PROPOSED STRATEGIC HOUSING DEVELOPMENT
'THE CONNOLLY QUARTER'

ENGINEERING SERVICES REPORT

PROJECT NO. O635

7TH OCTOBER 2019

OCSC
O'CONNOR | SUTTON | CRONIN
Multidisciplinary
Consulting Engineers

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NOTICE

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1. INTRODUCTION

1.1 Appointment

O'Connor Sutton Cronin (OCSC) was appointed by Oxley Holdings Limited to prepare an Engineering Services Report for the proposed redevelopment of the car-park site at Connolly Station, Dublin 1. The site is currently occupied by surface car-parking and low rise office and storage buildings associated with Connolly Station. The overall proposed masterplan will comprise mixed residential, commercial, amenity and community use with basement level car parking and associated infrastructure. Permission for this will be sought under separate applications. The first will be a Section 247 Strategic Housing Development (SHD) application to ABP for the mainly residential elements of the scheme along with the basement. The second will be a standard Section 34 application to DCC for the non-residential elements.

1.2 Site Location

The subject site is located immediately to the east of Connolly Station, Dublin 1. The site is bounded by Sherriff Street Lower and Commons Street to the south, Oriel Street Upper and Oriel Hall to the east and existing CIÉ development to the north and west – see ***Figure 1***. The total site comprises approximately 2.9 hectares.

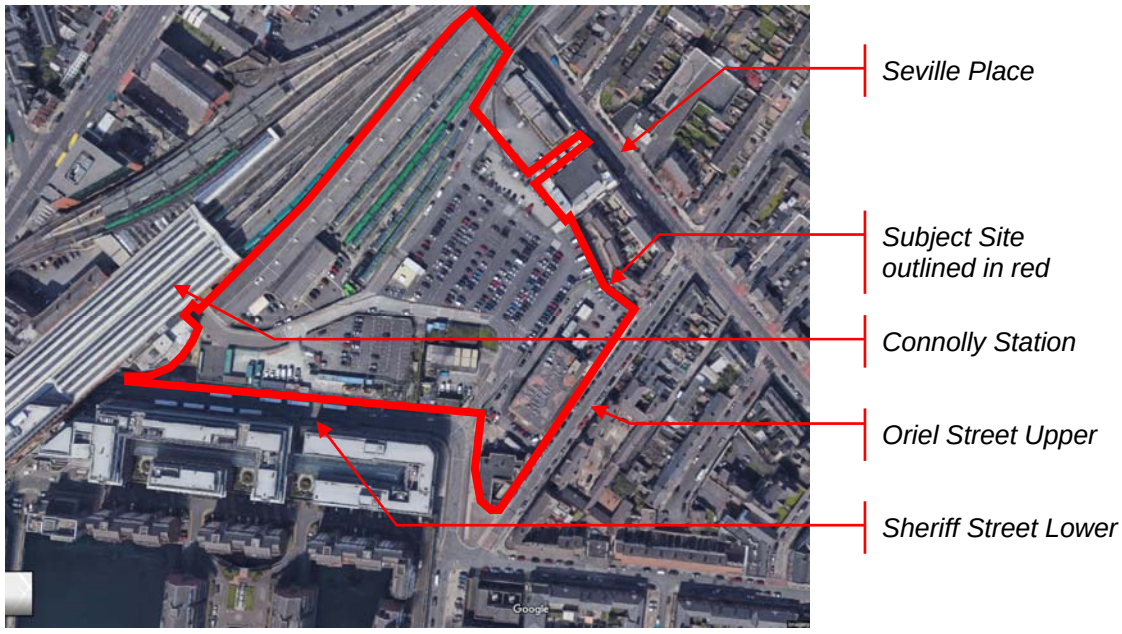


Figure 1: Site Location

1.3 Administrative Jurisdiction

The site is located within the administrative jurisdiction of Dublin City Council, whose offices are located at Civic Offices, Wood Quay, Dublin 8.

1.4 Scope of Report

This report was prepared as part of a planning application and addresses:

- Storm Water Drainage;
- Wastewater Drainage and;
- Potable Water Supply.

Traffic Impact Assessment and Site-Specific Flood Risk Assessment are provided under separate cover.

This report was compiled following a review of available data from the Office of Public Works (OPW), Ordnance Survey Ireland, Irish Water and Dublin City Council (DCC). The drainage strategy and design calculations were prepared taking cognisance of the following:

- DCC Requirements;
- BS EN 752 – Drainage Outside Buildings;
- BS EN 12056-2:2000 Gravity Drainage Systems Inside Buildings;
- Department of Housing, Planning, Community and Local Government – Technical Guidance Document 'H';
- Irish Water's Code of Practice for Wastewater Infrastructure;
- Irish Water's Code of Practice for Water Infrastructure;
- Greater Dublin Strategic Drainage Study (GDSDS);
- The Greater Dublin Region Code of Practice for Drainage Works;
- Dublin City Development Plan (2016-2022);
- Strategic Flood Risk Assessment (DCDP 2016-2022);
- The SuDS Manual (CIRA C753);
- Infiltration – Manual of Good Practice (CIRIA 156) and;
- The Planning System and Flood Risk Management, Office of Public Works, December 2009.

OCSC carried out a site inspection in February 2019. The inspection consisted of a walkover and visual inspection outside the site and in the general area.

1.5 Site Overview

The site is some 2.9 hectares in area and is currently occupied by surface car-parking and low rise office and storage buildings. The site is currently accessed from Sherriff Street Lower. A topographical survey of the existing site (see ***Appendix A***) shows that the footpath levels around the site vary; 1.5-1.9mAOD on Sherriff Street Lower and 1.0-1.7mAOD on Oriel Street Upper.

In the Dublin City Development Plan 2016-2022 (DCDP), the site is zoned Z5 "to consolidate and facilitate the development of the central area, and to identify, reinforce, strengthen and protect its civic design character and dignity" – see ***Figure 2***. Furthermore, the site is located within Strategic Development and Regeneration Area 6 – Docklands.

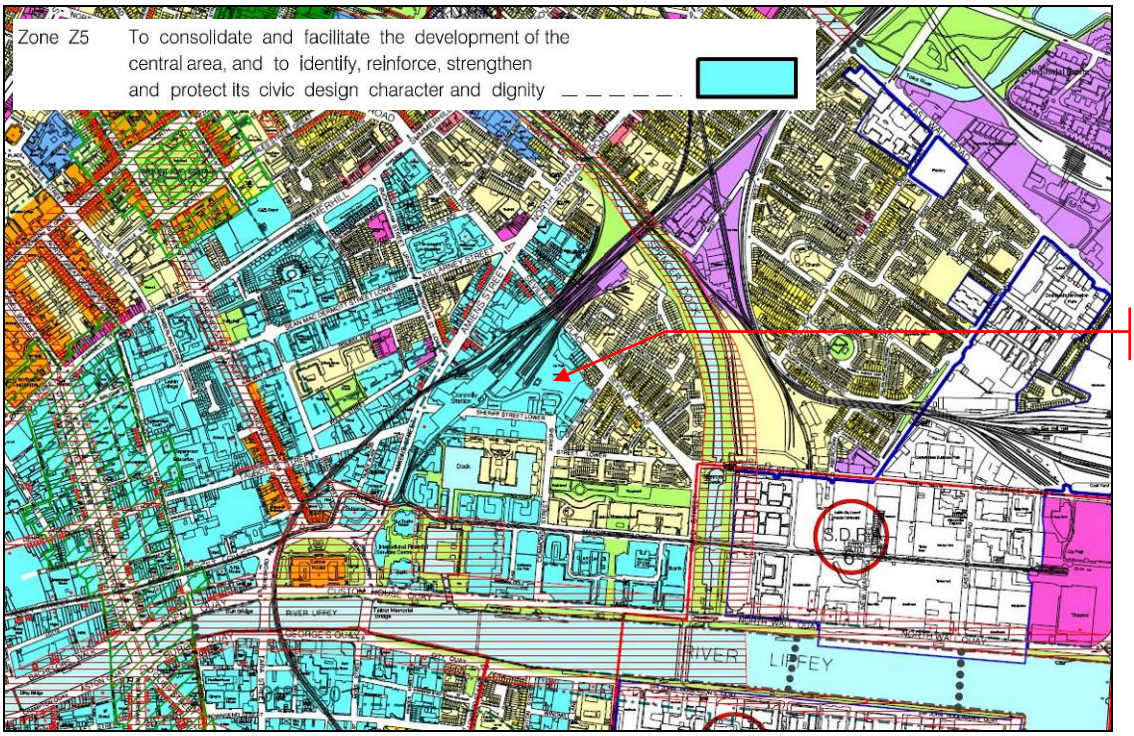


Figure 2: Extract from DCDP 2016-2022

1.6 Development Proposals

The site is currently occupied by surface car-parking and low rise office and storage buildings associated with Connolly Station. The proposed development comprises 741nr residential units, residential support amenities of 1,444m^2 and other uses (retail, commercial and community use) of 3,142m^2.

Figure 3: View of Masterplan Proposals

Existing track sidings are located in the northwest of the site; it is proposed to build over these sidings at high level, but the tracks will remain in the control of Irish Rail. Existing vaults with arches facing Sherriff Street Lower are located in the southwest of the site; these vaults are to be retained and renovated in part. It is proposed to construct a basement over much of the remaining areas of the site – see ***Figure 4*** *over*.

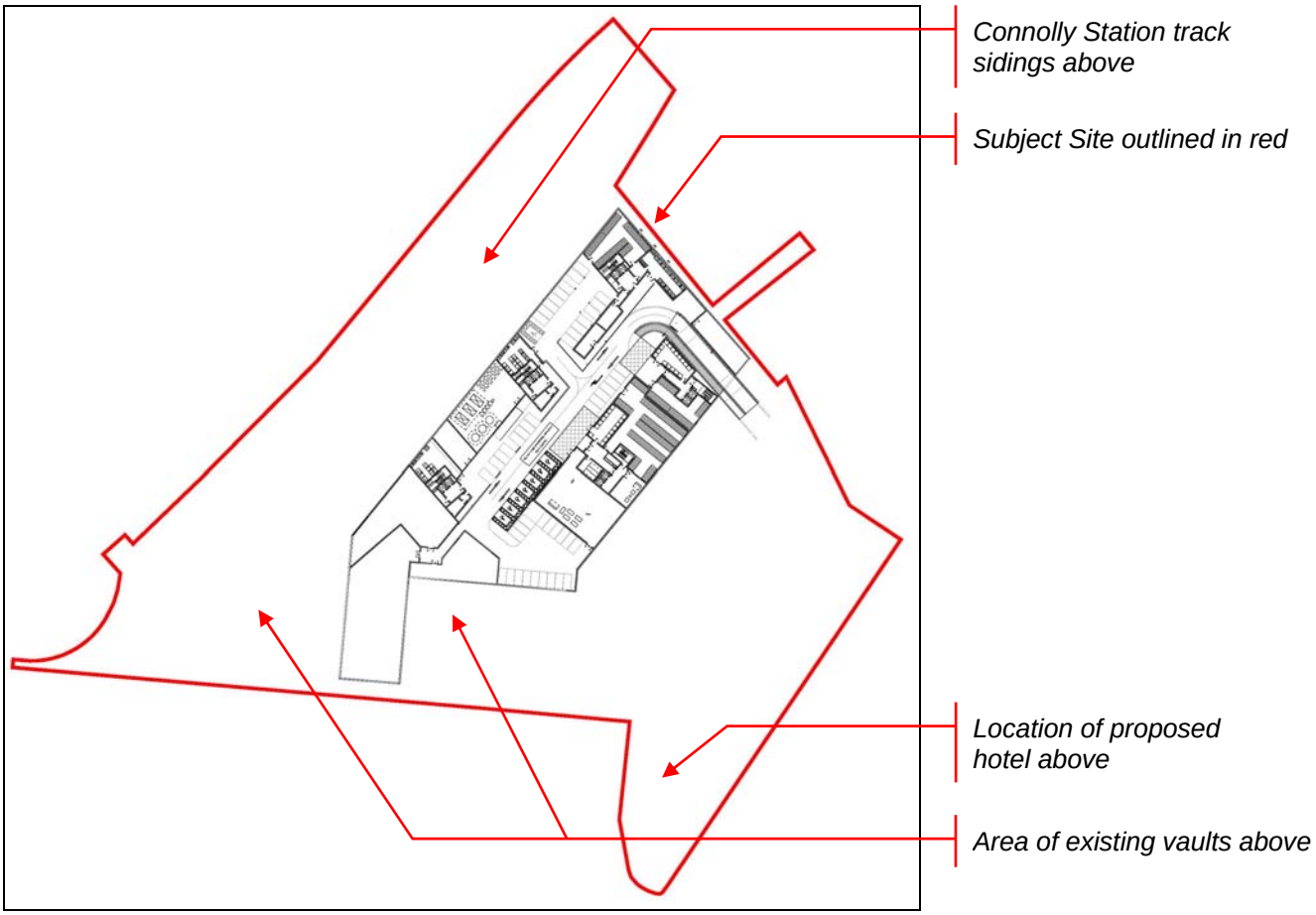


Figure 4: Proposed basement layout

At ground floor level, it is proposed to provide a thoroughfare through the development with Finished Floor Level (FFL) at 1.85m AOD; the thoroughfare will slope down to meet Oriel Street Upper on the eastern boundary of the site. The thoroughfare, which includes pockets of softstand landscaping, will be partially on the roof of the basement below – see ***Figure 5*** over.

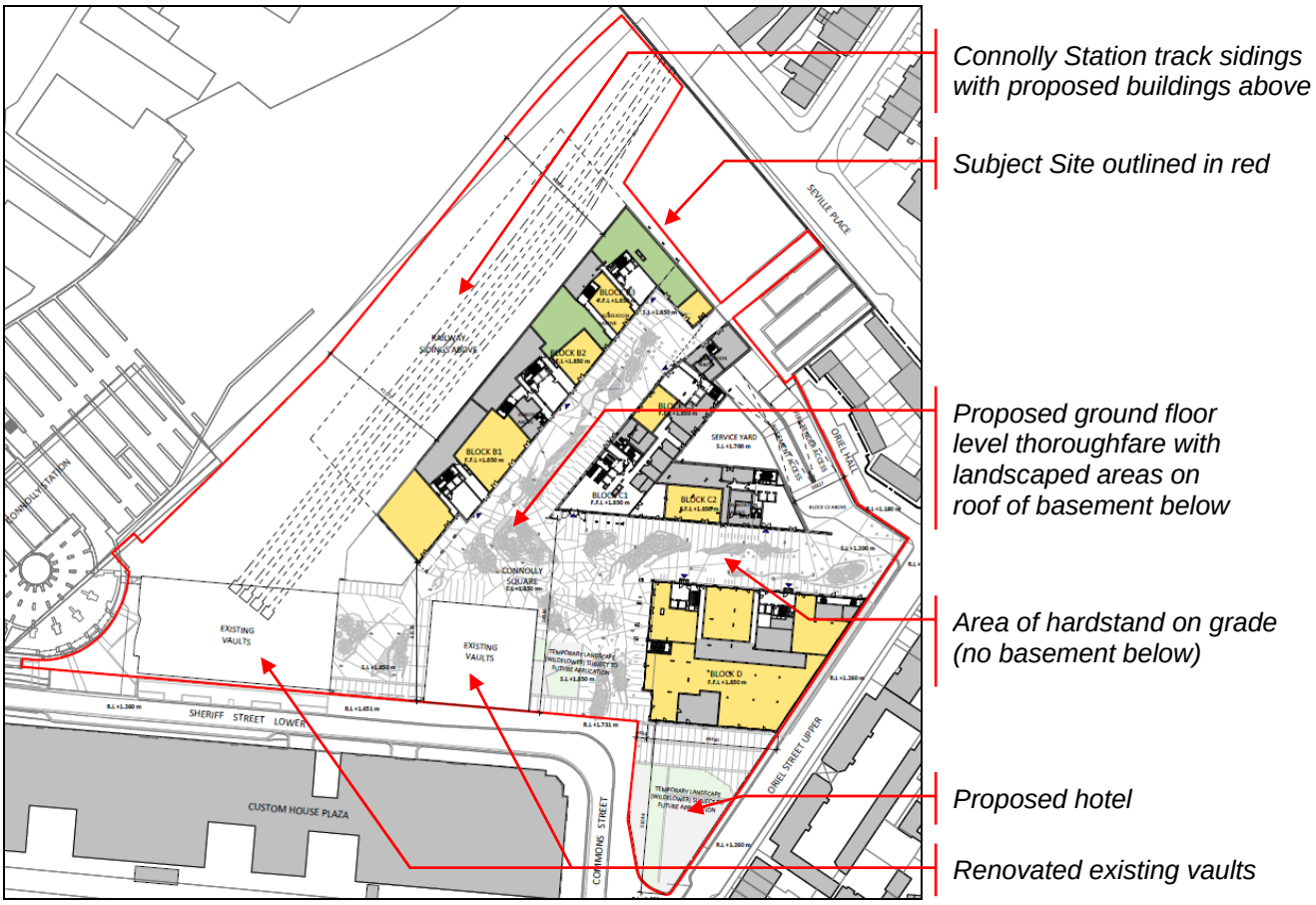


Figure 5: Proposed ground floor layout

At first floor level, it is proposed to provide a walkway linking all the proposed blocks; this walkway will link to Connolly Station and provide an alternative route for access/egress to residential areas – see ***Figure 6*** over. The walkway will also link landscaped amenity spaces provided over ground floor units.

