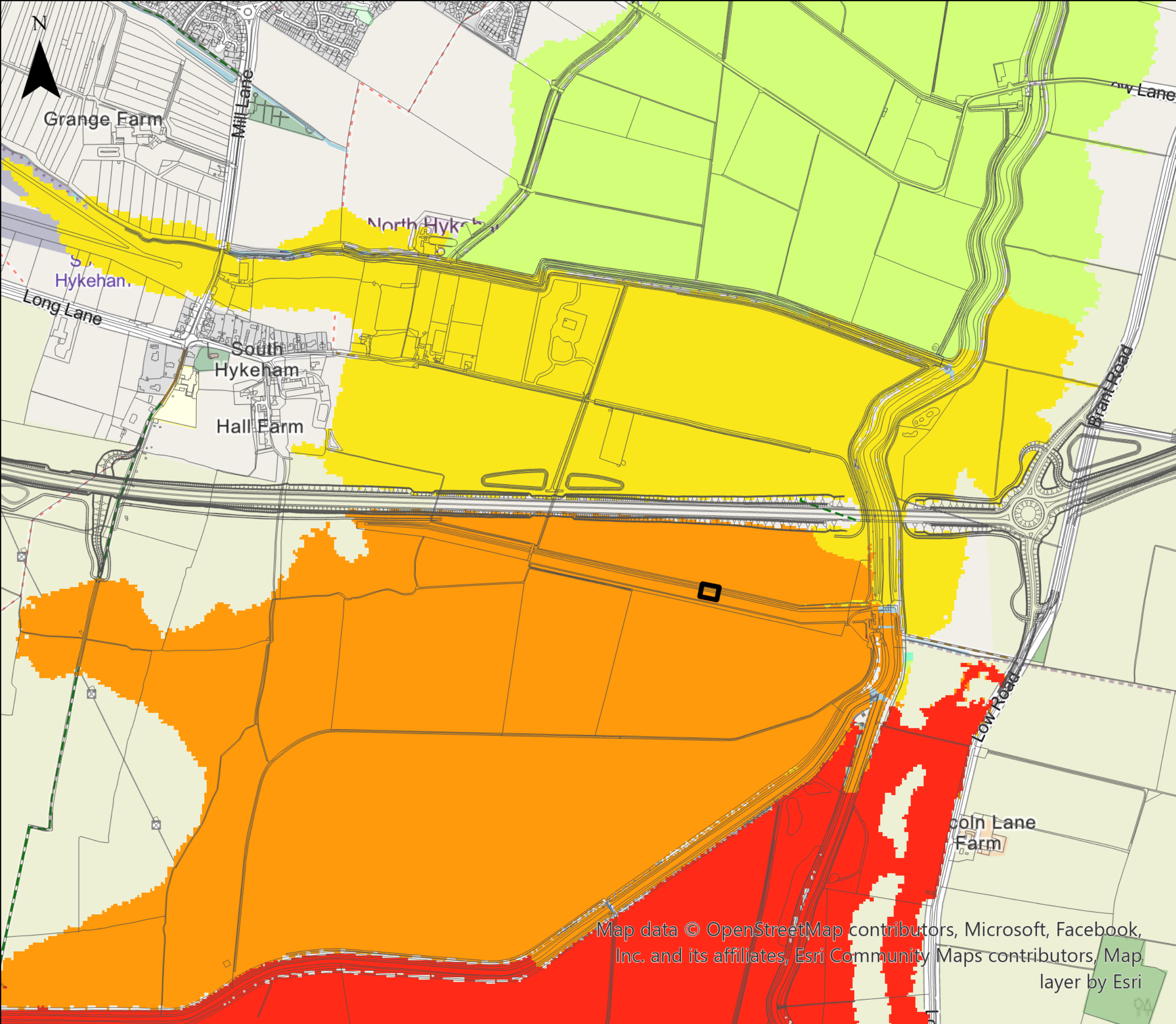

Legend

NHRR scheme

BREACH FSA

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Water Level (m AOD)

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- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1
Date	**Prepared By**
June 2023	HN

Client

Balfour Beatty

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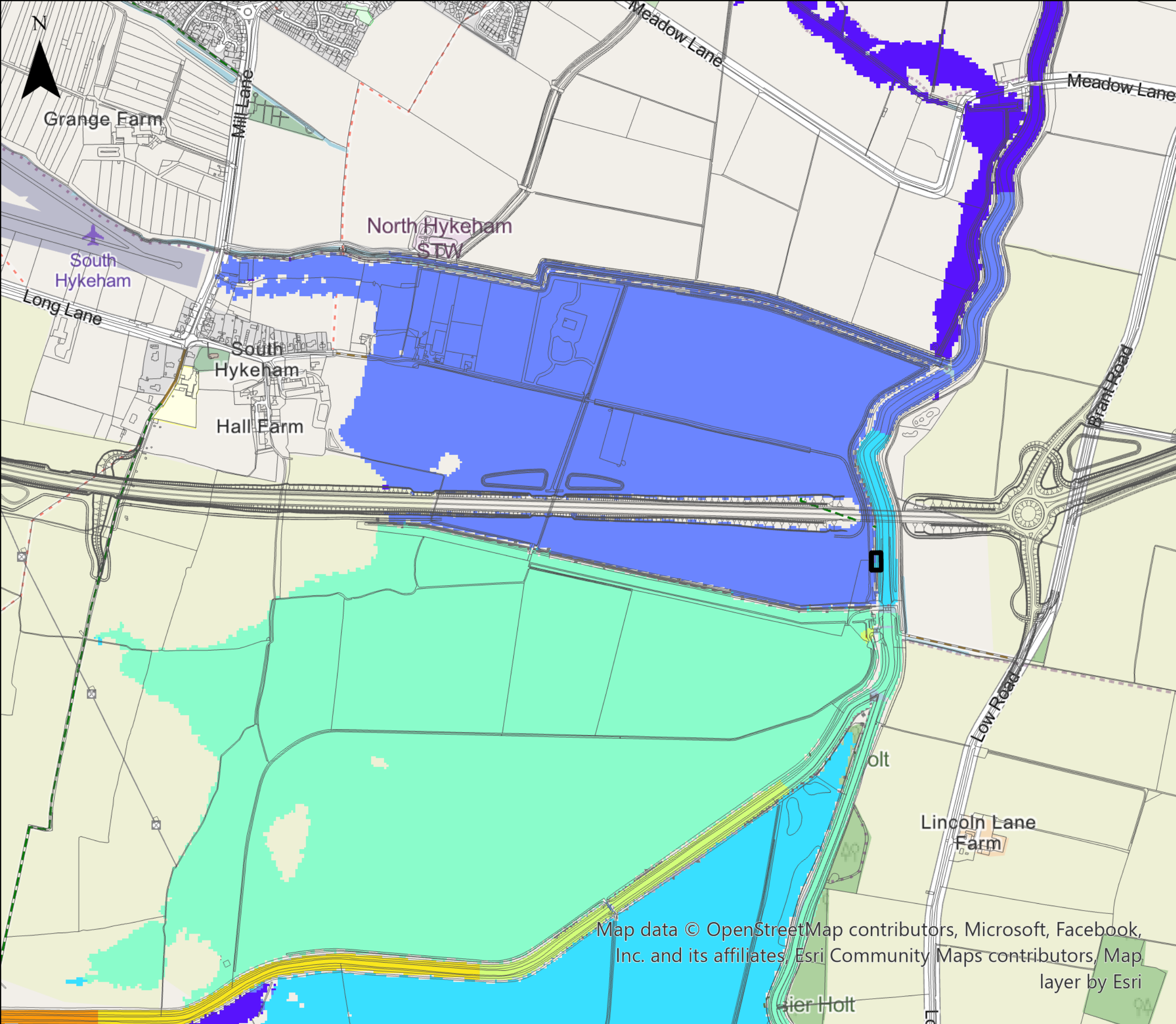

