APPENDIX 08

Water (Hydrology & Hydrogeology)

- AppendIx 8-1 Site Specific Flood Risk Assessment - Irish Hydrodata
- Appendix 8-2 - Topographical Survey – Precise Control

Appendix 8-1 – Site Specific Flood Risk Assessment - Irish Hydrodata

Document Ref. No. 1383_1/21

Proposed Strategic Housing Development at Coolflugh, Tower, Blarney, Co. Cork.

FLOOD RISK ASSESSMENT REPORT

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Glossary

AEP	Annual exceedance probability (the probability that an event of a specified magnitude will be exceeded in any given year)
CS	Current Climate Scenario
CC	Climate Change Uplift = 20%
Flood Zone A	The probability of flooding from rivers is greater than 1% (1:100)
Flood Zone B	The probability of flooding from rivers is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100)
Flood Zone C	The probability of flooding from rivers is low(less than 0.1% or 1 in 1000). Flood Zone C covers all areas of the plan which are not in zones A or B.
FSU	OPW Flood Studies Update
HEC-RAS	Hydrologic Engineering Center – River Analysis System
IoH	Institute of Hydrology
MDLAP	Municipal District Local Area Plan
ODM	Ordnance Datum Malin Head
OPW	Office of Public Works
PFRA	OPW National Preliminary Flood Risk Assessment
Qmed	Median Annual Flood (return period 2 years)
1%AEP	Approximates to 1:100 year event
0.1%AEP	Approximates to 1:1000 year event
1%AEPCC	Approximates to 1:100 year event including a climate change uplift
0.1%AEPCC	Approximates to 1:1000 year event including a climate change uplift

1. Introduction

1.1 General

Irish Hydrodata Limited (IHD) was commissioned by Cloghroe Developments Limited to prepare a site specific flood risk assessment [SSFRA] for lands at Coolflugh, Tower, Blarney. The report has been prepared for submission with a SHD planning application and in response to Issue 2 of An Bord Pleanala's Notice of Pre-Application Consultation Opinion (Case Reference ABP-308980-20, which requested the preparation of a "Site Specific Flood Risk Assessment" in accordance with the requirements of the Planning System and Flood Risk Management Guidelines for Planning Authorities, to include hydraulic modelling of the watercourse at the development site and to address in particular any potential downstream impacts on the Owennagearagh River to the south of the site and at the R617/R579 junction".

In addition to responding specifically to the Board's Opinion, this SSFRA has considered the flood risk-related reasons and considerations for the Board's decision to refuse permission for the development of 73 no. dwellings to the west of the subject site (ABP Ref. No. 307785-20).

The Board deemed that the proposed development on neighbouring lands would be premature pending the carrying out of works to mitigate flooding along the R579. However, the proposed Cloghroe SHD is not dependent on the R579 for access.

It is understood that the developers of the neighbouring lands have submitted a revised planning application (Cork City PA 21/40620) to take account of the previous reasons for refusal and that these proposals may include the carrying out of minor works to the stream which forms the boundary of both properties. However, this FRA assesses the proposed development independently of any future proposals to carry out work to the stream on the western boundary.

The principal elements of the proposed Cloghroe SHD comprise:

(i) Housing and commercial development within a 7.5Ha site with all associated roads and services;

(ii) Provision of surface water attenuation storage to manage runoff from the development;

(iii) Provision of flood water storage to mitigate against potential localised flooding in the southern part of the site arising from an adjoining stream.

The site layout and proposed works are indicated in Figure 1.1.

Figure 1.1 - Site layout and proposed development works

1.2 Site Description, Survey and Appraisal

Site topography and levels are available from several sources. These include engineering drawings, survey drawings and OSI LiDAR data. The general levels on the site and in the surrounding area are indicated in Figure 1.2. A section through the site from south to north is indicated in Figure 1.3.

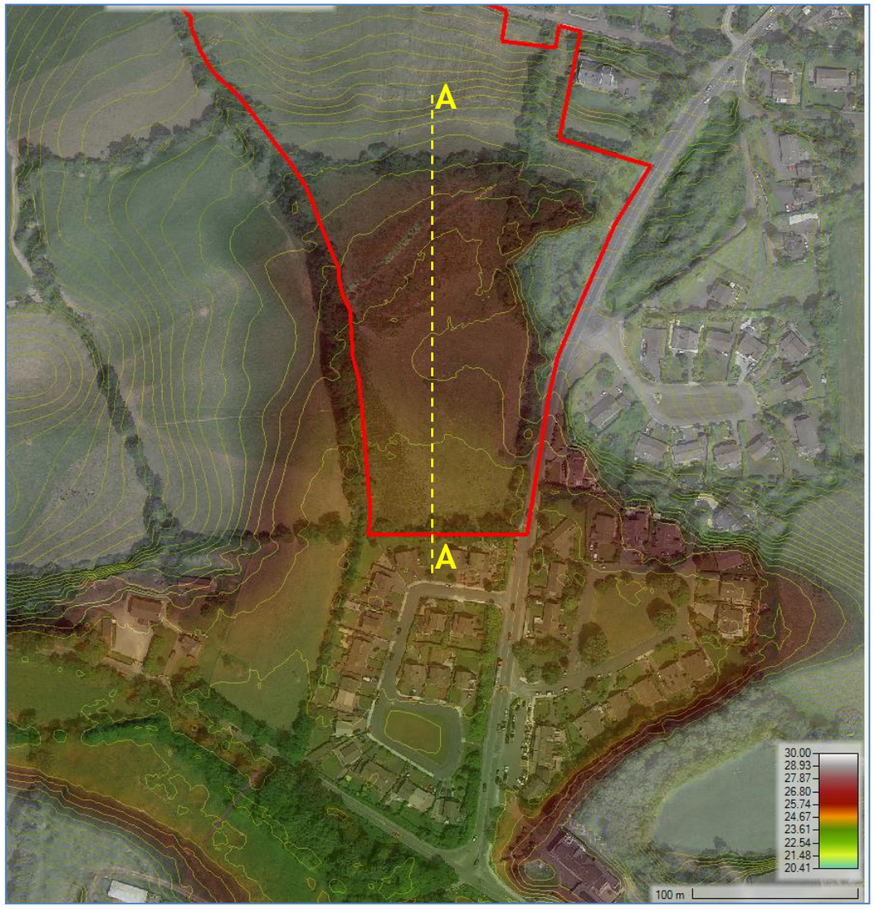

Figure 1.2 - Ground levels on site and surrounding areas

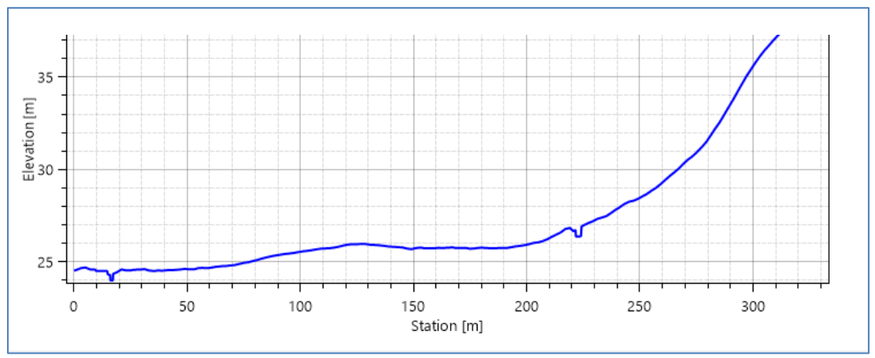

Figure 1.3 - Site Section A-A (from LiDAR data)

1.3 Local Watercourses

A small stream runs along the western boundary of the site over a distance of approx 350m. At the upper, northern end of the stream along the site boundary, the gradient is steep and the channel well defined. Towards the southern end, the gradient is much flatter and the channel less well defined. Waters locally flow in shallow channels on both sides of the registered boundary. Various culvert structures are located on the channel in the vicinity of the Senandale estate as shown in Figure 1.4. The Owennagearagh river is located about 170m to the south across the R579.

