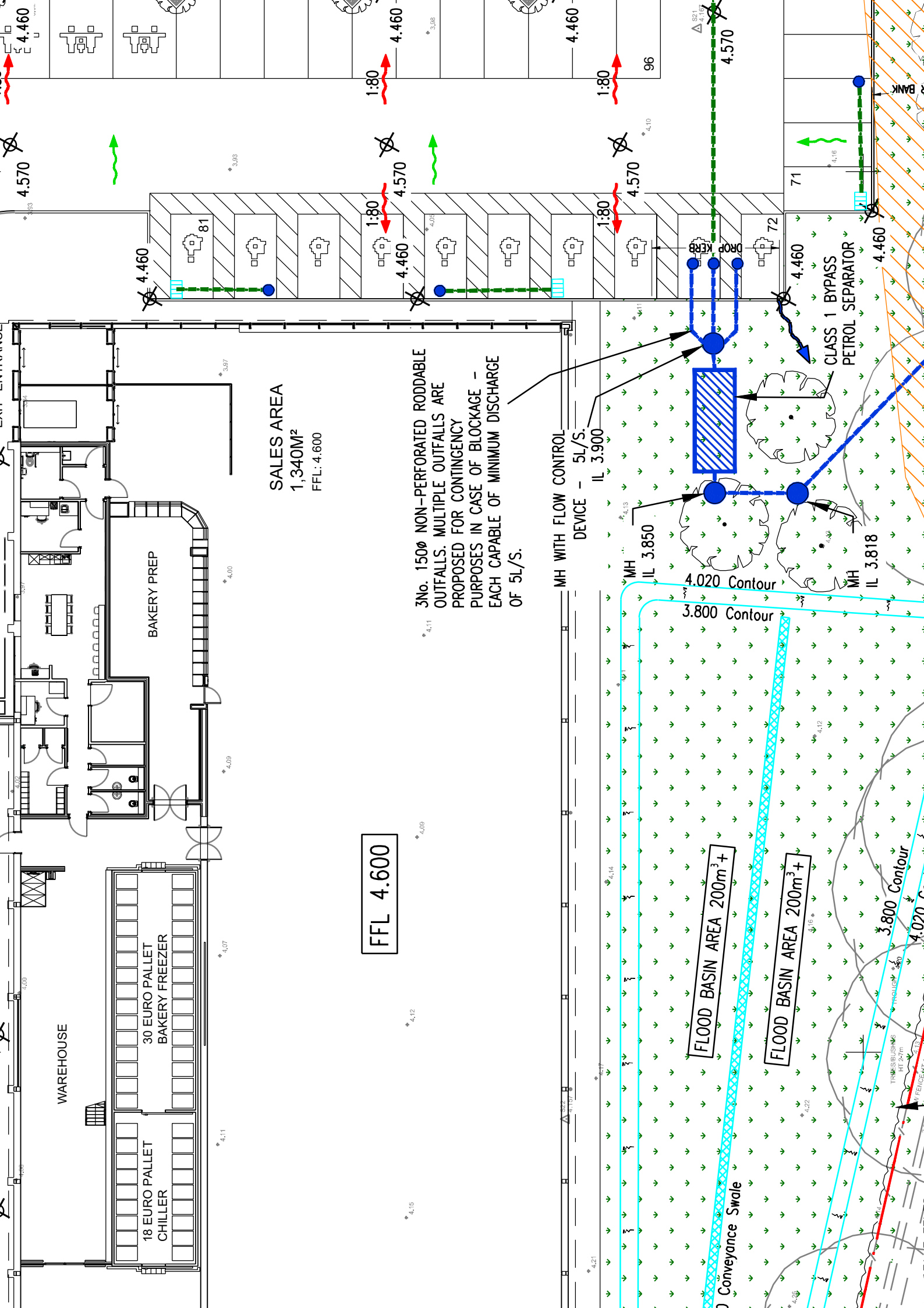


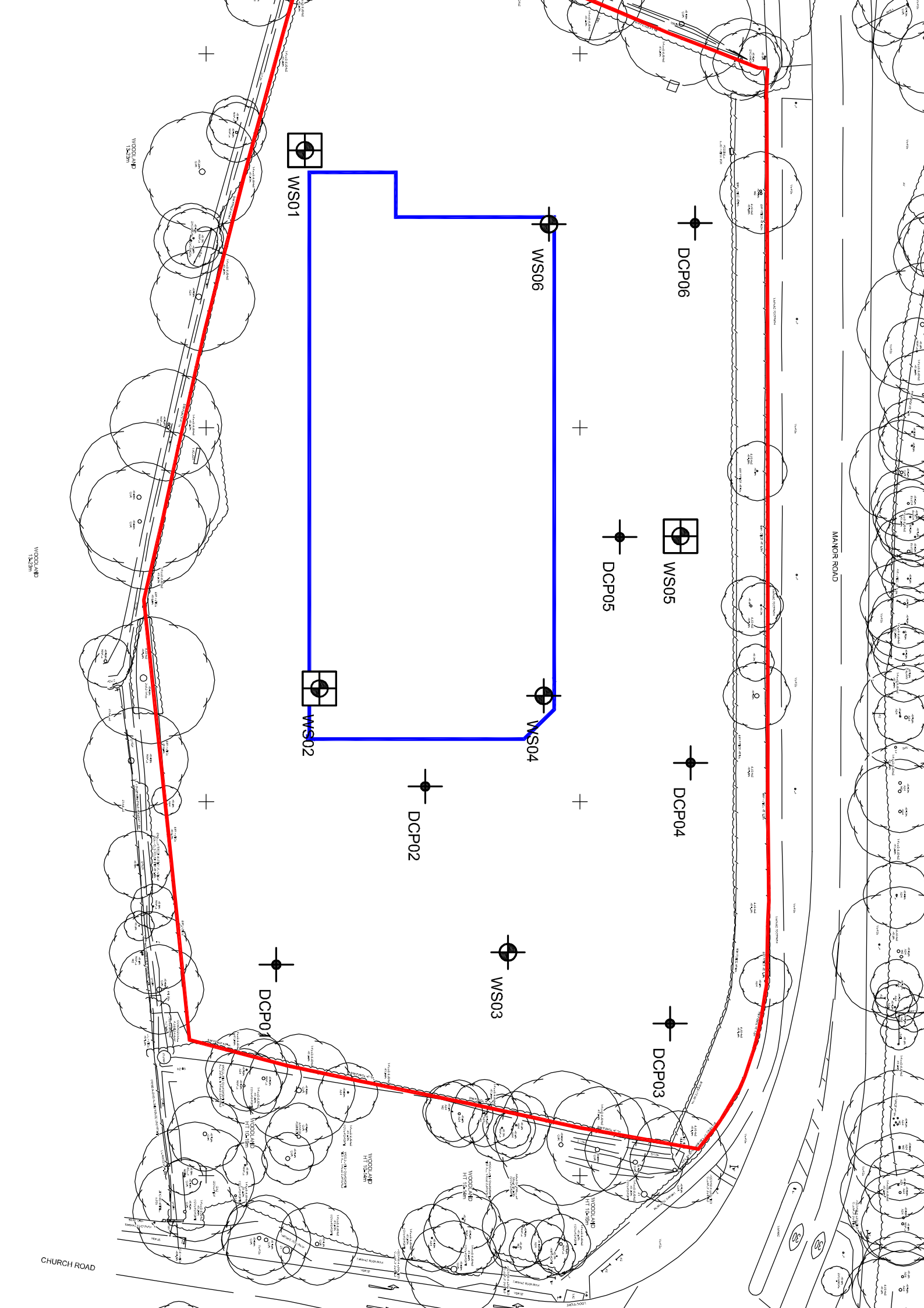
APPENDIX VII

HOP Flood and Drainage Drawings



APPENDIX VIII

Preliminary Site Investigation Information



VISIT NO: 1 of 6

<u>Ambient Concentration (% Vol)</u>	
CH ₄	ND
CO ₂	ND
O ₂	20.2

Monitoring Equipment	GFM 436 Gas Analyser	Weather Conditions	Sunny
Operator	EB	Surface Conditions	Wet

Text shown in Bold & Italic indicates either:
a) Carbon Dioxide equal to or above 5% by Volume
or
b) Methane equal to or above 1% by Volume

Checked:	SMD	Approved:	PJE
----------	-----	-----------	-----

VISIT NO: 2 of 6

<u>Ambient Concentration (% Vol)</u>	
CH ₄	ND
CO ₂	ND
O ₂	20.0

Monitoring Equipment	GFM 436 Gas Analyser	Weather Conditions	Light Cloud
Operator	EB	Surface Conditions	Wet

Text shown in Bold & Italic indicates either:
a) Carbon Dioxide equal to or above 5%
by Volume
or
b) Methane equal to or above 1% by Volume

Checked:	SMD	Approved:	PJE
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Exploratory Hole ID:	Client: Lidl UK GmbH				 www.opusinternational.co.uk				
WS01	Site: Hayling Island								
Job No:	J-B1118.00				Start Date:		End Date:		
				06/12/2016		06/12/2016			
Drilling Equipment/ Excavation Method:				Co-ords:		Backfill Date:		Field Records:	
Tracked Windowless Sampling Rig						06/12/2016		SMD	
				Ground Level (mAOD):		Logged:		Chkd:	
						SMD		PJE	
								PJE	
Strata Description	Depth (m)	Level (m)	Legend	Sample Type	Sample Depth (m)	Tests	Groundwater Records	Backfill Details	
Grass over TOPSOIL : Brown clayey SAND topsoil with rootlets.	0.35			ES1	0.20				
Soft, brown, sandy, gravelly CLAY. Gravel is subangular to subrounded, fine and medium chert and quartzite.				ES2	0.50				
				D3	1.00	N=8 (C)			
Brown, clayey, very gravelly, coarse SAND. Gravel is subangular to subrounded, fine and medium chert and quartzite.	1.35			D4	1.50	N=10 (C)			
Firm, brown, sandy, gravelly CLAY. Gravel is subangular to subrounded, fine and medium chert and quartzite.	1.60			D5	2.00				
Firm, reddish brown CLAY with slight grey-brown mottling.	2.10			D6	2.50	N=13 (C)			
				D7	3.50				
Firm to stiff, dark red-brown CLAY.	3.00					N=14 (C)			
						N=29 (C)			
									
	5.00								
Remarks:						Sample Type Key		Test Type Key	
1. SPT 'N' values corrected to a N60 value in accordance with BS EN 22476 Part 3 and where appropriate extrapolated for partial penetration.						D - Disturbed Representative		(C) - Cone SPT	
2. Groundwater not encountered during drilling.						B - Bulk Representative		(S) - Spoon SPT	
3. Hole terminated at 5.00m begl.						S - Spot Non-Representative		P - Pocket Penetrometer Reading	
4. Borehole installed with gas and groundwater monitoring standpipe as detailed above.						W - Water		PID - PID Reading	
						U - Undisturbed Representative		V - Hand Shear Vane Reading	
						J - Jar Sample			
						ES - Environmental Sample			
						Sheet:			
						Sheet 1 of 1			

Exploratory Hole ID: WS02	Client: Lidl UK GmbH		 www.opusinternational.co.uk						
Job No: J-B1118.00	Site: Hayling Island								
Drilling Equipment/ Excavation Method: Tracked Windowless Sampling Rig		Co-ords:	Start Date: 06/12/2016	End Date: 06/12/2016					
			Backfill Date: 06/12/2016	Field Records: SMD					
		Ground Level (mAOD):	Logged: SMD	Chkd: PJE					
				Appr: PJE					
Strata Description	Depth (m)	Level (m)	Legend	Sample Type	Sample Depth (m)	Tests	Groundwater Records	Backfill Details	
Grass over TOPSOIL : Brown clayey SAND topsoil with rootlets.	0.35			ES1	0.20	N=8 (C)	1.80 1.80		
Very soft to soft, brown, sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine and medium chert and quartzite.				ES2	0.50				
Becoming firm at 1.30m.				D3	1.00				
				D4	1.50				
Firm, reddish brown CLAY with slight grey-brown mottling.	2.00			D5	2.50	N=12 (C)			
Firm to stiff, dark red-brown CLAY.	3.10			D6	3.50	N=10 (C)			
						N=10 (C)			
	5.00					N=14 (C)			
Remarks: 1. SPT 'N' values corrected to a N60 value in accordance with BS EN 22476 Part 3 and where appropriate extrapolated for partial penetration. 2. Groundwater encountered at 1.80m begl. 3. Hole terminated at 5.00m begl. 4. Borehole installed with gas and groundwater monitoring standpipe as detailed above.						Sample Type Key D - Disturbed Representative B - Bulk Representative S - Spot Non-Representative W - Water U - Undisturbed Representative J - Jar Sample ES - Environmental Sample		Test Type Key (C) - Cone SPT (S) - Spoon SPT P - Pocket Penetrometer Reading PID - PID Reading V - Hand Shear Vane Reading	
Sheet:						Sheet 1 of 1			