Legend

- NHRR scheme
- BREACH RWUS

NHRR BREACH RWUS 100-year Water Level (m AOD)

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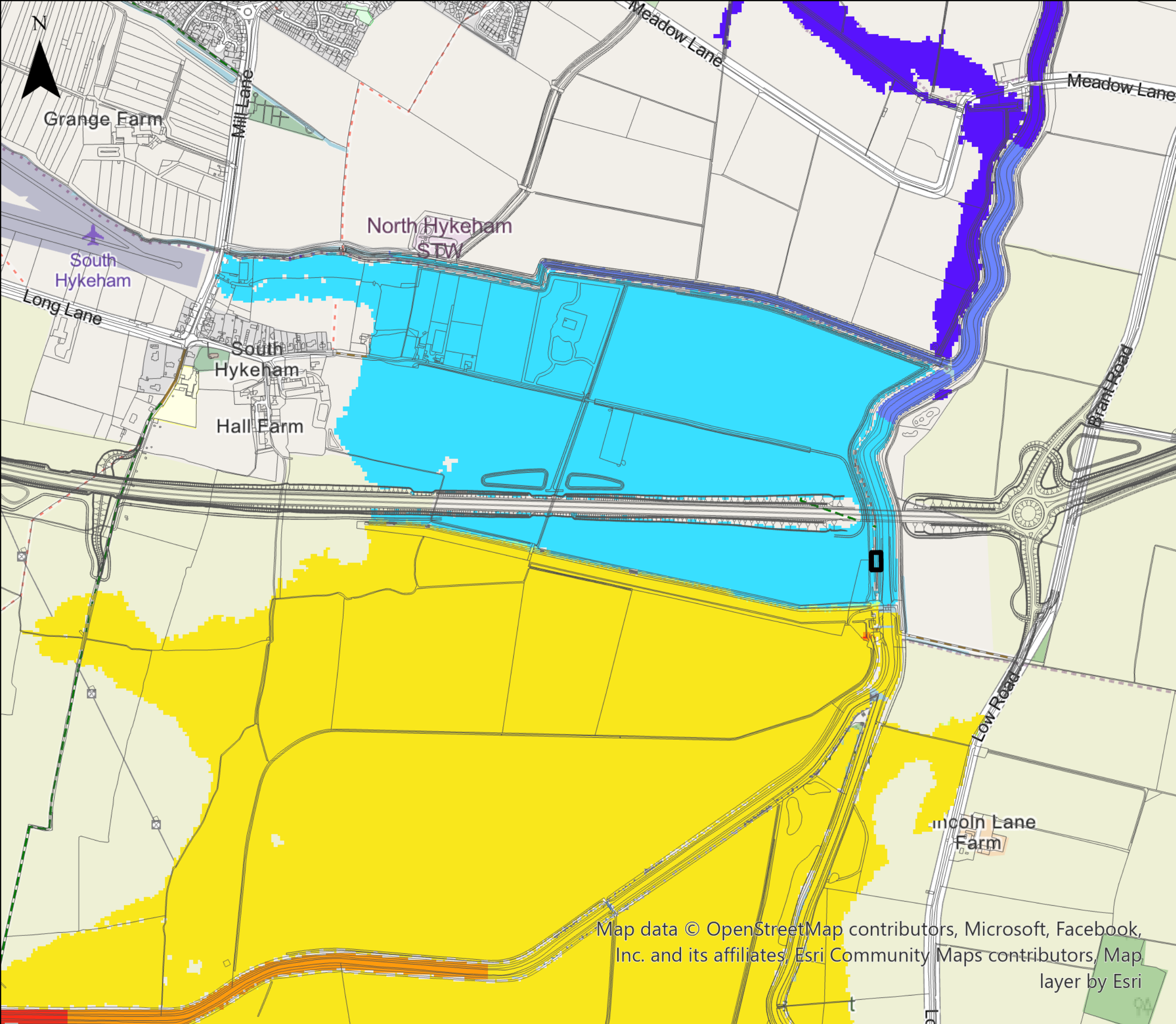
- 7.2 - 7.4
- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title	NHRR Hydraulic Modelling Water Level
Project Name	North Hykeham Relief Road
Project Number	1620013942
Issue	1
Date	June 2023
Prepared By	HN
Client	Balfour Beatty

RAMBOLL



Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 100-year Climate Change (2080 Higher)

Water Level (m AOD)