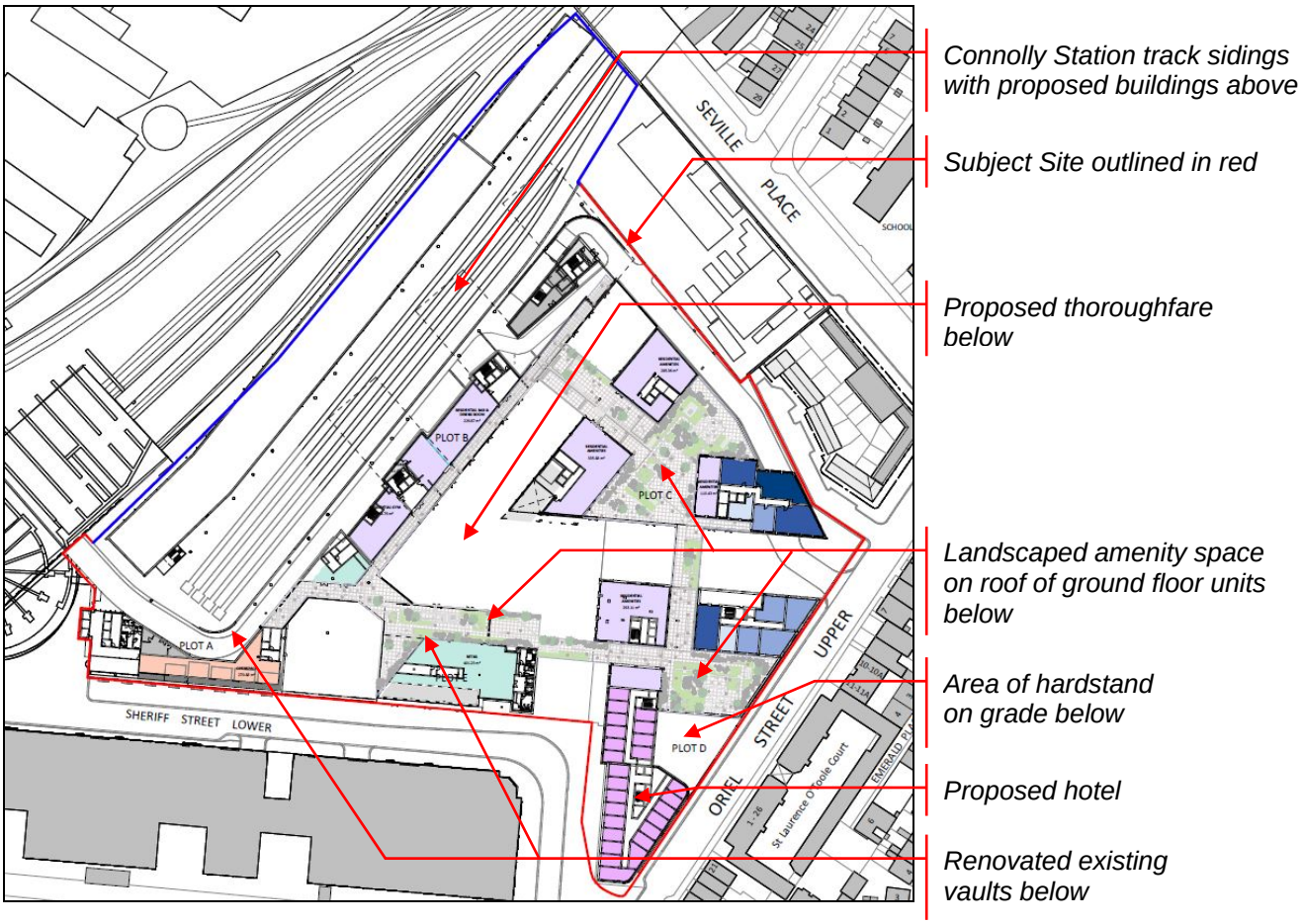


Figure 6: Proposed first floor layout

Additional landscaped amenity spaces will be provided at fourth floor level – see ***Figure 7*** over. Furthermore, the roofs of each individual block (multiple levels) will include green roofs.

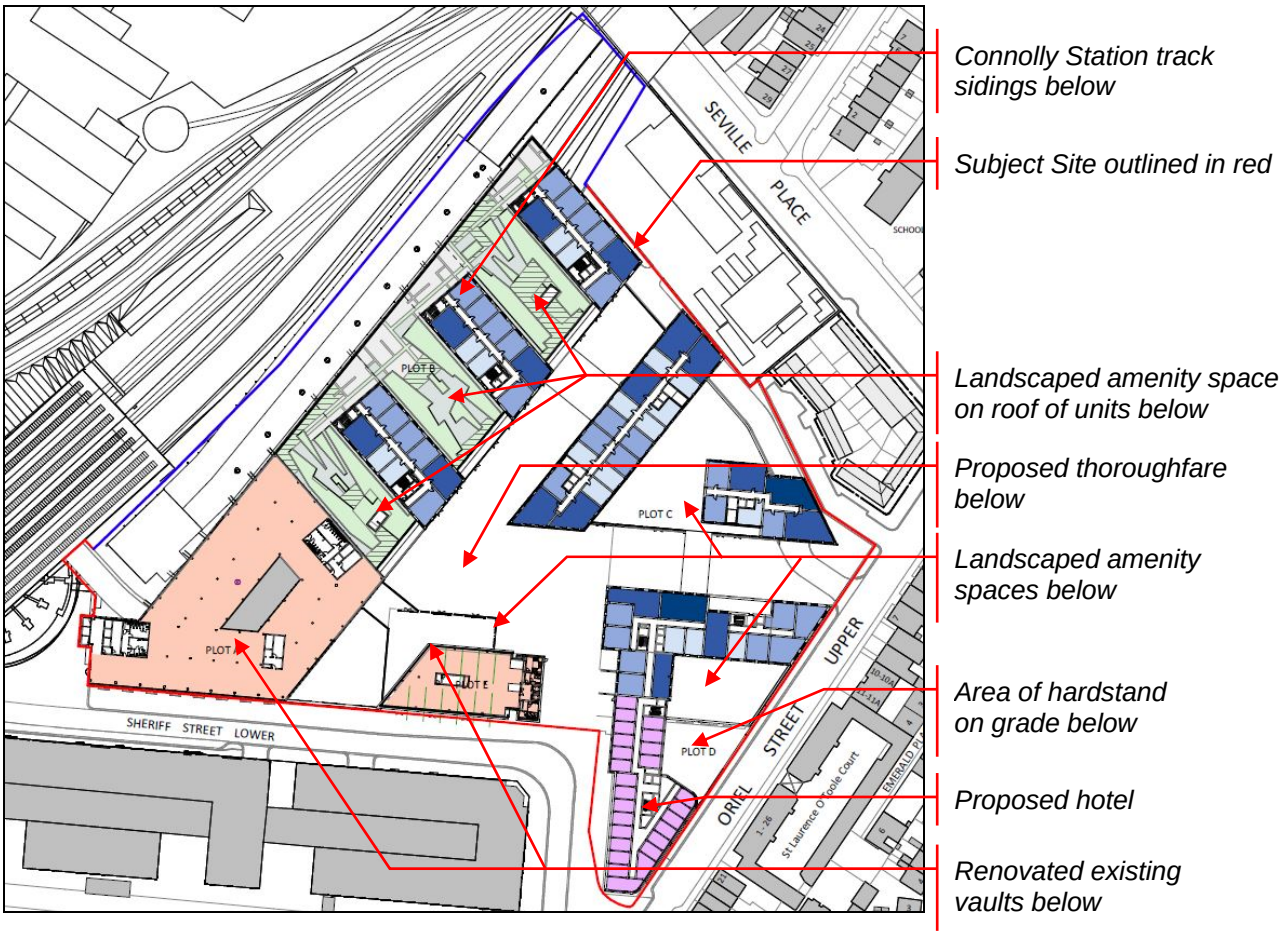


Figure 7: Proposed fourth floor layout

2. STORM WATER MANAGEMENT PLAN

2.1 Overview

The surface water drainage system for any development of the subject lands will be required to adhere to the requirements of Dublin City Council and the Greater Dublin Strategic Drainage Study (GDSDS, 2005). The City Development Plan states that applications for development must "demonstrate methods of controlling and limiting surface water run-off consistent with sustainable development". Surface water discharge from developed areas must be controlled and managed to mitigate potential impacts on the receiving environment.

The subject site is almost entirely covered by proposed buildings; the surface level across the site consists of roof or podium over habitable space below. Only a small area in the southeast of the site will be hardstand landscaped on grade. The development will incorporate a Sustainable Drainage System (SuDS) that controls runoff as close as possible to source through a management train of SuDS features such as green roofs, blue roofs, petrol interceptor, flow control and attenuation storage. It is acknowledged that landscaping can improve sustainability by assisting with surface water management; podium level amenity landscape areas will be utilised as green/blue roof to reduce the volume and rate of surface water runoff.

2.2 Flood Risk Zone

A Site-Specific Flood Risk Assessment (SSFRA) Report is submitted under separate cover. The SSFRA concludes that the subject site is in Flood Zone A/B and is in a defended area.

2.3 Pluvial Flooding and Overland Flow

The Strategic Flood Risk Assessment included in the DCDP contains a Pluvial Flood Depth and Flood Hazard Maps – extracts are reproduced in ***Figure 8*** and ***Figure 9*** over.

Figure 8: Extract from Flood ResilienCity Type 1 Pluvial Flood Depth Map (DCDP SFRA)

Figure 9: Extract from Flood ResilienCity Type 1 Pluvial Flood Hazard Map (DCDP SFRA)

The maps show small pockets of moderate pluvial flood risk present on the subject site; this corresponds to minor undulations in the ground level within the existing site. In developing the site, the ground levels will be re-profiled, removing these undulations. The maps also show pockets of pluvial flooding on existing public roads around the subject site. The development proposals provide building thresholds above adjacent road levels, thus mitigating the pluvial flood risk to proposed development.

The site is currently occupied by surface car-parking and low rise office and storage buildings; the site is largely in hardstand and is provided with no attenuation facility or flow control mechanism. The proposed drainage system will be designed to modern design standards and will collect surface water runoff from the site and attenuate to equivalent greenfield runoff rates; this will mitigate the potential pluvial flood risk arising from the subject site.

2.4 Existing Drainage

There is an existing sewerage network in place serving the area around the proposed development. Irish Water records (see ***Appendix B***) show the location of the existing drainage within the vicinity of the site. The Records show that the sewers in the wider area are combined (collecting both foul sewage and surface water runoff).

There is a brick arched sewer in Sherriff Street Lower that ranges in size from 1310mm to 1470mm; this sewer drains to a 1200mm-diameter concrete pipe that drains south towards Commons Street. The sewer in Oriel Street Upper drains northwards and begins as a 450mm-diameter vitrified clay pipe before changing to a 1000mm brick arched sewer; this sewer discharges to a 1590mm brick arched sewer in Seville Place.

All the sewers in the vicinity of the site drain to the Irish Water pumping station on Mayor Street Lower. The rising main from this pumping station runs north along Commons Street and west along Sherriff Street Lower (immediately to the southwest of the site) before discharging to a sewer in Amiens Street; following discussions with Irish Water, OCSC

understands that Irish Water are assessing plans to divert this rising main eastward to the pumping station at Spencer Dock.

There is an existing surface water drainage system serving the current development on the site (primarily surface car-parking). The existing drainage system provides no attenuation and no treatment of runoff. The existing drainage system on the site discharges un-attenuated surface water runoff to the existing sewerage network at Sherriff Street Lower.

2.5 Proposed Drainage

Due to the nature of the proposed development, most of the extent of the site will be covered in roof; the remainder of the site comprises some of the ground-level thoroughfare where there is no basement below. It is therefore proposed to provide green and blue roofs to collect, treat, convey and store surface water runoff. Where the thoroughfare is on ground (i.e. no basement below), it is proposed to provide Type C pervious paving to collect, treat, convey and store surface water runoff. Note that the sub-strata of the pervious paving will include high voids stone with perforated pipes whereas the surface layer will comprise a mix of permeable and non-permeable surfacing.

The roofs of each individual block (multiple levels) will include green roofs; the rainwater outlets (RWOs) from these roofs will be fitted with flow control devices to utilise the green roof for attenuation (i.e. a blue roof). The roof over the basement will also to utilised as a blue roof. It is proposed that the rainwater from all upper roof levels discharge to the blue roof over the basement and the pervious paving sub-strata.

It is proposed that roofs with green/blue roofs will be provided with a high-voids drainage layer, such as Polypipe's Permavoid 85 system – sample product details are provided in ***Appendix C***. The Permavoid system provides at least 92% voids, which allow for conveyance and storage across the system. The Permavoid system is available for trafficked and non-trafficked applications and is consistent with the use of roof areas as amenity space – see ***Figure 10*** *over*.

It is proposed that rainwater outlets (RWOs) from all upper level blue roofs be fitted with a flow control device; details of a sample RWO flow control device are provided in ***Appendix D***.

Figure 10: Example of roof-level amenity space with Permavoid drainage layer (from Polypipe Permavoid)

While it is intended that only a small portion of the surface area of the site is trafficked (at the entrance to the basement car-park), the thoroughfare at ground floor level is designed to allow occasional vehicular access, including fire tender access. It is therefore proposed that all runoff from the site will pass through Class 1 petrol interceptors prior to discharge off site.

All runoff will be limited to equivalent greenfield runoff rates (2 l/s/ha) using flow control devices (e.g. vortex flow control, orifice plate) prior to discharge to the receiving sewers.

The proposed surface water drainage layout is shown on O'Connor Sutton Cronin drawing O635-OCSC-XX-XX-DR-C-0500.

2.6 Specific SuDS Measures Proposed

It is proposed to provide a Sustainable Drainage System (SuDS) in accordance with the Greater Dublin Strategic Drainage Study Regional Drainage Policy Volume 2 - New Development (GDSDS-RDP Volume 2). Specific design requirements for SuDS components are established by the Construction Industry Research and Information Association's publication The SuDS Manual (C753). It is proposed that the following systems will be used:

- Green Roofs will be provided in within the subject site where large flat roof areas are provided. Amenity spaces at roof level will comprise a combination of paving and planted areas but will include a drainage layer throughout for the collection and storage of surface water runoff.

Figure 11: Example green roof

- Pervious Paving will be provided to the thoroughfare where there is no basement below. Pervious paving will be Type C to The SuDS Manual CIRIA C753. Note that the sub-strata of the pervious paving will include high voids stone with perforated pipes whereas the surface layer will comprise a mix of permeable and non-permeable surfacing.

- Attenuation Storage will be provided for runoff from all surfaces to allow for the restriction of discharge rates to equivalent greenfield runoff rates. Proposed attenuation storage volumes accommodate the design 100-year return period rainfall event within the designated storage area. All attenuation storage on the site will be provided in blue roof drainage layers and in pervious paving sub-strata.

- Limiting Discharge to ensure that the discharge rate is maintained at equivalent greenfield runoff rates. A discharge rate of 2 l/s/ha is proposed, resulting in a total discharge rate from the site of 5.8l/s.

- Interception Storage will be provided in green roofs and infiltration trenches (where ground conditions allow). Due to the extent of the proposed building and basement footprint, scope for infiltration is limited to a small area in the southeast of the site.

- Infiltration of runoff to groundwater can occur only in the southeast corner of the site, due to the extent of the building and basement footprint. Infiltration to groundwater will occur where ground conditions allow.

- Class 1 oil separators will be provided at all outfalls from the proposed drainage system. Class 1 by-pass oil separators in accordance with Pollution Prevention Guideline PPG3 be used at all locations.

- Rainwater Harvesting will be assessed for use in the proposed development.

2.7 Piped Network

As the proposal for surface water drainage for the development primarily comprises a blue roof over the basement, there is relatively little below-ground surface water piped drainage included in the development proposal. Below-ground piped drainage comprises: RWP connections in

the existing retained vaults; gully connections in the area of hardstand in the southeast corner and; RWP connections from the hotel block in the southeast corner. The proposed drainage network will include new piped gravity drainage designed in accordance with I.S. EN752: 2017 *"Drain & Sewer Systems outside Buildings"*, the DOE *'Recommendations for Site Development Works for Housing Areas'*, *'The Greater Dublin Region Code of Practice for Drainage Works'* and the recommendations of the *'Greater Dublin Strategic Drainage Study'*, (GDSDS). Full bore self-cleansing velocities of 1.0m/s will be achieved throughout the network.

2.8 Outfall Locations

The proposed surface water drainage system includes three separate outfalls to existing combined sewers: the 1470mm brick arched sewer in Sherriff Street Lower; the 1200mm-diameter concrete pipe sewer in Sherriff Street Lower and; the 1000mm brick arched sewer in Oriel Street Upper. Details of the proposed surface water discharge to Irish Water combined sewers was included in a Pre-Connection Enquiry submitted to Irish Water in August 2018; the Confirmation of Feasibility was received in October 2018 (see ***Appendix E***) and the Statement of Design Acceptance was received in June 2019 (see ***Appendix F***).

As there are no extant surface water sewers in the vicinity and discharge will be made to the combined sewers, the last private surface water manhole will be constructed with two outfall pipes: one pipe will be capped at site boundary and; one pipe will discharge to the last private wastewater drainage manhole, in accordance with DCC requirements.

2.9 Calculations

A computer model of the drainage systems has been developed using the MicroDrainage design software. Calculations for the design of storm drains have been compiled using the Modified Rational Method in accordance with EN752. The rainfall intensity levels have been obtained from Met Éireann – see ***Appendix G***. Rainfall levels have been increased by 20% for climate change factors. The performance of the proposed drainage systems will be assessed for 30-year and 100-year return period

storm events at a later detailed design stage. Calculations generated by the MicroDrainage SourceControl software are included in ***Appendix H***.

2.10 GDSDS Storm Water Review

The Greater Dublin Strategic Drainage Study (GDSDS) requires that storm water is reviewed under four Criteria as follows:

(i) Criterion 1 – River Water Quality Protection;
(ii) Criterion 2 – River Regime Protection;
(iii) Criterion 3 – Level of Service (Flooding) site;
(iv) Criterion 4 – River Flood Protection.

Criterion 1 – River Water Quality Protection

The drainage system for this development will contain a range of treatment methods for surface water as outlined earlier. Low rainfall events and the first flush of higher rainfall events will be intercepted by green roof and infiltration trenches where provided. This volume will not be discharged off site.

All runoff from the site will be passed through Class 1 oil separators in accordance with Pollution Prevention Guideline PPG3.

Criterion 2 – River Regime Protection

Discharge will be made via the proposed attenuation facilities and flow control devices. Discharge will be limited to equivalent greenfield runoff rates, providing a total maximum discharge rate of 5.8 l/s, based on a greenfield runoff rate of 2l/s/ha. The GDSDS-RDP Volume 2, Appendix E Section E2.4 states that this ensures "that sufficient stormwater runoff retention is achieved to protect the river during extreme events". Therefore, the proposals satisfy Criterion 2.

Criterion 3 – Level of Service (Flooding) Site

There are 4 sub-criteria for Level of Service, as set out in the GDSDS-RDP Volume 2, Section 6.3.4 (Table 6.3):

(i) No flooding on site except where planned (30-year high intensity rainfall event);

(ii) No internal property flooding (100-year high intensity rainfall event);
(iii) No internal property flooding (100-year river event and critical duration for site) and;
(iv) No flood routing off site except where specifically planned (100-year high intensity rainfall event).

Sub-Criterion 3.1

The performance of the proposed drainage system in the 30-year return period storm event has been analysed. The analysis shows that no flooding is expected in the 30-year return period storm event. Therefore, the proposals satisfy Sub-Criterion 3.1.