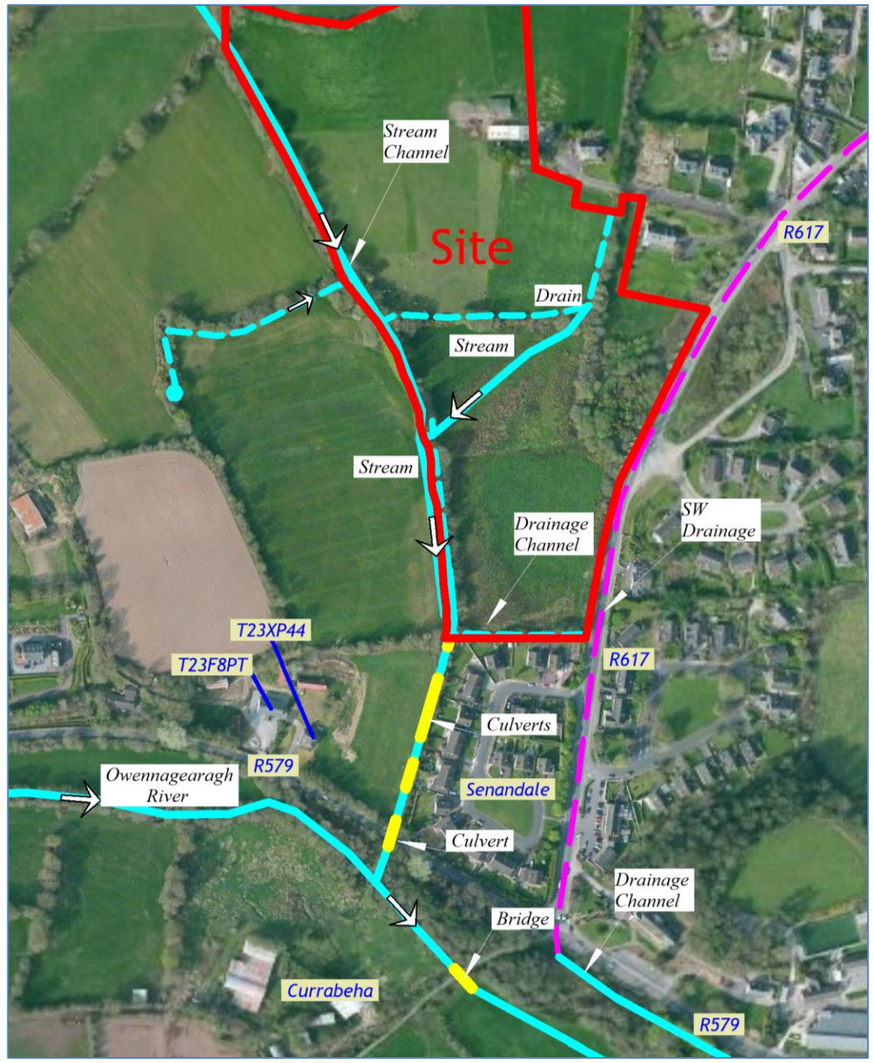

Figure 1.4 - Local watercourses, culverts and properties

1.4 Potential Sources of Flood Risk

The potential flood risk components associated with this site have been evaluated. These are summarised in Table 1.1. Only fluvial flooding is identified as a significant risk due to the proximity of the western stream channel and the Owennagearagh river. Other potential sources have very limited potential to impact the site and the proposed works will not materially impact local pluvial surface or groundwater flow pathways. The fluvial flood risk is addressed in detail in this report.

Source of Flooding	Potential Impact	Note
Fluvial	Significant	The Owennagearagh river is located to the south, a stream runs along the entire length of the western boundary, the southern part of the site is low-lying
Surface Water / Pluvial	Low	There is a limited external catchment feeding into the site area, a sod and stone ditch forms the northern boundary. The site grades from north to south and is above the local stream / drain bed levels. The terrain does not allow for large scale buildup of pluvial waters though some ponding may occur at local low points. The proposed site surface water drainage systems will convey surface waters from the development to the river downstream of Currabeha bridge.
Groundwater	Low	The site has an overall gradient from north to south. The southern part of the site is low-lying, underlying geology is sandstone/mudstone. A high water table could lead to local ponding though as the ground levels are above the stream / drain bed levels excess water will flow to the Owennagearag.
Water/Drainage Systems	Low	Water mains and drainage services will be located within the site. All will be installed in accordance with the latest guidelines and fully tested before commissioning. Potential adverse impacts on the site and surrounding areas

Table 1.1 – Flood risk summary

1.5 Flood Risk Indicators & Historic Data

Since May 2019 the site has been included within the Cork City boundary. Until such time as a new city development plan is enacted the Cork County development plans (County Plan and Municipal District Local Area Plan [MDLAP]) remain in effect. These plans included a strategic flood risk assessment. The associated MDLAP mapping shows Zone A/B flooding approximately 80m to the south of the site in the Senandale estate as indicated in Figure 1.5. The flood risk zones do not extend to the site area. The western stream is not included in the MDLAP flood analysis as its catchment area (0.9km^2) is below the 5km^2 threshold adopted for inclusion of watercourses.

The relevant local plan is the Blarney Macroom MDLAP[1]and in Section 4.8.17 it states that '*Any development on the lands to the south west of the village will require the preparation of a comprehensive flood risk assessment of those lands and their environs showing clearly that any*

[1]Cork County Council Municipal District Local Area Plan 2017

development will not give rise to flood risk to adjoining properties and include proposals to address existing flooding issues in the area'.

Figure 1.5 - Site overlain on CCC MDLAP map

The OPW website www.floodinfo.ie has no record of flooding events on the site. There are records of recurring flooding on the R579 and frequent flooding at the R579/R617 junction, (e.g. Figure 1.6). This flooding is partially the result of inadequate conveyance capacity in the Owennagearagh river channel and the restrictive bridge on the access road to Currabeha.

Figure 1.6 - View from St Senan's Church (ref: OPW floodinfo.ie, 6/Feb/1990)

1.6 Lee CFRAM Study

Mapping produced by the OPW for the Lee CFRAM[2] study shows localised flooding to the south across the R579 (Figure 1.7). It does not show any flooding within the Cloghroe SHD site.

The Lee CFRAMS Hydraulics Report[3] provides extreme event water level estimates at model nodes along the Owennagearagh channel. Data for relevant nodes are shown in Table 1.2. The values shown are for the current climate scenario and a Mid Range Future Scenario (MRFS). The MRFS as defined by Lee CFRAMS is the most likely climate change scenario and is characterised primarily by 20% extra fluvial flows and a 550mm sea level rise. The peak flood flow estimates are presented in Table 1.3.

Model Node	10%AEP	1%AEP	0.1%AEP
Current Scenario Water Levels			
8OWG_1303	24.29	24.46	24.61
8OWG_1200 (stream/river confluence)	23.87	24.07	24.17
Mid Range Future Scenario Water Levels			
8OWG_1303	24.38	24.56	24.70
8OWG_1200 (stream/river confluence)	23.99	24.13	24.26

Table 1.2 - LeeCFRAMS flood water level predictions (m OD) in Owennagearagh River

	10%AEP	1%AEP	0.1%AEP
Current Scenario	17.3	21.1	25.1
Mid Range Future Scenario	25.1	31.6	39.3

Table 1.3 - LeeCFRAMS flood flows (m^3/s) at node 8OWG_1200

[2] LeeCFRAMS Map M6,M8 RA/EXT/CURS/001 2012
[3] OPW Lee CFRAMS Hydraulics Report (2014)

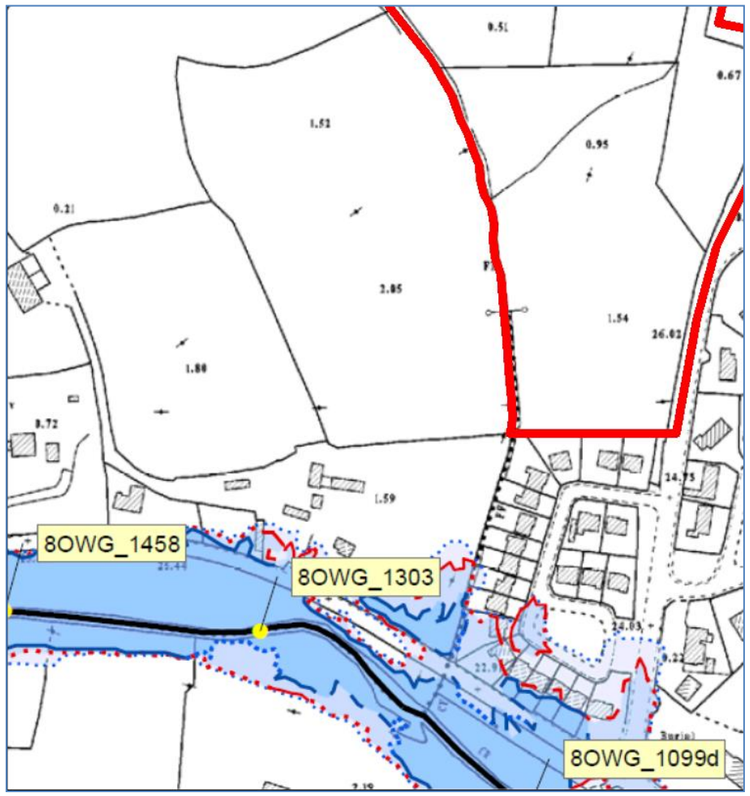

Figure 1.7 - Site overlain on Lee CFRAM Mapping (M6)

1.7 Site Surface Water Management

Surface water management proposals have been designed by MHL Consulting Engineers and surface runoff from the site area will be collected by the surface water drainage systems and routed through six underground storage tanks (Figure 1.8). As these proposals do not involve works to a watercourse, approval from the OPW in accordance with section 50 of the Arterial Drainage Act 1945 is not required. Outflow at greenfield rates will be directed to the existing municipal surface water drainage system on the R617 and will ultimately discharge to a drainage channel on the southern side of the R579. Accordingly, runoff from the site which would previously have gone to the western stream will now be directed to the east into the public stormwater system on the R617 and rejoin the Owennagearagh downstream of the Currabeha bridge.

The southern part of the site is low-lying. The stream channel is small and not maintained and locally obstructed by tree debris. Waters are prone to overflow on both sides of the channel. During such events, waters encroach on the lower parts of the site. It is not possible to significantly improve the flow capacity of this channel due to the local ground levels. However, as part of this SHD, it is proposed to provide an underground storage area to manage the overflow and thus provide protection for the site and adjoining properties in Senandale. The proposed location of this storage tank is shown in Figure 1.9 with a section through the system in Figure

1.10. Two environmental biodiversity ponds covering an area of approximately 600m^2 are also being provided within the proposed development (Figure 1.11), which will also facilitate flood water storage of up to 300m^3 during high flows.