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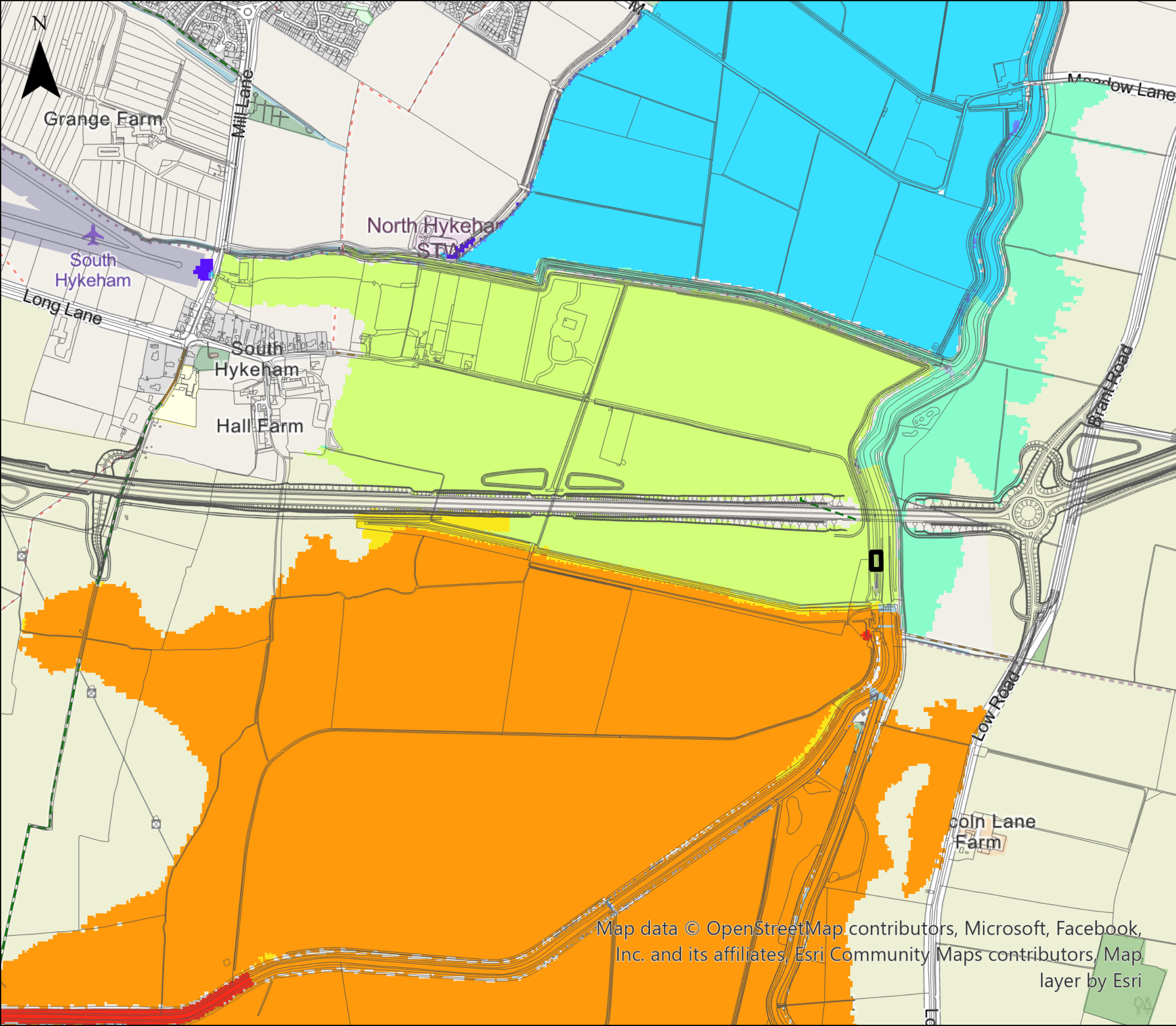
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title	
NHRR Hydraulic Modelling Water Level	
Project Name	
North Hykeham Relief Road	
Project Number	Issue
1620013942	1
Date	Prepared By
June 2023	HN
Client	
Balfour Beatty	

RAMBOLL



Legend

- NHRR scheme
- BREACH RWUS

NHRR BREACH RWUS 1000-year Water Level (m AOD)

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Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

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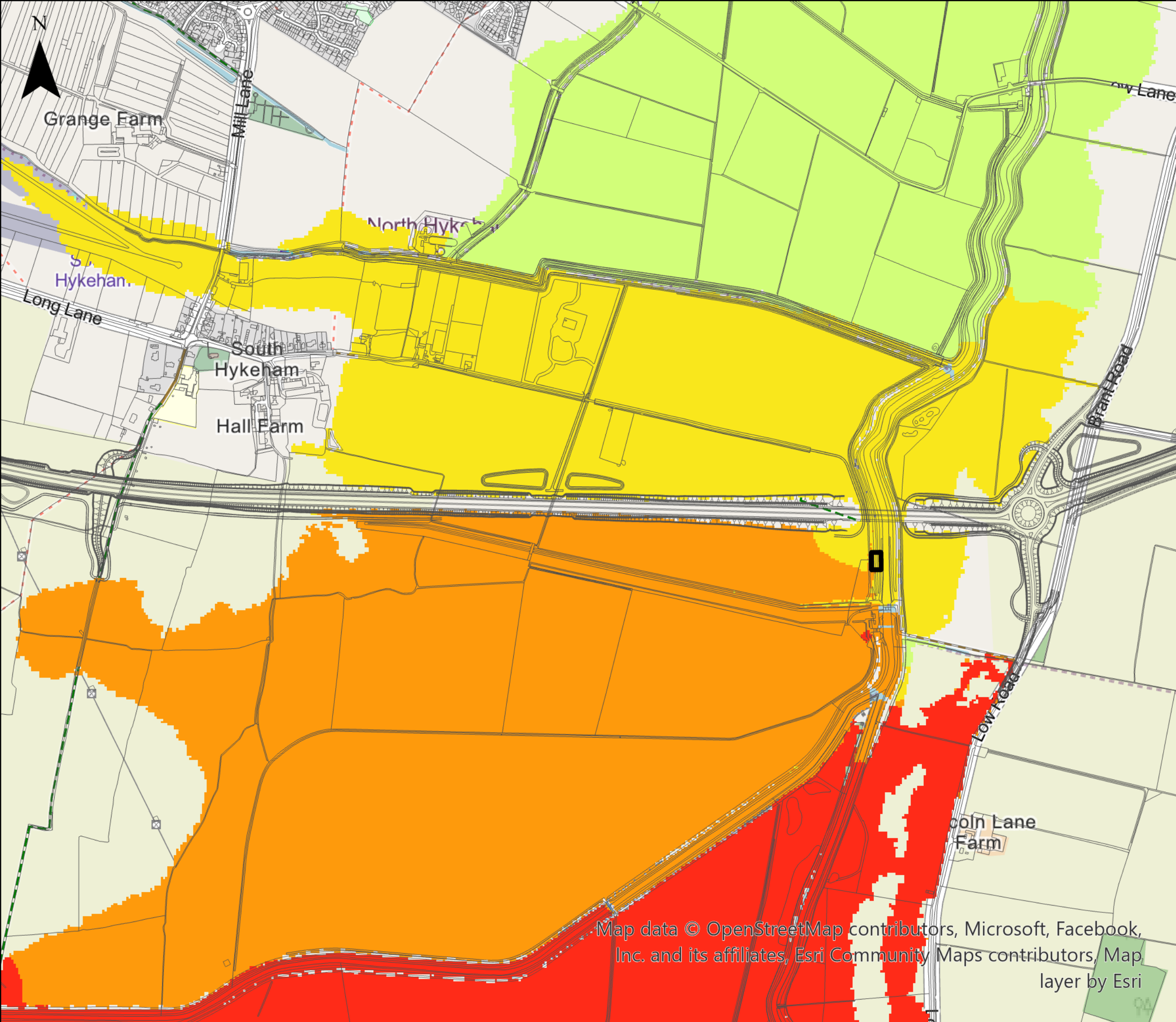

Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 1000-year Climate Change (2080 Higher)