Sub-Criterion 3.2

The performance of the proposed drainage system in 100-year return period storm event has been analysed. The analysis show that no flooding is expected in the 100-year return period storm event. Therefore, the proposals satisfy Sub-Criterion 3.2.

Sub-Criterion 3.3

Fluvial flood risk is assessed in the Site-Specific Flood Risk Assessment provided under separate cover. That report concludes that the site is in Flood Risk Zones A/B and in a defended area and that the proposed development mitigates the residual flood risk.

In accordance with the requirements of Sub-Criterion 3.3, the attenuation storage facilities proposed have been designed to provide at least 500mm freeboard to the expected FFLs within the subject site. Therefore, the proposals satisfy Sub-Criterion 3.3.

Sub-Criterion 3.4

The performance of the proposed drainage system in the 100-year return period storm events has been analysed. The analysis shows that no flooding is expected in the 100-year return period storm event. Notwithstanding this, all surfaces within the proposed development have been designed to provide overland flow routes through the development

to avoid ponding within the subject site. Therefore, the proposals satisfy Sub-Criterion 3.4.

Criterion 4 – River Flood Protection

In accordance with Criterion 4, runoff from the site will be limited to the greenfield runoff rate of 2 l/s/ha. By limiting the runoff to this flow rate, the GDSDS-RDP Volume 2, Appendix E Section E2.4 states that this ensures "that sufficient storm water runoff retention is achieved to protect the river during extreme events." Attenuation storage is provided for the 100-year return period storm event in the proposed attenuation facilities. Control of runoff rates will be achieved through the use of a flow control devices (e.g. vortex control device, orifice plate). Therefore, the proposals satisfy Criterion 4.

Table 1: Catchment Summary

Site Location	**Dublin City**	
Design Storm Return Period:	years	100
Climate Change Factor:	%	20
Soil Type:		2
Total Site Area:	ha	2.9
Hardstand Area:	ha	2.9
Softstand Area:	ha	0.0
Percentage Impervious (PIMP)	%	100
Allowable Outflow:		
IH124: $QBAR = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$		
AREA:	km^2	0.029
SAAR:	mm	750
SOIL:		0.3
QBAR	l/s/ha	1.98
Greenfield Runoff (as per GDSDS)	l/s/ha	2.0
Proposed outflow	l/s	5.8

3. WASTEWATER DRAINAGE

3.1 Overview

The wastewater drainage system for any development of the subject lands will be required to adhere to the requirements of the Building Regulations Part H and Irish Water's *Code of Practice for Wastewater Infrastructure* (IW-CDS-5030-03 Revision 1, IW, 2017).

As described earlier in Section 1.5, ground levels across the site generally fall from west to east, with levels varying between 1.9mAOD in the southwest to 1.0mAOD in the east.

3.2 Existing Drainage

There is an existing drainage network in place serving the area around the proposed development. Irish Water records (see ***Appendix B***) show the location of the existing drainage within the vicinity of the site. The Records show that the sewers in the wider area are combined (collecting both foul sewage and surface water runoff).

There is a brick arched sewer in Sherriff Street Lower that ranges in size from 1310mm to 1470mm; this sewer drains to a 1200mm-diameter concrete pipe that drains south towards Commons Street. The sewer in Oriel Street Upper drains northwards and begins as a 450mm-diameter vitrified clay pipe before changing to a 1000mm brick arched sewer; this sewer discharges to a 1590mm brick arched sewer in Seville Place.

All the sewers in the vicinity of the site drain to the Irish Water pumping station on Mayor Street Lower. The rising main from this pumping station runs north along Commons Street and west along Sherriff Street Lower (immediately to the southwest of the site) before discharging to a sewer in Amiens Street; following discussions with Irish Water, OCSC understands that Irish Water are assessing plans to divert this rising main eastward to the pumping station at Spencer Dock.

3.3 Proposed Drainage

Due to the nature of the proposed development, almost the entire extent of the site will be covered in proposed basement; it is therefore proposed that all wastewater from the development be collected in pipes suspended at high level within the basement. The suspended drainage will drain to last private manholes at three locations.

The proposed basement provides accommodation for car-parking and plant rooms. It is proposed to provide a pipe gravity system below basement level draining to a Class 2 oil separator and sump pump; a rising main will discharge to a stand-off manhole at ground level prior to gravity connection to the last private manhole within the site.

The proposed wastewater drainage layout is shown on O'Connor Sutton Cronin drawing O635-OCSC-XX-XX-DR-C-0520.

3.4 Outfall Locations

The proposed wastewater drainage system includes three separate outfalls to existing combined sewers: the 1470mm brick arched sewer in Sherriff Street Lower; the 1200mm-diameter concrete pipe sewer in Sherriff Street Lower and; the 1000mm brick arched sewer in Oriel Street Upper.

3.5 Calculations

Calculations for volumetric wastewater generation for the proposed development are included in ***Appendix I***. Calculations have been compiled in accordance with the requirements of Irish Water.

3.6 Irish Water Confirmation of Feasibility

Details of the proposed discharge to Irish Water combined sewers was included in a Pre-Connection Enquiry submitted to Irish Water in August 2018 and a Confirmation of Feasibility was received in October 2018. Following a meeting with Irish Water in November 2018 and further assessment by Irish Water, a revised Confirmation of Feasibility as received in April 2019 – see ***Appendix E***.

3.7 Irish Water Statement of Design Acceptance

Details of the proposed drainage was submitted to Irish Water and a Statement of Design Acceptance was received in June 2019 – see ***Appendix F***.

4. POTABLE WATER SUPPLY

4.1 Overview

The water supply system for any development of the subject lands will be required to adhere to the requirements of the Building Regulations Part G and Irish Water's *Code of Practice for Water Infrastructure* (IW-CDS-5020-03 Revision 1, IW, 2017).

As described earlier in Section 1.5, ground levels across the site generally fall from west to east, with levels varying between 1.9mAOD in the southwest to 1.0mAOD in the east.

4.2 Existing Watermains

There is an existing watermain network in place serving the area around the proposed development. Irish Water records (see ***Appendix B***) show the location of the existing watermains within the vicinity of the site. There is a 9-inch cast iron watermain in Sherriff Street Lower and a 6-inch cast iron watermain in Oriel Street Upper.

4.3 Calculations

Calculations for volumetric water demand for the proposed development are included in ***Appendix I***. Calculations have been compiled in accordance with the requirements of Irish Water.

4.4 Connection to the Existing Network

It is proposed to provide a connection to the existing 9-inch watermain on Sherriff Street Lower; this connection will be used as the primary supply point. Due to the size of the proposed development, it is also proposed to provide a secondary connection to the existing 6-inch watermain in Oriel Street Upper. The proposed network connections will be metered using a bulk non-mechanical meter, as per Irish Water requirements.

4.5 Proposed Watermains

The proposed connections will supply a water tank room in the basement, from where the proposed development will be provided with a boosted

supply. Details of the internal watermains and water tank room are provided by other members of the design team.

The proposed watermain layout is shown on O'Connor Sutton Cronin drawing O635-OCSC-XX-XX-DR-C-0540.

4.6 Water Saving Devices

In accordance with best practice, new water saving devices (low water usage appliances and aerated taps etc.) will be fitted as standard in future development within the subject site (subject to future planning applications).

4.7 Domestic Water Meters

Meters for apartments and similar properties will be installed internally within the Premises in accordance with the Building Control Authority's requirements and subject to review by Irish Water.

4.8 Irish Water Confirmation of Feasibility

Details of the proposed connections to Irish Water watermains was included in a Pre-Connection Enquiry submitted to Irish Water in August 2018 and a Confirmation of Feasibility was received in October 2018. Following a meeting with Irish Water in November 2018 and further assessment by Irish Water, a revised Confirmation of Feasibility as received in April 2019 – see ***Appendix E***. Irish Water advised that a watermain upgrade is required. The new watermain should be 300mm in diameter and extend for approximately 430m between an existing 600mm-diameter watermain on the North Quays and the proposed development site – see ***Figure 12*** over. The watermain upgrade includes a crossing of the Luas light rail line.

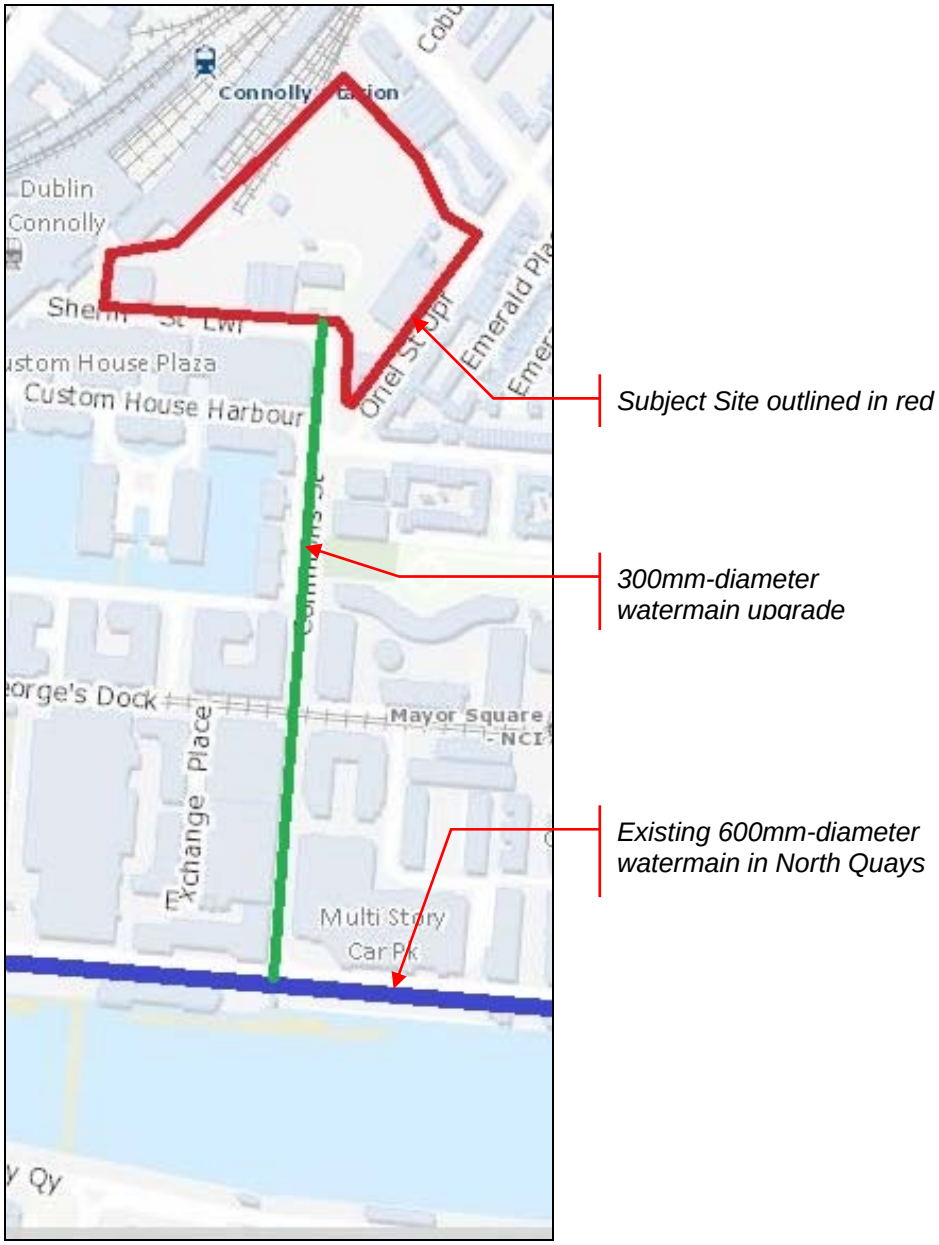


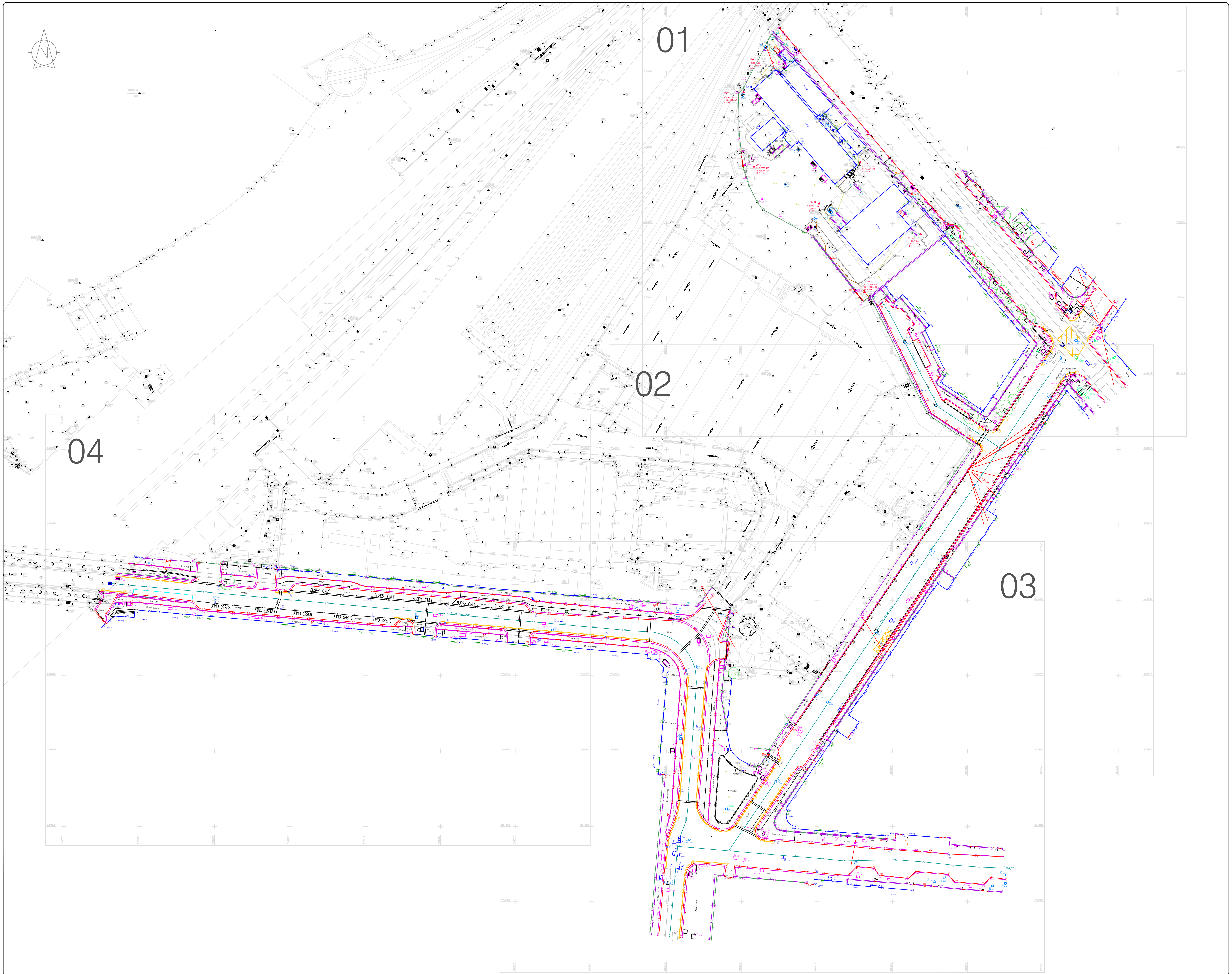
Figure 12: Scope of watermains upgrades advised by Irish Water

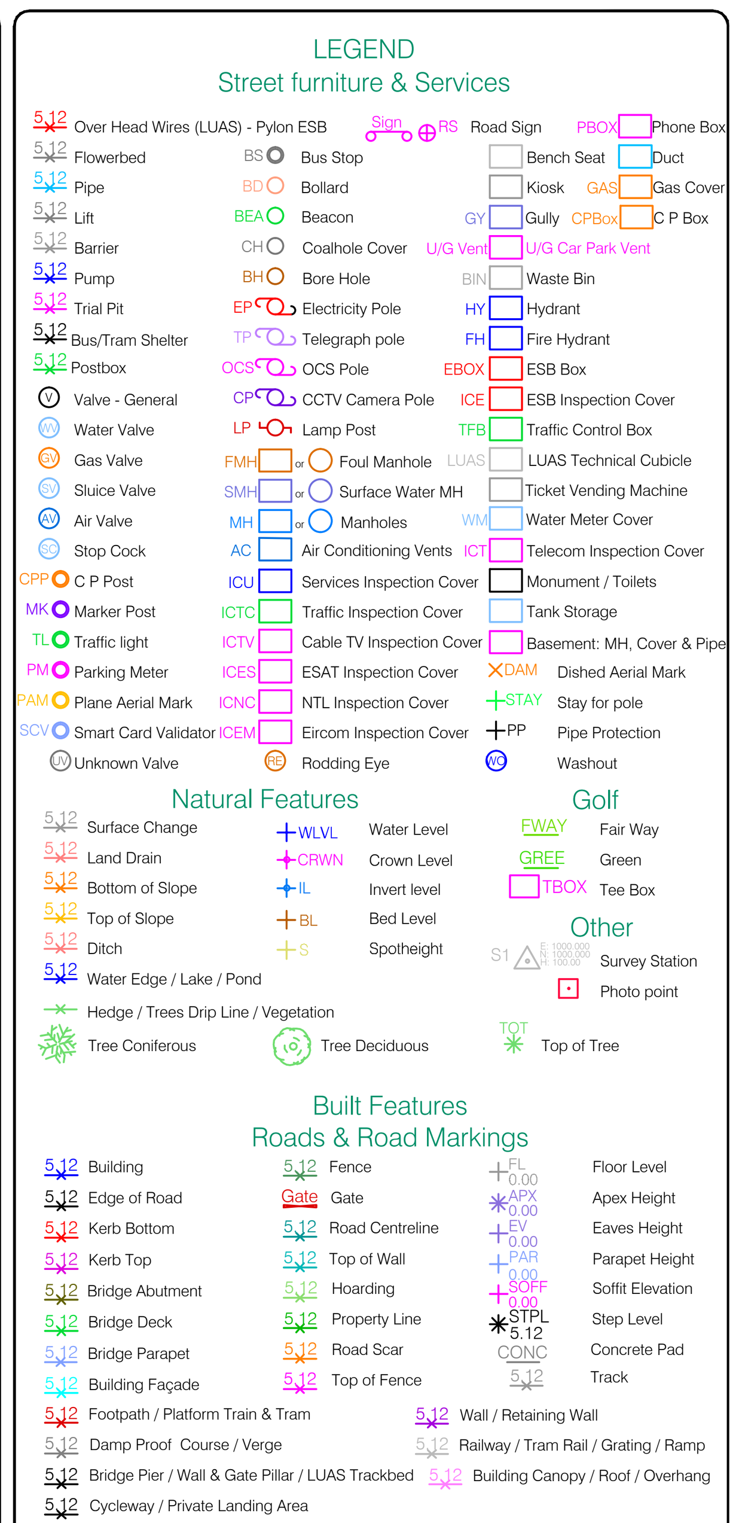
4.9 Irish Water Statement of Design Acceptance

Details of the proposed watermains were submitted to Irish Water and a Statement of Design Acceptance was received in June 2019 – see ***Appendix F***.

