Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

Flooding at Letterkenny General Hospital

Stage 2 Engineering Assessment

September 2013

TOBIN CONSULTING ENGINEERS

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REPORT

PROJECT: **Stage 2 Engineering Assessment**

CLIENT: **HSE Estates**

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EXECUTIVE SUMMARY

Terms of Reference

On Friday 26th July 2013, commencing at approximately 5.30pm, flooding of Letterkenny General Hospital occurred following intense rainfall in the area. The source of the flood water was a local stream, known as the Sprackburn Tributary, which is culverted underneath the hospital grounds.

Following the flooding incident TOBIN Consulting Engineers were asked to prepare a report on engineering aspects associated with the flooding incident, and to make recommendations for:

- Stage 1: Practical short-term risk reduction measures to protect the hospital against flooding during any similar short-term weather event, until such time as a longer term solution is put in place
- Stage 2: Long-term engineering solutions to minimize the risk of flooding at the hospital in the future

This report presents the findings from the Stage 2 Assessment.

Flood Risk Assessment

The document titled "*The Planning System and Flood Risk Management – Guidelines for Planning Authorities and Technical Appendices*" states that hospitals are considered to be *"Highly Vulnerable Developments"* and requires that, in order to ensure that the risk of flooding of the site is reduced or eliminated, consideration would need to be given to the impacts associated with a flood event that is expected to have a 0.1% chance of occurring, i.e. on average occurs once every 1000 years. For the purposes of this report we will use the term '*1000 year flood event*' to describe such an event.

The peak flow corresponding to the 1000 year flood event was found to be 5.48 m^3/s. Factoring in the effects of climate change in the future, this rises to a peak flow of 6.58m^3/s.

Hydraulic Assessment of the Existing Culvert

The result of this assessment indicate that, assuming water is not prevented from entering the culvert from, for example, blockages at the protective screens, the existing 1350mm culvert has a capacity of the order of 7m^3/s. Looking at the estimation of storm flows for various events, it would suggest that the culvert has adequate capacity to cater for the 1000 year flood event (6.58m^3/s), even taking account of the effect of climate change on future rainfall profiles.

Proposed Engineering Solution

The hydraulic assessment of the existing culvert has shown that the existing culvert has adequate capacity to cater for the 1000 year flood event. We would conclude that the primary reason for the flooding incident on 26th July 2013 was the fact that the screens became blocked and prevented water from entering the culvert.

However in order to further mitigate the risk of a recurrence of the flooding at the hospital site, we have developed a design for a 1500mm diameter storm routing culvert along the western perimeter of the hospital site which will at least duplicate the capacity of the existing culvert and operate in the event that a blockage to the existing culvert prevents any storm water flowing into it.

The route of this storm routing culvert is shown on the attached Drawing 7284-2001.

Programme

Discussions with Donegal County Council indicate that the proposed new culvert requires planning permission. This application is to be lodged on Friday 13th September 2013. It is anticipated that, subject to normal planning risks, a Grant of Permission can be issued by the Planning Authority by late November/early December 2013, allowing works to commence by mid December 2013 and, assuming that there are no significant delays during construction, is be completed by March 2014.

1. BACKGROUND

1.1 HISTORY OF THE FLOODING EVENT

On Friday 26th July 2013, commencing at approximately 5.30pm, flooding of Letterkenny General Hospital occurred following intense rainfall in the area. The source of the flood water was a local stream, known as the Sprackburn Tributary (of the River Swilly), which runs in a south-east direction towards the hospital and enters a 1350mm diameter circular culvert which runs through the hospital grounds.

Following the flooding incident TOBIN Consulting Engineers were asked to prepare a report on engineering aspects associated with the flooding incident, and to make recommendations for:

- Practical short-term risk reduction measures to protect the hospital against flooding during any similar short-term weather event, until such time as a longer term solution is put in place
- Long-term engineering solutions to minimize the risk of flooding at the hospital in the future

On 8th August 2013 we presented our initial report (Stage 1) on practical short-term measures to protect the hospital. The main conclusions of that report are summarized in Sections 1.2 to 1.5 below.