Exploratory Hole ID:	Client: Lidl UK GmbH				 www.opusinternational.co.uk				
WS03	Site: Hayling Island								
Job No:	J-B1118.00				Start Date:		End Date:		
				06/12/2016		06/12/2016			
Drilling Equipment/ Excavation Method:				Co-ords:		Backfill Date:		Field Records:	
Tracked Windowless Sampling Rig						06/12/2016		SMD	
				Ground Level (mAOD):		Logged:		Chkd:	
						SMD		PJE	
								PJE	
Strata Description	Depth (m)	Level (m)	Legend	Sample Type	Sample Depth (m)	Tests	Groundwater Records	Backfill Details	
Grass over TOPSOIL : Brown clayey SAND topsoil with rootlets.	0.35			ES1	0.20				
Soft, brown, sandy, gravelly CLAY. Gravel is subangular to subrounded, fine and medium chert and quartzite.				ES2	0.50				
Grey-brown, very sandy, subangular to subrounded, fine to coarse GRAVEL of quartzite and chert.	1.00			D3	1.20	N=25 (C)	1.70 1.70		
Light brown, slightly clayey, slightly gravelly, fine to coarse SAND. Gravel is subangular to subrounded, fine to coarse chert and quartzite.	1.50			D4	1.60	N=15 (C)			
Firm, reddish brown CLAY with slight grey-brown mottling.	2.20			D5	2.30	N=9 (C)			
Firm to stiff, dark red-brown CLAY.	3.10			D6	3.50	N=13 (C)			
	5.00					N=18 (C)			
Remarks:				Sample Type Key		Test Type Key			
1. SPT 'N' values corrected to a N60 value in accordance with BS EN 22476 Part 3 and where appropriate extrapolated for partial penetration.				D - Disturbed Representative		(C) - Cone SPT			
2. Groundwater encountered at 1.70m begl.				B - Bulk Representative		(S) - Spoon SPT			
3. Hole terminated at 5.00m begl.				S - Spot Non-Representative		P - Pocket Penetrometer Reading			
4. Borehole backfilled with arisings upon completion.				W - Water		PID - PID Reading			
				U - Undisturbed Representative		V - Hand Shear Vane Reading			
				J - Jar Sample					
				ES - Environmental Sample					
				Sheet:					
				Sheet 1 of 1					

Exploratory Hole ID:	Client: Lidl UK GmbH		 OPUS www.opusinternational.co.uk	
WS04	Site: Hayling Island			
Job No:	J-B1118.00		Start Date:	End Date:
		06/12/2016		06/12/2016
Drilling Equipment/ Excavation Method:		Co-ords:		Backfill Date:
Tracked Windowless Sampling Rig				06/12/2016
		Ground Level (mAOD):		Field Records:
				SMD
		Logged:		Chkd:
		SMD		PJE
				Appr:
				PJE

Strata Description	Depth (m)	Level (m)	Legend	Sample Type	Sample Depth (m)	Tests	Groundwater Records	Backfill Details
Grass over TOPSOIL : Brown clayey SAND topsoil with rootlets.	0.30			ES1	0.20	N=37 (C)	1.60 1.60	
Soft, brown, sandy, gravelly CLAY. Gravel is subangular to subrounded, fine and medium chert and quartzite.				ES2	0.50			
Brown, sandy, subangular to subrounded, fine to coarse GRAVEL of quartzite and chert.	0.80			D3	1.00			
								
Light brown, slightly gravelly, fine to coarse SAND. Gravel is subangular to subrounded, fine to coarse chert and quartzite.	1.70			D5	2.70			
Firm, reddish brown CLAY with slight grey-brown mottling.	2.50			D5	2.70	N=14 (C)		
Light brown, slightly gravelly, fine to coarse SAND. Gravel is subangular to subrounded, fine to coarse chert and quartzite.	3.00							
	4.00					N=11 (C)		

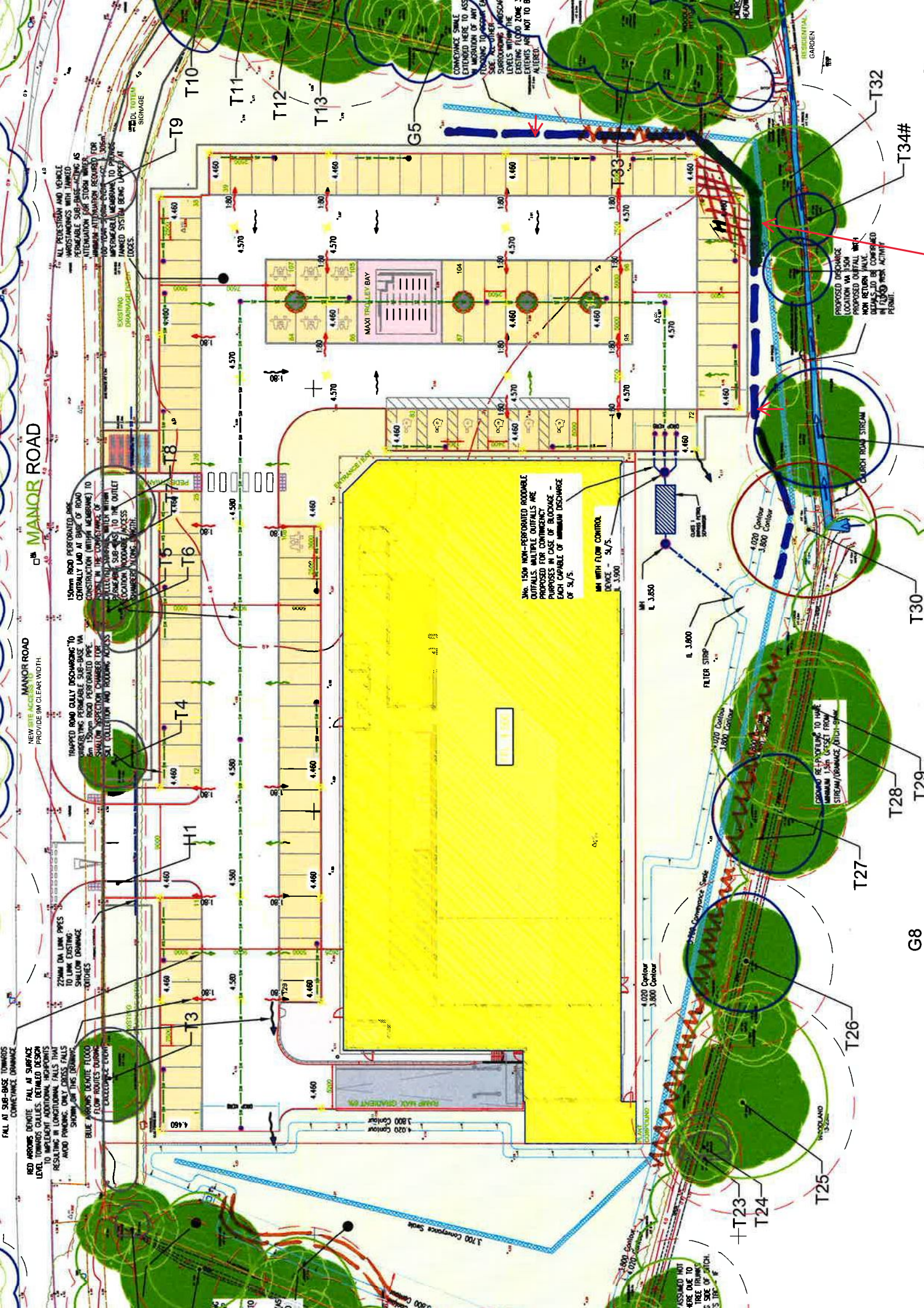
Remarks: 1. SPT 'N' values corrected to a N60 value in accordance with BS EN 22476 Part 3 and where appropriate extrapolated for partial penetration. 2. Groundwater encountered at 1.60m begl. 3. Hole terminated at 4.00m begl. 4. Borehole backfilled with arisings upon completion.	Sample Type Key D - Disturbed Representative B - Bulk Representative S - Spot Non-Representative W - Water U - Undisturbed Representative J - Jar Sample ES - Environmental Sample	Test Type Key (C) - Cone SPT (S) - Spoon SPT P - Pocket Penetrometer Reading PID - PID Reading V - Hand Shear Vane Reading
	Sheet: Sheet 1 of 1	

Exploratory Hole ID:	Client: Lidl UK GmbH				 www.opusinternational.co.uk				
WS05	Site: Hayling Island								
Job No:	J-B1118.00				Start Date:		End Date:		
				06/12/2016		06/12/2016			
Drilling Equipment/ Excavation Method:				Co-ords:		Backfill Date:		Field Records:	
Tracked Windowless Sampling Rig						06/12/2016		SMD	
				Ground Level (mAOD):		Logged:		Chkd:	
						SMD		PJE	
								PJE	
Strata Description	Depth (m)	Level (m)	Legend	Sample Type	Sample Depth (m)	Tests	Groundwater Records	Backfill Details	
Grass over TOPSOIL : Brown clayey SAND topsoil with rootlets.	0.30			ES1	0.20				
Brown, sandy, subangular to subrounded, fine to coarse GRAVEL of quartzite and chert.				ES2	0.50				
Brown mottled grey-brown, sandy, subangular to subrounded, fine to coarse GRAVEL of quartzite and chert.	1.10			D3	1.10	N=10 (C)			
Firm, reddish brown mottled grey brown CLAY	2.10			D4	2.20	N=12 (C)			
Firm, dark red-brown CLAY.	3.10					N=12 (C)			
	4.00					N=12 (C)			
Remarks:					Sample Type Key		Test Type Key		
1. SPT 'N' values corrected to a N60 value in accordance with BS EN 22476 Part 3 and where appropriate extrapolated for partial penetration.					D - Disturbed Representative		(C) - Cone SPT		
2. Groundwater not encountered during drilling.					B - Bulk Representative		(S) - Spoon SPT		
3. Hole terminated at 4.00m begl.					S - Spot Non-Representative		P - Pocket Penetrometer Reading		
4. Borehole installed with gas and groundwater monitoring standpipe as detailed above.					W - Water		PID - PID Reading		
					U - Undisturbed Representative		V - Hand Shear Vane Reading		
					J - Jar Sample				
					ES - Environmental Sample				
					Sheet:				
					Sheet 1 of 1				

Exploratory Hole ID:	Client: Lidl UK GmbH				 www.opusinternational.co.uk				
WS06	Site: Hayling Island								
Job No:	J-B1118.00				Start Date:		End Date:		
				06/12/2016		06/12/2016			
Drilling Equipment/ Excavation Method:				Co-ords:		Backfill Date:		Field Records:	
Tracked Windowless Sampling Rig						06/12/2016		SMD	
				Ground Level (mAOD):		Logged:		Chkd:	
						SMD		PJE	
								PJE	
Strata Description	Depth (m)	Level (m)	Legend	Sample Type	Sample Depth (m)	Tests	Groundwater Records	Backfill Details	
Grass over TOPSOIL : Brown clayey SAND topsoil with rootlets.	0.35			ES1	0.20	N=9 (C)			
Brown, sandy, subangular to subrounded, fine to coarse GRAVEL of quartzite and chert.				ES2	0.50				
				D3	1.00				
				D4	1.50				
Firm, reddish brown mottled grey brown CLAY	1.75			D5	2.00	N=10 (C)			
						N=11 (C)			
Firm, dark red-brown CLAY.	3.30			D6	3.50	N=14 (C)			
						N=22 (C)			
	5.00								
Remarks: 1. SPT 'N' values corrected to a N60 value in accordance with BS EN 22476 Part 3 and where appropriate extrapolated for partial penetration. 2. Groundwater not encountered during drilling. 3. Hole terminated at 5.00m begl. 4. Borehole backfilled with arisings upon completion.						Sample Type Key D - Disturbed Representative B - Bulk Representative S - Spot Non-Representative W - Water U - Undisturbed Representative J - Jar Sample ES - Environmental Sample		Test Type Key (C) - Cone SPT (S) - Spoon SPT P - Pocket Penetrometer Reading PID - PID Reading V - Hand Shear Vane Reading	
						Sheet: Sheet 1 of 1			