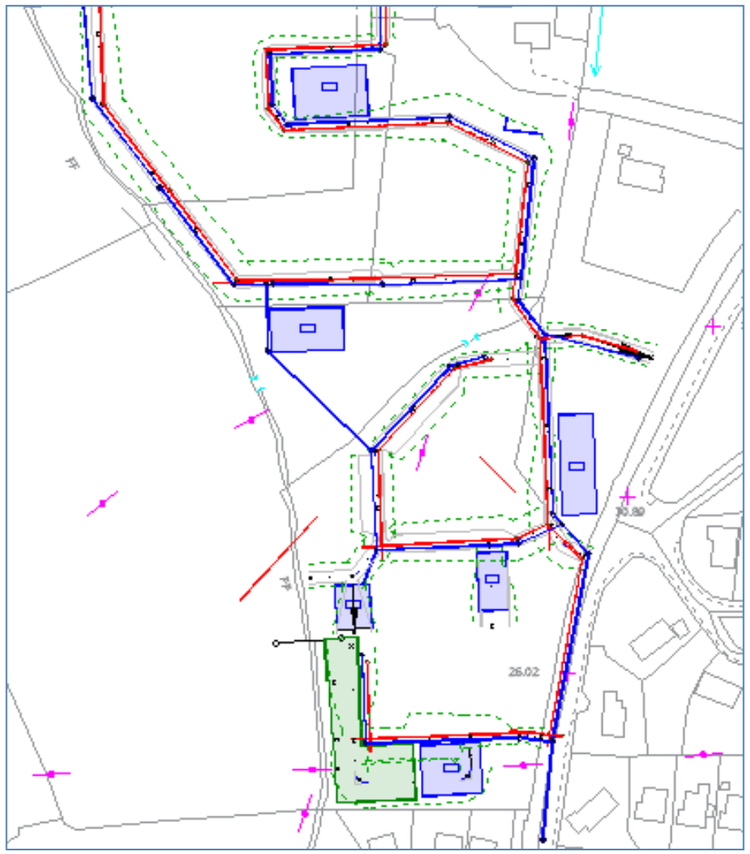

Figure 1.8 - Location of surface water attenuation tanks

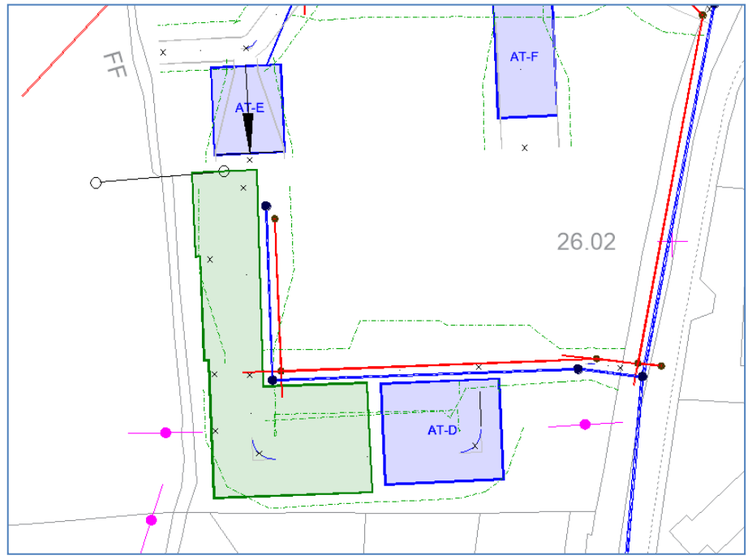

Figure 1.9 - Location of proposed flood water storage tank (1200m^3)

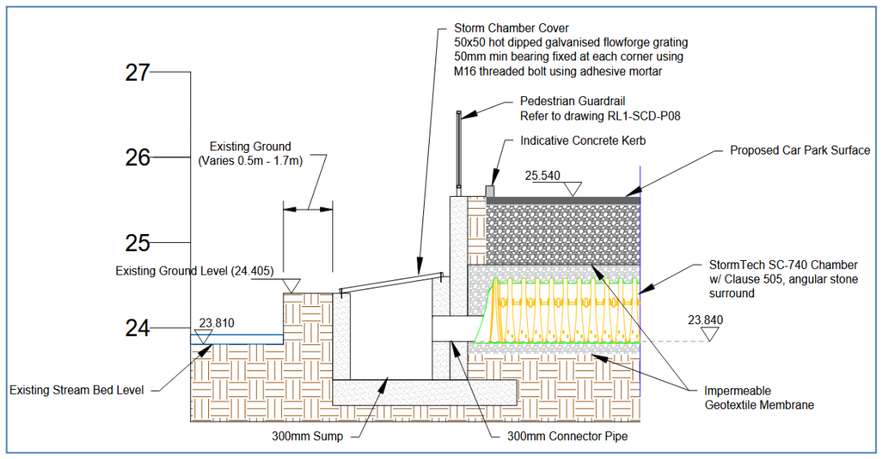

Figure 1.10 - Schematic section through proposed flood water storage tank

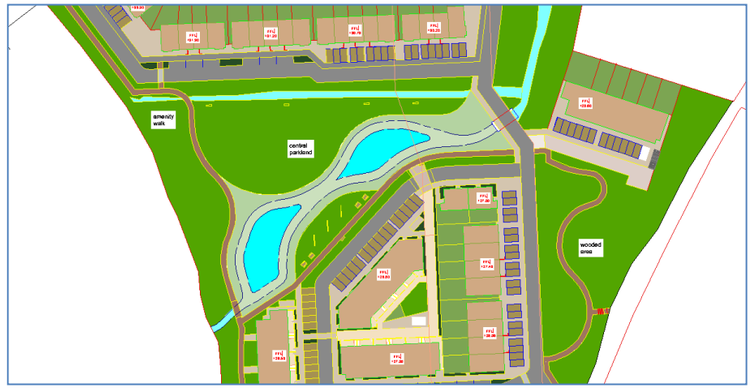

Figure 1.11 - Location of ponds/drainage basins

2. Flood Risk Assessment

2.1 Methodology

There are two watercourses in the vicinity of the site which potentially impact or are impacted by the development. The flood risk is assessed by computing peak flows in the watercourses and using a 2 dimensional hydraulic model to simulate the flow patterns and inundations within the site and surrounding areas. Industry standards are followed using established procedures and informed by recent OPW studies in the Lee catchment.

2.2 Watercourse Peak Flood Flow Estimates

Flood waters in the vicinity of the site originate either from the Owennagearagh river or the western stream. Peak flood flows were determined from un-gauged catchment analysis. The stream flood flows were estimated using the IoH124[4] method and the Owennagearagh flows were derived from the OPW Flood Studies Update rural regression equation.

2.3 Western Stream Flood Flow Estimates

The stream flowing along the western boundary of the site drains a catchment of approximately 0.9km^2 (Figure 2.1). This area is derived from OPW Flood Studies Update (FSU) data[5]with appropriate reductions for the site area and urbanised sections that are served by the local municipal drainage system. The catchment is comprised of farmlands with no unusual hydrological features. The overall gradient S_{1085} is 48m/km (1:21) while adjacent to the southern end of the site the gradient reduces to about 1:100. Estimates of the 1%AEP (100-year) flood flow were made with the IoH 124[6] method using the catchment parameters outlined in Table 2.1. The computed 1%AEP peak flood is 1.4m^3/s and the 0.1%AEP peak flood 1.86m^3/s.

The peak flood flows as calculated with a factorial error of 2.72 are considered to have a 95% confidence level (i.e. 95% chance that the flow will be below the computed value).

Parameter	Stream channel to culvert under R579
Stream Catchment Area	0.906 km^2
SOIL Index	0.3
SAAR	1100
Q_{bar}	0.262m^3/s
Factorial Error (95%)	2.72
Growth Factors	1%AEP = 1.96 0.1%AEP = 2.60
1%AEP	1.40m^3/s
0.1%AEP	1.86m^3/s

Table 2.1: - Computed stream flows from IoH124 method.

[4] Institute of Hydrology 1994, Flood Estimation for Small Catchments.
[5]OPW Flood Studies Update Web portal (opw.hydronet.com)
[6]Institute of Hydrology 1994, Flood Estimation for Small Catchments.

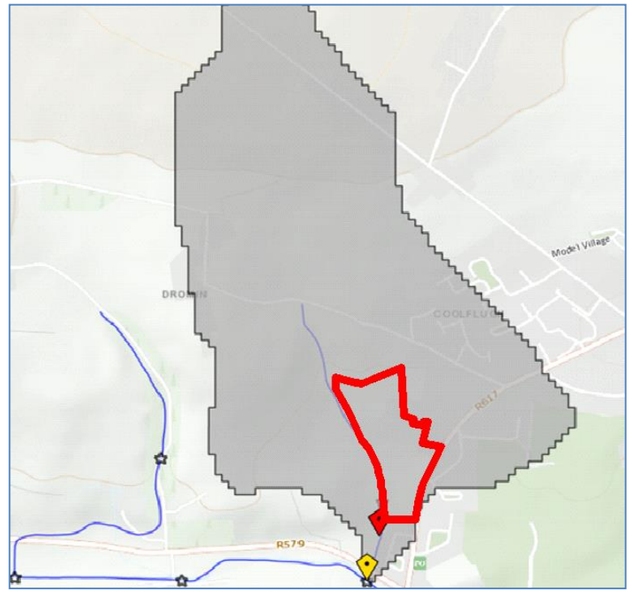

Figure 2.1 - Stream catchment area from OPW FSU data

2.4 Owennagearagh River Flood Flow Estimates

The peak flood flows in the Owennagearagh river were established using the OPW Flood Studies Update rural equation. The catchment covers an area of 39km^2 (Figure 2.2) and the parameters employed are listed in Table 2.2. The catchment is un-gauged and therefore catchment adjustment and growth factors were based on recommendations contained in the Lower Lee FRS report[7]. The calculated 1%AEP flood at the site is 36.7m^3/s and the 0.1%AEP flood is 55.81m^3/s. These values are higher and more conservative than those generated for the LeeCFRAM study (Section 1.6).