APPENDIX A

TOPOGRAPHICAL SURVEY





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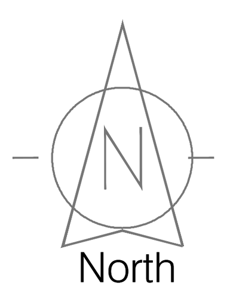

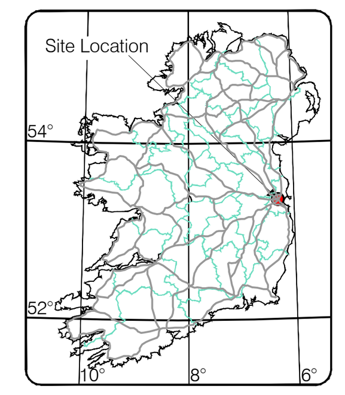

Map Sheet Layout:

Surveyed by : ED — Date: 02.08.2018 — Datum : Malin Head
Drawn by : LR — Date: 15.08.2018 — Grid System:
Checked by : PK — Date: 15.02.2018 — Irish National Grid ☒ ITM(15) ☐

Revisions

No.	Date	Description
0	15.08.2018	First Drawing

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Kilcullen Business Campus
Kilcullen Co. Kildare
Ireland
Phone: (+353) 045 484040
Fax: (+353) 045 484004
Email: info@murphysurveys.ie

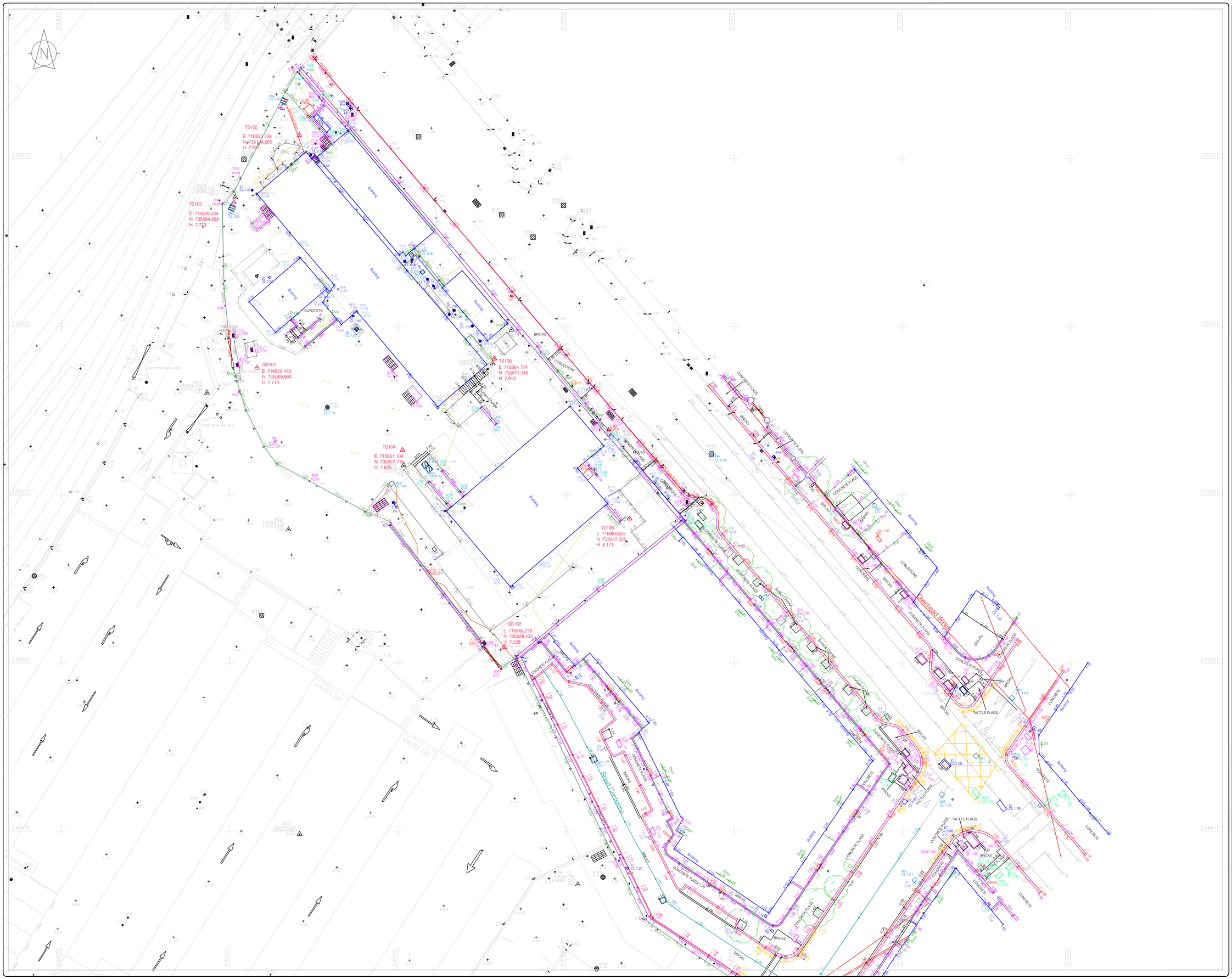
Client : O Connor Sutton Cronin

Project : Additional Survey At Connolly Station

Date : 15.08.2018 **Scale :** NTS

Description : Topographical Survey
Sheet 4

Drawing Number : MSL26950_T_3D_Rev0



LEGEND

Street furniture & Services

- Over Head Wires (LUAS) - Pylon ESB
- Flowerbed
- Pipe
- Lift
- Barrier
- Pump
- Trial Pit
- Bus/Tram Shelter
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North

Site Location

Map Sheet Layout:

Surveyed by :	ED	Date: 02.08.2018	Datum: Main-Head
Drawn by :	LR	Date: 15.08.2018	Grid System:
Checked by :	PK	Date: 15.02.2018	Irish National Grid ☒ ITM15☐

Revisions

No.	Date	Description
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Email: info@murphysurveys.ie

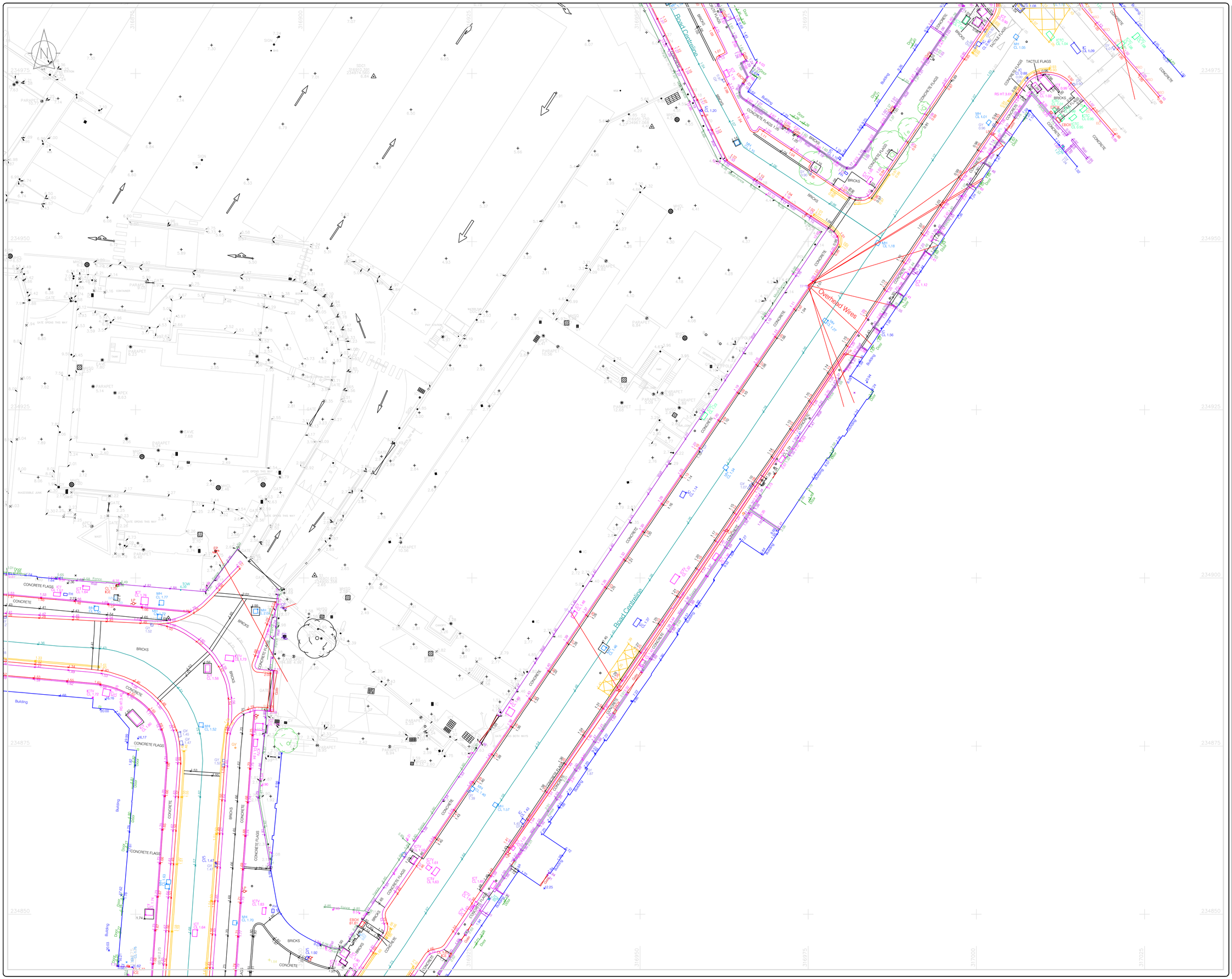
Client : O Connor Sutton Cronin

Project : Additional Survey At Connolly Station

Date : 15.08.2018 **Scale :** 1:250@A1

Description : Topographical Survey
Sheet 1 of 4

Drawing Number : MSL26950_T_3D_Rev0



LEGEND

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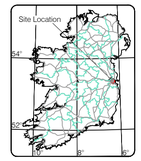
North

Site Location



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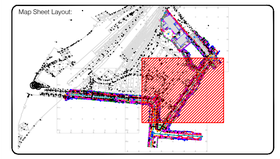

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Checked by :	PK	Date: 15.02.2018	Irish National Grid ☒ ITM:18☐

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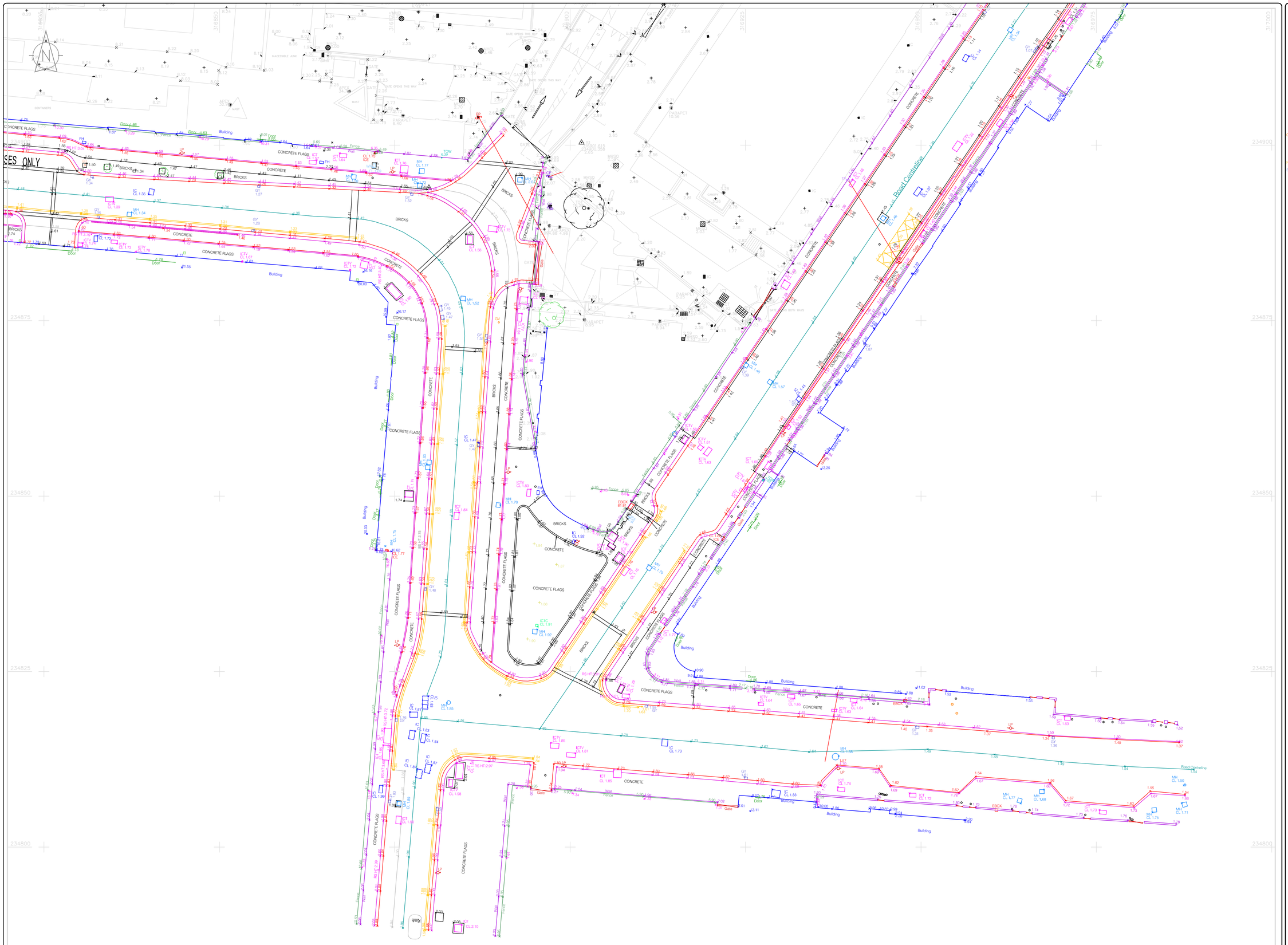
Date : 15.08.2018 **Scale :** 1:250@A1

Description : Topographical Survey
Sheet 2 of 4

Drawing Number : MSL26950_T_3D_Rev0



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North

Site Location

Map Sheet Layout:

Surveyed by : ED	Date: 02.08.2018
Drawn by : LR	Date: 15.08.2018
Checked by : PK	Date: 15.02.2018

Datum : Malin Head
Grid System: Irish National Grid ITM15

Revisions

No	Date	Description
0	15.08.2018	First Drawing

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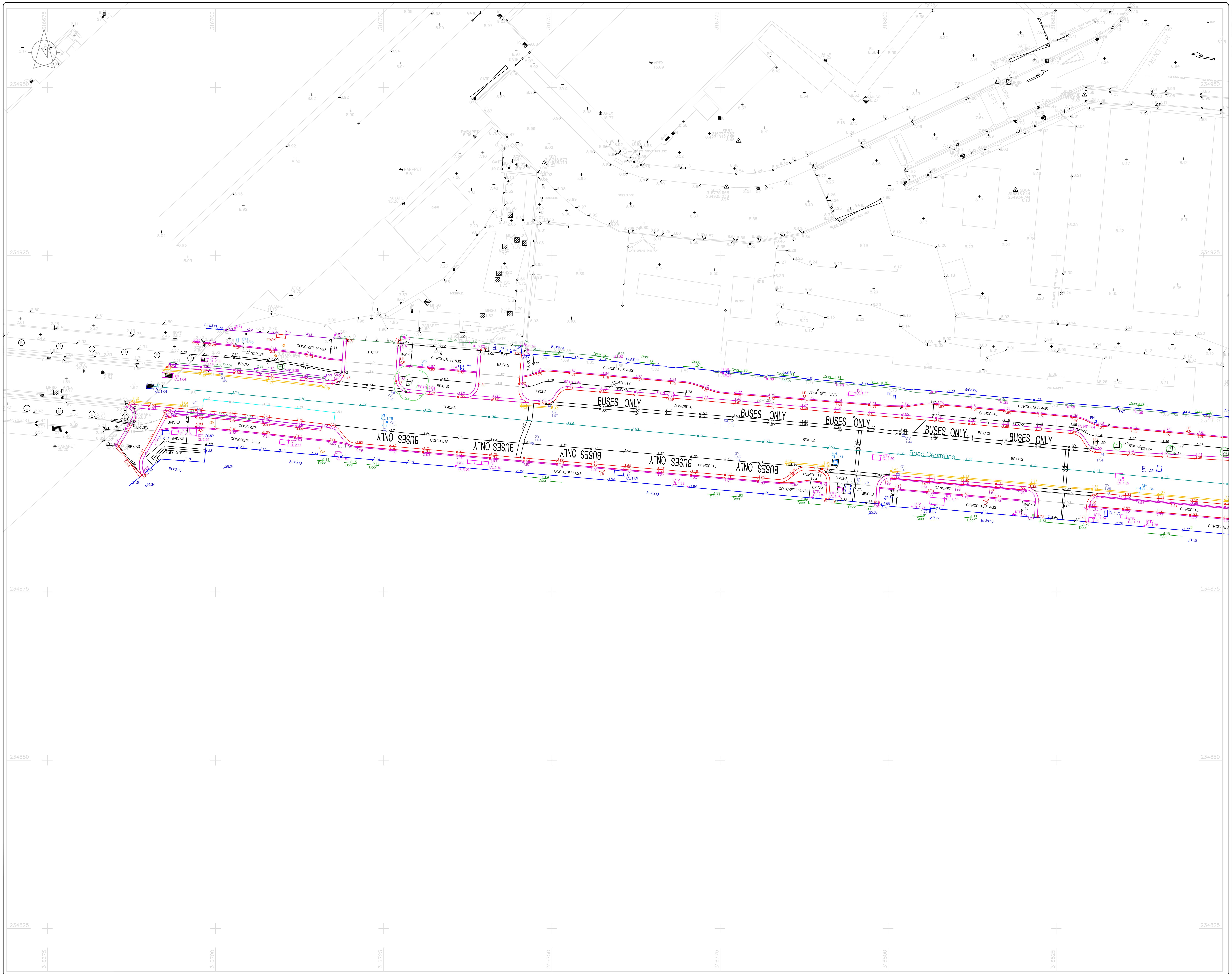
Client :	O Connor Sutton Cronin
Project :	Additional Survey At Connolly Station
Date : 15.08.2018	**Scale :** 1:250@A1
Description :	Topographical Survey Sheet 3 of 4
Drawing Number :	MSL26950_T_3D_Rev0