APPENDIX IX

RPS ARBORICULTURALIST SKETCH



APPENDIX X

Drainage Maintenance Schedule for Storm Water

LIDL, HAYLING ISLAND - PROPOSED MAINTENANCE SCHEDULE FOR STORM WATER DRAINAGE

Item:	Required Maintenance/Monitoring:	Suggested Frequency/Persons suitable:
Swale and Flood Basin:	Litter and debris removal.	Monthly.
	Grass cutting – for swale and access routes.	Monthly (during growing season), or as required.
	Grass cutting – meadow grass in and around basin.	Half yearly (spring – before nesting season, and autumn).
	Manage other vegetation and remove nuisance plants.	Monthly (at start, then as required).
	Tidy all dead growth before start of growing season.	Annually.
	Remove sediment from outlet by ditch.	Annually (or as required).
	Re-seed areas of poor vegetation growth.	Annually, or as required.
	Prune and trim trees and remove cuttings	2 years, or as required.
	Re-level uneven surfaces and reinstate design levels.	As required.
Surface Water Drainage:	Check inspection chambers and manholes for evidence of poor operation	Every six months
	Check functionality of Bypass Interceptor. Empty when necessary. Long term maintenance in accordance in with manufacturer's guidelines.	As per manufacturer's guidelines (or as required)
	Undertake a CCTV drainage survey of the rigid perforated pipes.	Every five to ten years, or as required.
	Replace or repair malfunctioning parts or structures	As required
Gullies	Check gullies and channel drains for evidence of poor operation	Every six months
	Remove sediment, oil/grease and floating debris	As necessary
	Replace or repair malfunctioning parts or structures	As required
	Keep growth of vegetation under control.	Monthly (or as required). Disturbance to be minimised by stream during animal spawning season (March to mid-July).
Surrounding Drainage Ditches and Church Road Stream on southern boundary	Check for blockages at the three following locations: 1) Where swale meets drainage ditch on south west corner; 2) At any headwalls; 3) at stream outlet headwall beside Church Road (access permitting). Clear all blockages.	Monthly (or as required).
	Remove excess silt. If non-hazardous deposit silt in area near top of bank, but not in locations likely to cause reintroduction of the silt from run-off, and not within flood basin area.	Annually (or as required).
	Remove litter and fallen tree debris.	Monthly (or as required).
Flood Flow Routes:	Ensure flood flow routes are not obstructed (i.e. lower lying portions of the land that will direct surface water runoff away from vulnerable assets in the event of drainage failure)	Every six months, and more frequently during periods of heavy rainfall (Caretaker)

Lidl UK GmbH will be responsible for the implementation of the maintenance schedule for storm water drainage, by appointing appropriate persons and/or management companies that are able to undertake these operations. This maintenance schedule has been produced with reference to the guidelines outlined in 'The SuDS Manual' (CIRIA C753: 2015). The suggested frequency of maintenance is considered a guide, and should not replace the guidance from manufactures of proprietary systems.

Refer to 'As-Built' drawings for location of below ground drainage assets.

APPENDIX XI

JBA Fluvial Model Assessment

Hayling Island Modelling Summary Report for Lidl UK GmbH Flood Risk Assessment

Final

September 2017

HOP Consulting Civil and Structural
Engineers

JBA Project Manager

Jennifer Hill
8a Castle Street
Wallingford
OX10 8DL

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft Report v1		Elliott Flynn
Final report v2	Addressed comments from Elliott Flynn	Elliott Flynn

Contract

This report describes work commissioned by Elliott Flynn, of HOP Consulting Civil and Structural Engineers on behalf of Lidl UK GmbH by an email dated 7th August 2017. HOP's representative for the contract was Elliott Flynn. Jenny Hill and Cheryl Briars of JBA Consulting carried out this work.

Prepared by Cheryl Briars BSc MSc
Assistant Analyst

Reviewed by Jennifer Hill BSc MSc MCIWEM C.WEM
Chartered Senior Analyst

Purpose

This document has been prepared as a Draft Report for HOP Consulting Civil and Structural Engineers. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to HOP Consulting Civil and Structural Engineers and Lidl UK GmbH.

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JBA is aiming to reduce its per capita carbon emissions.

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1 Introduction

JBA Consulting were commissioned to prepare a modelling assessment which could examine the fluvial flood risk in central Hayling Island. The driver for this study was the proposed development of a food store (Lidl), which is partially located within the Environment Agency's Flood Zone 3. However, the Flood Zones at this location were based on JFLOW modelling and the Environment Agency had advised that these were not suitable for use in a site-specific Flood Risk Assessment. A Flood Risk Assessment was produced in March 2017 but the Environment Agency objected to it on the basis of insufficient flood zone compensation. Therefore, this assessment was commissioned to better understand the fluvial flood risk at the Lidl development site.

Information provided by the Environment Agency in 2017 and included in the previous Flood Risk Assessment undertaken by HOP Civil and Structural Engineers in February 2017 showed that there is one 'main river' designated watercourse, the Church Road Stream, which runs alongside the proposed development site area and collects water from at least two additional drains/watercourses. A previous survey of the Church Road Stream included point levels within the site, however, additional survey is required to understand the channel geometry on and off the site.

The previous FRA noted that the Church Road Stream drains to a culvert under Church Road and that this was liable to blockage. Therefore, the JBA modelling assessment has included a blockage assessment of the culvert, as it is critical to the drainage of the site, and is only 225mm in diameter.

The Partnership for Urban South Hampshire, which includes Havant, produced a Strategic Flood Risk Assessment in 2007. The SFRA concludes that the predominate flood risk to Hayling Island is from the sea, however, the Environment Agency have confirmed that flood risk from the sea is not a concern at the site due to its central location on the island. Therefore, a fluvial only flood model was developed for this study to understand the flood risk at the site. However, the downstream condition of the model did consider the tidal cycle.

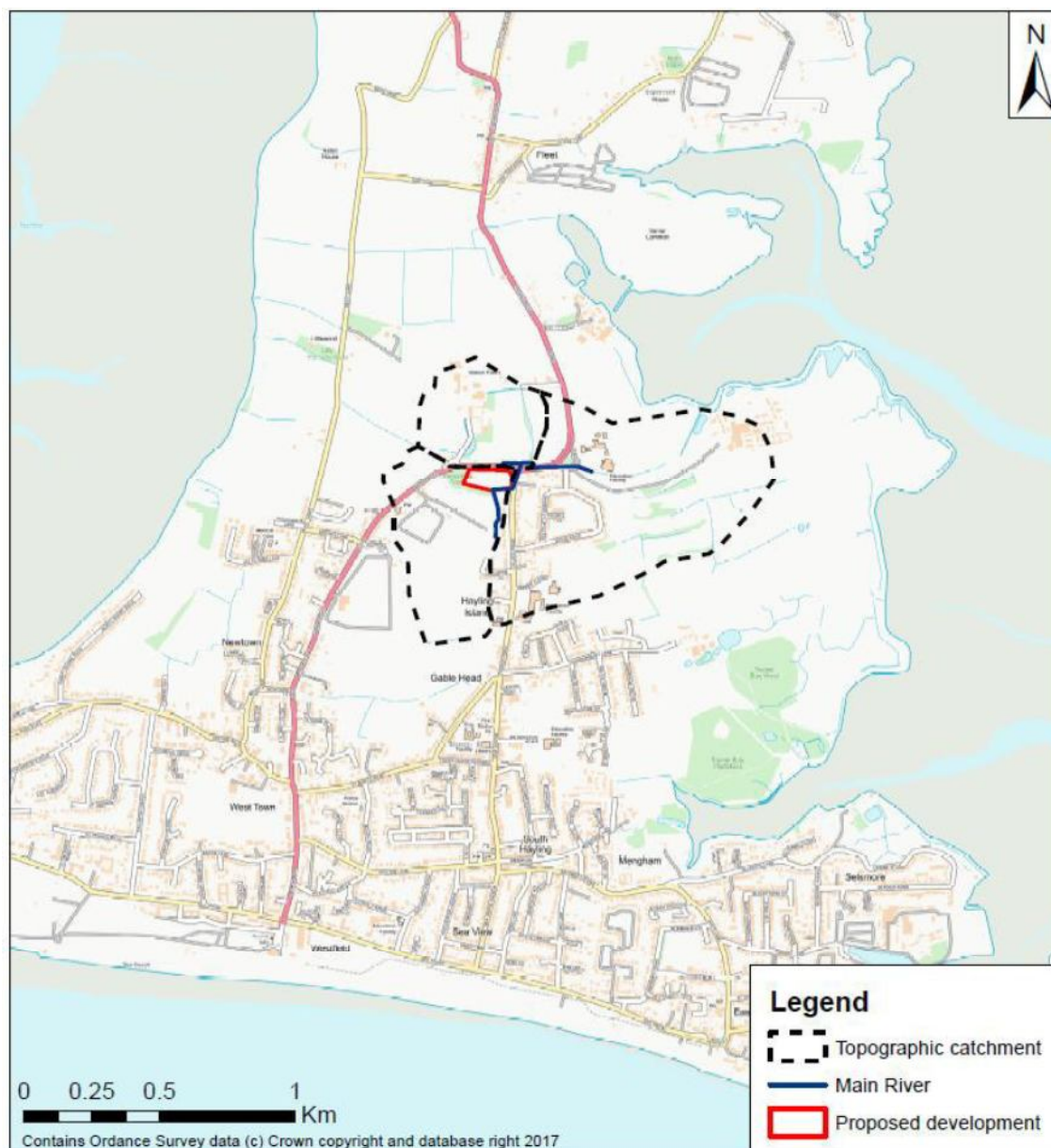
This report documents the model development and results which has been developed in the support of a further Flood Risk Assessment developed by HOP Engineers. The report has been broken down into the following sections:

- Description of the study area
- Hydrology
- Model build
- Model results
- Conclusions
- Appendices - mapped modelled outputs

2 Study area

The site location is approximately central within Hayling Island. The southern coastline, Hayling Bay, is located approximately 2km from the site, whilst the western shoreline of Langstone Harbour is 1km and the eastern shoreline of Chichester harbour is approximately 700m away. The study focuses on the area surrounding the proposed development and Church Road Stream (Figure 2-1). The proposed site development is bounded by the A2023 Manor Road along with a few small patches of woodland that are located to the west and east of the site. Church Road is beyond this area, which surrounds the majority of the southern boundary of the site. An area of residential development exists along the south east boundary of the site.

Figure 2-1: Study area



2.1 Proposed development

The proposed development is located on Manor Road and the site area is approximately 1.16ha in size and rectangular in shape. The land is currently made up of maintained grass. The proposed development involves construction of a two-storey building that will provide more than 100 car parking bays. The north of the site is bounded by the A2023 Manor Road and by Church Road in the south.

There are separate drainage ditches that surround the site development area, except on the southern and south-eastern boundary where Church Road Stream exists, categorised as Main River by the Environment Agency. The site is currently accessed by vehicles via a gate on the north-west corner. The development proposals include the development of a new vehicle crossover, access road and parking, however a significant portion of the land will remain as landscaping. An overview of the site is given in Table 2-1.

Table 2-1: Site description

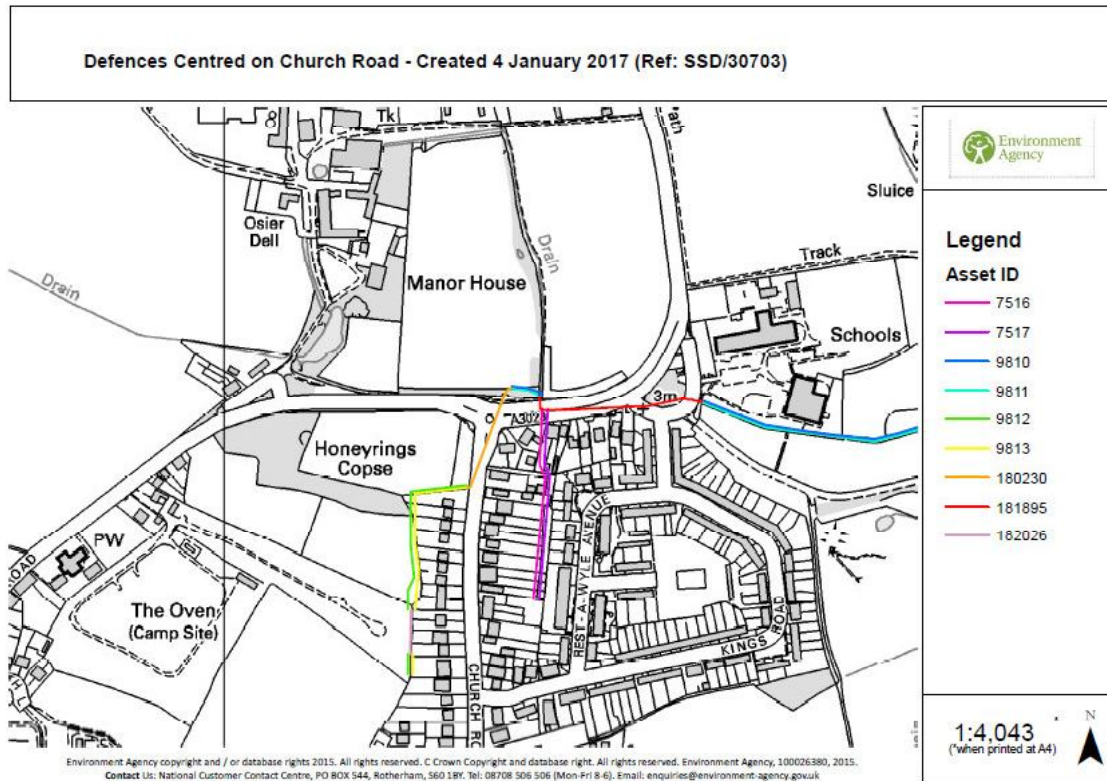
Site name	Lidl
Site area	1.16ha
Existing land use	Grassland utilised as pasture land for horses. It is considered to be flat and relatively featureless.
Proposed land use	Food store
OS NGR	SU 72195 00606
County	Havant, Hampshire
Country	United Kingdom
Local Planning Authority	Havant Borough Council
Lead Local Flood Authority	Havant Borough Council

2.2 Watercourses

Church Road Stream has been identified by the Environment Agency as a Main River. Church Road Stream flows northwards towards the site, at the rear of Church Road properties, before flowing eastwards as it reaches the site just within the site boundary. As the stream flow eastwards, it enters a small patch of woodland beyond the site boundary and reaches a brick headwall with a 225mm diameter outlet which conveys the stream into a public drainage network. Figure 2-2 shows Church Road Stream and the assets that surround it¹. The green and blue lines (asset IDs 9812, 9810 and 9811) represent open channel, whilst the other represent culverted cross sections. The yellow and green lines represent Church Road Stream.