1.2 RAINFALL INTENSITY

We have concluded that the primary contributing factor to the flooding on 26th July was the intensity of the rainfall that occurred in the catchment upstream of the hospital during the afternoon of Friday 26th July 2013.

Met Eireann do not operate a rainfall gauge in the general Letterkenny area, and the closest synoptic stations are at Malin Head and Finner Camp. The type of intense summer rainfall events such as that which occurred in Letterkenny on 26th July can be very localized and physical measurement of rainfall experienced at raingauges outside the catchment of the Sprackburn Tributary are of limited use. Met Eireann collate data from a privately operated raingauge just east of Letterkenny, but that gauge only gives daily totals and again is of limited use in this assessment.

We have consulted with Met Eireann Climate Section to try to put the level of rainfall experienced in Letterkenny on 26th July into context, and they have provided rainfall radar images from Met Eireann for the afternoon in question. The radar image for 1700 hrs BST/local time, included in this report as Figure 1 (corresponding to 1600 hrs GMT on the radar image), shows an intense localized rainfall event over the Sprackburn Tributary catchment.

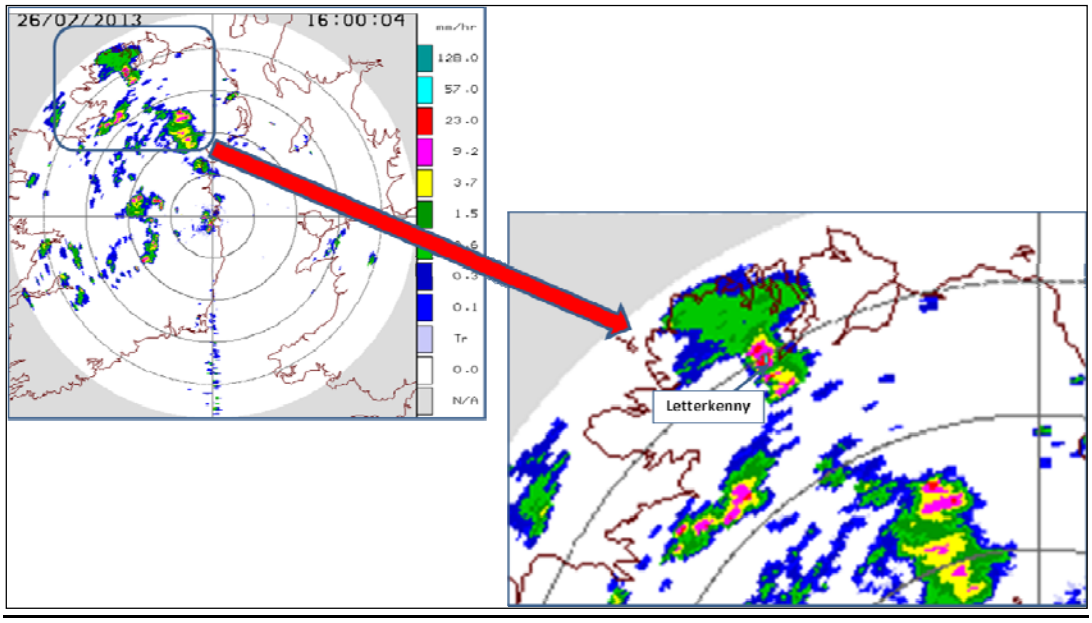


Figure 1: Met Eireann Rainfall Radar Image, 1700hrs BST (1600hrs GMT), Friday 26th July 2013

Looking at the radar image, it can be deduced that at 1700hrs (BST/local time), rainfall intensity exceeded 57mm/hr in an area local to the catchment of the Sprackburn Tributary. Based on verbal accounts of the event and on CCTV footage at the hospital it appears that the intense rainfall event lasted between 15 and 25 minutes. Following preliminary discussions with Met Eireann, this rainfall intensity and duration can be considered to be somewhere between a 1 in 20 year and a 1 in 25 year event.

We would however caution against drawing any definitive conclusions from this assessment of return period based on rainfall radar data, as the reliability of the assessment is low, given that the rainfall intensity data is taken from a radar based over 200km away and there are a number of topographical and other interferences that reduce the accuracy of the data.