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Sign RS Road Sign; Bench Seat; Kiosk; GY Gully; U/G Vent; BIN Waste Bin; HY Hydrant; FH Fire Hydrant; EBOX ESB Box; ICE ESB Inspection Cover; TFB Traffic Control Box; LUAS LUAS Technical Cubicle; Ticket Vending Machine; WM Water Meter Cover; ICT Telecom Inspection Cover; Monument / Toilets; Tank Storage; Basement: MH, Cover & Pipe; DAM Dished Aerial Mark; STAY Stay for pole; PP Pipe Protection; WO Washout

PBOX Phone Box; Duct; GAS Gas Cover; CPBox C P Box; U/G Car Park Vent

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WLVL Water Level; CRWN Crown Level; IL Invert level; BL Bed Level; S Spotheight

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Other

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FL Floor Level; APX Apex Height; EV Eaves Height; PAR Parapet Height; SOFF Soffit Elevation; STPL Step Level; CONC Concrete Pad; Track

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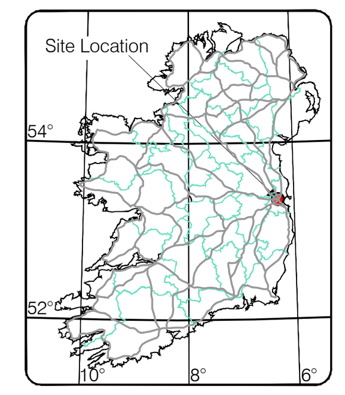
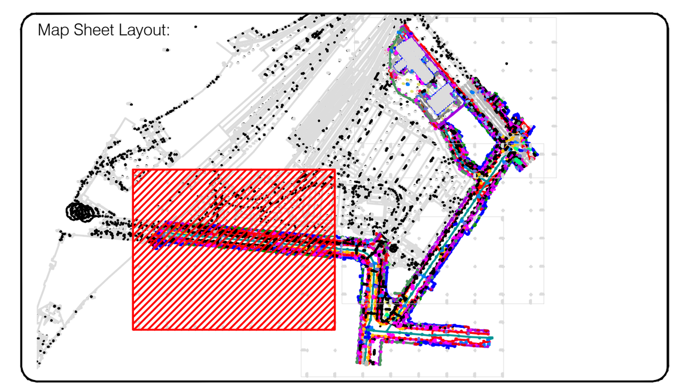


Map Sheet Layout:



Surveyed by : ED	Date: 02.08.2018	Datum : Malin Head
Drawn by : LR	Date: 15.08.2018	Grid System:
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Revisions

No.	Date	Description
0	15.08.2018	First Drawing

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Fax: (+353) 045 484004
Email: info@murphysurveys.ie

Client : O Connor Sutton Cronin

Project : Additional Survey At Connolly Station

Date : 15.08.2018 **Scale :** 1:250@A1

Description : Topographical Survey
Sheet 4

Drawing Number : MSL26950_T_3D_Rev0

APPENDIX B

IRISH WATER RECORD PLANS

UISCE ÉIREANN : IRISH WATER

Legend

- Unknown Meter ; Other Meter
- Sluice Valve Open
- Sluice Valve Closed
- Butterfly Valve Open
- Sluice Valve Closed

Water Hydrants

Hydrant Function

- Fire Hydrant
- Cap
- Other Fittings

Water Distribution Mains

Owned By

- Distribution Water Main
- Water Abandoned Lines

Sewer Manholes

Manhole Type

- Standard

Sewer Discharge Points

Discharge Type

- Other; Unknown

Sewer Inlets

Inlet Type

- Catchpit
- Gravity - Combined
- Gravity - Foul
- Gravity - Overflow
- Pumping - Combined

Storm Manholes

Manhole Type

- Standard
- Surface Gravity Mains

1:500 at A0

Last edited: 12/06/2018

Metres

0 25 50 100

UISCE ÉIREANN : IRISH WATER

Legend

- Boundary Meter
- Unknown Meter ; Other Meter
- PRV
- Sluice Valve Open
- Sluice Valve Closed
- Butterfly Valve Open
- Sluice Valve Closed
- Double Air Control Valve

Water Hydrants

Hydrant Function

- Fire Hydrant
- Telemetry Kiosk
- Cap
- Other Fittings

Water Distribution Mains

Owned By

- Irish Water
- Irish Water

Sewer Discharge Points

Discharge Type

- Overflow
- Other; Unknown
- Pump Station

Sewer Inlets

Inlet Type

- Catchpit
- Gravity - Combined
- Gravity - Foul
- Gravity - Overflow
- Pumping - Combined
- Pumping - Foul
- Syphon - Overflow

Storm Manholes

Manhole Type

- Standard
- Cascade
- Lamphole
- Other; Unknown

Storm Discharge Points

Discharge Type

- Outfall
- Surface Gravity Mains
- Surface Gravity Mains Private

Storm Inlets

Inlet Type

- Gully

1:1,000 at A0

Last edited: 05/10/2018

Metres

0 25 50 100

Ordnance Survey Ireland 2018

APPENDIX C

DETAILS OF PERMAVOID

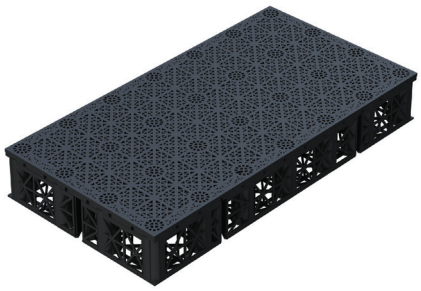
Permavoid Modular Cell 85

Data Sheet

PRODUCT INFORMATION **P1** **ISSUE 4 - JUNE 2018**

Product code: PVPP85

Permavoid is a geocellular interlocking system designed for shallow ground water storage or infiltration, to be used in place of traditional aggregate sub-base or can provide source control at both roof and podium level, removing the need for heavier and less efficient systems. The system has an exceptionally high compressive and tensile strength and bending resistance with a proprietary jointing system to create a horizontal structural 'raft' within the pavement that is ideal for the shallow attenuation of surface water. The system can also be combined in layers using interlocking shear connectors to increase depth in 85mm and 150mm increments. This is particularly useful in designing infiltration systems, allowing flexibility in balancing the soil permeability/infiltration area of the Permavoid storage units and residual temporary attenuation.



Applications

The Permavoid units are suitable for use as a stormwater attenuation and/or infiltration system. The system comprises of single, interconnected cells which can be installed in the ground as part of sub-base formation, or above ground as part of roof or podium attenuation systems for source control. Permavoid is suitable for use in a range of applications including residential, industrial estates, car parks, sports pitches, roofs, basements, pedestrian areas and rainwater harvesting.

Key Benefits

- High strength, high capacity, shallow, sub-base replacement system
- Stormwater attenuation and/or infiltration system
- Used as part of a sustainable drainage system (SuDS) scheme to offer stormwater storage at shallow construction depth
- 100% recyclable
- Units are manufactured from 90% recycled polypropylene (PP)

Performance

The structural load bearing capacity of the Permavoid units have been tested in accordance with the following European Standard: BS 7533-13:2009. The system's structural design life expectancy, based upon creep test data (tested in accordance with CIRIA guidelines) is as follows; for lightly loaded areas such as car parks a design life of 50 years is achievable. For areas with prolonged HGV loading a typical design life may only be 25 years, depending on the design of the pavement surfacing and structural layers over the tank.

Installation

All calculations for Permavoid units are based upon site-specific load cases, pavement construction types and thicknesses, soil cover and ground conditions and the suitability must therefore be approved for each project.

Technical Support

Detailed guidance and assistance is available.
For further information, please contact our Technical Team on **+44 (0) 1509 615100** or email **civils@polypipe.com** or visit **www.polypipe.com/civils-technical-hub**

ELEMENT	VALUE
PHYSICAL PROPERTIES	
Weight per unit	2.25kg
Weight per square metre	9kg
Length	708mm
Width	354mm
Depth	85mm
SHORT TERM COMPRESSIVE STRENGTH	
Vertical	715kN/m²
Lateral	156kN/m²
SHORT TERM DEFLECTION	
Vertical	1mm per 126kN/m²
Lateral	1mm per 15kN/m²
TENSILE STRENGTH	
Of a single joint	42.4kN/m²
Of a single joint at (1% secant modulus)	18.8kN/m²
Bending resistance of unit	0.71kN/m
Bending resistance of single joint	0.16kN/m
OTHER PROPERTIES	
Volumetric void ratio	92%
Average effective perforated surface area	52%
Intrinsic permeability (k)	Minimum 1.0 x 10^{-5}
Ancillary	Permavoid Permatie Permavoid Shear Connector
Material	Polypropylene (PP)

HYDRAULIC PERFORMANCE			
3 units wide, 1 unit deep (1.06m x 0.15m)			
FREE DISCHARGE			
Gradient (%)	0	1	2
Flow Rate (l/m/s)	4	6	7

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Charnwood Business Park, Loughborough, Leicestershire LE11 1LE
Tel: +44 (0) 1509 615100 Fax: +44 (0) 1509 610215 Email: civils@polypipe.com
www.polypipe.com/wms

Polypipe

Permavoid Modular Cell 85

Data Sheet

Permavoid Modular Cell 85 can be utilised in these SuDS techniques

TECHNIQUES													
Blue-Green roofs	Podium Decks	Trees	Sports Pitches	Cycle Paths	Permeable Paving (sub base & podium)	Bioretention & Rain Gardens	Attenuation Storage Tanks	Infiltration	Swales	Filter Drains	Detention Basins	Ponds & Wetlands	Filter Strips
✓	✓	✓	✓		✓	✓	✓	✓	✓				

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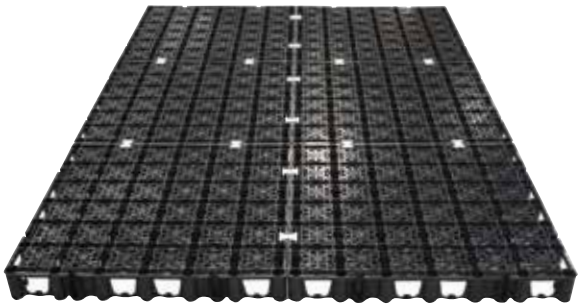
Permavoid² 85

Data Sheet

PRODUCT INFORMATION **P1** **ISSUE 2 - SEPT 2018**

Product Code: PVPP85RX6

The Permavoid² 85 comprises of six pre-connected units and is designed to provide attenuation for shallow non-loaded applications. Ideal for use in the most diverse roof and podium deck applications, alongside hard-landscaping. It is 85mm high, manufactured from recycled polypropylene and minimises installation time.



Key Benefits

- Provides surface water management and makes space for water in urban environments
- Supports numerous surface activities
- High capacity, shallow, sub-base replacement system for non-trafficked applications
- 93% void ratio provides excellent storage capacity
- Plan area of 3m² maximises unit coverage, increasing laying efficiency
- Manufactured from recycled material
- Design life in excess of 50 years
- 100% recyclable at the end of its service life

Applications

The Permavoid² 85 is designed for use in applications that will not be exposed to traffic loading, including:

- Green Roofs
- Blue Roofs
- Podium Decks
- Sports Pitches
- Hardscaped and Landscaped SuDS

Installation

All calculations for Permavoid units are based upon site-specific load cases, pavement construction types and thicknesses, soil cover and ground conditions and the suitability must therefore be approved for each project.

For irrigation applications, please see our Permavoid² 85 Irrigation with capillary cone technology.

ELEMENT	VALUE
PHYSICAL PROPERTIES	
Weight per panel	17.4kg
Length	2136mm
Width	1424mm
Depth	85mm
Storage volume (litres per panel)	242.4l
Volumetric void ratio	93%
Vertical compressive strength	600kN/m²
OTHER PROPERTIES	
Ancillary	Permavoid Permatie
Material	Polypropylene (PP)

All values stated above are nominal and may vary within manufacturing tolerances.

Technical Support

Detailed guidance and assistance is available.
For further information, please contact our Technical Team on **+44 (0) 1509 615100** or email **civils@polypipe.com** or visit **www.polypipe.com/civils-technical-hub**

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Permavoid² 85

Data Sheet

Permavoid² 85 can be utilised in these SuDS techniques

TECHNIQUES													
Blue-Green roofs	Podium Decks	Trees	Sports Pitches	Cycle Paths	Permeable Paving (sub base & podium)	Bioretention & Rain Gardens	Attenuation Storage Tanks	Infiltration	Swales	Filter Drains	Detention Basins	Ponds & Wetlands	Filter Strips
✓	✓		✓		✓		✓						

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Permavoid 85mm Podium Deck Roof Diffuser Chamber

Data Sheet

PRODUCT INFORMATION **P1** **ISSUE 2 - JULY 2018**

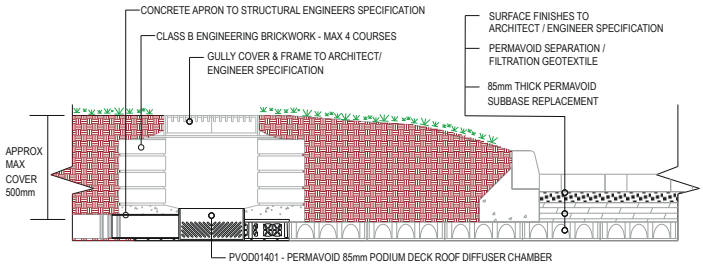
Product code: PVOD01401

Designed for use in shallow Permavoid podium deck constructions, the Permavoid 85mm Podium Deck Roof Diffuser Chamber collects rainwater via the 110mm Ø inlet pipe, filters through the perforated walls and dispersed into the surrounding 85mm Permavoid storage system. It is compatible with standard 110mm Ø push fit couplings.

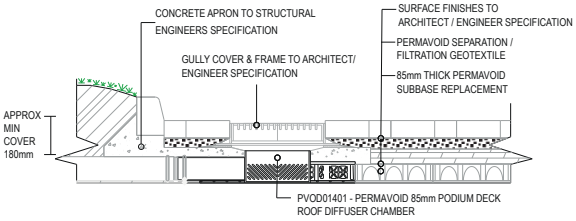
Key Benefits

- 8l/s controlled inlet water flow
- Passive flow control
- Easy access for routine maintenance
- Effective water dispersal
- Integrates with surrounding Permavoid
- Compatible with 110mm Ø standard couplings
- 100% recyclable

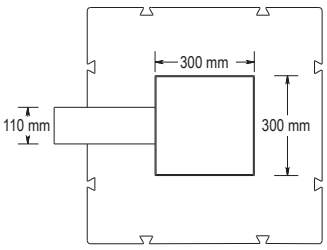
Application 1 - maximum cover approximately 500mm

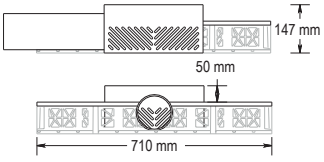


Application 2 - minimum cover approximately 180mm



ELEMENT	VALUE
PHYSICAL PROPERTIES	
Length	800mm
Width	710mm
Depth	147mm
Sump depth	10mm
Inlet spigot Ø OD	110mm
Inlet spigot length	90mm
Maximum flow	8l/s
Unit weight	11.8kg
Material	HDPE/PP
PACKAGING DETAILS	
Packaging unit type	Double wall cardboard
Packaging unit dimension	832(L) x 732(W) x 169(H) mm
Packaging unit weight	11.8kg
Number of units per pallet	16
Pallet dimensions	1200(L) x 1200(W) x 1626(H) mm
Pallet weight	214kg





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www.polypipe.com/wms

Polypipe

Permavoid 85mm Podium Deck Roof Diffuser Chamber

Data Sheet

Permavoid 85mm Podium Deck Roof Diffuser Chamber can be utilised in these SuDS techniques

TECHNIQUES													
Blue-Green roofs	Podium Decks	Trees	Sports Pitches	Cycle Paths	Permeable Paving (sub base & podium)	Bioretention & Rain Gardens	Attenuation Storage Tanks	Infiltration	Swales	Filter Drains	Detention Basins	Ponds & Wetlands	Filter Strips
✓	✓												

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APPENDIX D

DETAILS OF SAMPLE RWO FLOW CONTROL

OverFlow & FlowControl

PRODUCT DATA SPECIFICATIONS

OverFlow

FlowControl

PRODUCT DESCRIPTION

The **OMG OverFlow** accessory is a spun aluminum round drain attachment. The product is designed to be used with all OlyFlow® retrofit and new connection drains that are supplied with a clamping ring assembly. The purpose of the overflow drain assembly is to provide additional water drainage, if necessary, when water level on the roof exceeds 4-in. in height. 2-in. OverFlow is also available.

The **OMG FlowControl** is a spun aluminum round drain attachment with two specially designed weirs that provide a specific limited water flow rate under different water pressures (water head) on the roof. This product is designed and tested for application with all OlyFlow retrofit drains that are supplied with a clamping ring assembly. If the water level on the roof exceeds 4-in. in height, the FlowControl drain assembly will perform as an overflow drain.

The FlowControl offers the following performance:

Under a 4-in. head of water . . . . . **20 GPM**
Under a 3-in. head of water . . . . . **15 GPM**
Under a 2-in. head of water . . . . . **10 GPM**
Under a 1-in. head of water . . . . . **5 GPM**

FEATURES & BENEFITS

OverFlow

- Fits all OlyFlow RetroDrains that come with a clamping ring.
- Constructed of .050-in. spun aluminum.
- Provides additional drainage when water level exceeds 4-in. (also available in 2-in.)
- Simple and easy to install.

FlowControl

- Fits all OlyFlow RetroDrains that come with a clamping ring.
- Controls the flow rate under different water pressures.
- Constructed of .050-in. spun aluminum.
- Provides additional drainage when water level exceeds 4-in.
- Simple and easy to install.