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- 7.4 - 7.6
- 7.6 - 7.8
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Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1
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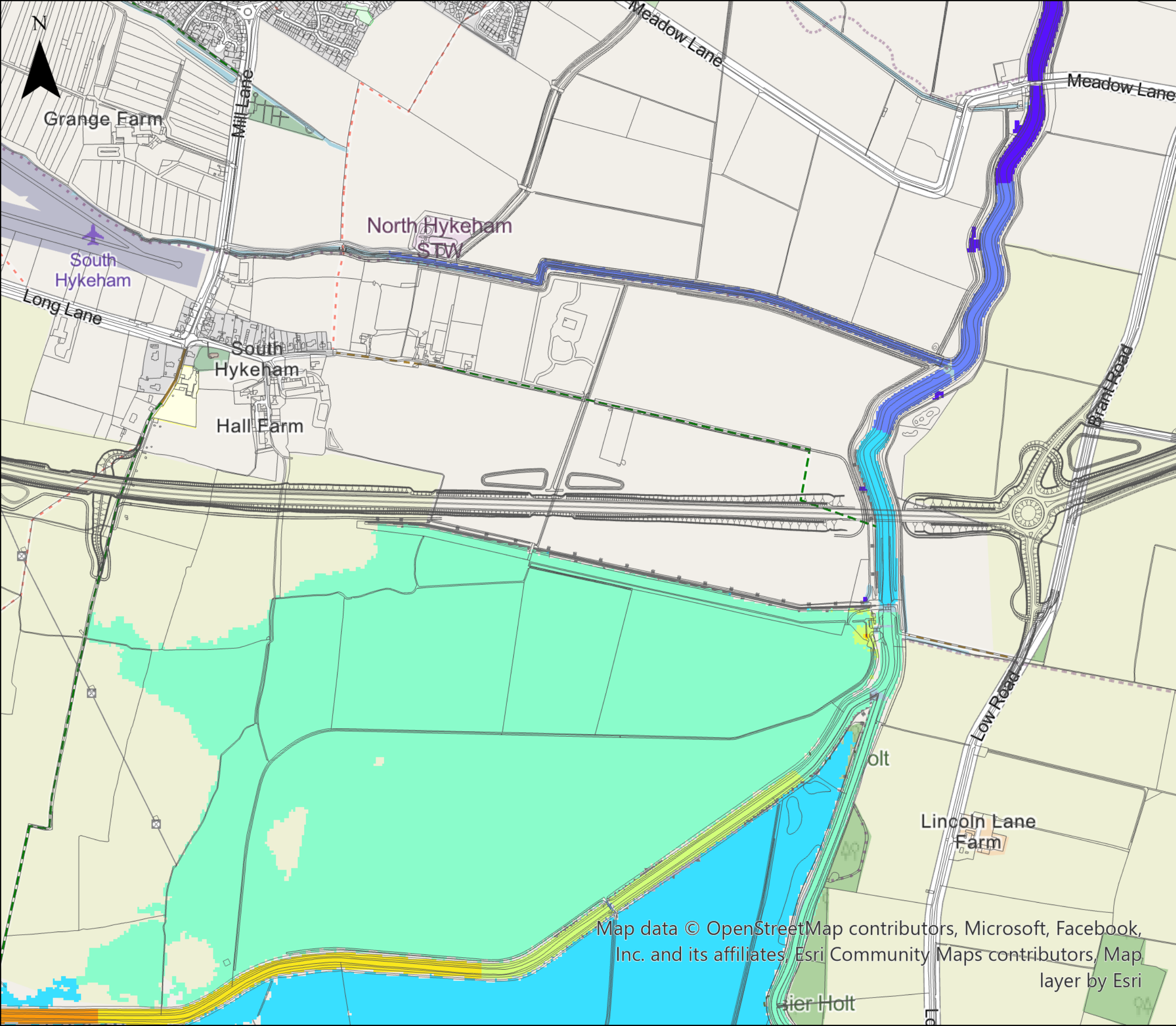

Legend

NHRR scheme

NHRR 100-year Water Level (m AOD)

- < 6.6
- 6.6 - 6.8
- 6.8 - 7.0
- 7.0 - 7.2
- 7.2 - 7.4
- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

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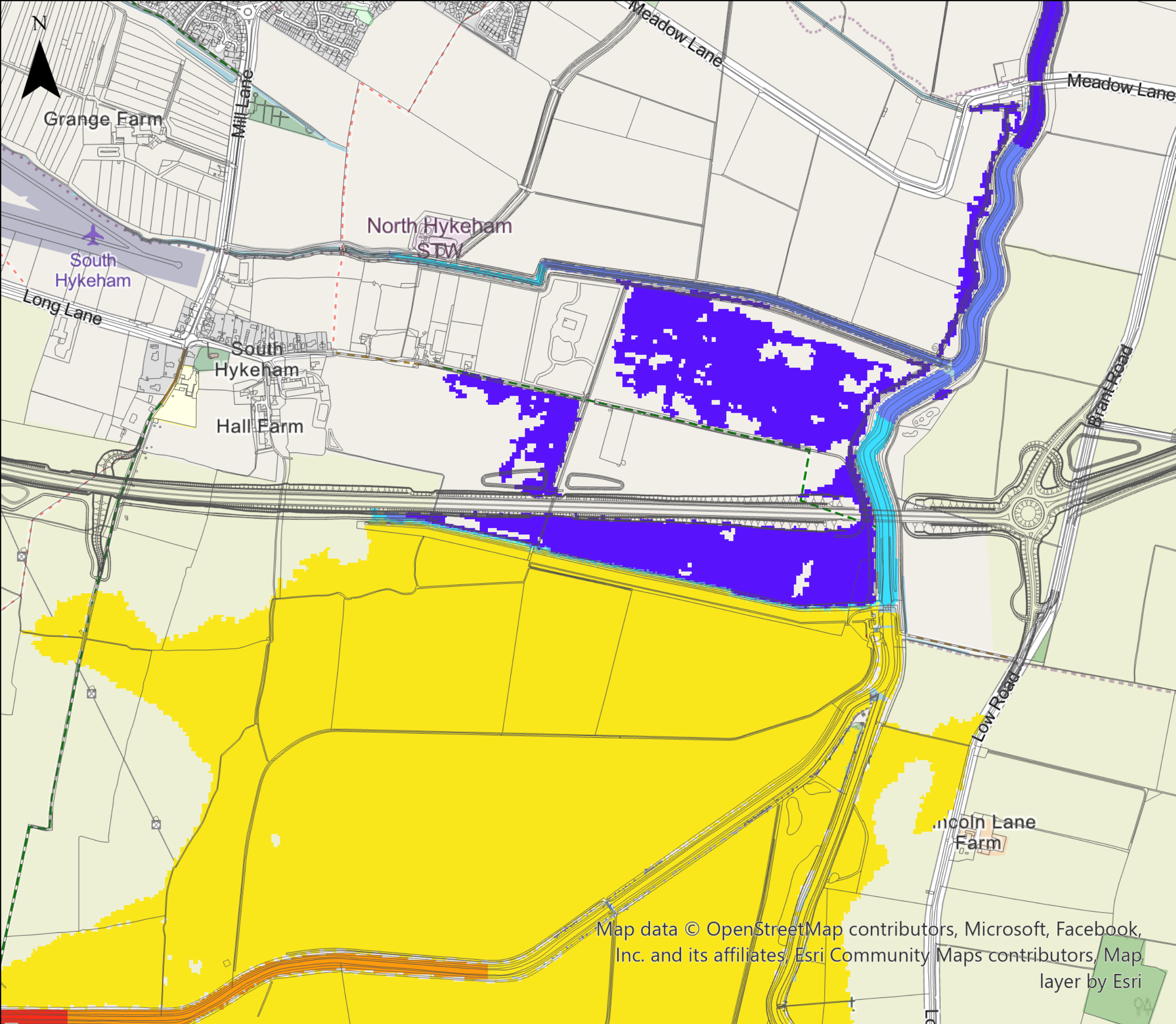