¹ <http://www.hayling-island.lidl.co.uk/download-reports/>

Figure 2-2: Defences Centred on Church Road



2.3 Site geology

The British Geological Survey 'Geology of Britain Viewer' was used to identify the local geology². The bedrock geology in the study area is underlain by the London Clay formation, which consists of clay, silt, sand and gravel. This is a relatively impermeable geology. As a result, rainfall falling directly onto the lower catchment is less likely to infiltrate, and more likely to generate surface water runoff. In addition, runoff draining from the upper catchment is likely to remain on the surface rather than infiltrate. The bedrock geology is overlain by River Terrace Deposits, which consists of sand silt and clay.

2.4 Flood history

There has been a several flooding events that Hayling Island have experienced in the past. Hayling Island experienced flooding during the 1970s and 1980's, particularly along the South Eastern peninsula of the island³. The Environment Agency historic flood map identified that there was a recorded flood event within near to the study area on 30th October 2000 on Church Lane. The source of this flooding has been linked to Gable Head watercourse. No other previous flooding has been evident as part of an online search that was carried out.

² British Geological Survey (BGS): Geology of Britain Viewer

³ The Hayling Site, online: <http://www.hayling.co.uk/life/flooding/> accessed on 22/09/2017

3 Hydrology

The catchment area of Hayling Island serving the Church Road Stream is relatively small and has low permeable top soil, therefore the catchment has been considered to be 'flashy' in nature and reactive to short time periods of rainfall. Full hydrographs were required for return periods of 1 in 20, 100, 1000 each year events and the 1 in 100 year event accounting for climate change.

3.1 Flow estimation method

The UK Flood Estimation Handbook (FEH) was used to estimate fluvial flows as is recommended for small catchments⁴. The FEH Statistical method was used as the BFIHOST value exceeded that which is recommended for use of the ReFH1 method. The newer ReFH2 method was considered for use in place of the original ReFH because the new method has been shown to give improved results for permeable catchments and a re-calibration of the design event using the new FEH13 rainfall statistics. However, ReFH2 was not used because it has not been published in full or (to our knowledge) formally peer reviewed and it has been found to generate unrealistically high flows on some small impermeable catchments, in some cases with the model producing a greater volume of river flow than the volume of input rainfall.

Design hydrographs were required for the hydraulic model. Therefore, the FEH Statistical peak flows were fitted to ReFH derived hydrographs.

FEH Statistical flow estimates were derived for the downstream extent of the Church Road Stream. These flows were then scaled by area to represent the three main subcatchments shown in Figure 2-1.

3.2 Catchment Descriptors

A qualitative check of several FEH CD-ROM catchment descriptors was undertaken. The catchment boundary was checked against the topography of the area and where high points fall. The AREA was modified to fit a smaller area as it was not considered sensible when reviewing the original flood zones that had been estimated using the original boundary of 0.65km². The new catchment boundary was identified using 2m EA open source LiDAR data. The updated catchment boundary had an area of 0.95km². This total area was divided into three subcatchments. The DPLBAR was modified to reflect the change in the AREA. The FEH Handbook states $DPLBAR = AREA^{0.548}$ for manual alteration of DLPBAR. This power term is based on research across the whole country. Observation of the catchment area showed the FARL value to be correct, as it had a value of 1 reflecting that there is no reservoir influence in the catchment. The BFIHOST seems reasonable based on the geology and soil types in the region. URBEXT values were checked against the urban extent outlined on OS mapping and aerial photography. Therefore, all other catchment descriptors remained the same as exported from the FEH CD-ROM.

3.3 Climate change allowances

In line with Environment Agency guidance the effects of climate change on flood extents must be accounted for, demonstrating changes in flood risk over the lifetime of a development. Making allowance for climate change helps to minimise vulnerability and provide resilience to flooding in the future. The climate change scenarios are published in the EA's guidance, flood risk assessments: climate change allowances that was initially released in February 2016⁵. The three allowances to be tested are the Central, Higher Central and Upper End estimates of total potential change in peak flow rates anticipated for the '2080s' (2070-2115). The uplifts for the South East region were used as the watercourse is located in the South East Basin District, as described in Table 3-1.

⁴http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SC090031_-_Phase_1_Technical_Report.sflb.ashx

⁵ Flood Risk Assessments Climate Change Allowances, <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances> accessed on 25/09/2017.

Table 3-1: Climate change uplift allowances

Emissions Scenario	Total potential change anticipated for the 2080's (2070-2115)
Upper end	105%
Higher central	45%
Central	35%

For less vulnerable development such as the proposed development, the higher central emissions scenario is relevant. Therefore, the 1 in 100-year event plus 45% uplift to account for climate change was the focus of this study.

4 Model Build

A new hydraulic model was built for Church Road Stream. Due to the number of small channels and extended culverts, InfoWorks ICM was the most suitable software package to model this type of watercourse. InfoWorks ICM has been benchmarked and approved by the Environment Agency.

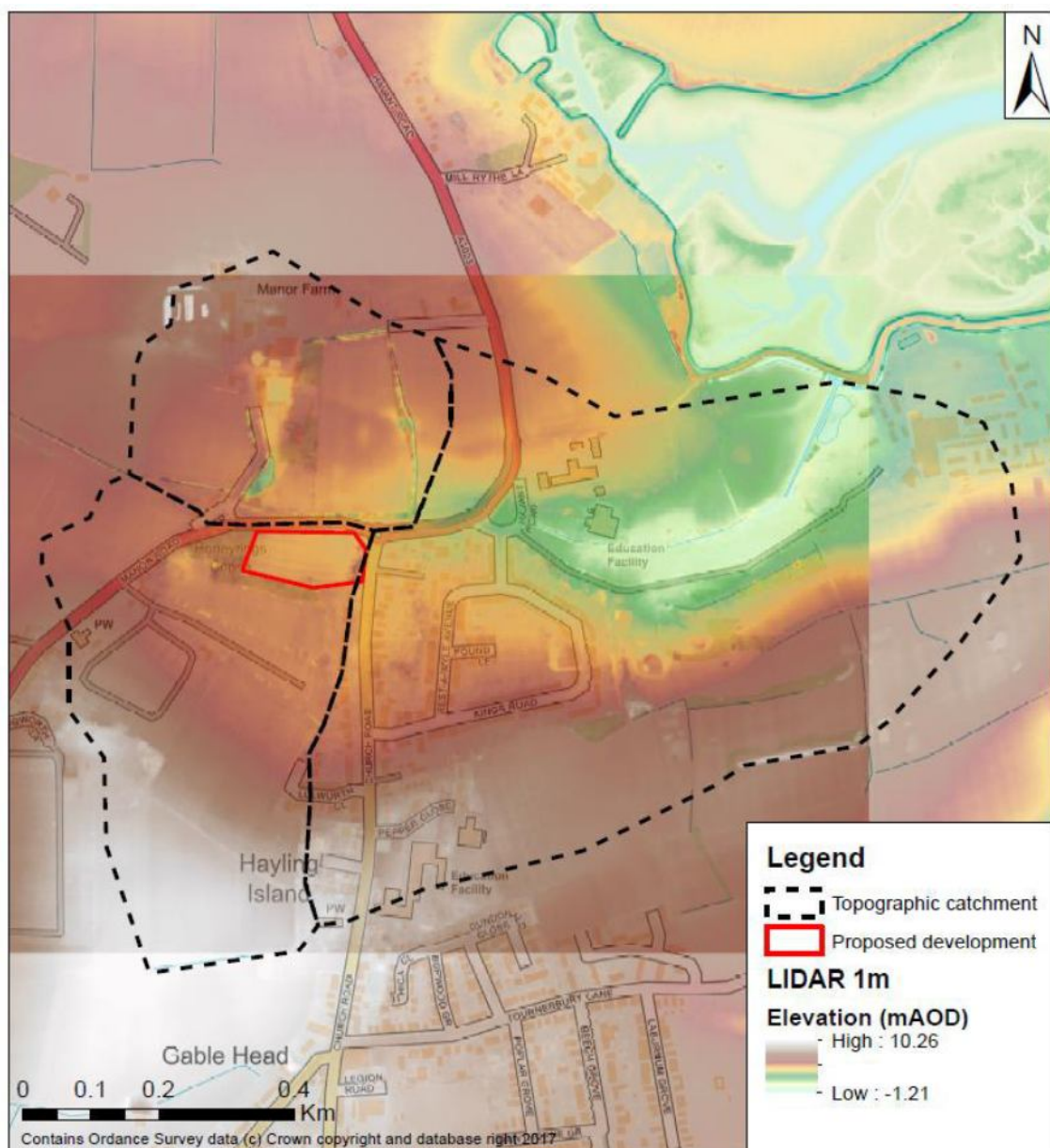
4.1 Available data

This section outlines the data used to inform the Church Road Stream modelling project.

4.1.1 Topographic data

One-metre LIDAR was available from the Environment Agency (EA) which is freely available data. The catchment has been split into three smaller catchment areas, northern, southern and lower division boundaries, as displayed in Figure 4-1. The LIDAR data demonstrates that the area of Hayling Island is particularly flat, with the highest point of elevation being approximately 8.4mAOD at the far southern tip of the catchment boundary. The topography gradually reduces northwards through the site and rises again at the northern boundary. The proposed development site has a topographic elevation of approximately 4mAOD.

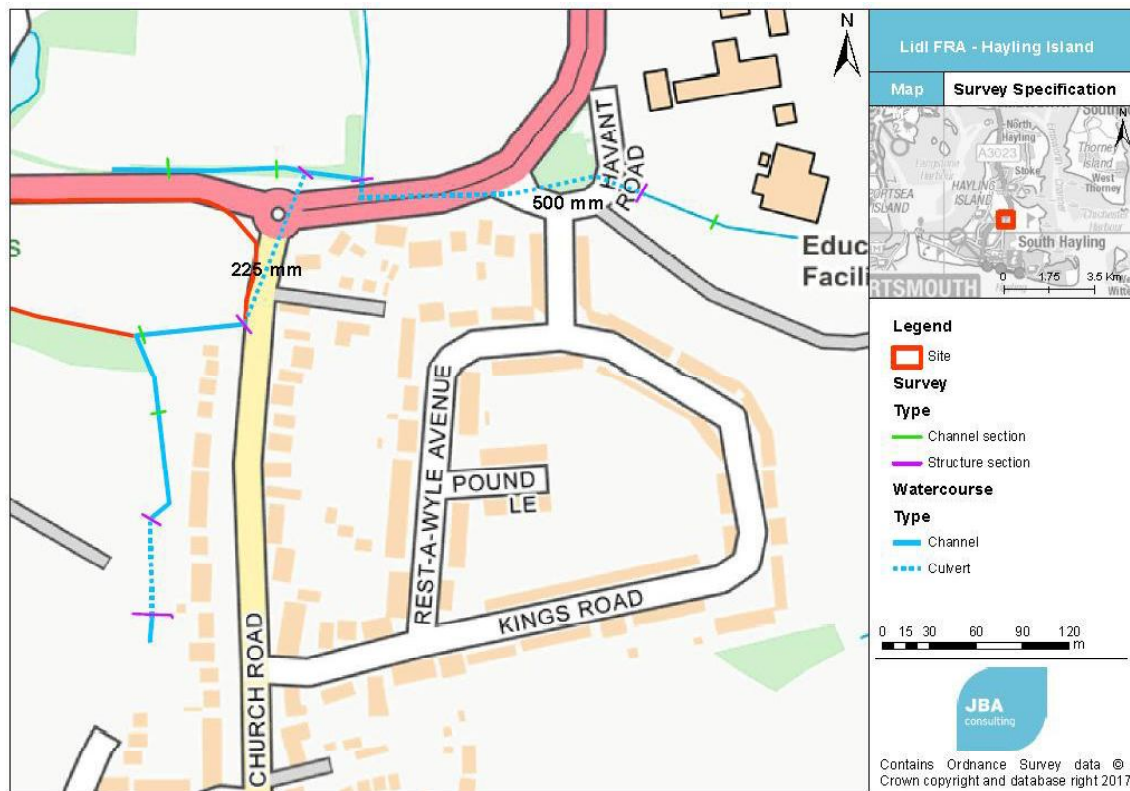
Figure 4-1: 1m LIDAR DTM data



4.1.2 Survey data

A topographic channel survey was complete by GC Surveys in August 2017 to inform the modelling study. The survey included 11 cross sections of Church Road Stream and the local drainage ditches. The location of cross sections can be seen in Figure 4-2.