Parameter	River to Cloghroe
Catchment Area	39.6 km^2
SAAR	1159 mm
BFISOIL	0.696
FARL	1
DRAIND	0.804 km/km^2
S1085	13.63 m/km
ARTDRAIN2	0
URBEXT	0.0001
Qmed	8.20 m^3/s
CAF	1.71
Growth Factors	1%AEP = 2.62 0.1%AEP = 3.98
1%AEP	36.74 m^3/s
0.1%AEP	55.81 m^3/s

Table 2.2 - River flows based on FSU rural equation

[7]Lower Lee Flood Relief Scheme, Hydrology Report 2017

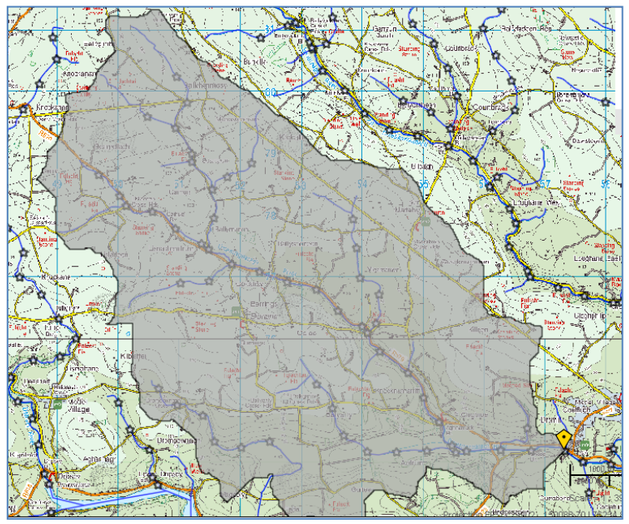

Figure 2.2 - Owennagearagh river catchment extent from OPW FSU data

2.5 Design Floods

The proposed design floods are based on the calculated peak floods with a 20% uplift to account for climate change. The peak values are summarised in Table 2.3. A time varying hydrograph was generated for the western stream to represent the passage of a flood wave. The hydrograph shape is shown schematically in Figure 2.3 and was scaled according to peak flow as required for model simulations. A constant peak value was applied to the river to provide a worst case scenario for flooding.

Flood Event	Owennagearagh River Flow (m^3/s)		Stream Flow (m^3/s) to R579 culverts	
	Current Climate Scenario	Future (CC) Climate Scenario	Current Climate Scenario	Future (CC) Climate Scenario
1%AEP	36.74	**44.09**	1.40	**1.68**
0.1%AEP	55.81	**66.97**	1.86	**2.23**

Table 2.3 - Design flood event flows used in hydraulic analysis

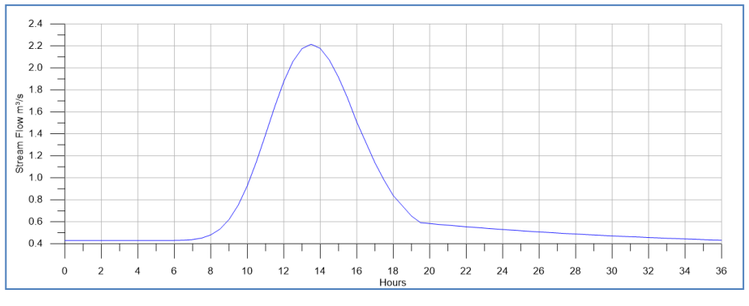

Figure 2.3 - Western stream flood hydrograph

2.6 Digital Terrain Model

LiDAR derived elevation data was sourced from Ordnance Survey Ireland (OSI) and used to define a digital terrain model (DTM) within the study area. The horizontal resolution of this dataset is 2m and the vertical accuracy is 0.25m. The LiDAR data was compared with the topographical survey data. Comparisons were good in the hard surface areas where differences of about 0.1m were observed (Figure 2.4) and less so in grassed areas where differences of up to 0.2m were observed.

The LiDAR data is a bare earth representation of the topography in which all the buildings and vegetation have been automatically removed. Local adjustments were made to the DTM where erroneous data points were evident. LiDAR does not penetrate water and in order to include the river and stream channels, features from the topographical surveys were imposed on the DTM.

Two terrains were developed:

1 The existing terrain incorporating the LiDAR data, an interpolated Owennagearagh river channel and a stream channel from the northern extent of the site to the R579;

2 The proposed developed site where low areas are raised by over 1m, 1200m^3 of underground flood storage is installed and approximately 600$m^2$of surface pond storage is provided.

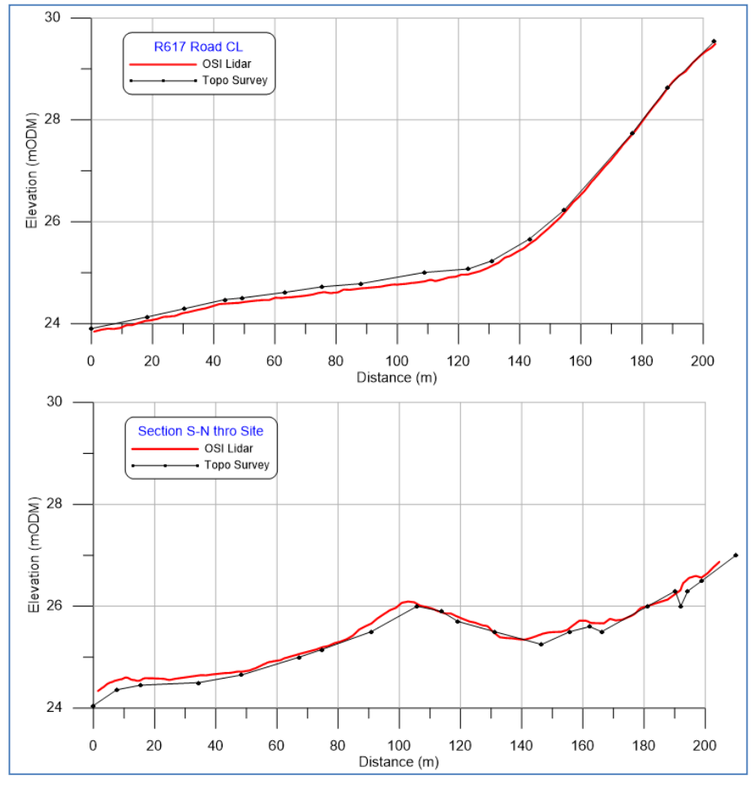

Figure 2.4 - LiDAR and topographic survey data comparisons

2.7 River Hydraulic Model

A 2-dimensional HEC-RAS[8] model was set up covering the area shown in Figure 2.5 using the DTM data. The model cell size was typically 6m x 6m in open areas and reduced to 1m in areas where more detail was required. HEC-RAS implements subgrid modelling whereby the detailed underlying terrain (subgrid) is used to develop geometric and hydraulic property tables that represent the cells and the cell faces. Computational cells do not have to have a flat bottom, and cell faces/edges do not have to be a straight line, with a single elevation. The property tables are used in the modelling process.

The flow hydrograph was applied at the western stream upstream boundary, a constant flow at the river boundary and a normal depth condition at the downstream boundary. Manning roughness coefficients of 0.04 or 0.06 were applied in the grassland and more vegetated areas respectively.

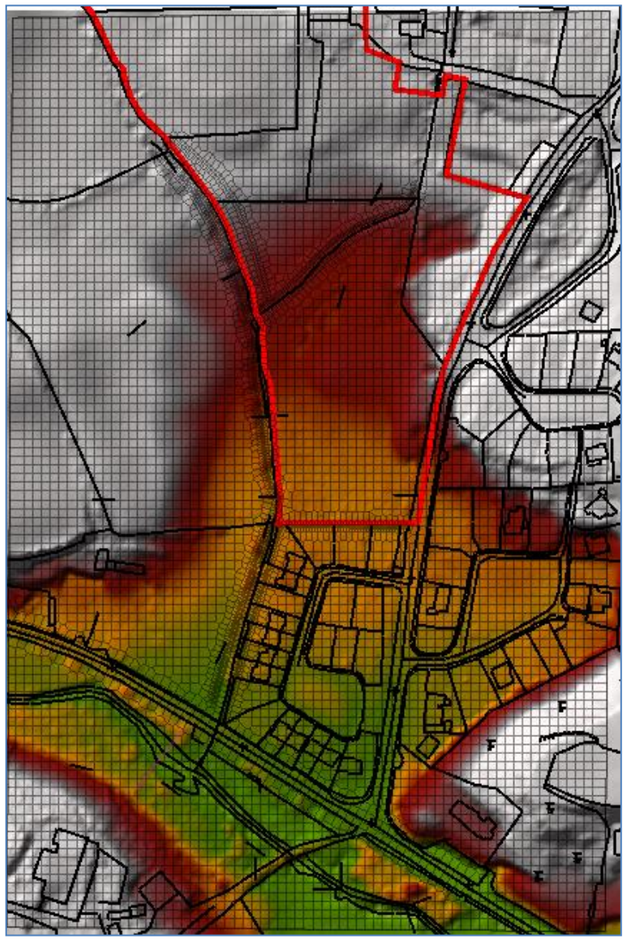

Figure 2.5 - 2D hydraulic flow model area

[8] Hydrologic Engineering Centre, 2021, HEC-RAS River Analysis System

2.8 Model Calibration

There are no flood level or flow data available for either the stream or the river. The validity of the model has been ensured through the selection of appropriate standard model parameters and the use of conservative estimates for peak flood flows. The model predictions are qualitatively compared with CCC MDLAP data (Figure 1.5) and with OPW CFRAM data (Figure 1.7).

3. Flood Modelling Results

3.1 Modelled Flood Scenarios

Model simulations were conducted for the various flood scenarios on the existing and developed terrain. The range of simulations is listed in Table 3.1.