Legend

NHRR scheme

NHRR 100-year Climate Change (2080 Higher)

Water Level (m AOD)

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Scale

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Figure Title

NHRR Hydraulic Modelling Water Level

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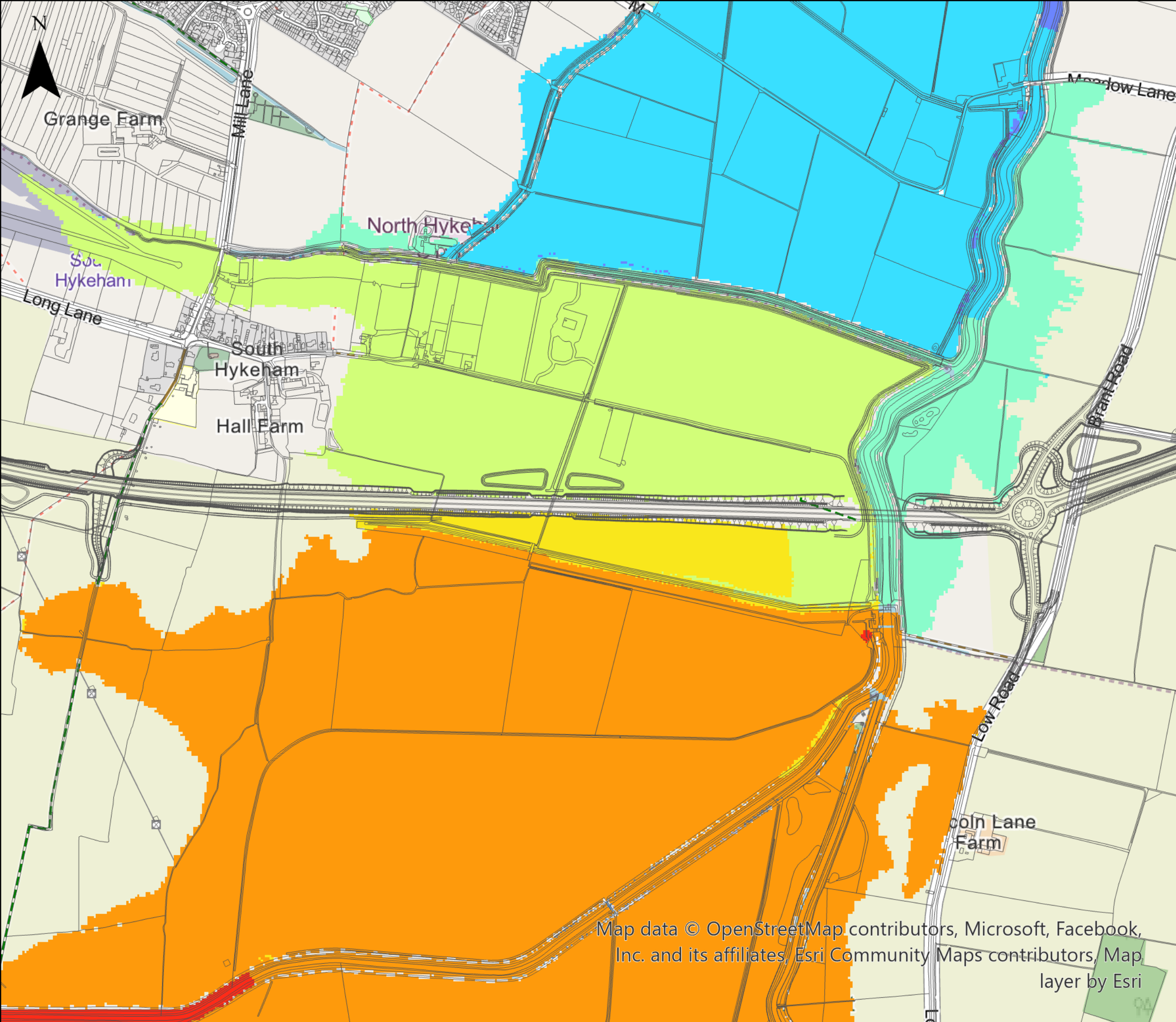

Legend

NHRR scheme

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Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

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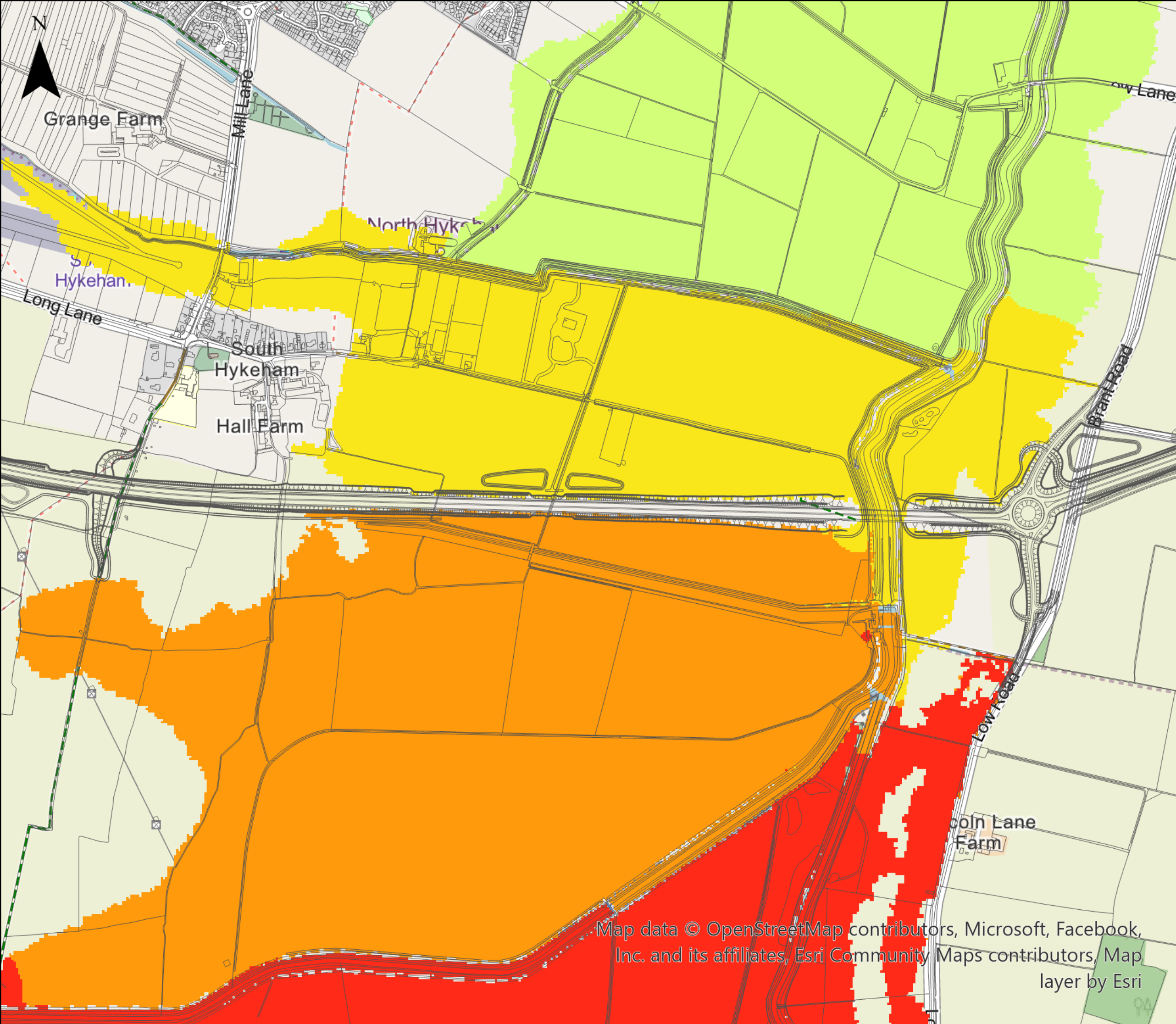