Figure 4-2: Channel cross section survey extent



4.1.3 Land use data

OS StreetView mapping and aerial photography has been used to define land use across the catchment. This data has been used in the model build to define the land surface across the modelled area of interest. This included urban areas of roads and buildings and rural areas of green areas, and Honeyrings Corpse (proposed development site)). The land use data has also been used to define building footprints, roughness zones, and mesh zones.

4.2 Model development

This section describes the development of the model representing the baseline and proposed development scenarios.

4.2.1 Baseline model

The initial model build focused on running the hydraulic model for five fluvial flood events for the return periods of 1 in 100-year, 1 in 20-year, 1 in 1000-year and 1 in 100 years plus climate change annual exceedance probabilities (AEP's) in line with Environment Agency guidance published in 2016.

The 2D model

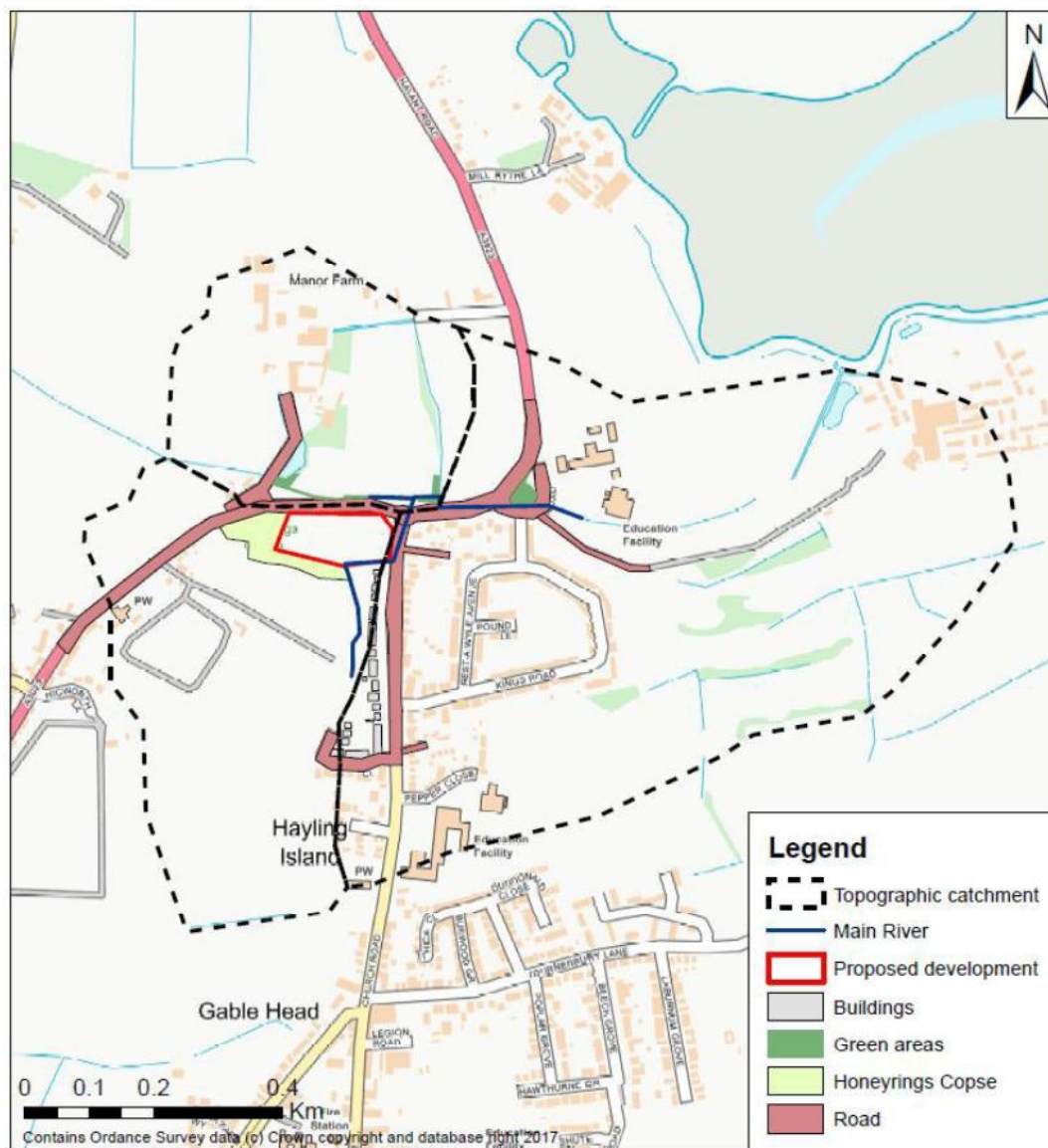
The development of the 2D model is outlined in Table 4-1.

Table 4-1: Hydraulic model development

Physical feature	Model feature	Count	Description
Topography	2D zone	1	The 2D zone was the whole topographic catchment as defined by the watershed around the study site which consisted of three sub-divisions (a northern, southern and lower division). The 2D zone was then divided into a mesh of elements. Each element took its elevation from LiDAR. The elements varied in size. The roughness and infiltration rate of each element in the 2D model was set by overlying zones as described below. A rainfall storm was applied across the 2D zone for the 5, 1, 0.1 and 1+ climate change Annual Exceedance Probabilities.
Land cover	Roughness zones	25	The roughness zones were digitised using OS StreetView mapping of the study site and survey results images that were provided. Each land surface has its own defined roughness.
Buildings	Roughness zones	10	The roughness zones were digitised using OS StreetView mapping of buildings. The buildings represent a significant flow obstruction so a Manning's n of 0.3 was used.
Open channel	River reach	4	The river line was informed by the survey data that was provided by Grantham Coates Survey Ltd.
Culverts	Conduits	3	The culvert was informed by the survey data that was provided by Grantham Coates Survey Ltd.

The 2D model schematic of Hayling Island model build for Church Road Stream can be seen in Figure 4-3.

Figure 4-3: Church Road Stream 2D model Schematic



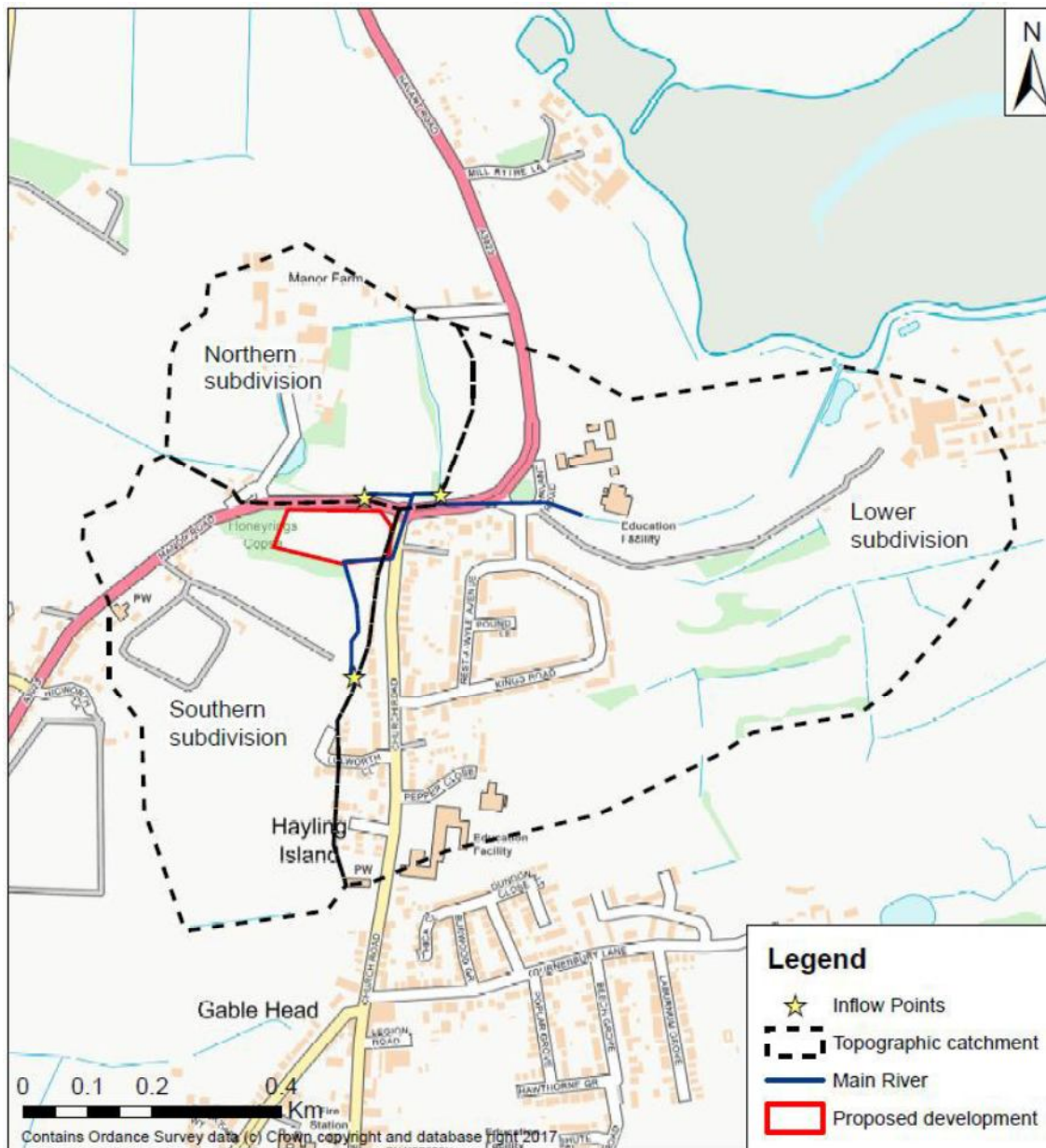
4.2.2 Church Road Stream flows

Hydrographs were calculated for a range of return periods including the 1 in 100-year, 1 in 20-year, 1 in 1000-year and 1 in 100 years plus climate change annual exceedance probabilities (AEP's) in line with Environment Agency guidance published in 2016. The approach that was taken to produce flow estimates for the model was the use of the ReFH method to produce the design hydrographs and the FEH Statistical method was used to represent the peak flows for each of the different return periods. Combining both methods provided robust flow estimates and enabled full hydrographs to be derived.

Three inflow locations were selected within the study area boundary (Figure 4-4), one at the downstream extent of the open channel nearest to Lulworth Close and at two points upstream along the watercourse near to Manor Road. The total flow to the catchment was scaled down and fitted to the area of the topographic catchment that surrounded each of the three inflow points. Flows to each subdivision of the catchment was based on a percentage of the total area. 15% of the flow was applied to the northern subdivision of the catchment area, 25% was applied to the southern subdivision and 61% was applied to the lower subdivision. The subdivisions that were used are displayed in Figure 4-4.

The Mean High Water Spring tidal cycle for Portsmouth was applied to the downstream extent of the Church Lane Stream model. Tidal peaks were timed to coincide with fluvial peaks. This was to represent the impact of tide locking.

Figure 4-4: Topographic divisions of the Hayling Island catchment



4.2.3 Boundary conditions

The boundary of the 2D zone has been set to normal conditions to allow water to freely flow out of the study area.

4.3 Blockage assessment

A blockage assessment was undertaken for the Hayling Island model which identifies the residual flood risk to the site which could occur if the highway culvert was blocked. The results of this assessment could then be used to inform strategies to avoid the risk presented. This scenario was based on if the Church Road culvert was to be 100% blocked, in anticipation of the Environment Agency's requirement as it is critical to the drainage of the site, and is only 225m in diameter.

This blockage scenario was represented by deleting the culvert and replacing it with a weir of the headwall, allowing fluvial flows to overtop the culvert.