1.3 CONDITION OF THE CATCHMENT

The rate of runoff into the Sprackburn Tributary, from any rainfall event, is dependent on the physical characteristics of the catchment, including the catchment gradient, soil and vegetation type, the extent to which a period of dry weather has hardened the upper levels of the soil making them impermeable, and the extent of impermeable paved areas. Paved areas such as roads and footpaths upstream in the catchment would contribute to a high flowrate in the stream during a rainfall event of this nature.

1.4 DESCRIPTION OF THE CULVERT

The Sprackburn Tributary enters a 1350mm diameter culvert to the north of the hospital buildings, as shown in Figure 2. The culvert is protected by two screens, a primary screen (left hand side of the photo) sitting in the stream approximately 15m upstream of a secondary screen at the entrance to the culvert itself (back right of the photo). These screens were installed to:

(a) prevent bulky debris from being washed into the culvert (i.e. a trash screen), and
(b) for safety reasons, to prevent unauthorized access to the culvert (i.e. a security screen).

Figure 2: Screens and Culvert Entrance (photo taken 30th July 2013)

During the rainfall event on the evening of 26th July these screens became blocked with debris washed down from the upper catchment, leading to a situation where water could not enter the culvert and an overspill occurred, overtopping the culvert headwall and flooding the hospital car park and property.

As part of the response to the emergency during the overspill, hospital staff removed debris from the two screens to alleviate the flooding. Based on accounts from the personnel who removed the material and from our inspection of material taken from the screens (which was still on site), the debris consisted of a wide range of material, including tree branches (large and small), domestic rubbish, tyres and other items including barbeques, gas cylinders and large items of plastic. The presence of such loose material in or adjacent to the stream or capable of being washed into the stream by heavy overland flows was a major contributory factor to the flood event.

1.5 RECOMMENDED SHORT-TERM MEASURES

In our Stage 1 report we recommended a number of risk mitigation measures which would protect the hospital in the short term from a recurrence of the flood event, until a longer term engineered solution could be put in place. The purpose of such measures was to minimize the risk of further flooding of the hospital buildings if a similar rainfall event occurred before a longer term solution was put in place. These measures, which have all been implemented, include:

- Cleaning of the stream channel
- Putting in place an inspection protocol for the screens
- Putting in place an inspection protocol for the catchment
- Provision of standby mechanical excavator
- CCTV at the screens
- Provision of sandbags

2. FLOOD RISK ASSESSMENT

2.1 EXISTING CHANNEL/CULVERT

Figure 2 shows the approximate route of the culverted section of the Sprackburn Tributary which traverses the hospital grounds. The culvert consists of three distinct sections.

- Section 1; 1350mm diameter concrete culvert passing underneath the hospital, 324 metres long to an underground chamber (Chamber A).
- Section 2; twin 1000mm diameter concrete pipes, 27 metres long passing under Circular Road to a second underground chamber (Chamber B)
- Section 3; twin 900mm diameter concrete pipes, 96 metres long, running parallel to Oatfield Terrace and discharging back into an open channel