Legend

NHRR scheme

NHRR 1000-year Climate Change (2080 Higher)

Water Level (m AOD)

- < 6.6
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- 7.4 - 7.6
- 7.6 - 7.8
- 7.8 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Water Level

Project Name

North Hykeham Relief Road

Project Number	Issue
1620013942	1
Date	Prepared By
June 2023	HN

Client

Balfour Beatty

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APPENDIX 5
NHRR HYDRAULIC MODEL LOG

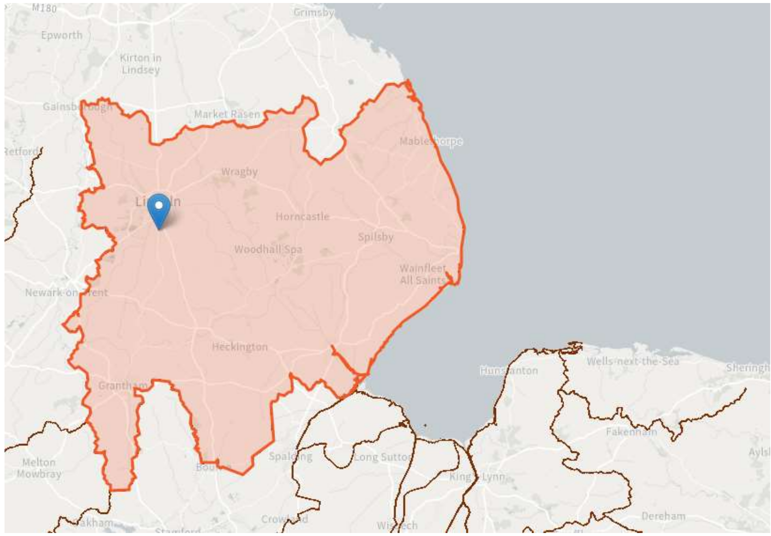
Run details									Model Control Files							
ID	Scenario	Event	Complete	Run Type	End Time	Mass Error	Run Description	Simulation Details	TCF	ECF	TOC	TGC	TBC	TMF	bc_dbase	TEF
1	BAS	100	Unstable	Testing			FMP-TUFLOW Hydraulic Model setup	Did not start up	1	/	/	1	1	1	bc_dbase_Witham_NHRR_001.csv	1
2	BAS	100	Unstable	Testing			ESTRY-TUFLOW Hydraulic Model setup	First ESTRY-TUFLOW model run. Unstable on first startup Downstream Boundary Unstable (WITH_0-18)	2	/		2	2	1	bc_dbase_Witham_NHRR_001.csv	1
3	BAS	100	Unstable	Testing			Updating downstream boundary to use UWA_3809 from infoworks model. Using WITH_0000 instead of WITH_0-19 downstream of bridge for stability, (bed level of WITH_0-19 was higher than WITH_0000 causing instabilities), changing Channel type to SN for stability.	Instability at downstream boundary, added roughness patch	3	/	/	3	3	1	bc_dbase_Witham_NHRR_002.csv	1
4	BAS	100	Unstable	Testing			Adding Operational Structures (TOC) file, required multiple itterations to get .TOC file to work. Needed a separate .ECF file to work enable TOC to run. Updating inflow boundaries to FEHCD methodology (As in reporting)		4	1	5	4	4	1	bc_dbase_Witham_NHRR_003.csv	1
5	BAS	100	Finished	Testing			1. Starting Witham Sluice Gate as Open 5. Changing 1D downstream boundary HQ curve to use 1D_NWK TUFLOW output (WITH_0000D) 7. Separately digitising 3 culverts at Witham Sluice Gate, changing last 4 attributes to rectangular culvert losses rather than weir losses.		5	1	5	5	5	1	bc_dbase_Witham_NHRR_003.csv	1
6	BAS	100	Finished	Testing			1. Setting Reservoir Defence Level to 7.54 m AOD 2. Abstraction at Meadow Lane	TOC For River Witham sluice gate was wrong	6	2	6	6	5	1	bc_dbase_Witham_NHRR_003.csv	1
7	BAS	100	Finished	Testing			1. Grid size to 10 2. Timestep adjusted 3. Correcting TOC files so Witham main sluice gate is correctly opporated 4. Adding culvert under the Beck 5. Adjusted IDB stream representation downstream of reservoir to allow flow and culvert boundaries	Toc for WITHAM sluice gate was wrong	7	3	7	7	6	1	bc_dbase_Witham_NHRR_Infoworks_(	1
8	BAS	100	Finished	Testing			1. Updated TOC file 2. Updated Opeational Structures to try to resolve warning 1132 3. Updated wier that was unstable 4. removed feeder flows from two channels 5. removed structures from CF channel (couldn't even see these on google earth) 6. Included Pike Dyke inflows and channel representation (downstream end of model)		8	4	8	8	8	1	bc_dbase_Witham_NHRR_Infoworks_(	1
9	BAS	100	Finished	Testing			1. Lowered WB at DMY2789 to 8m AOD 2. Updated bank Line		9	5	8	9	9	1	bc_dbase_Witham_NHRR_Infoworks_(	1
10	BAS	100	Finished	Testing			Changed DMY2789 to River Section		10	6	8	9	10	1	bc_dbase_Witham_NHRR_Infoworks_(	1
11	BAS	100	Finished	Testing			Changed DMY2789 to Structure with 2D Bridge Deck		11	7	8	10	11	1	bc_dbase_Witham_NHRR_Infoworks_(	1