5 Model results

5.1 Baseline model

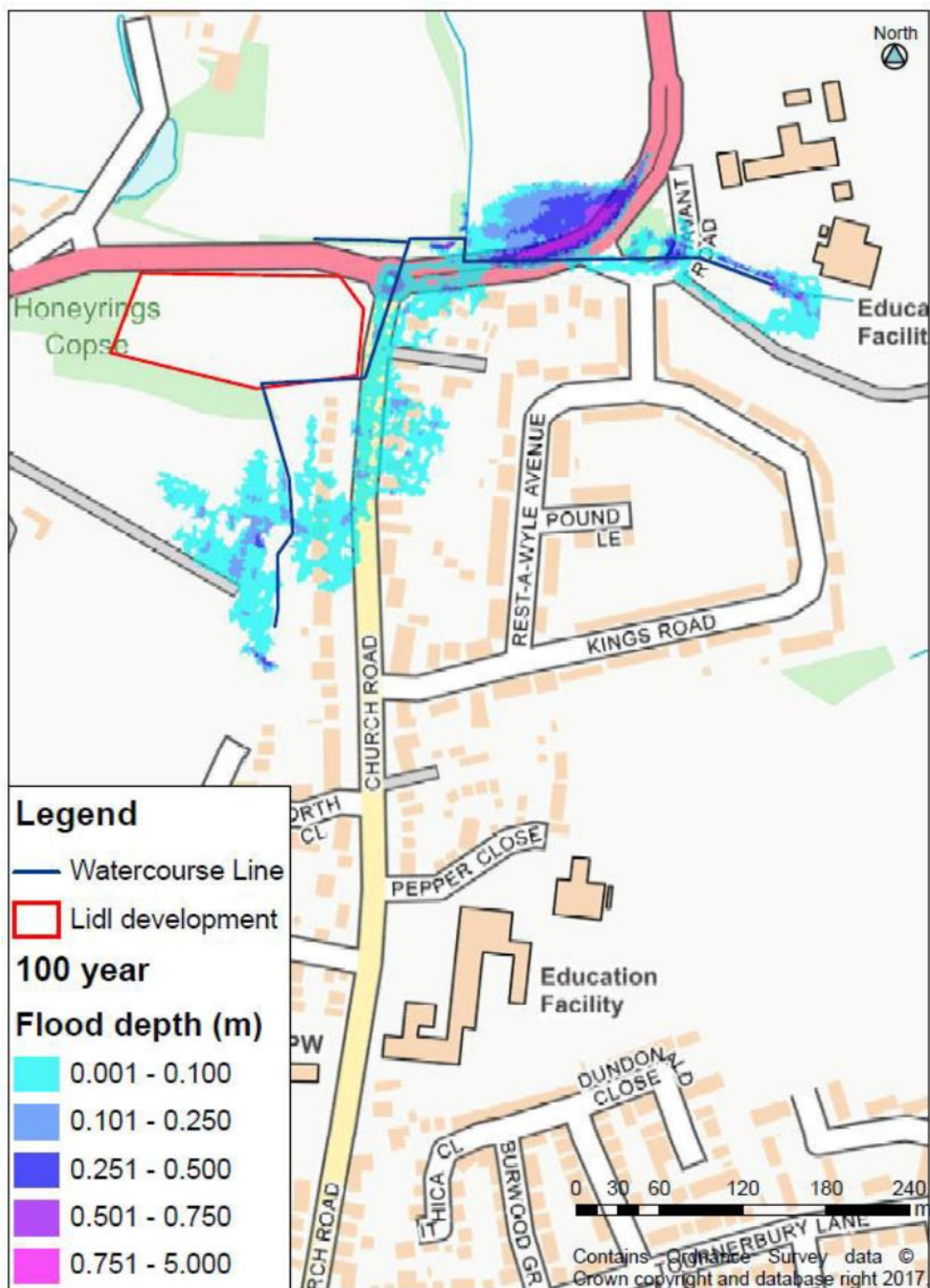
The baseline model results for the four different return periods are outlined below. A full suite of model results are shown in Appendix A.

5.1.1 100-year

Under the baseline scenario, no flooding has been predicted to occur at the proposed development or within the site boundary. However, access to the site from the east, on both Church Road and Manor Road appear to be predicted to flood. The roundabout to the east of the site boundary on Manor Road is predicted to have depths of flooding of 0.57m. Under this event access and egress to the site would be restricted and it would have to be from the west. The maximum flood extent predicted for the 100-year AEP is shown in Figure 5-1.

The results under the 100-year extent show the maximum depth of flooding to be highest at the downstream extent of the model by the education facility. A large amount of flooding under the 100-year extent is shown to occur at the junction on Manor Road to Havant Road, with depths of up to 0.5m. At the upstream extent of the model, a range of flood depths have been predicted to occur around both the culverted and open section of the channel, ranging between 0.29m and 0.3m.

Figure 5-1: 1-100 year event model results

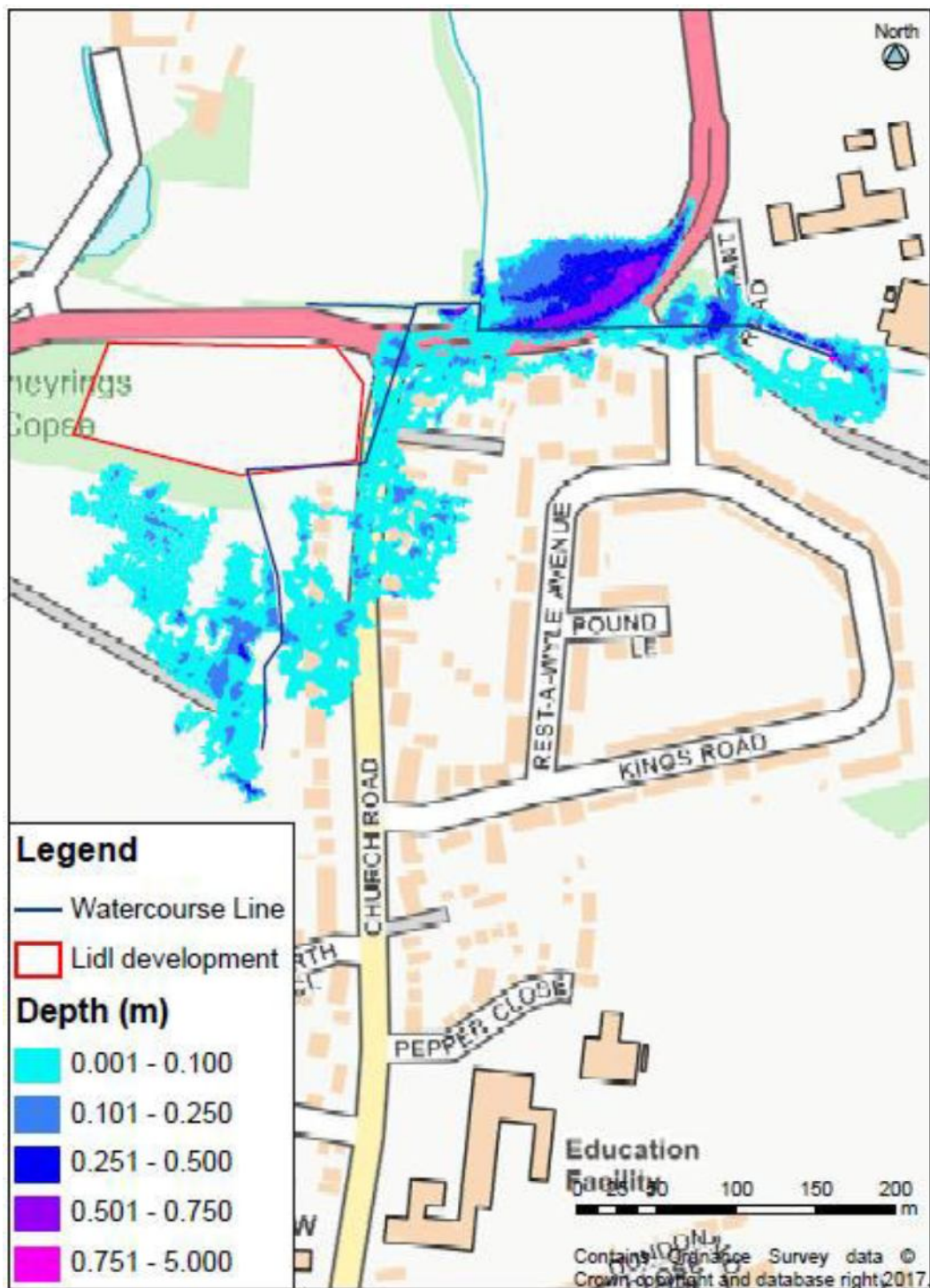


5.1.2 100-year plus 45% climate change

The flooding that is predicted under the 1 in 100 year plus 45% climate change scenario does not show flooding to affect the development at the site boundary (Figure 5-2). The nearest predicted flood risk to the site boundary exists in to the south of the site, displaying a depth of 0.1m.

The modelled flood extent is most prominent at the bend in Manor Road at the junction for Havant Road. The maximum flood extent under this scenario in the downstream extent of the model, with a depth of 0.84m. The maximum flood extent predicted for the 100-year plus 45% climate change AEP is displayed in Figure 5-2.

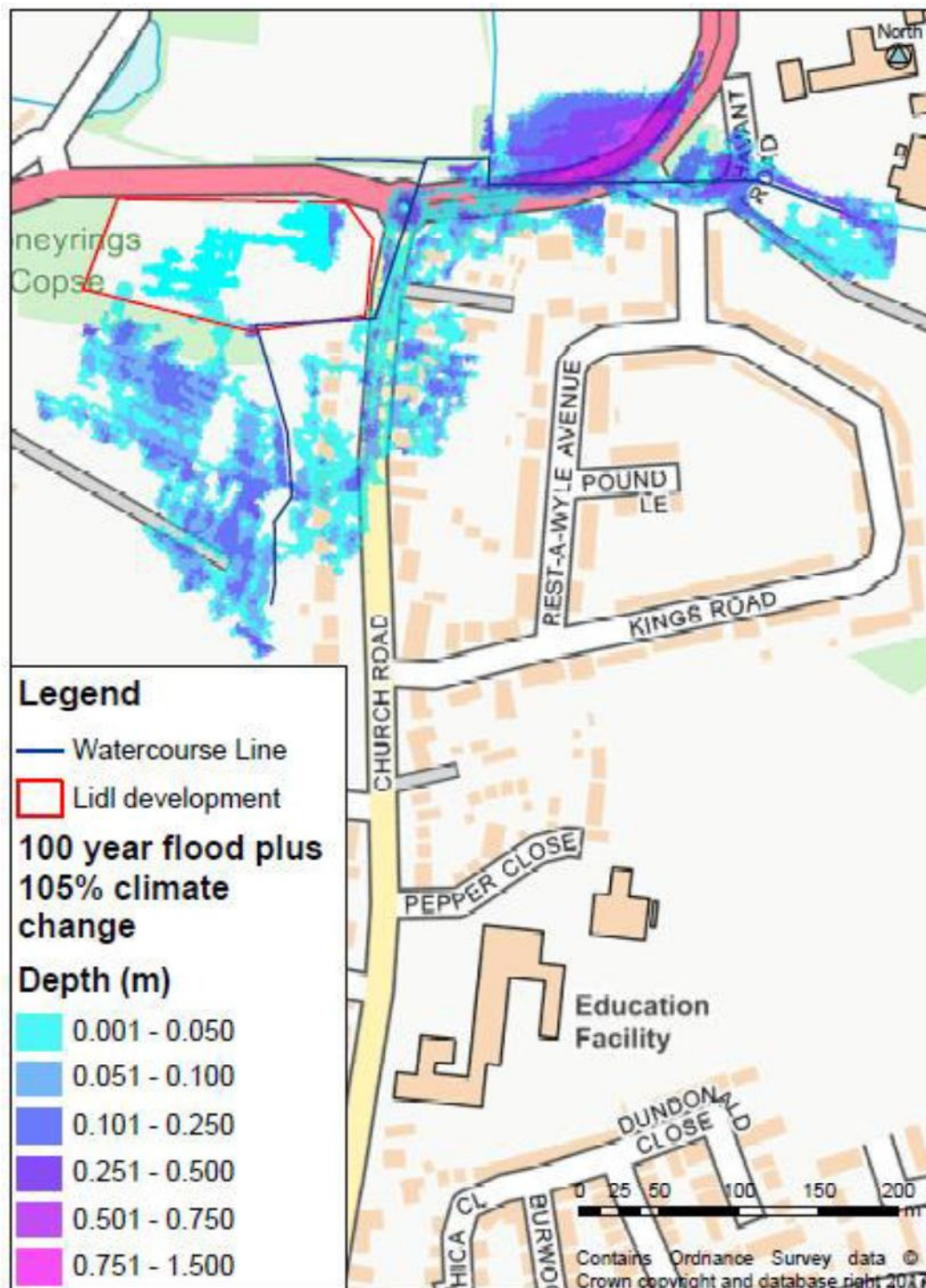
Figure 5-2: 1 in 100 year plus 45% climate change



5.1.3 100-year plus 105% climate change

Under the 1 in 100 year plus climate change scenario, the development footprint showed flooding. The depth of flooding across the land boundary had a total volume of 68.97m³. The flood extent that was shown under this scenario had a pathway of flooding from the south west of the site boundary, that went in a north easterly direction. The presence of the development would however block this path of flooding and would therefore stop the risk of flooding across the development. The result of this modelling scenario is displayed in Figure 5-3.