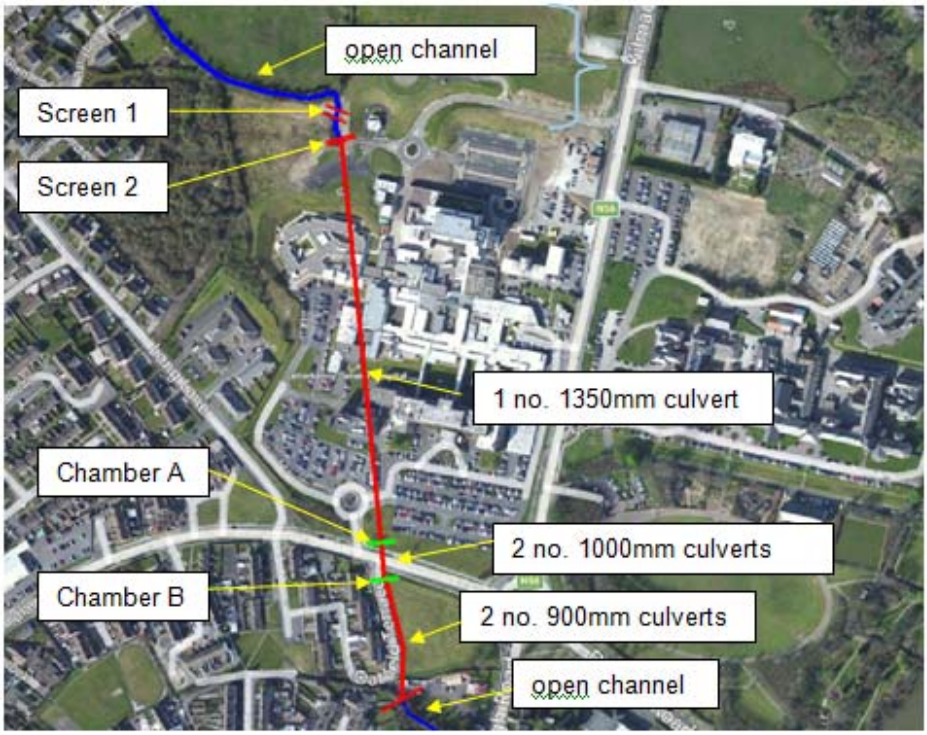


Figure 2 Layout of the Channel/Culvert in the Vicinity of Letterkenny Hospital

2.2 EXTENT OF THE FLOOD RISK ASSESSMENT

In deciding on the appropriate level of flood risk assessment for the Letterkenny Hospital site reference is made to the November 2009 Department of Environment, Heritage and Local Government (DoEHLG) and the Office of Public Works (OPW) document titled "*The Planning System and Flood Risk Management – Guidelines for Planning Authorities and Technical Appendices*". For the purpose of this report the guidelines have been abbreviated to PSFRM Guidelines.

These guidelines outline a three staged approach to be adopted in carrying out flood risk assessments:

- Stage 1 – Flood risk identification
- Stage 2 – Initial flood risk assessment
- Stage 3 – Detailed flood risk assessment

Due to the proximity of the Sprackburn Tributary to the hospital and the history of localized flooding events at this site, the site has been identified as having a potential flood risk and as a result a quantitative assessment or '*detailed flood risk assessment*' is required.

The PSFRM guidelines discuss flood risk in terms of three flood zones where tests are required for particular developments located within defined flood zones. The flood zones and applicable assessments are summarised in Table 1.

Table 1 Extract from the PSFRM Guidelines – Flood Zones

Flood Zone	Probability of Flooding (Fluvial Return Periods)	Recommendation based on Vulnerability of Development		
		Highly Vulnerable	Less Vulnerable	Water Compatible
A	Highest Probability (more frequent than 1 in 100-yr)	Justification Test	Justification Test	Appropriate
B	Moderate Probability (1 in 100-yr to 1 in 1000-yr)	Justification Test	Appropriate	Appropriate
C	Low Probability (less frequent than 1 in 1000-yr)	Appropriate	Appropriate	Appropriate
Note: The PSFRM Guidelines provide probabilities for fluvial and tidal flooding… for clarity, only fluvial flooding probabilities have been included in this table				

The guidelines state that hospitals are considered to be *"Highly Vulnerable Developments"* and with flooding having already occurred in the north western portion of the site it has been assumed in this report that the probability of flooding at the proposed sites may be at least moderate (Flood Zone B). For this reason a Justification Test has been undertaken.

2.3 ESTIMATION OF THE DESIGN FLOOD

We have carried out an assessment of the design flood using the Flood Studies Report (FSR) method for ungauged catchments. The key parameters used in this assessment are listed in Appendix A.

Taking the precautionary principle, and in order to ensure that the risk of flooding of the site is reduced or eliminated, the design flood has been assessed on the basis of a 1,000 year flood event.

The peak flow corresponding to the 1000 year flood event was found to be 5.48 m^3/s. Factoring in the effects of climate change in the future, this rises to a peak flow of 6.58m^3/s.

We have also estimated the design flood for 5 year and 100 year flood events. Table 2 shows the peak flow for each of these return periods.