Flood extent maps are prepared on the basis of the bare earth DTM. All non-structural walls and embankments are discounted. Only engineered flood defences are included, where relevant. The maps thus show a best estimate representation of likely worst case flood inundation areas.

Topography	Western Stream	Owennagearagh River
Existing & Modified Terrains	1%AEP= 1.4m^3/s 1%AEP CC = 1.7 m^3/s 0.1%AEP CC = 2.2 m^3/s	10m^3/s 1%AEP CC = 44 m^3/s 0.1%AEP CC = 67 m^3/s

Table 3.1 - Modelled peak flood and terrain scenarios

3.2 Flood Extent Maps – Existing Terrain

The impact of high flows in the Owennagearagh river were first simulated to assess the impact of this watercourse alone on the site. Figure 3.1 shows the simulated 1%AEPCC peak river flood coupled with a small flow (0.2m^3/s) in the western stream. The R579 is flooded as are several houses in Senandale and the R617/579 junction. Flood waters do not extend as far north as the site in the open areas but will progress further in the stream/drainage channels. The water level in the drainage channel along the northern boundary of Senandale is predicted to reach about 24.3m OD.

Figure 3.1-Extent of inundation arising from 1%AEPCC peak flow in river and a nominal flow in the western stream (0.2m^3/s)

The impact of the various stream peak flood estimates combined with a river flow of 10m^3/s are examined in Figures 3.2a-c. The inundation areas remain broadly the same as the peak flows increase.

Modelled plots for stream peak floods combined with the larger 1%AEPCC river flood of 44m^3/s are presented in Figure 3.3a-c. These show that the lower part of the site, Senandale estate and the R617/579 junction are impacted to varying extents by floodwaters and that the Owennagearagh flow does not increase inundation within the site (Figure 3.2c vs. Figure 3.3c).

Fig 3.2a - Existing terrain, stream = 1%AEP (1.4m^3/s), River = 10m^3/s

Fig 3.2b - Existing terrain, stream = 1%AEPCC (1.7m^3/s), river = 10m^3/s

Fig 3.2c - Existing terrain, stream = 0.1%AEPCC (2.2m^3/s), river = 10m^3/s

Fig 3.3a - Existing terrain, stream = 1%AEP (1.4m^3/s), river = 1%AEPCC (44m^3/s)

Fig 3.3b - Existing terrain, stream = 1%AEPCC (1.7m^3/s), river = 1%AEPCC (44m^3/s)

Fig 3.3c - Existing terrain, stream = 0.1%AEPCC (2.2m^3/s), river = 1%AEPCC (44m^3/s)

3.3 Flood Extent Maps – Developed Terrain

The modelled impact of the site development on the local flood inundation patterns are presented in Figures 3.5a-c and 3.6a-c. Flood waters are contained within the upstream biodiversity ponds and the 1200m^3 underground storage tank and are prevented from entering the Senandale estate. A flow control structure will be required on the drainage channel along the boundary with Senandale to ensure backflow from the stream does not occur. This has been designed as part of the surface water management proposals prepared by MHL Consulting Engineers and Figure 3.4 below highlights the same.

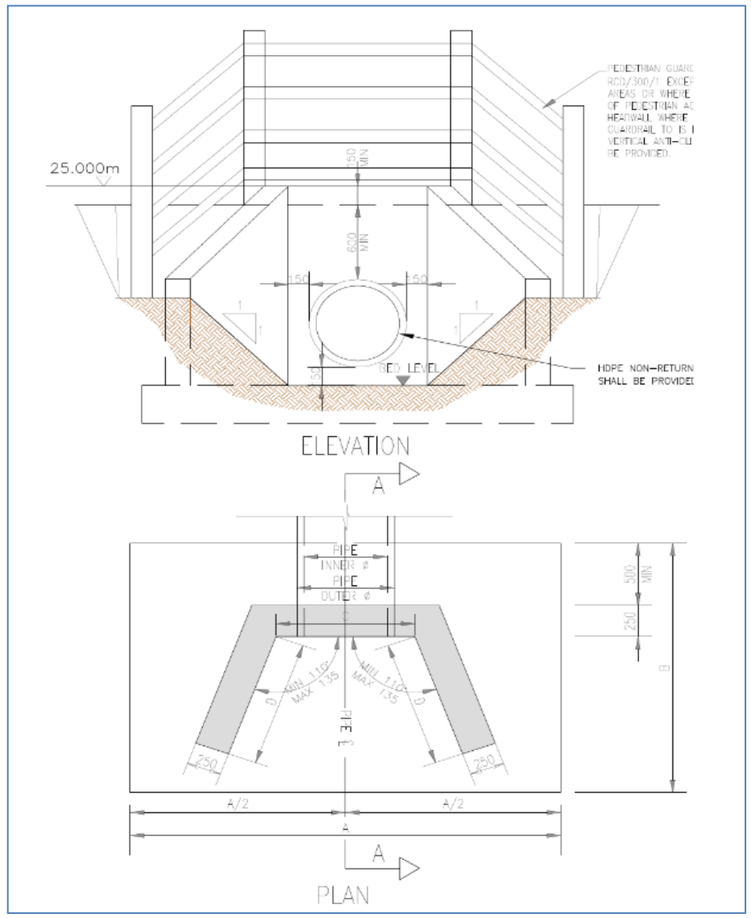

Figure 3.4 – Non return valve for drainage channel at rear of Senandale (refer to MHL drawing)

Fig 3.5c - Developed terrain, stream = 0.1%AEPCC (2.2m^3/s), river = 10m^3/s

Fig 3.5b - Developed terrain, stream = 1%AEPCC (1.7m^3/s), river = 10m^3/s

Fig 3.5a - Developed terrain, stream = 1%AEP (1.4m^3/s), River = 10m^3/s

Fig 3.6c - Developed terrain, stream flow = 0.1%AEPCC (2.2m³/s), river = 1%AEPCC (44m³/s)

Fig 3.6b - Developed terrain, stream = 1%AEPCC (1.7m³/s), river = 1%AEPCC (44m³/s)

Fig 3.6a - Developed terrain, stream = 1%AEP (1.4m³/s), river = 1%AEPCC (44m³/s)

3.4 Stage Hydrograph Comparison

Water elevation data for various modelled flood scenarios have been extracted for the locations shown in Figure 3.7. The locations were chosen to give a good indication of the existing and proposed water levels. Point X is located on the lands to the west, Point Y at the location of the underground storage tank and Sections B-B, C-C and D-D along the flow pathways.

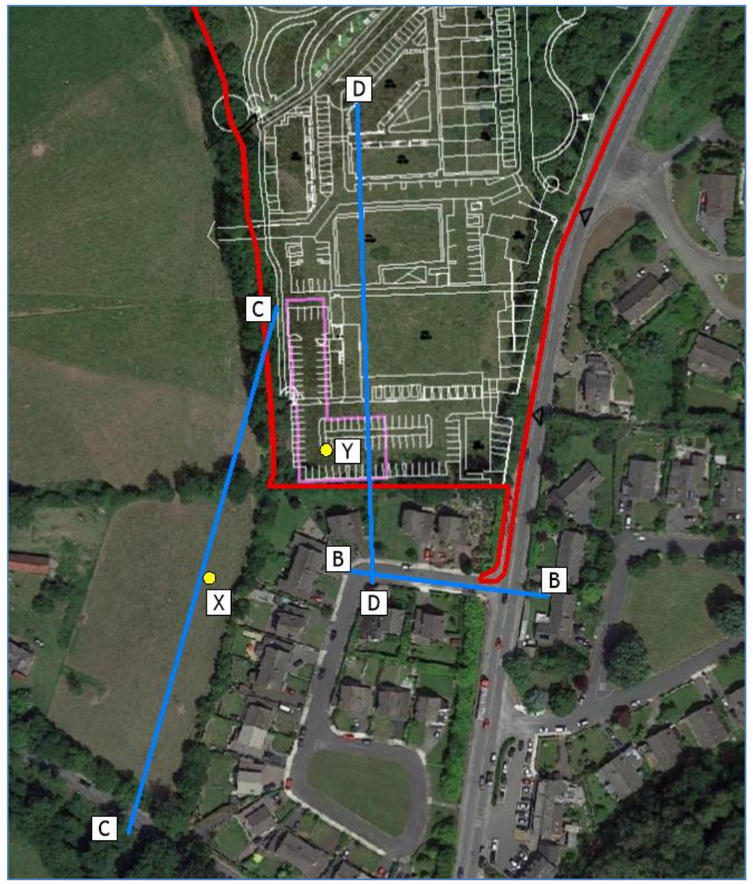

Figure 3.7-Model data extract locations

A plot of the peak stream flows versus the flood water flows along profile B-B in Senandale is shown in Figure 3.8. The modelling predicts that up to about 0.33m³/s water could flow southwards across this profile through the estate and along the R617.

A plot of the peak stream flows versus the water level at Point X for the existing and developed terrain scenarios is shown in Figure 3.9. The maximum increase in water level at this location arising from the development is about 20mm for the 0.1%AEPCC event and 10mm for the 1%AEPCC event.