Figure 5-3: 100-year plus 105% climate change



5.2 Blockage assessment

Result from the blockage assessment are mapped in Appendix A. The results showed that if the culvert was to block, the water would back up and fill the Church Road Stream. When the capacity of the stream is exceeded, flow would spill forward, over Church Road, rather than backing up onto the proposed development site. Therefore, the results from the hydraulic modelling predicted no flooding within the site boundary during a blockage scenario.

6 Conclusion

The project aim was to investigate the fluvial flood risk from Church Lane Stream at a proposed development within central Hayling Island. The proposed development is located within the Environment Agency's current Flood Zone 3. However, the Flood Zones were based on 2D only JFLOW modelling and were thought to overestimate the flood risk. The only scenario that presented any risk of flooding to the proposed site boundary was under the 100-year plus 105% climate change. The project aimed to understand the fluvial flood risk at the site and the surrounding area by creating a detailed 1D-2D InfoWorks ICM model. By better understanding the fluvial flood risk, this information could be used by HOP Engineers to design an appropriate level of floodplain compensation required at the site.

The objectives were achieved by collecting survey information on the channel geometry on and off the site, completing a hydrological assessment generating flows for the 5, 1, and 0.1% AEPs and the 1% AEP plus climate change, in line with Environment Agency guidance published in 2016, completing baseline flood risk modelling and conducting a blockage assessment of the culvert under Church Road.

Based on the results of the hydraulic modelling that was carried out in this assessment, it was concluded that the existing Flood Zones are an overestimation of the fluvial flood risk at the site. The detailed model results suggested that the entire site should be within Flood Zone 1 as the site was not predicted to be at risk of flooding under any of the scenarios that were tested. This confirms that the floodplain compensation can be reduced.

Appendices

A Appendix - Mapped model outputs

- A.1 20-year
- A.2 100-year
- A.3 1000-year
- A.4 1000-year plus 25% climate change
- A.5 1000-year plus 45% climate change
- A.6 1000-year plus 105% climate change
- A.7 100-year blockage assessment
- A.8 100-year blockage assessment plus 45% climate change

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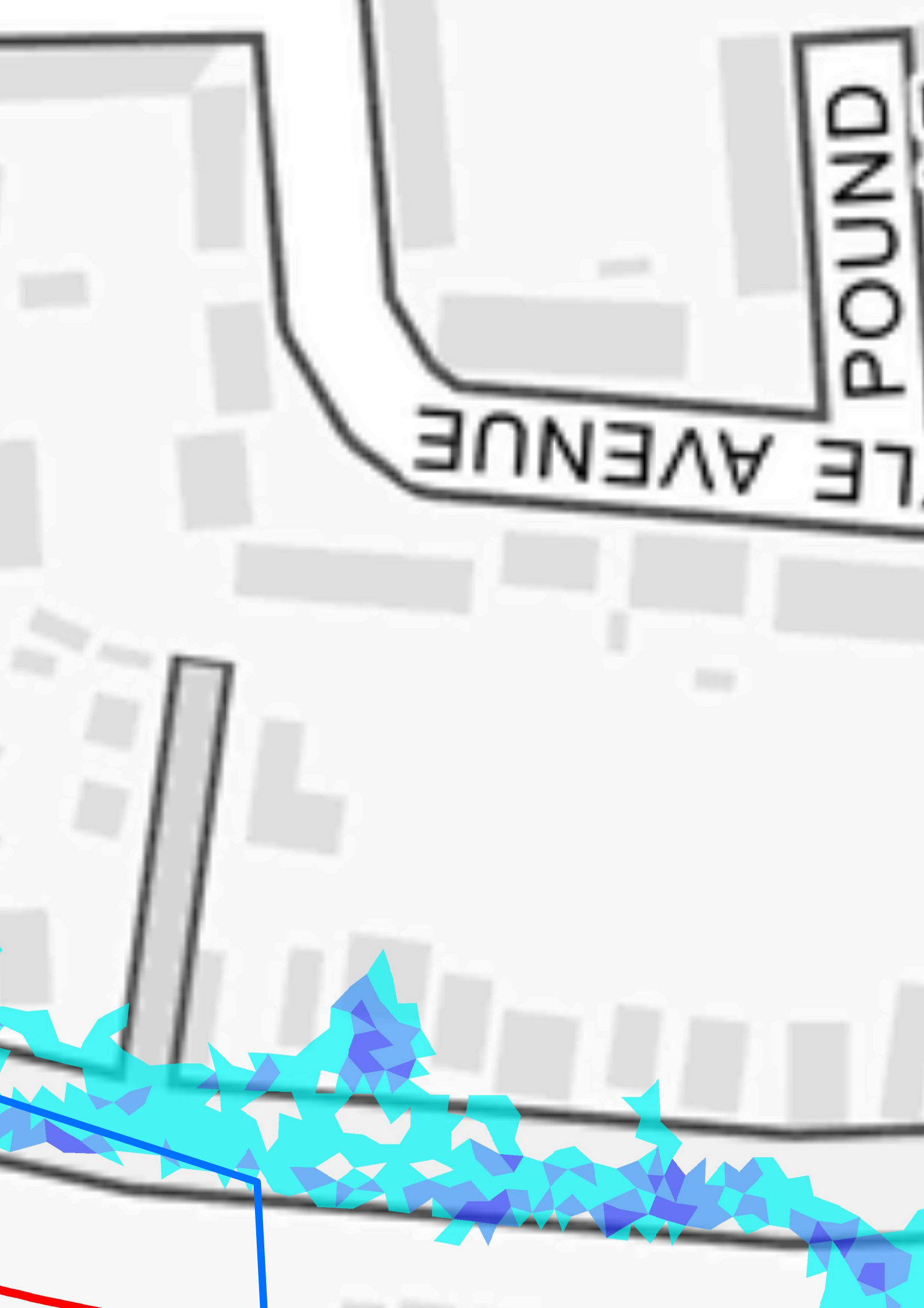
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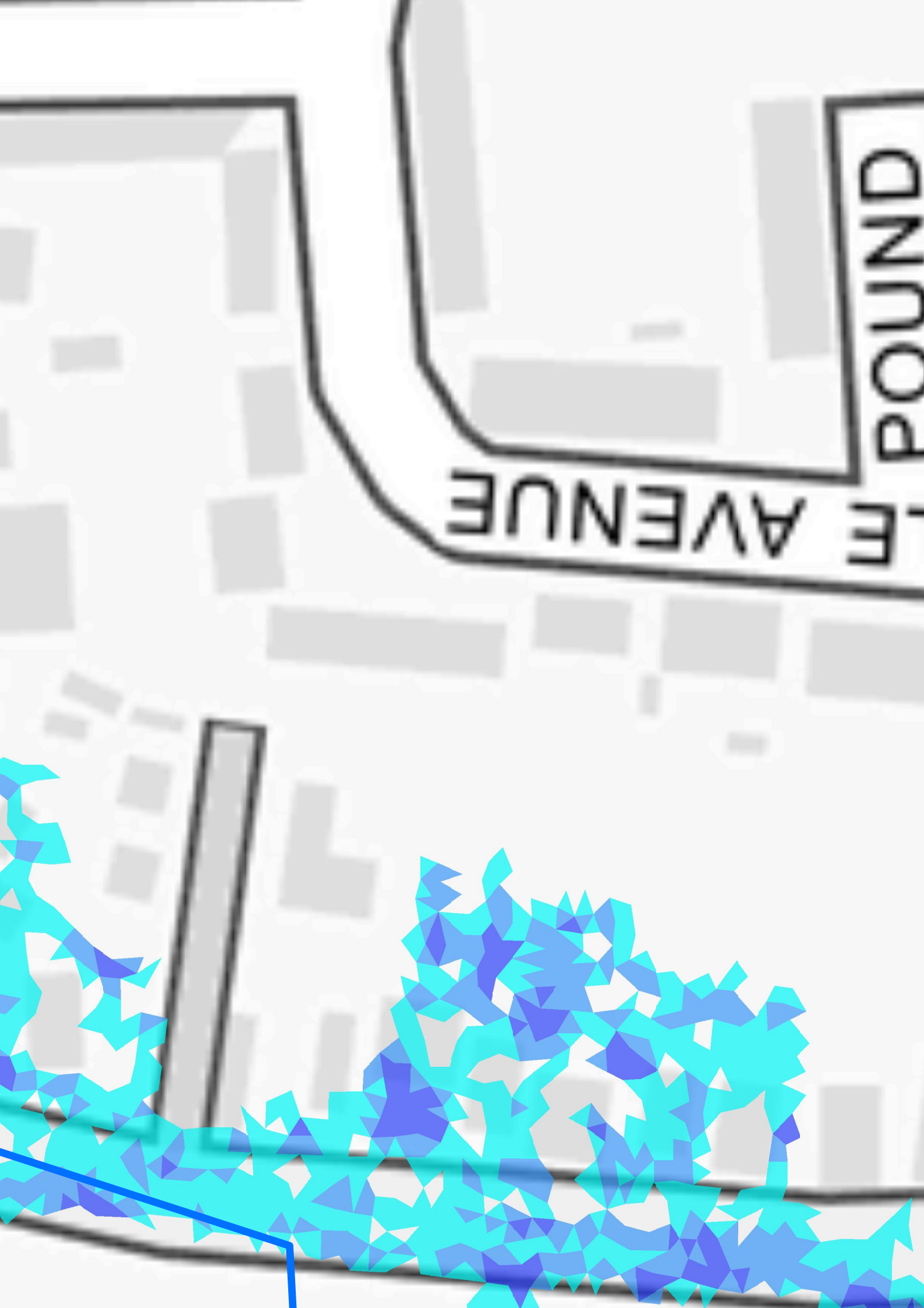
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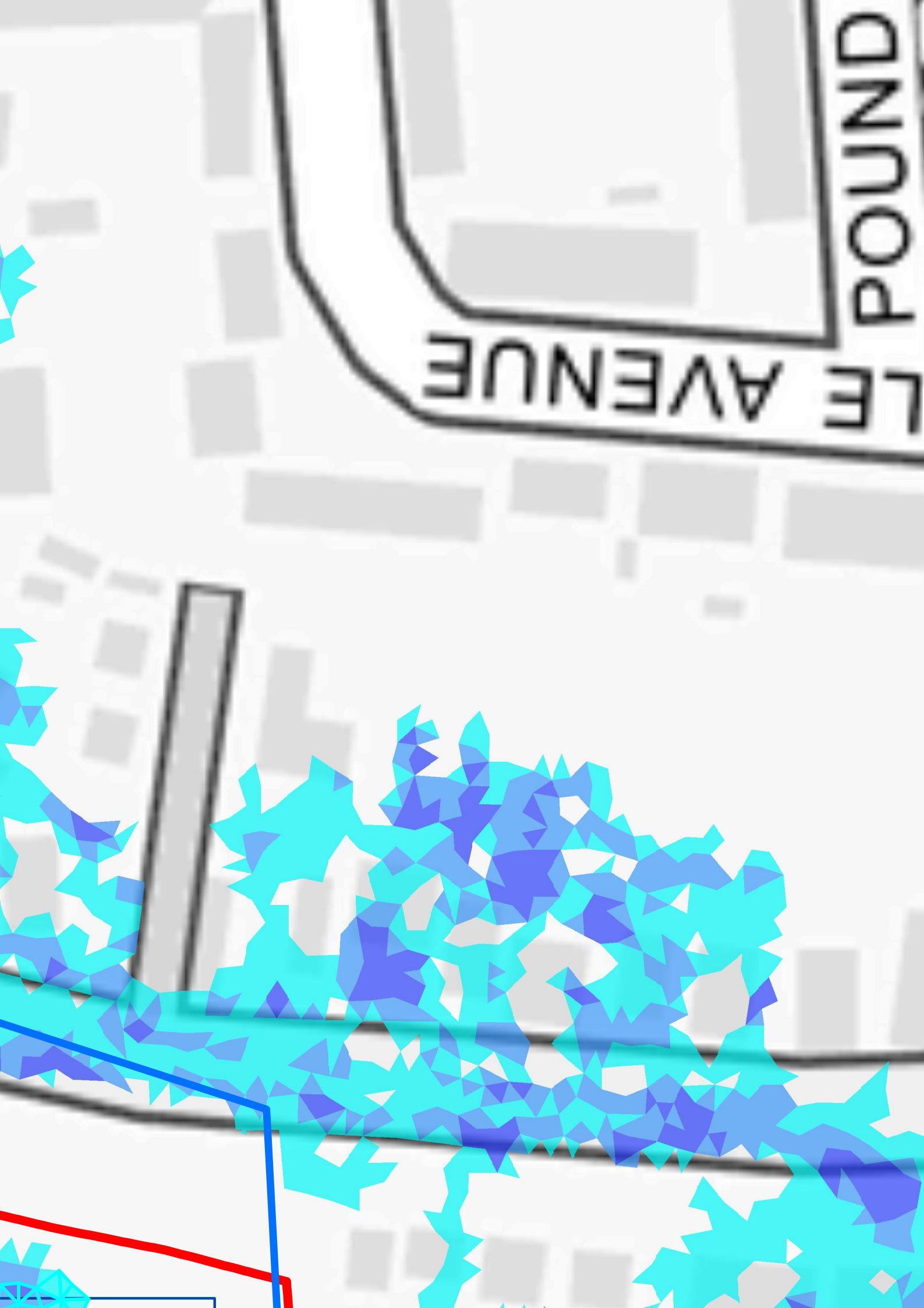