12	BAS	100	Finished	Testing			Copy of 009 after realising issue was a unsnapped nwk line. Updates to 009 1. Snap River NWK to Structure NWK at DMY2789 2. Weir Structure (DMY1402) edited to 8.4, average of road level (not top of railings as previous) 3. Bank levels upstream of DMY2789 updated to better reflect topography		12	8	8	11	9	1	bc_dbase_Witham_NHRR_Infoworks_(	1
13	BAS BREACH	100 1000	Unstable	Testing			1. Breach Added 2. Using FEH inflows instead of Infoworks for conservative approach. 3. Updated structure DMY3011 to rectangular culvert for stability		13	9	8	12	9	1	bc_dbase_Witham_NHRR_003.csv	1
14	BAS	100	Finished	Testing			1. Updating Effective Crest of Washland Reservoir 2. Updating Boundary Condition for Sluice Gate WITH_4925G 3. Update inflows, added climate change column (Upper 2080 - 57%) T100CC2080UPPER and added time to 200hrs by copying last line in dataset 4. DMY3011 structure very unstable, Found to be a NWK line snapping issue so was corrected. 5. Updated River Code layer in line with number 4 update. 6. Breach trigger value updated to onset 500mm below defence crest	Model ran stable	14	10	8	13	12	1	bc_dbase_Witham_NHRR_003.csv	1
15	ALL	ALL	Finished	ss	130	-1.67	1. Update model with NHRR Design Terrain 2. Adding NHRR Culverts	Model ran, instabilities noticed at Sluice gate 1D-2D boundary to washland. NHRR flooded, fed back to design team to update design	15	11	8	13	13	1	bc_dbase_Witham_NHRR_003.csv	1
16	BAS	ALL	Finished	Testing	120	-1.95	1. Updating Operational Structures Sluice Gates to try to Stabilise flow at the 1D-2D boundary between the sluice gate and the washland - Adjust SX boundary location - Smooth terrain at entrance to washland		16	12	8	14	14	1	bc_dbase_Witham_NHRR_003.csv	1
17	BAS	T100	Finished	Testing	120	-0.97	TCF-15 1. Read channels before bank levels 2. Read in bank levels for US of the BECK 3. HX line add at US of BECK 1D channel	Instability at sluice gates still present	17	11	8	15	15	1	bc_dbase_Witham_NHRR_003.csv	1
18	BAS	T100	Interrupted	Testing	110.9	-0.98	1. Check and updated where required defence levels at key locations (River Brook upstream of the River Witham Confluence) 2. Updated Witham Washland Reservoir Level to 7.4 m AOD 3. Repositioned The Beck Upstream defence to allow representation of watercourse in between defences in the 2D domain	Instability at sluice gates still present	18	11	8	16	15	1	bc_dbase_Witham_NHRR_003.csv	1
19	BAS	T100	Finished	Testing	120	-1.46	1. Removed some cross sections around the Witham Sluice Gate to increase the distance between cross-sections to increase channel storage capacity. 2. Updated the channel type around sluice gates to SN 3. Updated defence lines, river code layer, WLL and IWL and the TOC file to reflect point 1 update	Better stability but still not great	19	13	10	17	16	1	bc_dbase_Witham_NHRR_003.csv	1

20	BAS	T100	Finished	Testing	120	-1.43	(Copy of 18) 1. Changed nwk channel type upstream and downstream of sluice gates to SN	Stability improved but not as much as 19	20	14	8	16	15	1	bc_dbase_Witham_NHRR_003.csv	1
21	BAS	T100	Interrupted	Testing	81.49	-1.45	Copy of 19 1. Roughness Patch smoothing roughness at sluice gate to 0.035	minimal impact on results.	21	13	10	18	16	1	bc_dbase_Witham_NHRR_003.csv	1
22	BAS	T100	Interrupted	Testing	100.5	-1.43	Copy of 19 1. TOC file adjusted to instantaneous opening and closing of structures to stop fluctuations	No impact on results	22	15	11	17	16	1	bc_dbase_Witham_NHRR_003.csv	1
23	BAS	T100	Interrupted	Testing	106	-1.71	Copy of 19 1. TOC file adjusted to instantaneous opening and closing of structures to stop fluctuations 2. Roughness Patch smoothing roughness at sluice gate to 0.035 3. Smoothing topography to 4.39m AOD at washland sluice gate boundary	Much more stable, but not perfect.	23	15	11	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
24	BAS	T100	Interrupted	Testing	69.54	-1.72	Copy of 23 1. New TOC file with "Fully Open" and "Closed" instead of "Open" and "Close".	No difference compared to 23	24	16	12	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
25	BAS	T100	Interrupted	Testing	95.11	-1.71	Copy of 23 1. New TOC file with "NO CHANGE" removed	No difference compared to 23	25	17	13	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
26	BAS	T100	Interrupted	Testing	98.44	-1.76	Copy of 23 1. New TOC file (copy of 10 so not an instantaneous closure, as this had not impact (22 results)), correcting statement so Witham Gate only closes if Washland sluice gate is open 2. SN back to S	Less severe oscillations, but still present	26	18	14	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
27	BAS	T100	Finished	Testing	120	-1.64	Copy of 26 1. TOC File updated to include of Period No Change < 0.25 --> SPECIFICYING OPEN CLOSE FULLY OPEN CLOSED	Oscillations still present	27	19	15	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
28	BAS	T100	Interrupted	Testing	95.65	-1.65	Copy of 26 1. Roughness Patch at Sluice Gate set to 0.08 manning's n	Roughness Patch acts to increase the magnitude of ossicilations	28	18	14	20	17	1	bc_dbase_Witham_NHRR_003.csv	1
29	BAS	T100	Interrupted	Testing	110.5	-1.64	Copy of 26 1. TOC File updated to include of Period No Change < 1 --> SPECIFICYING OPEN CLOSE FULLY OPEN CLOSED	smooths the 1D curve but with more violent and sudden ossicilations	29	19	15	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
30	BAS	T100	Interrupted	Testing	100.6	-1.59	Copy of 29 1. Roughness Patch at Sluice Gate set to 0.08 manning's n	Roughness Patch acts to increase the magnitude of ossicilations	30	19	15	20	17	1	bc_dbase_Witham_NHRR_003.csv	1
31	BAS	T100	Interrupted	Testing	78.16	-1.76	Copy of 31 1. Altered TOC - if statement testing if Open, stay open if above closing threshold	No difference compared to 29	31	21	17	19	17	1	bc_dbase_Witham_NHRR_003.csv	1
32	BAS NHRR	T100 T100CC	Finished	Testing	100	-1.84 -2.79	Copy of 26 1. Adding missing culvert under Blackmoor Road	Oscillations still present but less severe than 26	32	22	14	19	18	1	bc_dbase_Witham_NHRR_003.csv	1
33	ALL	ALL	Finished	ss	100	-1.72 -2.21	Copy of 32 Changed operational sluice gates to SGOWB tpye		33	23	14	19	18	1	3	1
D20P	100CC	ALL	Finished	Testing	100	-0.14	Increasing slope of 1d and 2d downstream boundary by 20%	Reduces Mass Error to acceptable range, No impact to osscilations around the flood gates	33	23	14	19	18	1	3	1