PHYSICAL DATA

The data below is constant for each OMG OverFlow and OMG FlowControl.

OVERFLOW	FLOWCONTROL
SIZE: **4" Height** **2" Height** **MATERIAL:** **.050" aluminum**	**SIZE:** **4" Height** **MATERIAL:** **.050" aluminum**

ORDERING INFORMATION

CAT. NO.	DESCRIPTION	HEIGHT	PKG.	DIMENSIONAL WEIGHT
OVFLOW4	OverFlow	4"	Each	1 lb.
OVFLOW2	OverFlow	2"	Each	1 lb.
RAFLCN	FlowControl	4"	Each	1 lb.

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APPENDIX E

IRISH WATER CONFIRMATION OF FEASIBILITY

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9 Prussia Street
Dublin 7

Uisce Éireann
Bosca OP 6000
Baile Átha Cliath 1
Éire

Irish Water
PO Box 6000
Dublin 1
Ireland

T: +353 1 89 25000
F: +353 1 89 25001
www.water.ie

11 April 2019

Dear Sir/Madam,

Re: Customer Reference No 825727485 pre-connection enquiry - Subject to contract | Contract denied
[Connection for 700 domestic units, 208 bedroom hotel and 6000sqm retail unit]

Irish Water has reviewed your pre-connection enquiry in relation to water and wastewater connections at Sheriff Street Lower, Seville Place, Dublin. Based upon the details that you have provided with your pre-connection enquiry and on the capacity currently available in the network(s), as assessed by Irish Water, we wish to advise you that, subject to a valid connection agreement being put in place, your proposed connection to the Irish Water network(s) can be facilitated.

In the case of wastewater connections this assessment does not confirm that a gravity connection is achievable. Therefore a suitably sized pumping station may be required to be installed on your site. All infrastructure should be designed and installed in accordance with the Irish Water Code of Practice.

Water:
In order to accommodate the proposed connection at the Premises, upgrade works are required to increase the capacity of the Irish Water network. The existing 6" CI main on Commons Street requires an upgrade to a 300mmID for approximately 430m from the existing 600mm Trunk main on the North Quays to the boundary of the site. A new bulk meter and associated telemetry system may also be required. Note: laying this main will include a Luas rail track crossing.
Irish Water does not currently have any plans to carry out the works required to provide the necessary upgrade and capacity.

Wastewater:
Irish Water has carried out investigations for this development by data capture in the surrounding area and modelled the results including the outfalls from this development, IW can confirm that upgrades are not required to the wastewater network to allow connection to the network at this time.

Strategic Housing Development
Irish Water notes that the scale of this development dictates that it is subject to the Strategic Housing Development planning process. Therefore:
A. In advance of submitting your full application to An Bord Pleanala for assessment, you must have reviewed this development with Irish Water and received a Statement of Design Acceptance in relation to the layout of water and wastewater services. All infrastructure should be designed and installed in accordance with the Irish Water Codes of Practice and Standard Details.
B. You are advised that this correspondence does not constitute an offer in whole or in part to provide a connection to any Irish Water infrastructure and is provided subject to a connection agreement being signed and appropriate connection fee paid at a later date.

A connection agreement can be applied for by completing the connection application form available at **www.water.ie/connections**. Irish Water's current charges for water and wastewater connections are set out in the Water Charges Plan as approved by the Commission for Regulation of Utilities.

If you have any further questions, please contact Paul Lowry from the design team on 018230377 or email paullowr@water.ie. For further information, visit **www.water.ie/connections**

Yours sincerely,

Maria O'Dwyer
Connections and Developer Services

APPENDIX F

IRISH WATER STATEMENT OF DESIGN ACCEPTANCE

Ballymore Group c/o Niall McMenamin,
OCSC,
9 Prussia Street,
Dublin

Uisce Éireann
Bosca OP 448
Oifig Sheachadta
na Cathrach Theas
Cathair Chorcaí

Irish Water
PO Box 448
South City
Delivery Office
Cork City

www.water.ie

28 June 2019

Re: Design Submission for Development at Connolly Station, Sheriff Street Lower/Oriel Street Upper/Seville Place, Dublin (the "Development") (the "Design Submission") / 825727485.

Dear Niall,

Many thanks for your recent Design Submission.

We have reviewed your proposal for the connection(s) at the Development. Based on the information provided, which included the documents outlined in Appendix A to this letter, Irish Water has no objection to your proposals.

This letter does not constitute an offer, in whole or in part, to provide a connection to any Irish Water infrastructure. Before you can connect to our network you must sign a connection agreement with Irish Water. This can be applied for by completing the connection application form at www.water.ie/connections. Irish Water's current charges for water and wastewater connections are set out in the Water Charges Plan as approved by the Commission for Regulation of Utilities (CRU) (https://www.cru.ie/document_group/irish-waters-water-charges-plan-2018/).

You the Customer (including any designers/contractors or other related parties appointed by you) is entirely responsible for the design and construction of all water and/or wastewater infrastructure within the Development which is necessary to facilitate connection(s) from the boundary of the Development to Irish Water's network(s) (the "**Self-Lay Works**"), as reflected in your Design Submission. Acceptance of the Design Submission by Irish Water does not, in any way, render Irish Water liable for any elements of the design and/or construction of the Self-Lay Works.

If you have any further questions, please contact your Irish Water Representative

Name: Paul Lowry
Phone: 01 8230377
Email: paullowr@water.ie

Yours sincerely,

Maria O'Dwyer

Connections and Developer Services

Appendix A

Document Title & Revision

• O635-OCSC-XX-XX-DR-C-0520-S3-P02	Proposed Wastewater Drainage Layout Plan
• O635-OCSC-XX-XX-DR-C-0521-S3-P01	Proposed Wastewater Drainage Longitudinal Sections
• O635-OCSC-XX-XX-DR-C-0530-S3-P01	Wastewater Standard Details Sheet 1 of 4
• O635-OCSC-XX-XX-DR-C-0531-S3-P01	Wastewater Standard Details Sheet 2 of 4
• O635-OCSC-XX-XX-DR-C-0532-S3-P01	Wastewater Standard Details Sheet 3 of 4
• O635-OCSC-XX-XX-DR-C-0533-S3-P01	Wastewater Standard Details Sheet 4 of 4
• O635-OCSC-XX-XX-DR-C-0540-S3-P02	Proposed Water Supply Layout Plan
• O635-OCSC-XX-XX-DR-C-0550-S3-P01	Water Main Standard Details Sheet 1 of 2
• O635-OCSC-XX-XX-DR-C-0551-S3-P01	Water Main Standard Details Sheet 2 of 2

Standard Details/Code of Practice Exemption: N/A

*For further information, visit **www.water.ie/connections***

Notwithstanding any matters listed above, the Customer (including any appointed designers/contractors, etc.) is entirely responsible for the design and construction of the Self-Lay Works. Acceptance of the Design Submission by Irish Water will not, in any way, render Irish Water liable for any elements of the design and/or construction of the Self-Lay Works.

APPENDIX G

MET ÉIREANN RAINFALL DATA

Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 316900, Northing: 235000,

	Interval		Years												
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	150,	200,	250,	500,
5 mins	2.5,	3.6,	4.2,	5.0,	5.6,	6.0,	7.5,	9.2,	10.4,	11.9,	13.3,	14.4,	16.1,	17.5,	18.5,	N/A ,
10 mins	3.5,	5.0,	5.8,	7.0,	7.8,	8.4,	10.5,	12.9,	14.4,	16.6,	18.6,	20.1,	22.5,	24.3,	25.8,	N/A ,
15 mins	4.1,	5.9,	6.8,	8.2,	9.2,	9.9,	12.4,	15.1,	17.0,	19.6,	21.9,	23.7,	26.5,	28.6,	30.4,	N/A ,
30 mins	5.5,	7.7,	8.8,	10.6,	11.8,	12.7,	15.7,	19.0,	21.3,	24.4,	27.1,	29.3,	32.6,	35.1,	37.2,	N/A ,
1 hours	7.2,	10.0,	11.5,	13.6,	15.1,	16.2,	19.9,	23.9,	26.6,	30.3,	33.6,	36.2,	40.1,	43.1,	45.6,	N/A ,
2 hours	9.6,	13.0,	14.9,	17.5,	19.3,	20.7,	25.2,	30.1,	33.3,	37.8,	41.7,	44.7,	49.4,	52.9,	55.8,	N/A ,
3 hours	11.3,	15.2,	17.3,	20.3,	22.4,	23.9,	28.9,	34.4,	38.0,	43.0,	47.3,	50.7,	55.7,	59.6,	62.8,	N/A ,
4 hours	12.6,	17.0,	19.3,	22.6,	24.8,	26.5,	31.9,	37.9,	41.7,	47.1,	51.7,	55.3,	60.8,	64.9,	68.4,	N/A ,
6 hours	14.9,	19.9,	22.4,	26.2,	28.7,	30.6,	36.6,	43.3,	47.6,	53.5,	58.7,	62.6,	68.6,	73.2,	77.0,	N/A ,
9 hours	17.5,	23.2,	26.1,	30.4,	33.2,	35.3,	42.1,	49.5,	54.3,	60.8,	66.6,	70.9,	77.5,	82.5,	86.6,	N/A ,
12 hours	19.7,	25.9,	29.1,	33.7,	36.8,	39.1,	46.4,	54.5,	59.6,	66.6,	72.8,	77.4,	84.5,	89.8,	94.2,	N/A ,
18 hours	23.2,	30.2,	33.9,	39.1,	42.5,	45.1,	53.4,	62.3,	68.0,	75.8,	82.5,	87.7,	95.4,	101.3,	106.1,	N/A ,
24 hours	26.0,	33.8,	37.7,	43.4,	47.1,	50.0,	58.9,	68.5,	74.6,	83.0,	90.2,	95.7,	104.0,	110.3,	115.4,	132.9,
2 days	31.7,	40.4,	44.7,	51.0,	55.1,	58.1,	67.8,	78.0,	84.5,	93.3,	100.9,	106.5,	115.1,	121.6,	126.8,	144.6,
3 days	36.2,	45.7,	50.4,	57.2,	61.5,	64.8,	75.0,	85.9,	92.7,	101.9,	109.8,	115.7,	124.6,	131.3,	136.7,	155.0,
4 days	40.2,	50.4,	55.4,	62.6,	67.2,	70.6,	81.4,	92.7,	99.9,	109.5,	117.6,	123.8,	133.0,	139.9,	145.5,	164.3,
6 days	47.2,	58.5,	64.1,	71.9,	76.9,	80.7,	92.4,	104.7,	112.3,	122.6,	131.3,	137.8,	147.6,	154.9,	160.8,	180.5,
8 days	53.3,	65.6,	71.6,	80.1,	85.5,	89.5,	102.0,	115.1,	123.2,	134.0,	143.2,	150.1,	160.3,	167.9,	174.1,	194.7,
10 days	58.9,	72.1,	78.5,	87.5,	93.2,	97.5,	110.7,	124.5,	133.0,	144.4,	154.0,	161.2,	171.8,	179.8,	186.2,	207.6,
12 days	64.1,	78.1,	84.9,	94.4,	100.4,	104.9,	118.8,	133.1,	142.0,	153.9,	163.9,	171.4,	182.4,	190.7,	197.3,	219.4,
16 days	73.8,	89.2,	96.6,	107.0,	113.6,	118.5,	133.5,	149.0,	158.5,	171.3,	182.0,	189.9,	201.7,	210.5,	217.5,	241.0,
20 days	82.7,	99.3,	107.4,	118.5,	125.6,	130.8,	146.9,	163.4,	173.5,	187.0,	198.4,	206.8,	219.2,	228.4,	235.8,	260.4,
25 days	93.0,	111.1,	119.8,	131.9,	139.5,	145.1,	162.3,	180.0,	190.8,	205.2,	217.2,	226.1,	239.2,	249.0,	256.8,	282.7,

NOTES:
N/A Data not available
These values are derived from a Depth Duration Frequency (DDF) Model
For details refer to:
'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

APPENDIX H

SURFACE WATER DRAINAGE CALCULATIONS

Cascade Summary of Results for CatchmentWest_RoofLevel.srcx

Upstream Structures	Outflow To	Overflow To
(None)	CatchmentWest_GroundLevel.srcx	(None)

Half Drain Time : 3469 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	40.012	0.012	0.0	0.0	0.0	38.3	O K
30 min Summer	40.019	0.019	0.0	0.1	0.1	60.0	O K
60 min Summer	40.026	0.026	0.0	0.2	0.2	83.1	O K
120 min Summer	40.034	0.034	0.0	0.3	0.3	109.0	O K
180 min Summer	40.039	0.039	0.0	0.4	0.4	125.5	O K
240 min Summer	40.043	0.043	0.0	0.4	0.4	137.9	O K
360 min Summer	40.049	0.049	0.0	0.5	0.5	155.8	O K
480 min Summer	40.053	0.053	0.0	0.6	0.6	168.8	O K
600 min Summer	40.056	0.056	0.0	0.6	0.6	178.7	O K
720 min Summer	40.058	0.058	0.0	0.7	0.7	186.6	O K
960 min Summer	40.062	0.062	0.0	0.7	0.7	198.4	O K
1440 min Summer	40.066	0.066	0.0	0.8	0.8	213.1	O K
2160 min Summer	40.070	0.070	0.0	0.8	0.8	223.7	O K
2880 min Summer	40.072	0.072	0.0	0.8	0.8	230.6	O K
4320 min Summer	40.074	0.074	0.0	0.8	0.8	238.6	O K
5760 min Summer	40.075	0.075	0.0	0.8	0.8	241.8	O K
7200 min Summer	40.075	0.075	0.0	0.8	0.8	242.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	85.194	0.0	3.4	121
30 min Summer	58.879	0.0	7.6	128
60 min Summer	38.241	0.0	24.6	144
120 min Summer	24.118	0.0	37.3	182
180 min Summer	18.261	0.0	45.2	228
240 min Summer	14.961	0.0	51.3	280
360 min Summer	11.264	0.0	60.7	390
480 min Summer	9.197	0.0	67.7	504
600 min Summer	7.854	0.0	73.1	620
720 min Summer	6.901	0.0	77.2	736
960 min Summer	5.625	0.0	82.8	970
1440 min Summer	4.216	0.0	86.5	1444
2160 min Summer	3.158	0.0	162.4	1920
2880 min Summer	2.570	0.0	168.1	2280
4320 min Summer	1.920	0.0	163.6	3052
5760 min Summer	1.560	0.0	268.9	3880
7200 min Summer	1.328	0.0	272.9	4696

Cascade Summary of Results for CatchmentWest_RoofLevel.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	40.075	0.075	0.0	0.8	0.8	240.8	O K
10080 min Summer	40.074	0.074	0.0	0.8	0.8	238.4	O K
15 min Winter	40.014	0.014	0.0	0.1	0.1	45.2	O K
30 min Winter	40.022	0.022	0.0	0.1	0.1	69.3	O K
60 min Winter	40.030	0.030	0.0	0.2	0.2	95.2	O K
120 min Winter	40.039	0.039	0.0	0.4	0.4	124.2	O K
180 min Winter	40.044	0.044	0.0	0.5	0.5	142.8	O K
240 min Winter	40.049	0.049	0.0	0.5	0.5	156.6	O K
360 min Winter	40.055	0.055	0.0	0.6	0.6	176.9	O K
480 min Winter	40.060	0.060	0.0	0.7	0.7	191.5	O K
600 min Winter	40.063	0.063	0.0	0.7	0.7	202.9	O K
720 min Winter	40.066	0.066	0.0	0.8	0.8	212.1	O K
960 min Winter	40.070	0.070	0.0	0.8	0.8	226.0	O K
1440 min Winter	40.076	0.076	0.0	0.8	0.8	243.6	O K
2160 min Winter	40.080	0.080	0.0	0.9	0.9	256.7	O K
2880 min Winter	40.082	0.082	0.0	0.9	0.9	262.5	O K
4320 min Winter	40.084	0.084	0.0	0.9	0.9	269.4	O K
5760 min Winter	40.084	0.084	0.0	0.9	0.9	270.0	O K
7200 min Winter	40.083	0.083	0.0	0.9	0.9	267.1	O K
8640 min Winter	40.082	0.082	0.0	0.9	0.9	262.5	O K
10080 min Winter	40.080	0.080	0.0	0.9	0.9	256.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	271.3	5536
10080 min Summer	1.041	0.0	264.6	6352
15 min Winter	85.194	0.0	4.6	121
30 min Winter	58.879	0.0	10.0	127
60 min Winter	38.241	0.0	30.9	142
120 min Winter	24.118	0.0	44.8	180
180 min Winter	18.261	0.0	54.1	226
240 min Winter	14.961	0.0	61.5	276
360 min Winter	11.264	0.0	72.5	384
480 min Winter	9.197	0.0	80.5	496
600 min Winter	7.854	0.0	86.3	610
720 min Winter	6.901	0.0	90.5	724
960 min Winter	5.625	0.0	95.6	954
1440 min Winter	4.216	0.0	97.7	1408
2160 min Winter	3.158	0.0	186.8	2056
2880 min Winter	2.570	0.0	192.2	2368
4320 min Winter	1.920	0.0	184.4	3260
5760 min Winter	1.560	0.0	310.7	4176
7200 min Winter	1.328	0.0	315.9	5064
8640 min Winter	1.164	0.0	314.9	5968
10080 min Winter	1.041	0.0	307.5	6800

Cascade Rainfall Details for CatchmentWest_RoofLevel.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	16.200	Shortest Storm (mins)	15
Ratio R	0.279	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Green Roof

Area (m^3)	3600	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.065419	32	36	0.013208	64	68	0.002667	96	100	0.000538
4	8	0.053561	36	40	0.010814	68	72	0.002183	100	104	0.000441
8	12	0.043852	40	44	0.008854	72	76	0.001787	104	108	0.000361
12	16	0.035903	44	48	0.007249	76	80	0.001463	108	112	0.000295
16	20	0.029395	48	52	0.005935	80	84	0.001198	112	116	0.000242
20	24	0.024066	52	56	0.004859	84	88	0.000981	116	120	0.000198
24	28	0.019704	56	60	0.003978	88	92	0.000803			
28	32	0.016132	60	64	0.003257	92	96	0.000658			

Cascade Model Details for CatchmentWest_RoofLevel.srcx

Storage is Online Cover Level (m) 40.500

Cellular Storage Structure

Invert Level (m) 40.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.93
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	3450.0	0.0	0.086	0.0	0.0
0.085	3450.0	0.0			