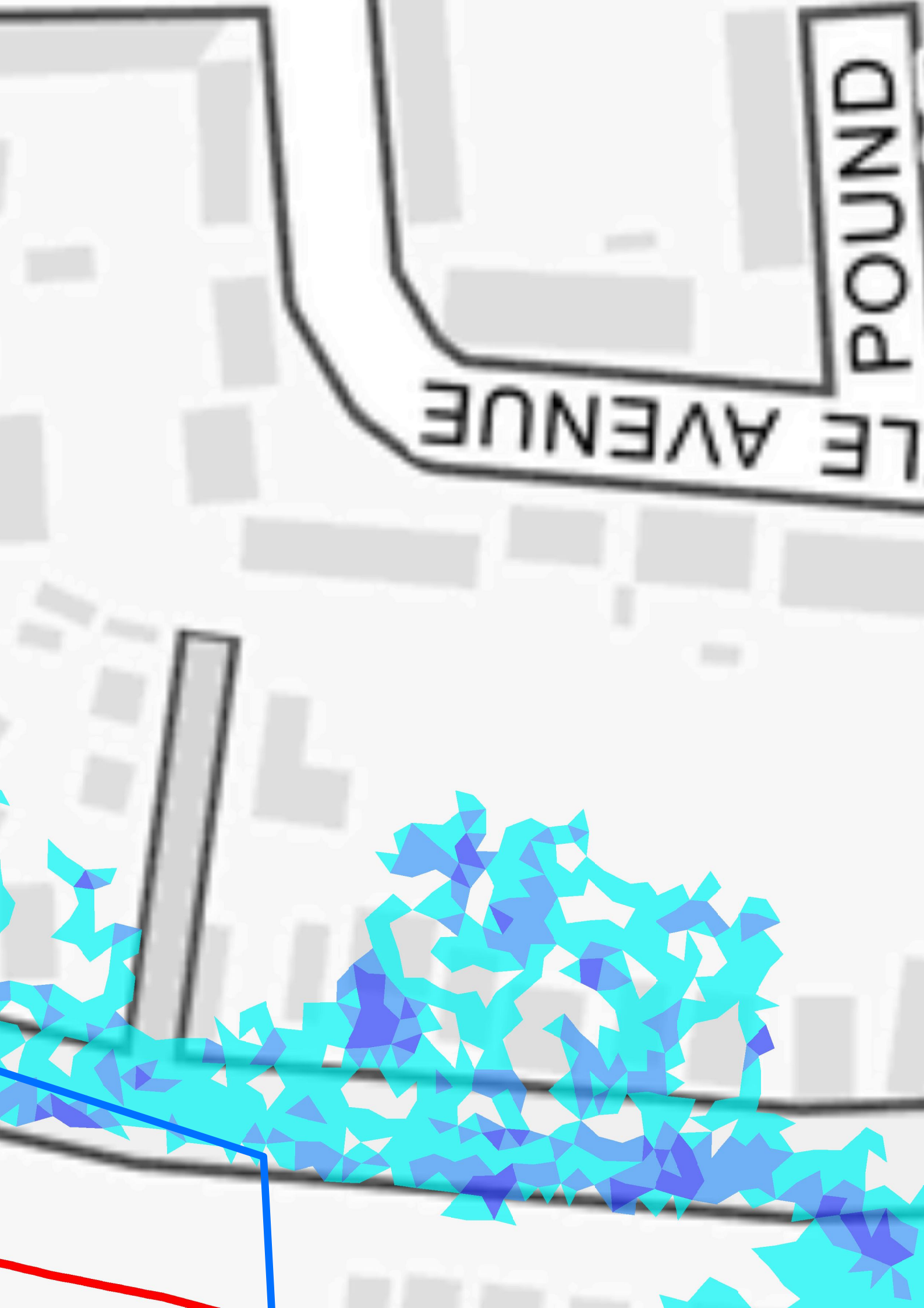
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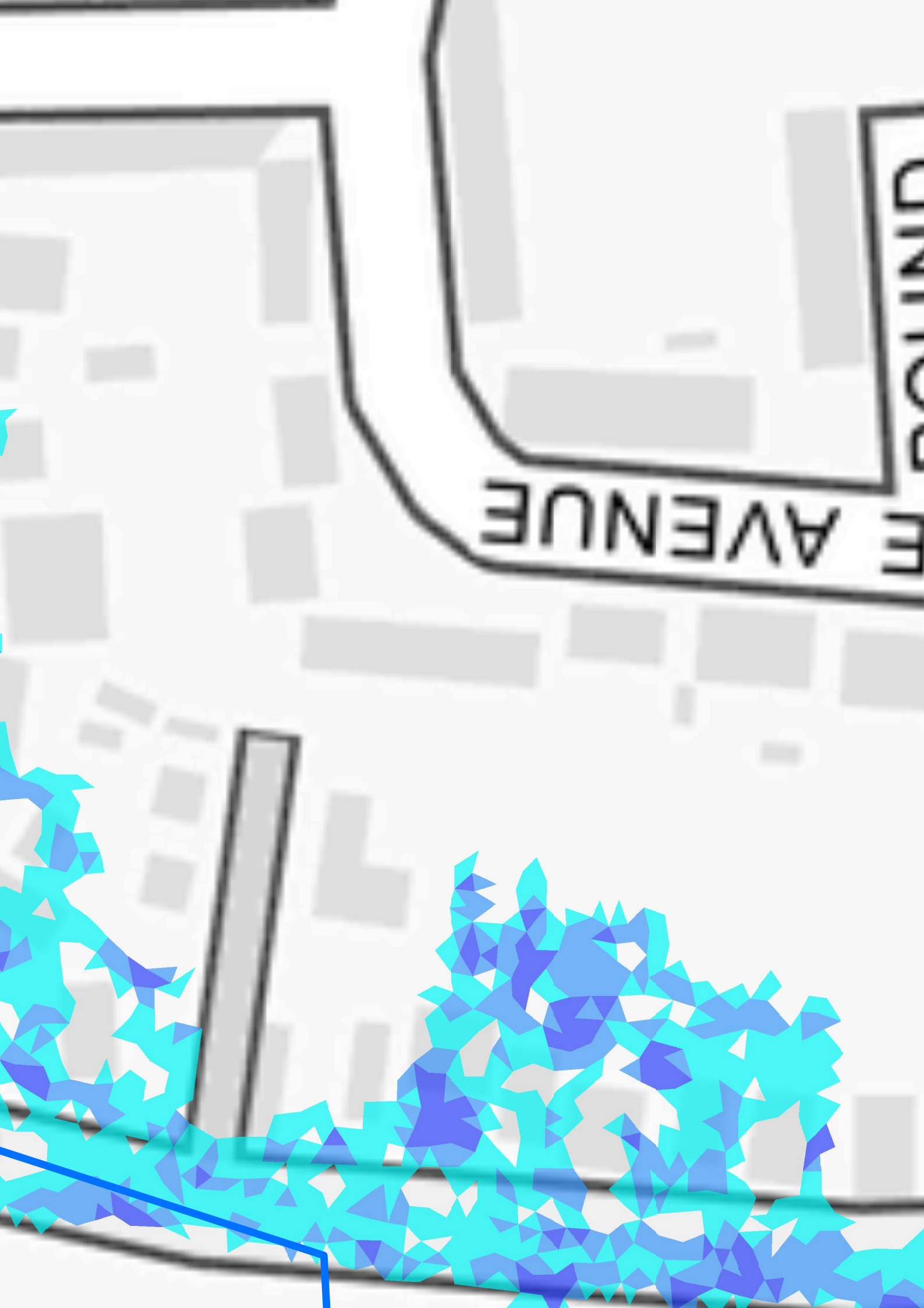
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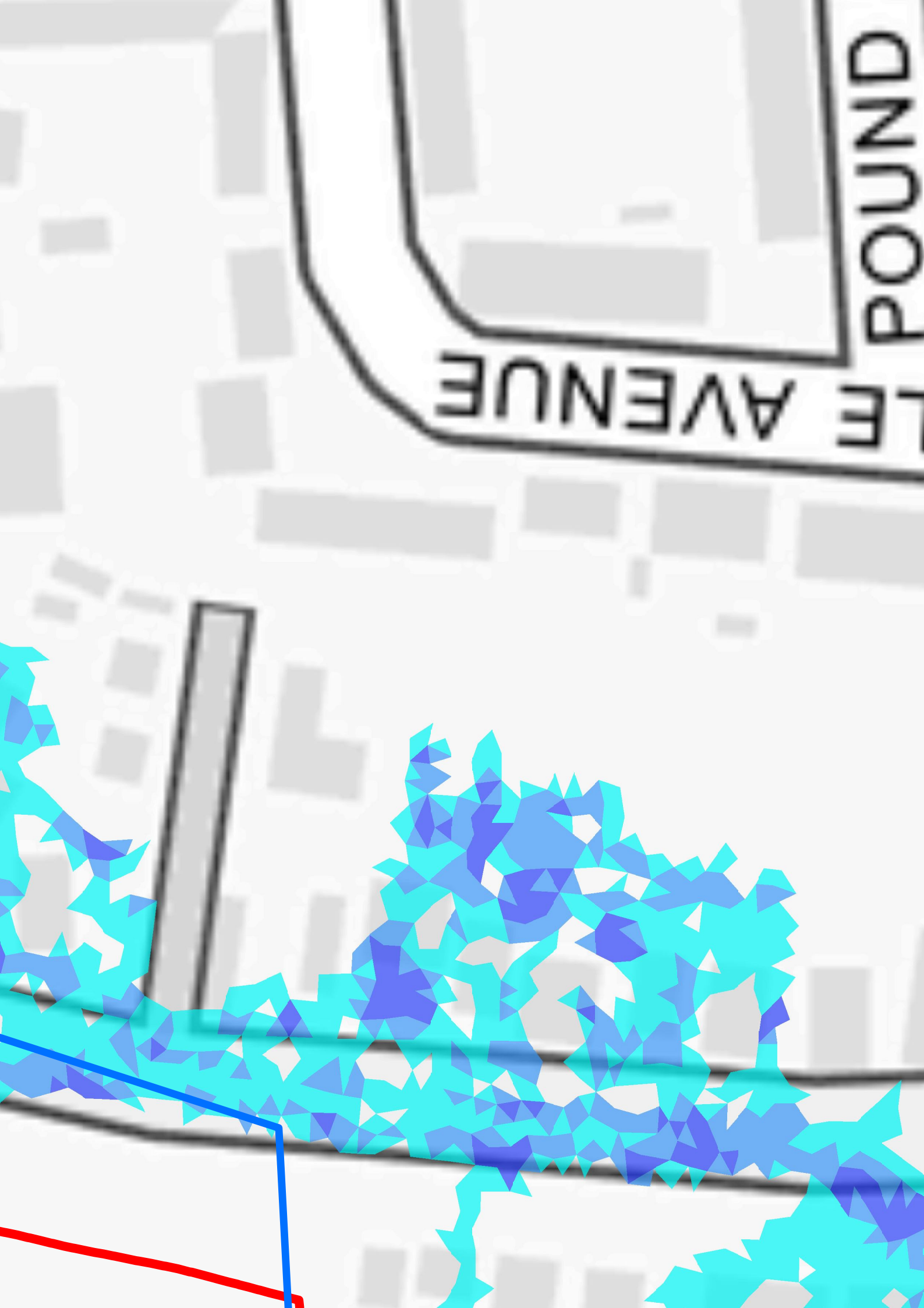












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