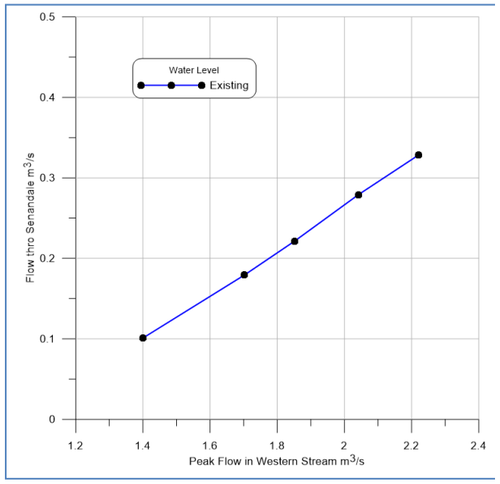

Figure 3.7 – Peak flood flow in stream vs. flow along Section B-B Senandale

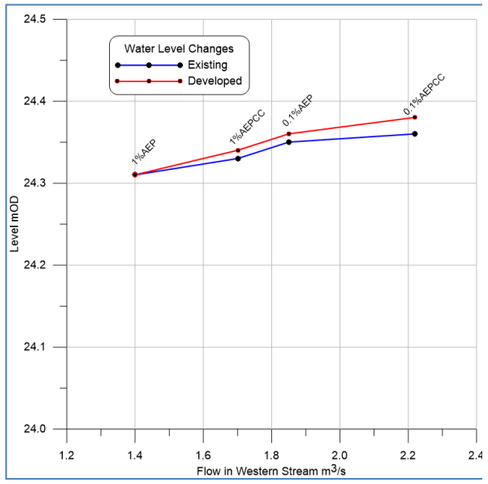

Figure 3.8 – Peak flood flow in stream vs. water level at Point X

Changes in water levels associated with the passage of the 0.1%AEPCC flood are presented in Figure 3.10. Water levels at Point X increase by 20mm while at Point Y they increase by up to 60mm as a result of the development and are contained within the storage tank.

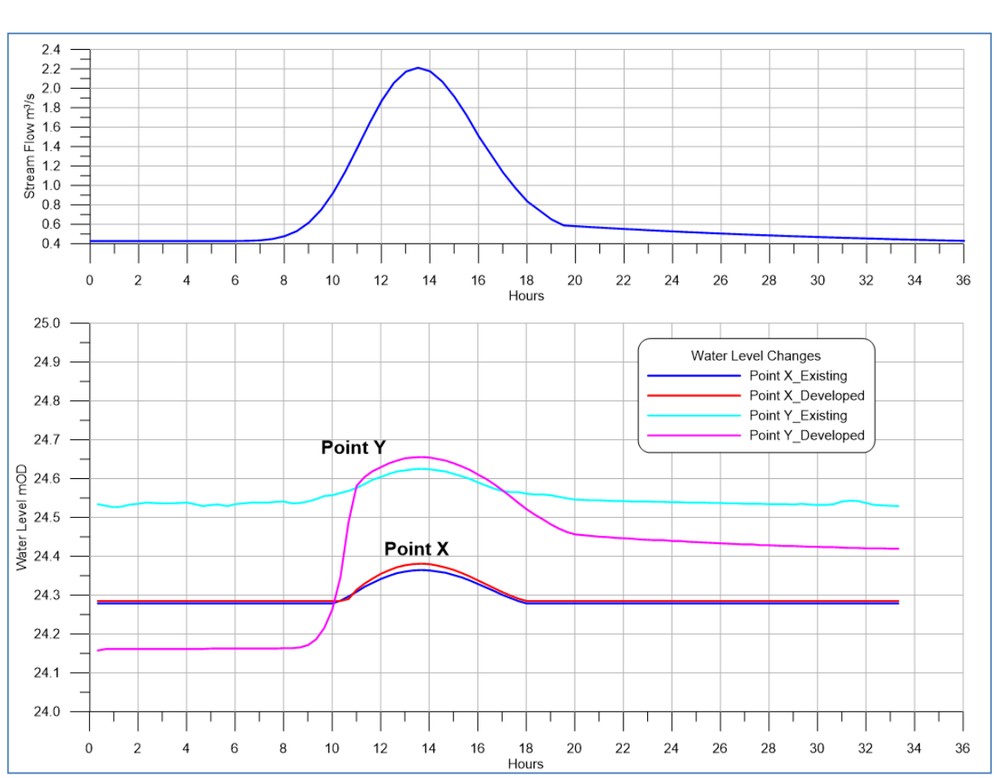

Figure 3.10 –Water level at Point X (west of Senandale) and at Point Y (storage area)

3.5 Longitudinal Water Surface Profile Comparison

Predicted maximum water levels along the profile line C-C-are presented in Figures 3.11.Results from three simulations are shown:

- Existing 0.1%AEPCC in stream, 1%AEPCC in river;
- Developed 0.1%AEPCC in stream, 1%AEPCC in river;
- Existing 0.1%AEPCC in stream, 0.1%AEPCC in river.

These simulations show that there will be a negligible change in water levels arising from the development. The wider influence of the Owennagearagh on water levels is clearly evident and during a 0.1%AEPCC event, water levels are predicted to be 300mm above the R579 road level. Water level changes resulting from the development along profile C-C are small and only evident from chainages 90m to 160m as shown by Figure 3.11.

Section D-D from Senandale northwards through the site (Figure 3.12) shows that flood waters will be removed from the low-lying site areas and contained within the storage tank where the overall water level increase will be 60mm during the 0.1%AEPCC event.

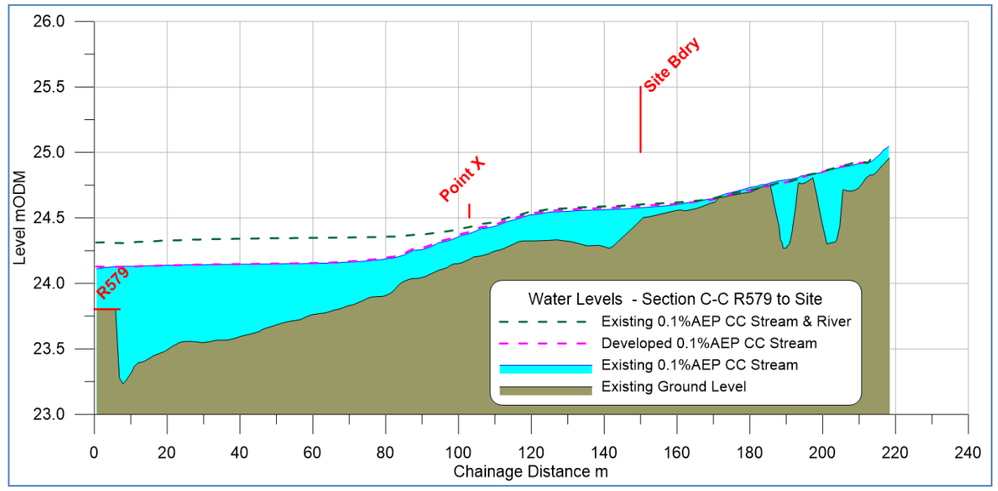

Figure 3.11 –Peak water level profiles along Section C-C

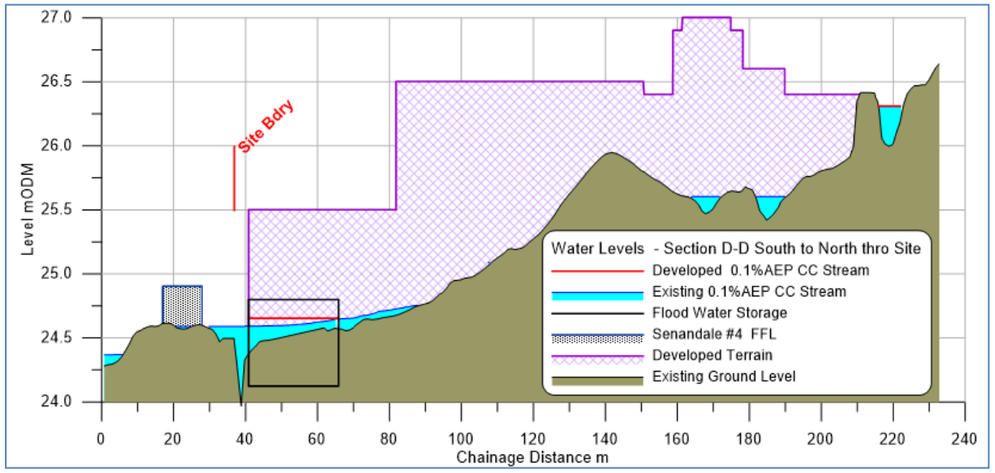

Figure 3.12 –Peak water level profiles along Section D-D

3.6 Velocity Mapping

Velocity maps have been generated for the peak stream flow and existing and developed terrain (Figures 3.13& 3.14). There is an obvious improvement in the Senandale estate area when stream flood waters are excluded and there are no observable changes that would suggest any adverse impact on the adjoining lands or properties to the west.

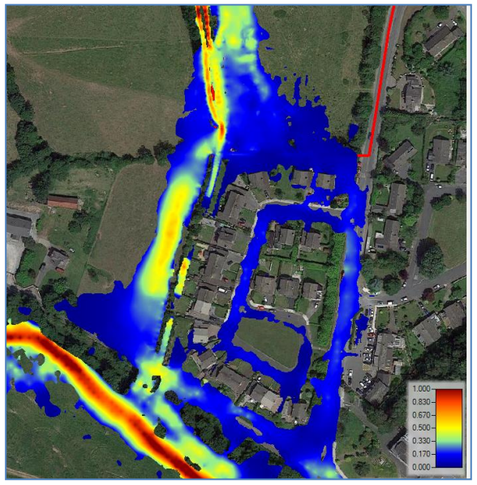

Figure 3.13 – Velocity map, existing terrain

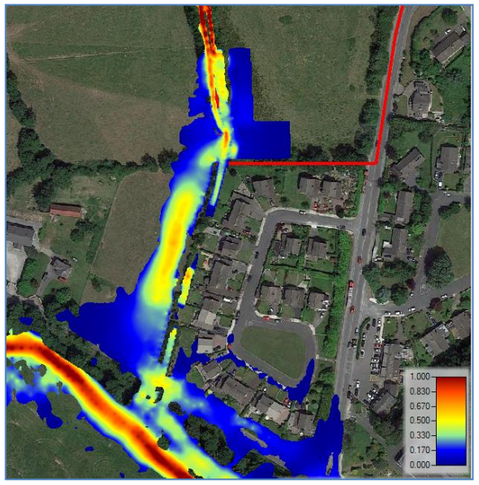

Figure 3.14 - Velocity map, developed terrain

3.7 Modelling Results Summary

The modelling study has shown that the site is not at risk of flooding from the Owennagearagh river. Predicted flood water inundation from this source is similar to those previously identified by the OPW LeeCFRAM study and the CCC MDLAP. Predicted extreme water levels are about 24.3m OD and therefore waters will back up the stream and drainage channel at the northern boundary of Senandale.