Orifice Outflow Control

Diameter (m) 0.041 Discharge Coefficient 0.600 Invert Level (m) 40.000

Cascade Summary of Results for CatchmentWest_GroundLevel.srcx

Upstream Structures	Outflow To	Overflow To
CatchmentWest_RoofLevel.srcx	(None)	(None)

Half Drain Time : 778 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.286	0.021	0.0	1.0	1.0	22.7	O K
30 min Summer	1.293	0.028	0.0	1.0	1.0	31.0	O K
60 min Summer	1.301	0.036	0.0	1.0	1.0	39.3	O K
120 min Summer	1.308	0.043	0.0	1.0	1.0	47.5	O K
180 min Summer	1.312	0.047	0.0	1.0	1.0	52.1	O K
240 min Summer	1.315	0.050	0.0	1.0	1.0	55.2	O K
360 min Summer	1.318	0.053	0.0	1.0	1.0	59.0	O K
480 min Summer	1.320	0.055	0.0	1.0	1.0	61.2	O K
600 min Summer	1.322	0.057	0.0	1.0	1.0	62.8	O K
720 min Summer	1.323	0.058	0.0	1.0	1.0	64.3	O K
960 min Summer	1.325	0.060	0.0	1.0	1.0	66.8	O K
1440 min Summer	1.328	0.063	0.0	1.0	1.0	70.0	O K
2160 min Summer	1.331	0.066	0.0	1.0	1.0	72.6	O K
2880 min Summer	1.332	0.067	0.0	1.0	1.0	73.6	O K
4320 min Summer	1.331	0.066	0.0	1.0	1.0	72.4	O K
5760 min Summer	1.329	0.064	0.0	1.0	1.0	70.2	O K
7200 min Summer	1.326	0.061	0.0	1.0	1.0	67.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	85.194	0.0	27.3	22
30 min Summer	58.879	0.0	40.1	36
60 min Summer	38.241	0.0	67.0	66
120 min Summer	24.118	0.0	91.0	124
180 min Summer	18.261	0.0	106.2	184
240 min Summer	14.961	0.0	118.1	244
360 min Summer	11.264	0.0	136.2	364
480 min Summer	9.197	0.0	149.9	484
600 min Summer	7.854	0.0	160.9	604
720 min Summer	6.901	0.0	167.8	724
960 min Summer	5.625	0.0	165.6	964
1440 min Summer	4.216	0.0	159.2	1442
2160 min Summer	3.158	0.0	289.7	2160
2880 min Summer	2.570	0.0	303.6	2880
4320 min Summer	1.920	0.0	275.5	4020
5760 min Summer	1.560	0.0	436.9	4792
7200 min Summer	1.328	0.0	451.7	5560

Cascade Summary of Results for CatchmentWest_GroundLevel.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	1.324	0.059	0.0	1.0	1.0	64.8	O K
10080 min Summer	1.321	0.056	0.0	1.0	1.0	61.8	O K
15 min Winter	1.288	0.023	0.0	1.0	1.0	25.6	O K
30 min Winter	1.297	0.032	0.0	1.0	1.0	35.0	O K
60 min Winter	1.305	0.040	0.0	1.0	1.0	44.6	O K
120 min Winter	1.314	0.049	0.0	1.0	1.0	54.3	O K
180 min Winter	1.319	0.054	0.0	1.0	1.0	60.0	O K
240 min Winter	1.323	0.058	0.0	1.0	1.0	64.0	O K
360 min Winter	1.328	0.063	0.0	1.0	1.0	69.4	O K
480 min Winter	1.331	0.066	0.0	1.0	1.0	72.9	O K
600 min Winter	1.333	0.068	0.0	1.0	1.0	75.4	O K
720 min Winter	1.335	0.070	0.0	1.0	1.0	77.2	O K
960 min Winter	1.337	0.072	0.0	1.0	1.0	80.0	O K
1440 min Winter	1.342	0.077	0.0	1.0	1.0	84.6	O K
2160 min Winter	1.345	0.080	0.0	1.0	1.0	88.8	O K
2880 min Winter	1.348	0.083	0.0	1.0	1.0	91.2	O K
4320 min Winter	1.349	0.084	0.0	1.0	1.0	92.5	O K
5760 min Winter	1.347	0.082	0.0	1.0	1.0	90.7	O K
7200 min Winter	1.343	0.078	0.0	1.0	1.0	86.4	O K
8640 min Winter	1.339	0.074	0.0	1.0	1.0	81.6	O K
10080 min Winter	1.335	0.070	0.0	1.0	1.0	77.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	459.2	6384
10080 min Summer	1.041	0.0	460.7	7160
15 min Winter	85.194	0.0	31.4	22
30 min Winter	58.879	0.0	46.6	36
60 min Winter	38.241	0.0	78.5	64
120 min Winter	24.118	0.0	105.0	122
180 min Winter	18.261	0.0	122.6	182
240 min Winter	14.961	0.0	136.3	240
360 min Winter	11.264	0.0	157.2	360
480 min Winter	9.197	0.0	169.0	478
600 min Winter	7.854	0.0	169.0	596
720 min Winter	6.901	0.0	168.9	714
960 min Winter	5.625	0.0	167.6	952
1440 min Winter	4.216	0.0	162.5	1426
2160 min Winter	3.158	0.0	322.7	2128
2880 min Winter	2.570	0.0	312.3	2828
4320 min Winter	1.920	0.0	287.4	4196
5760 min Winter	1.560	0.0	499.0	5520
7200 min Winter	1.328	0.0	516.0	6624
8640 min Winter	1.164	0.0	525.5	7168
10080 min Winter	1.041	0.0	510.0	7952

Cascade Rainfall Details for CatchmentWest_GroundLevel.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	16.200	Shortest Storm (mins)	15
Ratio R	0.279	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.150

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.100	4	8	0.050

Cascade Model Details for CatchmentWest_GroundLevel.srcx

Storage is Online Cover Level (m) 1.650

Cellular Storage Structure

Invert Level (m) 1.265 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.92
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	1200.0	0.0	0.086	0.0	0.0
0.085	1200.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0045-1000-1200-1000
Design Head (m)	1.200
Design Flow (l/s)	1.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	45
Invert Level (m)	0.150
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	1.0
Flush-Flo™	0.196	0.7
Kick-Flo®	0.398	0.6
Mean Flow over Head Range	-	0.8

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.7	1.200	1.0	3.000	1.5	7.000	2.2
0.200	0.7	1.400	1.1	3.500	1.6	7.500	2.3
0.300	0.7	1.600	1.1	4.000	1.7	8.000	2.4
0.400	0.6	1.800	1.2	4.500	1.8	8.500	2.4
0.500	0.7	2.000	1.3	5.000	1.9	9.000	2.5
0.600	0.7	2.200	1.3	5.500	2.0	9.500	2.6
0.800	0.8	2.400	1.4	6.000	2.1		
1.000	0.9	2.600	1.4	6.500	2.2		

Cascade Summary of Results for CatchmentCentral_RoofLevel.srcx

Upstream Structures	Outflow To	Overflow To
(None)	CatchmentCentral_GroundLevel.srcx	(None)

Half Drain Time : 3567 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	40.012	0.012	0.0	0.1	0.1	75.6	O K
30 min Summer	40.019	0.019	0.0	0.1	0.1	118.2	O K
60 min Summer	40.026	0.026	0.0	0.2	0.2	164.0	O K
120 min Summer	40.034	0.034	0.0	0.4	0.4	215.3	O K
180 min Summer	40.039	0.039	0.0	0.6	0.6	247.9	O K
240 min Summer	40.043	0.043	0.0	0.7	0.7	272.6	O K
360 min Summer	40.049	0.049	0.0	0.8	0.8	308.9	O K
480 min Summer	40.053	0.053	0.0	0.9	0.9	335.4	O K
600 min Summer	40.056	0.056	0.0	1.0	1.0	356.0	O K
720 min Summer	40.059	0.059	0.0	1.1	1.1	372.5	O K
960 min Summer	40.063	0.063	0.0	1.2	1.2	397.5	O K
1440 min Summer	40.068	0.068	0.0	1.3	1.3	428.2	O K
2160 min Summer	40.071	0.071	0.0	1.5	1.5	449.3	O K
2880 min Summer	40.073	0.073	0.0	1.5	1.5	462.5	O K
4320 min Summer	40.076	0.076	0.0	1.6	1.6	479.0	O K
5760 min Summer	40.077	0.077	0.0	1.6	1.6	486.6	O K
7200 min Summer	40.077	0.077	0.0	1.6	1.6	488.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	85.194	0.0	4.4	122
30 min Summer	58.879	0.0	10.3	131
60 min Summer	38.241	0.0	34.5	146
120 min Summer	24.118	0.0	54.5	184
180 min Summer	18.261	0.0	70.2	230
240 min Summer	14.961	0.0	82.6	284
360 min Summer	11.264	0.0	99.4	394
480 min Summer	9.197	0.0	110.5	508
600 min Summer	7.854	0.0	118.9	622
720 min Summer	6.901	0.0	125.6	738
960 min Summer	5.625	0.0	135.4	972
1440 min Summer	4.216	0.0	145.5	1444
2160 min Summer	3.158	0.0	285.1	1984
2880 min Summer	2.570	0.0	296.8	2304
4320 min Summer	1.920	0.0	294.5	3056
5760 min Summer	1.560	0.0	491.5	3872
7200 min Summer	1.328	0.0	499.9	4688

Cascade Summary of Results for CatchmentCentral_RoofLevel.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	40.077	0.077	0.0	1.6	1.6	487.9	O K
10080 min Summer	40.077	0.077	0.0	1.6	1.6	484.9	O K
15 min Winter	40.014	0.014	0.0	0.1	0.1	89.0	O K
30 min Winter	40.022	0.022	0.0	0.2	0.2	136.8	O K
60 min Winter	40.030	0.030	0.0	0.3	0.3	188.0	O K
120 min Winter	40.039	0.039	0.0	0.6	0.6	245.2	O K
180 min Winter	40.045	0.045	0.0	0.7	0.7	282.0	O K
240 min Winter	40.049	0.049	0.0	0.8	0.8	309.8	O K
360 min Winter	40.055	0.055	0.0	1.0	1.0	350.6	O K
480 min Winter	40.060	0.060	0.0	1.1	1.1	380.3	O K
600 min Winter	40.064	0.064	0.0	1.2	1.2	403.4	O K
720 min Winter	40.067	0.067	0.0	1.3	1.3	422.1	O K
960 min Winter	40.071	0.071	0.0	1.5	1.5	450.2	O K
1440 min Winter	40.077	0.077	0.0	1.6	1.6	485.1	O K
2160 min Winter	40.081	0.081	0.0	1.7	1.7	510.0	O K
2880 min Winter	40.083	0.083	0.0	1.8	1.8	522.0	O K
4320 min Winter	40.085	0.085	0.0	1.9	1.9	536.7	O K
5760 min Winter	40.085	0.085	0.0	1.9	1.9	539.1	O K
7200 min Winter	40.085	0.085	0.0	1.9	1.9	535.4	O K
8640 min Winter	40.084	0.084	0.0	1.8	1.8	528.6	O K
10080 min Winter	40.082	0.082	0.0	1.8	1.8	520.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	495.8	5528
10080 min Summer	1.041	0.0	480.3	6352
15 min Winter	85.194	0.0	6.0	123
30 min Winter	58.879	0.0	13.4	130
60 min Winter	38.241	0.0	43.3	146
120 min Winter	24.118	0.0	69.3	184
180 min Winter	18.261	0.0	87.7	230
240 min Winter	14.961	0.0	100.7	280
360 min Winter	11.264	0.0	118.6	388
480 min Winter	9.197	0.0	131.6	500
600 min Winter	7.854	0.0	141.9	612
720 min Winter	6.901	0.0	150.2	726
960 min Winter	5.625	0.0	162.5	956
1440 min Winter	4.216	0.0	174.4	1408
2160 min Winter	3.158	0.0	335.9	2044
2880 min Winter	2.570	0.0	350.7	2316
4320 min Winter	1.920	0.0	349.2	3216
5760 min Winter	1.560	0.0	577.2	4120
7200 min Winter	1.328	0.0	588.2	5000
8640 min Winter	1.164	0.0	584.7	5888
10080 min Winter	1.041	0.0	569.0	6760

Cascade Rainfall Details for CatchmentCentral_RoofLevel.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	16.200	Shortest Storm (mins)	15
Ratio R	0.279	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Green Roof

Area (m^3)	7080	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.128658	32	36	0.025976	64	68	0.005244	96	100	0.001059
4	8	0.105336	36	40	0.021267	68	72	0.004294	100	104	0.000867
8	12	0.086242	40	44	0.017412	72	76	0.003515	104	108	0.000710
12	16	0.070609	44	48	0.014256	76	80	0.002878	108	112	0.000581
16	20	0.057810	48	52	0.011672	80	84	0.002356	112	116	0.000476
20	24	0.047330	52	56	0.009556	84	88	0.001929	116	120	0.000390
24	28	0.038751	56	60	0.007824	88	92	0.001580			
28	32	0.031727	60	64	0.006405	92	96	0.001293			

Cascade Model Details for CatchmentCentral_RoofLevel.srcx

Storage is Online Cover Level (m) 40.500

Cellular Storage Structure

Invert Level (m) 40.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.93
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	6800.0	0.0	0.086	0.0	0.0
0.085	6800.0	0.0			

Orifice Outflow Control

Diameter (m) 0.064 Discharge Coefficient 0.600 Invert Level (m) 40.000

Cascade Summary of Results for CatchmentCentral_GroundLevel.srcx

	Upstream Structures	Outflow To	Overflow To
CatchmentCentral_RoofLevel.srcx	(None)	(None)	

Half Drain Time : 965 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.288	0.023	0.0	3.0	3.0	97.0	O K
30 min Summer	1.297	0.032	0.0	3.0	3.0	132.9	O K
60 min Summer	1.306	0.041	0.0	3.0	3.0	169.6	O K
120 min Summer	1.315	0.050	0.0	3.1	3.1	206.7	O K
180 min Summer	1.320	0.055	0.0	3.1	3.1	228.0	O K
240 min Summer	1.324	0.059	0.0	3.1	3.1	242.5	O K
360 min Summer	1.328	0.063	0.0	3.1	3.1	260.6	O K
480 min Summer	1.330	0.065	0.0	3.1	3.1	270.9	O K
600 min Summer	1.332	0.067	0.0	3.1	3.1	276.8	O K
720 min Summer	1.333	0.068	0.0	3.1	3.1	279.8	O K
960 min Summer	1.333	0.068	0.0	3.1	3.1	283.1	O K
1440 min Summer	1.334	0.069	0.0	3.1	3.1	284.7	O K
2160 min Summer	1.333	0.068	0.0	3.1	3.1	282.1	O K
2880 min Summer	1.332	0.067	0.0	3.1	3.1	277.8	O K
4320 min Summer	1.329	0.064	0.0	3.1	3.1	265.4	O K
5760 min Summer	1.325	0.060	0.0	3.1	3.1	250.4	O K
7200 min Summer	1.322	0.057	0.0	3.1	3.1	233.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	85.194	0.0	105.4	22
30 min Summer	58.879	0.0	147.7	36
60 min Summer	38.241	0.0	213.8	64
120 min Summer	24.118	0.0	281.1	124
180 min Summer	18.261	0.0	327.7	184
240 min Summer	14.961	0.0	364.1	244
360 min Summer	11.264	0.0	417.6	362
480 min Summer	9.197	0.0	457.0	482
600 min Summer	7.854	0.0	489.1	602
720 min Summer	6.901	0.0	516.0	722
960 min Summer	5.625	0.0	521.8	962
1440 min Summer	4.216	0.0	508.6	1440
2160 min Summer	3.158	0.0	821.9	1860
2880 min Summer	2.570	0.0	879.6	2284
4320 min Summer	1.920	0.0	885.2	3116
5760 min Summer	1.560	0.0	1199.2	3976
7200 min Summer	1.328	0.0	1252.8	4824

Cascade Summary of Results for CatchmentCentral_GroundLevel.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	1.317	0.052	0.0	3.1	3.1	216.6	O K
10080 min Summer	1.313	0.048	0.0	3.1	3.1	199.2	O K
15 min Winter	1.291	0.026	0.0	3.0	3.0	109.1	O K
30 min Winter	1.301	0.036	0.0	3.0	3.0	149.8	O K
60 min Winter	1.311	0.046	0.0	3.0	3.0	191.5	O K
120 min Winter	1.322	0.057	0.0	3.1	3.1	234.8	O K
180 min Winter	1.328	0.063	0.0	3.1	3.1	260.3	O K
240 min Winter	1.332	0.067	0.0	3.1	3.1	278.1	O K
360 min Winter	1.338	0.073	0.0	3.1	3.1	301.6	O K
480 min Winter	1.341	0.076	0.0	3.1	3.1	316.6	O K
600 min Winter	1.344	0.079	0.0	3.1	3.1	326.7	O K
720 min Winter	1.346	0.081	0.0	3.1	3.1	333.8	O K
960 min Winter	1.348	0.083	0.0	3.1	3.1	342.0	O K
1440 min Winter	1.349	0.084	0.0	3.1	3.1	348.2	O K
2160 min Winter	1.350	0.085	0.0	3.1	3.1	351.5	O K
2880 min Winter	1.349	0.084	0.0	3.1	3.1	346.4	O K
4320 min Winter	1.343	0.078	0.0	3.1	3.1	324.0	O K
5760 min Winter	1.338	0.073	0.0	3.1	3.1	301.5	O K
7200 min Winter	1.332	0.067	0.0	3.1	3.1	276.7	O K
8640 min Winter	1.326	0.061	0.0	3.1	3.1	250.5	O K
10080 min Winter	1.319	0.054	0.0	3.1	3.1	223.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	1287.7	5624
10080 min Summer	1.041	0.0	1306.7	6456
15 min Winter	85.194	0.0	119.0	21
30 min Winter	58.879	0.0	167.6	36
60 min Winter	38.241	0.0	244.3	64
120 min Winter	24.118	0.0	323.3	122
180 min Winter	18.261	0.0	376.6	182
240 min Winter	14.961	0.0	416.4	240
360 min Winter	11.264	0.0	475.2	358
480 min Winter	9.197	0.0	520.2	474
600 min Winter	7.854	0.0	524.3	590
720 min Winter	6.901	0.0	524.3	708
960 min Winter	5.625	0.0	523.5	942
1440 min Winter	4.216	0.0	516.4	1400
2160 min Winter	3.158	0.0	937.6	2076
2880 min Winter	2.570	0.0	987.9	2740
4320 min Winter	1.920	0.0	921.3	3648
5760 min Winter	1.560	0.0	1370.8	4464
7200 min Winter	1.328	0.0	1431.6	5400
8640 min Winter	1.164	0.0	1472.3	6304
10080 min Winter	1.041	0.0	1495.1	7160