42	NHRR	100CC	Finished	Testing	100	-2.06	Copy of 33 1. SN Channel 2. Add stability z shape to allow free flow of water at blackmoor road culvert	Reduces Mass Error, Ossicilations around the flood gates -Magnitude Increases	42	33	14	21	18	1	3	1
43	NHRR	100CC	Finished	Testing	100	-1.96	Copy of 33 1. TOC Period of no Change <15mins 2. Add stability z shape to allow free flow of water at blackmoor road culvert	Reduces Mass Error, Ossicilations around the flood gates -Magnitude Increases -Frequency decreases	43	34	15	21	18	1	3	1
44	NHRR	100CC	Finished	Testing	100	-2.22	Copy of 33 1. SX - 3 cells 2. Add stability z shape to allow free flow of water at blackmoor road culvert	No impact on Mass Error, severity of oscilations slightly reduced, but times when magnitude increases	44	35	14	21	19	1	3	1
45	NHRR	100CC	Finished	Testing	100	-2.09	Copy of 33 1. increase number of xs near Witham Sluice to original 2. Add stability z shape to allow free flow of water at blackmoor road culvert	Reduces Mass Error, but magnitude of ossicilations around the flood gates increase	45	36	14	21	18	1	3	1
46	NHRR	100CC	Finished	Testing	100	-2.29	Copy of 33 1. increase 1D roughness around the Sluice gates 2. Add stability z shape to allow free flow of water at blackmoor road culvert	Slightly increases mass error, no change in ossicilations around the flood gates	46	37	14	21	18	1	3	1
47	NHRR	100 100CC	Interrupted	Testing	70.86100	0.22 -0.11	Copy of 33 1. SN Channel 3. SX - 3 cells 4. Update downstream 1D boundary 5. Add stability z shape to allow free flow of water at blackmoor road culvert	Downstream boundary reduces 1D-MB to acceptable range. The magnitude of the ossilations around the flood gates increase for the 100cc event.	47	38	14	21	19	1	4	1
48	NHRR	100CC	Interrupted	Testing		-0.19	Copy of 33 1. TOC gate speed reduced to 0.005 m/s 4. Update downstream 1D boundary 5. Add stability z shape to allow free flow of water at blackmoor road culvert	Slight reduction in severity in oscillation, although very similar	48	39	19	21	18	1	4	1
49	NHRR	100CC	Interrupted	Testing		-0.29	Copy of 33 1. TOC Opening/Closing period instead of Gate Speed - set to 10 mins 4. Update downstream 1D boundary 5. Add stability z shape to allow free flow of water at blackmoor road culvert	Signficant reduction in severity in oscilations	49	40	20	21	18	1	4	1
50	All	ALL	Finished	Final		-0.28	Copy of 49 1. Update NHRR ascii with most up to date design 2. Update NHRR Culverts to allow model to run		50	41	20	22	18	1	4	1

			57%	32%	32%
Model Inflows	**T100**	**T1000**	**T100CC2080UPPER**	**T100CC2080HIGHER**	**T1000CC2080HIGHER**
Brant_GS_US	33.474	62.996	52.554	44.186	83.155
Brant_GS_DS	34.743	65.355	54.547	45.861	86.269
Witham_U_5_FEH	33.184	60.589	52.099	43.803	79.977
Witham_U_2_FEH	12.295	22.785	19.303	16.229	30.076
UWC_7019	42.900	77.550	67.353	56.628	102.366



Witham Management Catchment peak river flow allowances

	Central	Higher	Upper
2020s	9%	14%	27%
2050s	8%	15%	32%
2080s	21%	32%	57%

This map contains information generated by UK Centre for Ecology and Hydrology using UK Climate projections.

Witham Management Catchment

	Central	Higher	Upper
2020s	9%	14%	27%
2050s	8%	15%	32%
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Reference tables for Manning's n values for Channels, Closed Conduits Flowing Partially Full, and Corrugated Metal Pipes.

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.03	0.033
b. same as above, but more stones and weeds	0.03	0.035	0.04
c. clean, winding, some pools and shoals	0.033	0.04	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.05
e. same as above, lower stages, more ineffective slopes and sections	0.04	0.048	0.055
f. same as "d" with more stones	0.045	0.05	0.06
g. sluggish reaches, weedy, deep pools	0.05	0.07	0.08
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.1	0.15
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.03	0.04	0.05
b. bottom: cobbles with large boulders	0.04	0.05	0.07
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.03	0.035
2. high grass	0.03	0.035	0.05
b. Cultivated areas			
1. no crop	0.02	0.03	0.04
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.03	0.04	0.05
c. Brush			
1. scattered brush, heavy weeds	0.035	0.05	0.07
2. light brush and trees, in winter	0.035	0.05	0.06
3. light brush and trees, in summer	0.04	0.06	0.08
4. medium to dense brush, in winter	0.045	0.07	0.11
5. medium to dense brush, in summer	0.07	0.1	0.16
d. Trees			
1. dense willows, summer, straight	0.11	0.15	0.2
2. cleared land with tree stumps, no sprouts	0.03	0.04	0.05
3. same as above, but with heavy growth of sprouts	0.05	0.06	0.08
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.08	0.1	0.12
5. same as 4. with flood stage reaching branches	0.1	0.12	0.16
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.02
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.03
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.03
2. grass, some weeds	0.025	0.03	0.033
3. dense weeds or aquatic plants in deep channels	0.03	0.035	0.04
4. earth bottom and rubble sides	0.028	0.03	0.035
5. stony bottom and weedy banks	0.025	0.035	0.04
6. cobble bottom and clean sides	0.03	0.04	0.05
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.05	0.06
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.04
2. jagged and irregular	0.035	0.04	0.05
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.05	0.08	0.12
2. clean bottom, brush on sides	0.04	0.05	0.08
3. same as above, highest stage of flow	0.045	0.07	0.11
4. dense brush, high stage	0.08	0.1	0.14
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.01	0.011	0.013
2. mortar	0.011	0.013	0.015

b. Wood			
1. planed, untreated	0.01	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.01	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.02
4. unfinished	0.014	0.017	0.02
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.02	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.02
2. random stone in mortar	0.017	0.02	0.024
3. cement rubble masonry, plastered	0.016	0.02	0.024
4. cement rubble masonry	0.02	0.025	0.03
5. dry rubble or riprap	0.02	0.03	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.02	0.025
2. random stone mortar	0.02	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.03
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.03		0.5

Manning's n for Closed Conduits Flowing Partly Full

Type of Conduit and Description	**Minimum**	**Normal**	**Maximum**
1. Brass, smooth:	0.009	0.01	0.013
2. Steel:			
Lockbar and welded	0.01	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.01	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.03
6. Cement:			
Neat Surface	0.01	0.011	0.013
Mortar	0.011	0.013	0.015
7. Concrete:			
Culvert, straight and free of debris	0.01	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.02
8. Wood:			
Stave	0.01	0.012	0.014
Laminated, treated	0.015	0.017	0.02
9. Clay:			

Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
10. Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.02
Rubble masonry, cemented	0.018	0.025	0.03

Manning's n for Corrugated Metal Pipe (AISI,

Type of Pipe, Diameter and Corrugation Dimension	n
1. Annular 2.67 x 1/2 inch (all diameters)	0.024
2. Helical 1.50 x 1/4 inch	
8" diameter	0.012
10" diameter	0.014
3. Helical 2.67 x 1/2 inch	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.02
60" diameter	0.021
4. Annular 3x1 inch (all diameters)	0.027
5. Helical 3x1 inch	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
6. Corrugations 6x2 inches	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.03
180" diameter	0.028