The western stream has been modelled and stream waters are found to overflow both to the west and to the east under a range of high flow conditions. The southern part of the site is low-lying and localised inundation is predicted. Flooding will occur during the 1%AEP event and thus the affected part of the site, Figure 3.15, lies in Zone A as defined by the Flood Risk Guidelines. The inundated area is about 6000m^2 of which5000m^3 lies within the site and the remaining 1000m^2 is located within Senandale estate properties.

The modelling shows that during extreme events, flood waters will flow through Senandale estate and that peak flows could exceed 0.3m^3/s.

The maximum water depths associated with the 0.1%AEPCC stream flood event are shown in Figure 3.16. Typical depths within the site area are less than 100mm. The calculated maximum water volume on the site and within the northern part of Senandale at any one time is 700m^3.

The ground levels in the low-lying parts of the site will be locally raised by over 1m during development. This will provide a barrier to overland stream flood flows reaching Senandale from the north. To mitigate potential adverse impacts arising from the diversion of these overland flows the development proposals incorporate 1200m^3 of underground flood water storage and up to 300m^3 storage in the biodiversity ponds. Modelling has shown that these measures effectively manage the peak flows by a combination of storage and diversion back into to the western stream. The total flood plain area available post development decreases to about 2750m^2 from the 6000m^2 noted above while the volume storage available increases by 500m^3 through the underground system with additional uncontained volume (up to 300m^{3}during the most extreme event) available in the upstream biodiversity ponds. The significant overall increase in storage will mitigate against any adverse impacts associated with the decrease in floodplain area.

A consequence of protecting Senandale and diverting conveyance flows to the west is that there will be a small increase in water levels over a very localised region on the adjoining lands to the west. This increase is predicted to be about 20mm at Point X(Figure 3.7) for the 0.1%AEPCC stream event and decreases quickly further to the south where Owennagearagh river levels dominate (see Figure 3.11). The predicted water depths in the general area range from 150mm to over 500mm (Figure 3.16). These lands are partially in Flood Zone A and have been earmarked for open space in the adjoining development. The proposed development will have no impact on these lands and the potential increase in water levels of 20 mm in the northern part of this area

will not have any impact on the proposed access road or the development potential of the lands. In these circumstances, the residual risk of flooding to the lands to the west is acceptable given the local context.

The potential local increase in water levels of 20 mm will not increase in flood risk to any of the Senandale properties or to the dwelling further west (T23XP44 in Figure 1.4).

The provision of surface water attenuation on the site reduces peak runoff from the catchment. The reduction will be in the region 0.3 to 0.4m^3/s depending on the flood hydrograph profile. The peak flow reaching the Owennagearagh is thus reduced accordingly. This represents a valuable reduction in overall peak flows and will lead to relatively small but valuable improvement in downstream flood levels.

The proposed development will prevent flood waters reaching the R617/579 junction overland through Senandale estate. This together with the surface water attenuation and peak flow reduction noted previously will lead to an overall improvement in the flood risk at the junction.

Figure 3.15 -Flood Zone A areas as defined by the 1%AEP flood event in the stream

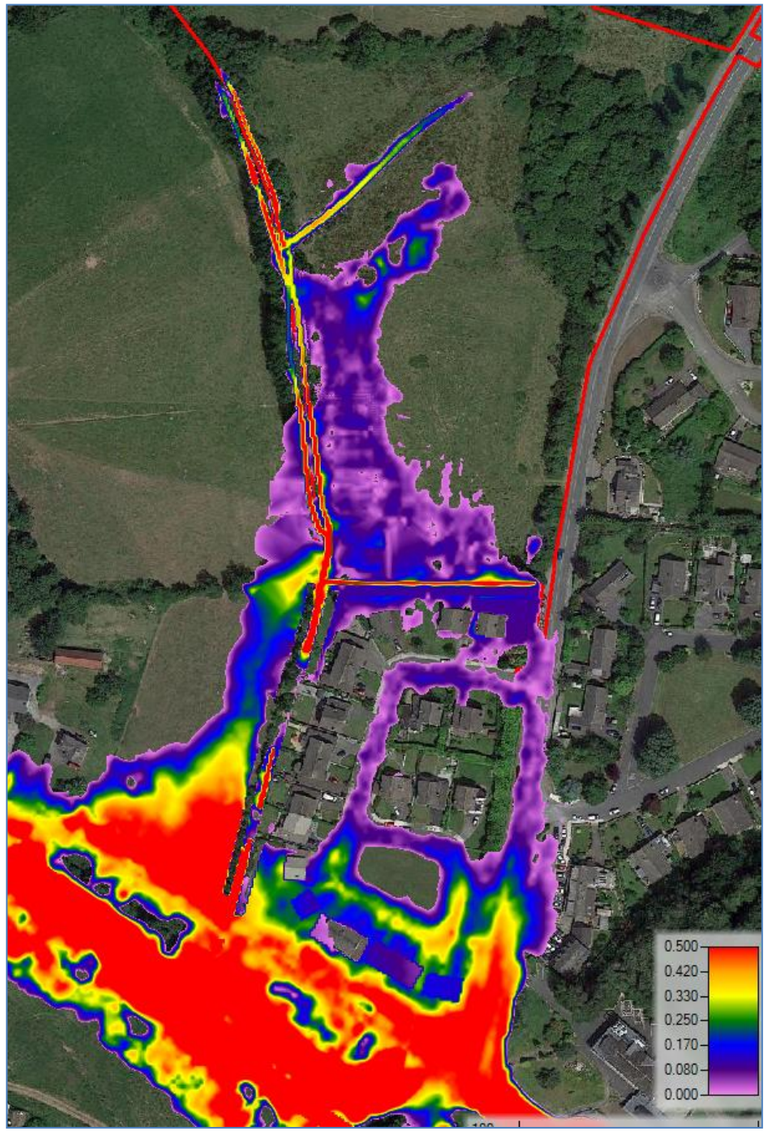

Figure 3.16 -Maximum water depths, existing terrain for 0.1%AEP CC event

4. Sequential Approach &Justification Test

The subject land is included within the development boundary of Tower as defined by the 2017 MDLAP and where the principle of development is accepted. The MDLAP illustrates Zone A/B flood risk area approximately 80m to the south as indicated in Figure 1.5, but the flood zones do not extend to the subject site. The OPW website www.floodinfo.ie has no record of flooding events on the site. Mapping produced by the OPW for the Lee CFRAM study shows localised flooding to the south across the R579 (Figure 1.7), but again it does not show any flooding within the site.

In accordance with Section 5.8 of the Flood Risk Guidelines and given the presence of a stream on the western boundary, the applicants at pre-application stage committed to preparing a site specific flood risk assessment. The Guidelines adopt a sequential approach to managing flood risk by reducing exposure to flooding through land-use planning. Given the low risk of flooding identified on the site, it is considered that the proposed development is consistent with the "sequential approach" advocated by Section 3.2 of the Flood Risk Guidelines and complies with "the broad philosophy underpinning the sequential approach in flood risk management".

4.1 Justification Test

In accordance with the Planning Guidelines on *The Planning System and Flood Risk Management*, a Development Management Justification Test (hereinafter referred to as "the Justification Test") is required in respect of the proposed development.

To allow consideration of development which may be subject to potential flood risk, the Guidelines provide a Justification Test, which establishes the criteria under which desirable development of a site in a floodplain may be warranted. The decision making process for undertaking a Justification Test is set out in paragraph 3.2, page 23 of the Guidelines. The Justification Test comprises two processes: (1) Justification Test for Development Plans and; (2) Justification Test for Development Management. Paragraph 3.8 of the Guidelines provides that the Development Management Justification Test, described in Chapter 5 of the Guidelines, is used at the planning application stage where it is intended to develop land on Flood Zone A or B for uses or development vulnerable to flooding that would generally be inappropriate for that land.

As the lands are deemed to be suitable for residential development and comply with the zoning objectives of the 2017 MDLAP, in accordance with the sequential approach mechanisms defined by Figure 3.2 of the Flood Risk Guidelines, a justification test is required. The justification test for the proposed development is carried out below.

In accordance with Section 5.15 of the Guidelines, the planning authority (or, in this case, An Bord Pleanála) must be satisfied that the proposed development satisfies all of the criteria of the justification test as it applies to development management as outlined in Box 5.1 of the

Guidelines. This section of the SSFRA report demonstrates the manner in which the criteria in Box 5.1 are satisfied in respect of the proposed Cloghroe SHD.

1. *The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.*

The subject land is included within the development boundary of Tower as defined by the 2017 MDLAP and where the principle of development is accepted. The MDLAP illustrates Zone A/B flood risk area approximately 80m to the south as indicated in Figure 1.5, but the flood zones do not extend to the subject site. The MDLAP was adopted in accordance with the Flood Risk Guidelines and contained a Strategic Flood Risk Assessment.