Cascade Rainfall Details for CatchmentCentral_GroundLevel.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	16.200	Shortest Storm (mins)	15
Ratio R	0.279	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.632

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.500	4	8	0.132

Cascade Model Details for CatchmentCentral_GroundLevel.srcx

Storage is Online Cover Level (m) 1.650

Cellular Storage Structure

Invert Level (m) 1.265 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.92
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	4500.0	0.0	0.086	0.0	0.0
0.085	4500.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0081-3100-1200-3100
Design Head (m)	1.200
Design Flow (l/s)	3.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	81
Invert Level (m)	0.150
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	3.1
Flush-Flo™	0.356	3.1
Kick-Flo®	0.723	2.5
Mean Flow over Head Range	-	2.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.3	1.200	3.1	3.000	4.7	7.000	7.1
0.200	2.9	1.400	3.3	3.500	5.1	7.500	7.3
0.300	3.0	1.600	3.5	4.000	5.4	8.000	7.5
0.400	3.0	1.800	3.7	4.500	5.7	8.500	7.7
0.500	3.0	2.000	3.9	5.000	6.0	9.000	7.9
0.600	2.8	2.200	4.1	5.500	6.3	9.500	8.2
0.800	2.6	2.400	4.3	6.000	6.6		
1.000	2.8	2.600	4.4	6.500	6.8		

Cascade Summary of Results for CatchmentEast_RoofLevel.srcx

Upstream Structures	Outflow To	Overflow To
(None)	CatchmentEast_GroundLevel.srcx	(None)

Half Drain Time : 4213 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	40.011	0.011	0.0	0.0	0.0	47.8	O K
30 min Summer	40.018	0.018	0.0	0.1	0.1	74.8	O K
60 min Summer	40.025	0.025	0.0	0.2	0.2	103.6	O K
120 min Summer	40.033	0.033	0.0	0.3	0.3	136.1	O K
180 min Summer	40.037	0.037	0.0	0.4	0.4	156.8	O K
240 min Summer	40.041	0.041	0.0	0.4	0.4	172.4	O K
360 min Summer	40.047	0.047	0.0	0.5	0.5	195.3	O K
480 min Summer	40.051	0.051	0.0	0.6	0.6	212.0	O K
600 min Summer	40.054	0.054	0.0	0.6	0.6	224.9	O K
720 min Summer	40.056	0.056	0.0	0.7	0.7	235.4	O K
960 min Summer	40.060	0.060	0.0	0.8	0.8	251.3	O K
1440 min Summer	40.065	0.065	0.0	0.8	0.8	271.4	O K
2160 min Summer	40.069	0.069	0.0	0.8	0.8	286.7	O K
2880 min Summer	40.071	0.071	0.0	0.9	0.9	295.5	O K
4320 min Summer	40.073	0.073	0.0	0.9	0.9	306.6	O K
5760 min Summer	40.075	0.075	0.0	0.9	0.9	312.1	O K
7200 min Summer	40.075	0.075	0.0	0.9	0.9	314.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	85.194	0.0	3.2	122
30 min Summer	58.879	0.0	7.4	130
60 min Summer	38.241	0.0	24.6	146
120 min Summer	24.118	0.0	38.8	184
180 min Summer	18.261	0.0	46.9	230
240 min Summer	14.961	0.0	53.3	284
360 min Summer	11.264	0.0	63.2	394
480 min Summer	9.197	0.0	70.8	508
600 min Summer	7.854	0.0	76.5	622
720 min Summer	6.901	0.0	80.9	738
960 min Summer	5.625	0.0	87.0	972
1440 min Summer	4.216	0.0	91.7	1446
2160 min Summer	3.158	0.0	179.5	2104
2880 min Summer	2.570	0.0	185.1	2420
4320 min Summer	1.920	0.0	178.4	3160
5760 min Summer	1.560	0.0	310.3	3976
7200 min Summer	1.328	0.0	313.2	4800

Cascade Summary of Results for CatchmentEast_RoofLevel.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	40.075	0.075	0.0	0.9	0.9	313.7	O K
10080 min Summer	40.075	0.075	0.0	0.9	0.9	312.0	O K
15 min Winter	40.013	0.013	0.0	0.1	0.1	56.3	O K
30 min Winter	40.021	0.021	0.0	0.1	0.1	86.5	O K
60 min Winter	40.028	0.028	0.0	0.2	0.2	118.8	O K
120 min Winter	40.037	0.037	0.0	0.4	0.4	155.1	O K
180 min Winter	40.043	0.043	0.0	0.4	0.4	178.4	O K
240 min Winter	40.047	0.047	0.0	0.5	0.5	195.9	O K
360 min Winter	40.053	0.053	0.0	0.6	0.6	221.6	O K
480 min Winter	40.057	0.057	0.0	0.7	0.7	240.5	O K
600 min Winter	40.061	0.061	0.0	0.8	0.8	255.1	O K
720 min Winter	40.064	0.064	0.0	0.8	0.8	267.1	O K
960 min Winter	40.068	0.068	0.0	0.8	0.8	285.5	O K
1440 min Winter	40.074	0.074	0.0	0.9	0.9	309.7	O K
2160 min Winter	40.079	0.079	0.0	0.9	0.9	329.2	O K
2880 min Winter	40.081	0.081	0.0	0.9	0.9	338.2	O K
4320 min Winter	40.083	0.083	0.0	1.0	1.0	348.0	O K
5760 min Winter	40.084	0.084	0.0	1.0	1.0	351.4	O K
7200 min Winter	40.084	0.084	0.0	1.0	1.0	350.1	O K
8640 min Winter	40.083	0.083	0.0	1.0	1.0	346.4	O K
10080 min Winter	40.081	0.081	0.0	0.9	0.9	341.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	309.7	5624
10080 min Summer	1.041	0.0	299.6	6456
15 min Winter	85.194	0.0	4.3	122
30 min Winter	58.879	0.0	9.5	130
60 min Winter	38.241	0.0	31.6	144
120 min Winter	24.118	0.0	46.5	184
180 min Winter	18.261	0.0	56.3	230
240 min Winter	14.961	0.0	64.1	280
360 min Winter	11.264	0.0	76.0	388
480 min Winter	9.197	0.0	84.6	500
600 min Winter	7.854	0.0	91.1	612
720 min Winter	6.901	0.0	96.0	726
960 min Winter	5.625	0.0	102.0	958
1440 min Winter	4.216	0.0	104.6	1414
2160 min Winter	3.158	0.0	207.1	2080
2880 min Winter	2.570	0.0	211.9	2688
4320 min Winter	1.920	0.0	200.8	3340
5760 min Winter	1.560	0.0	359.2	4272
7200 min Winter	1.328	0.0	363.3	5184
8640 min Winter	1.164	0.0	359.3	6064
10080 min Winter	1.041	0.0	347.5	6960

Cascade Rainfall Details for CatchmentEast_RoofLevel.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	16.200	Shortest Storm (mins)	15
Ratio R	0.279	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Green Roof

Area (m³)	4480	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.081410	32	36	0.016436	64	68	0.003318	96	100	0.000670
4	8	0.066653	36	40	0.013457	68	72	0.002717	100	104	0.000549
8	12	0.054571	40	44	0.011018	72	76	0.002224	104	108	0.000449
12	16	0.044679	44	48	0.009021	76	80	0.001821	108	112	0.000368
16	20	0.036580	48	52	0.007385	80	84	0.001491	112	116	0.000301
20	24	0.029949	52	56	0.006047	84	88	0.001221	116	120	0.000246
24	28	0.024520	56	60	0.004951	88	92	0.001000			
28	32	0.020076	60	64	0.004053	92	96	0.000818			

Cascade Model Details for CatchmentEast_RoofLevel.srcx

Storage is Online Cover Level (m) 40.500

Cellular Storage Structure

Invert Level (m) 40.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.93
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	4500.0	0.0	0.086	0.0	0.0
0.085	4500.0	0.0			

Orifice Outflow Control

Diameter (m) 0.043 Discharge Coefficient 0.600 Invert Level (m) 40.000

Cascade Summary of Results for CatchmentEast_GroundLevel.srcx

	Upstream Structures	Outflow To	Overflow To
	CatchmentEast_RoofLevel.srcx	(None)	(None)

Half Drain Time : 1085 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	1.287	0.022	0.0	1.5	1.5	49.5	O K
30 min Summer	1.295	0.030	0.0	1.5	1.5	67.9	O K
60 min Summer	1.303	0.038	0.0	1.5	1.5	86.7	O K
120 min Summer	1.311	0.046	0.0	1.5	1.5	106.0	O K
180 min Summer	1.316	0.051	0.0	1.5	1.5	117.3	O K
240 min Summer	1.319	0.054	0.0	1.5	1.5	125.1	O K
360 min Summer	1.324	0.059	0.0	1.5	1.5	135.3	O K
480 min Summer	1.327	0.062	0.0	1.5	1.5	141.7	O K
600 min Summer	1.328	0.063	0.0	1.5	1.5	145.8	O K
720 min Summer	1.330	0.065	0.0	1.5	1.5	148.5	O K
960 min Summer	1.331	0.066	0.0	1.5	1.5	151.8	O K
1440 min Summer	1.333	0.068	0.0	1.5	1.5	155.8	O K
2160 min Summer	1.333	0.068	0.0	1.5	1.5	157.0	O K
2880 min Summer	1.333	0.068	0.0	1.5	1.5	155.3	O K
4320 min Summer	1.330	0.065	0.0	1.5	1.5	150.4	O K
5760 min Summer	1.328	0.063	0.0	1.5	1.5	144.5	O K
7200 min Summer	1.325	0.060	0.0	1.5	1.5	137.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	85.194	0.0	54.6	22
30 min Summer	58.879	0.0	78.5	37
60 min Summer	38.241	0.0	115.8	66
120 min Summer	24.118	0.0	154.1	126
180 min Summer	18.261	0.0	178.0	184
240 min Summer	14.961	0.0	196.7	244
360 min Summer	11.264	0.0	225.3	364
480 min Summer	9.197	0.0	247.3	484
600 min Summer	7.854	0.0	253.8	602
720 min Summer	6.901	0.0	254.0	722
960 min Summer	5.625	0.0	253.4	962
1440 min Summer	4.216	0.0	247.6	1442
2160 min Summer	3.158	0.0	453.0	2160
2880 min Summer	2.570	0.0	470.3	2620
4320 min Summer	1.920	0.0	432.6	3412
5760 min Summer	1.560	0.0	671.0	4208
7200 min Summer	1.328	0.0	696.8	5040

Cascade Summary of Results for CatchmentEast_GroundLevel.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	1.322	0.057	0.0	1.5	1.5	130.9	O K
10080 min Summer	1.319	0.054	0.0	1.5	1.5	123.6	O K
15 min Winter	1.289	0.024	0.0	1.5	1.5	55.7	O K
30 min Winter	1.298	0.033	0.0	1.5	1.5	76.5	O K
60 min Winter	1.308	0.043	0.0	1.5	1.5	97.8	O K
120 min Winter	1.317	0.052	0.0	1.5	1.5	120.4	O K
180 min Winter	1.323	0.058	0.0	1.5	1.5	133.8	O K
240 min Winter	1.327	0.062	0.0	1.5	1.5	143.3	O K
360 min Winter	1.333	0.068	0.0	1.5	1.5	156.4	O K
480 min Winter	1.337	0.072	0.0	1.5	1.5	165.1	O K
600 min Winter	1.339	0.074	0.0	1.5	1.5	171.3	O K
720 min Winter	1.342	0.077	0.0	1.5	1.5	176.0	O K
960 min Winter	1.344	0.079	0.0	1.5	1.5	181.9	O K
1440 min Winter	1.346	0.081	0.0	1.5	1.5	187.1	O K
2160 min Winter	1.348	0.083	0.0	1.5	1.5	191.4	O K
2880 min Winter	1.348	0.083	0.0	1.5	1.5	191.4	O K
4320 min Winter	1.345	0.080	0.0	1.5	1.5	184.4	O K
5760 min Winter	1.341	0.076	0.0	1.5	1.5	173.7	O K
7200 min Winter	1.336	0.071	0.0	1.5	1.5	164.1	O K
8640 min Winter	1.332	0.067	0.0	1.5	1.5	153.8	O K
10080 min Winter	1.327	0.062	0.0	1.5	1.5	143.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	713.2	5880
10080 min Summer	1.041	0.0	720.9	6664
15 min Winter	85.194	0.0	62.0	22
30 min Winter	58.879	0.0	88.0	36
60 min Winter	38.241	0.0	133.9	66
120 min Winter	24.118	0.0	175.7	124
180 min Winter	18.261	0.0	203.2	182
240 min Winter	14.961	0.0	224.9	240
360 min Winter	11.264	0.0	253.6	358
480 min Winter	9.197	0.0	254.0	476
600 min Winter	7.854	0.0	254.2	594
720 min Winter	6.901	0.0	254.2	712
960 min Winter	5.625	0.0	253.7	944
1440 min Winter	4.216	0.0	251.0	1412
2160 min Winter	3.158	0.0	494.3	2100
2880 min Winter	2.570	0.0	481.3	2768
4320 min Winter	1.920	0.0	449.4	4064
5760 min Winter	1.560	0.0	763.1	4712
7200 min Winter	1.328	0.0	793.0	5552
8640 min Winter	1.164	0.0	811.3	6488
10080 min Winter	1.041	0.0	797.5	7368

Cascade Rainfall Details for CatchmentEast_GroundLevel.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	16.200	Shortest Storm (mins)	15
Ratio R	0.279	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.322

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.222	4	8	0.100

Cascade Model Details for CatchmentEast_GroundLevel.srcx

Storage is Online Cover Level (m) 1.650

Cellular Storage Structure

Invert Level (m) 1.265 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.92
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	2500.0	0.0	0.086	0.0	0.0
0.085	2500.0	0.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0055-1500-1200-1500
Design Head (m)	1.200
Design Flow (l/s)	1.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	55
Invert Level (m)	0.150
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	1.5
Flush-Flo™	0.242	1.2
Kick-Flo®	0.493	1.0
Mean Flow over Head Range	-	1.2

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.1	1.200	1.5	3.000	2.3	7.000	3.4
0.200	1.2	1.400	1.6	3.500	2.4	7.500	3.5
0.300	1.2	1.600	1.7	4.000	2.6	8.000	3.6
0.400	1.2	1.800	1.8	4.500	2.7	8.500	3.7
0.500	1.0	2.000	1.9	5.000	2.9	9.000	3.8
0.600	1.1	2.200	2.0	5.500	3.0	9.500	3.9
0.800	1.2	2.400	2.1	6.000	3.1		
1.000	1.4	2.600	2.1	6.500	3.3		

APPENDIX I

WASTEWATER GENERATION CALCULATIONS

JOB NAME:	JOB NO:	DATE:
Project Connolly	O635	04/10/2019
TITLE:	**CALCS BY:**	**CHECK'D:**
Wastewater Flow	FS	NMM

Zone	Area (m^2)	No. of Units (nr)	Area/person (m^2)	Occupancy (nr/m^2)	Population	Flow (l/unit/day)	BOD (g/unit/day)	Infiltration (% of flow)	Total Flow (m^3/day)	Total BOD (kg/day)	DWF (l/s)	Peak Factor	Peak Flow
Residential													
Residential Units		741		2.7	2000.7	150	60	10%	330.1	120.04	3.82		
TOTAL Residential		741			2000.7				330.1	120.0	3.8	3.0	11.46
Non-Residential													
Retail, Commercial & Community(1)	3142		25	0.040	125.7	50	30	10%	6.9	3.77	0.08		
Residential Support Amenity(1)	1444		25	0.040	57.8	50	30	10%	3.2	1.73	0.04		
TOTAL Non-Residential					183.4				10.1	5.5	0.1	4.5	0.53
TOTAL					2184.14				**340**	**126**	**3.9**		11.99

(1) Flow rate for office without canteen

Residential Occupancy rates from Appendix C of IW Code of Practice for Wastewater Infrastructure, December 2017 (IW-CDS-5030-03)

Flow rates from Appendix D of IW Code of Practice for Wastewater Infrastructure, December 2017 (IW-CDS-5030-03)

Infiltration rates from Appendix C of IW Code of Practice for Wastewater Infrastructure, December 2017 (IW-CDS-5030-03)

BOD loading rates from EPA Wastewater Treatment Manual, For Small Communities..., Table 3

Peaking Factor from Appendix C of IW Code of Practice for Wastewater Infrastructure, December 2017 (IW-CDS-5030-03)

APPENDIX J

WATER DEMAND CALCULATIONS

JOB NAME:	JOB NO:	DATE:
Project Connolly	O635	04/10/2019
TITLE:	**CALCS BY:**	**CHECK'D:**
Water Demand	FS	NMM

Zone	Area (m^2)	No. of Units (nr)	Area/person (m^2)	Occupancy (nr/m^2)	Population	Flow (l/unit/day)	Total Flow (m^3/day)	Average (l/s)	AvDay/PkWeek (Factor)	AvDay/PkWeek (l/s)	Pipe Sizing (Factor)	Pipe Sizing (l/s)
Residential												
Residential Units		741		2.7	2000.7	150	300.1	3.473	1.25	4.342		
TOTAL Residential		741			2000.7		300.1	3.47		4.34	3.0	13.03
Non-Residential												
Retail, Commercial & Community(1)	3142		25	0.040	125.7	50	6.3	0.073	1.25	0.091		
Residential Support Amenity(1)	1444		25	0.040	57.8	50	2.9	0.033	1.25	0.042		
TOTAL Non-Residential					183.4		9.2	0.11		0.13	5.0	0.66
TOTAL					2184.1		**309.3**	**3.6**		4.5		13.69

(1) Flow rate for office without canteen

Flow rates from Appendix D of IW Code of Practice for Wastewater Infrastructure, December 2017 (IW-CDS-5030-03)

Peaking Factors from IW Code of Practice for Water Infrastructure, December 2017 (IW-CDS-5020-03)

Proposal:	DN200 HDPE		
Diameter:	176.47	mm	(HDPE DN200 SDR17 PE100 PN10)
Cross Sectional Area:	0.02446	m^2	
Permissible Maximum Velocity:	1.50	m/s	(IW-CDS-5020-03 Cl.3.2)
Permissible Minimum Velocity:	0.30	m/s	(IW-CDS-5020-03 Cl.3.2)
Design Flow:	13.7	l/s	
Design Flow Velocity:	0.56	m/s	
Check:	OK		

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