2. *The proposal has been subject to an appropriate flood risk assessment that demonstrates:*

(i) The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;

The completed Flood Risk Assessment highlights that the proposed development will not increase flood risk elsewhere and the lands to the west, which may experience a localised marginal increase (<20mm) in flood water, are and will remain within Flood Zone A. The proposed development will have no impact on the future development strategy or potential of these lands. The proposed development will reduce the flood risk on adjoining properties in Senandale, to the south.

(ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;

The mitigation measures proposed as part of the proposed development will increase the volume of flood storage available by up to 800m^3 and eliminate the risk of flooding on adjacent properties in Senandale.

(iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and

The proposed underground storage tanks will include a flow control structure on the drainage channel along the boundary with Senandale to ensure backflow from the stream does not occur

and this will ensure the continued protection of adjoining properties. This will ensure that residual risks are managed to an acceptable level.

(iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The flood risk is confined to the south-west of the subject site and the flood mitigation measures have no impact on the design of the streetscape to the west or the proposed public plaza area, which will contribute to the vibrancy and vitality of the area in a positive manner.

The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

As highlighted above the residual risk of flooding will be minimal due to the installation of a flow control structure, which will protect the adjacent properties in Senandale in particular. Given the nature of the proposed development, zoning objectives for the site and adjacent lands the local development context, is primarily residential, with the exception of the proposed supermarket. Based on these factors it is concluded that the minimal levels of residual risk are acceptable in the existing and emerging local context.

Based on the above, we consider that proposed development has passed the justification test and based on the proposed mitigation measures proposed, the Board is enabled to decide to grant planning permission, in accordance with the sequential approach outlined in the Flood Risk Guidelines.

5. Conclusions

Detailed 2-dimensionalhydraulicmodellinghas been carried out for the site and surrounding areas. Model results confirm that only the southern low-lying part of the site is at risk of flooding. The majority of the proposed development area and all of the proposed dwellings are elevated and well above the maximum possible floodwater level. The stream along the western boundary is the source of flood waters and these potentially impact the site, the adjoining Senandale estate and the R617/579 junction.

Simulation of the developed terrain and the mitigation proposals, containing 1200m^3 of underground flood water storage and an area of 600$m^2$of unconfined open drainage basin storage (up to 300m^3 volume for extreme flood events), confirm that these measures effectively manage the risk of flooding in accordance with the recommendations of the Flood Risk Guidelines. While the proposed development will reduce the available flood plain area, the mitigation measures will increase volume storage available by up to 800$m^3$and eliminate the risk of flooding on the site. In addition to effectively mitigating flood risk on the subject site, these measures will eliminate the existing flood risk from the western stream at this location to the adjacent properties in Senandale.

However, a consequence of protecting the site and properties in Senandale from flood risk is that there will be a small localised increase in water levels, 10mm for the 1%AEPCC event and up to 20mm for the 0.1%AEPCC event, on lands to the west of Senandale. These lands are already in Flood Zone A and the increased levels are marginal. This is consistent with the landowners development strategy for these lands and will not impact on their development potential. The main source of flood risk to the lands to the west and Senandale remains from the Owennagearagh river to the south.

The proposed works involve development on a floodplain and removal of potential storage area. The impact can be fully mitigated by the provision of underground and pond storage. The development will provide long-term protection for properties at the northern end of Senandale and will prevent onward overland flow to the R617/579 junction.

The site occupies about 8% of the existing western stream catchment area and surface water runoff will be attenuated and discharged into the existing public drainage system at greenfield rates. This provides a small but beneficial reduction in peak flows reaching the river and downstream areas. There will be no adverse impacts on the Owennagearagh or on the R617/579 junction arising from the proposed development.

On the basis of the items outlined above the proposed development is considered to have passed the Justification Test and the Board is enabled to grant permission in line with the recommendations of the Flood Risk Guidelines.

Appendix 8-2 – Topographical Survey – Precise Control

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GRID
NORTH

Survey Notes:

GRID:
THIS SURVEY IS RELATED TO ORDNANCE SURVEY GRID. IRISH TRANSVERSE MERCATOR (OSGM15).

DATUM:
LEVELS ARE RELATED TO ORDNANCE SURVEY DATUM. (MALIN HEAD, OSGM15 ADJUSTMENT).

SURVEY ABBREVIATION LIST.

AV : WATER MAIN AIR VALVE
BH : BENCH
BL : BOLLARD
BS : BUS STOP
CL : COVER LEVEL
C/L : CENTRE LINE
DP : DOWN PIPE
EIC : ESB INSPECTION COVER
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NOTES:
FURTHER LEVELS ARE SHOWN ON FROZEN LAYERS WITHIN THE AUTOCAD DRAWING. (LAYERS PRECEDED WITH Z)

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Rev.	Drn.	Date.	Description.

PRECISE CONTROL
LAND AND ENGINEERING SURVEYORS
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t: 021 4351050 – e: info@precisecontrol.com – w: www.precisecontrol.com

Job Title:
Cloghroe, Tower,
Co. Cork.

Survey:
3d Topographic Survey

For:
MHL

Plot Scale: 1:1000@A1	Surveyed by : md
Date : 06-12-19	Drawn by : md
Job Nr. : 19130	Checked by : hme
Drg. Nr.: 19130d.dwg	Rev.: 0

574700n

574800n

GRID NORTH

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Job Title:
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Survey:
3d Topographic Survey
Sheet 1 of 4

For:
MHL

Plot Scale: 1:250	Surveyed by : md
Date : 06-12-19	Drawn by : md
Job Nr. : 19130	Checked by : hme
Drg. Nr.: 19130d.dwg	Rev.: 0

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Job Title:
Cloghroe, Tower,
Co. Cork.

Survey:
3d Topographic Survey
Sheet 2 of 4

For:
MHL

Plot Scale: 1:250	Surveyed by : md
Date : 06-12-19	Drawn by : md
Job Nr. : 19130	Checked by : hme
Drg. Nr.: 19130d.dwg	Rev.: 0

Survey Notes:

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TL : TRAFFIC LIGHT
TM : TELECOM MARKER
TOF : TOP OF FENCE LEVEL
TOT : TOP OF TREE LEVEL
TOW : TOP OF WALL LEVEL
TP : TELECOM POLE
TPL : TELECOM PILLAR
TRIC : TRAFFIC INSPECTION COVER
U/G : UNDERGROUND
UM : UTILITY MARKER
UP : UTILITY PILLAR
VL : VALVE
VP : VENT PIPE
WM : WATER MAIN METER
WV : WATER MAIN VALVE

NOTES:

FURTHER LEVELS ARE SHOWN ON FROZEN LAYERS WITHIN THE AUTOCAD DRAWING. (LAYERS PRECEDED WITH 'Z')

EVERY EFFORT HAS BEEN MADE TO OBTAIN ALL DETAIL, HOWEVER SOME DETAIL MAY HAVE BEEN HIDDEN AT THE TIME OF THE SURVEY DUE TO PARKED CARS OR OTHER OBSTRUCTIONS.

Rev.	Drn.	Date.	Description.

PRECISE CONTROL
LAND AND ENGINEERING SURVEYORS
Unit 11, Eastgate Way, Eastgate, Little Island, T45 TD77, Co. Cork.
t: 021 4351050 – e: info@precisecontrol.com – w: www.precisecontrol.com

Job Title:
Cloghroe, Tower,
Co. Cork.

Survey:
3d Topographic Survey
Sheet 3 of 4

For:
MHL

Plot Scale: 1:250	Surveyed by : md
Date : 06-12-19	Drawn by : md
Job Nr. : 19130	Checked by : hme
Drg. Nr.: 19130d.dwg	Rev.: 0

Survey Notes:

GRID:

THIS SURVEY IS RELATED TO ORDNANCE SURVEY GRID. IRISH TRANSVERSE MERCATOR (OSGM15).

DATUM:

LEVELS ARE RELATED TO ORDNANCE SURVEY DATUM. (MALIN HEAD, OSGM15 ADJUSTMENT).

SURVEY ABBREVIATION LIST.

AV : WATER MAIN AIR VALVE
BH : BENCH
BL : BOLLARD
BS : BUS STOP
CL : COVER LEVEL
C/L : CENTRE LINE
DP : DOWN PIPE
EIC : ESB INSPECTION COVER
EM : ESB MARKER
EP : ESB POLE
EPL : ESB PILLAR
ER : EARTH ROD
ESB : ELECTRICITY SUPPLY BOARD
FFL : FINISHED FLOOR LEVEL
FH : FIRE HYDRANT
FHR : FIRE HYDRANT RISER
FP : FLAG POLE
GM : GAS MARKER
GUY : GUY WIRE TO POLE
GV : GAS VALVE
IC : INSPECTION COVER
IL : INVERT LEVEL
LP : LIGHT POST
LS : LIGHT STANDARD
LT : LIGHT TOWER
MH : MANHOLE
O/H : OVERHEAD
OSBM : O.S. BENCH MARK
PB : POST BOX
RG : ROAD GULLY
SAP : TREE SAPLING
SC : WATER MAIN STOP COCK
SH : SHORE
SN : SIGN
STN : SURVEY STATION
SV : WATER MAIN SLUICE VALVE
TBM : TEMPORARY BENCH MARK
TFL : LEVEL AT DOOR THRESHOLD
TIC : TELECOM INSPECTION COVER
TK : TELEPHONE KIOSK
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Survey:
3d Topographic Survey
Sheet 4 of 4

For:
MHL

Plot Scale: 1:250	Surveyed by : md
Date : 06-12-19	Drawn by : md
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Drg. Nr.: 19130d.dwg	Rev.: 0