Table 2 Peak Design Flows for Various Return Periods

Return Period (years)	Flow (m^3/s)	Flow with Climate Change (m^3/s)
5	1.63	1.96
100	3.30	3.96
1000	**5.48**	**6.58**

2.4 HYDRAULIC ASSESSMENT OF EXISTING CULVERT

The hydraulic capacity of the existing culvert was assessed using the *CIRIA Culvert Design Manual Report 168:1997*. Invert levels along the culvert profile (from our level survey), a visual observation of the changes of direction to estimate form losses (from CCTV), and an allowance for the possibility of siltation in the culvert causing a slightly reduced cross-section, were inputted into the assessment.

For the purposes of this assessment, the culvert was split into three sections:

- *Section 1*: 1350mm single pipe, 324m long, entry invert level 62.20mOD, exit invert level 50.12mOD, average gradient 1 in 27.
- *Section 2*: twin 1000 pipes, 27m long, entry invert level 50.12mOD, exit invert level 49.17mOD, average gradient 1 in 28.
- *Section 3*: twin 900mm pipes, 96m long, entry invert level 49.17mOD, exit invert level 45.85mOD, average gradient 1 in 29.

The result of this assessment indicate that, assuming water is not prevented from entering the culvert from, for example, blockages at the protective screens, the existing 1350mm culvert has a capacity of the order of 7m^3/s.

Looking at the estimation of storm flows for various events, it would suggest that the culvert has adequate capacity to cater for the 1 in 1000 year flood event (6.58m^3/s), even taking account of the effect of climate change on future rainfall profiles.

2.5 ASSESSMENT OF ACTUAL FLOWS DURING THE 26TH JULY EVENT

As stated in Section 1.2, Met Eireann do not operate a rainfall gauge in the general Letterkenny area that can give localized rainfall intensity data, which is needed to definitively calculate the actual flows experienced in the catchment on 26th July 2013.

To give an indication of the intensity of the event on 26th July 2013, based on rainfall radar data taken from the images provided by Met Eireann, and based on the catchment characteristics pertaining to the Sprackburn Tributary, a peak flow of in excess of 4m^3/s can be estimated, which on the basis of the figures in Table 2 corresponds to a 1 in 100 year flood event (0.1% probability). As stated earlier, the rainfall event on 26th July is estimated to have a 1 in 20 year probability of recurrence (5% probability). The difference between these probabilities is explained by the steepness of the catchment and other catchment characteristics of the Sprackburn Tributary that tend to exacerbate an intense rainfall event.

As stated earlier we would advise that the use of rainfall radar data to provide accurate local rainfall intensity values is limited, as there are a number of factors that can affect the reliability of the data given the remoteness of the Letterkenny area from the radar location in Dublin.

3. PROPOSED ENGINEERED SOLUTION

3.1 PROPOSED DESIGN

The hydraulic assessment of the existing culvert has shown that the culvert has adequate capacity to cater for the 1 in 1000 year flood event (corresponding to a peak flow of 6.58m^3/s). On this basis, and on the assumption that the peak flows experienced on 26th July were less than those corresponding to a 1 in 1000 year flood event, it would seem that the primary reason for the flooding incident on 26th July 2013 was the fact that the screens became blocked and prevented water from entering the culvert.

However in order to further mitigate the risk of a recurrence of the flooding at the hospital site, we have developed a design for a 1500mm diameter storm routing culvert along the western perimeter of the hospital site which will at least duplicate the capacity of the existing culvert and operate in the event that a blockage to the existing culvert prevents any storm water flowing into it.

The proposed storm flow routing culvert has the following characteristics:

- Entry invert level: 63.69mOD
- Invert level at end point: 50.12mOD
- Total length: 448m
- Average Gradient: 1 in 33
- Design flow: 6.58m3/s (for 1 in 1000 year flood event)

On the basis of the above parameters, the CIRIA Culvert Design Manual Report 168:1997 estimates the maximum capacity of the proposed culvert to be 11.84m3/s, giving a factor of safety of 1.8.

The route of this storm routing culvert is shown in Appendix B.

3.2 SITE INVESTIGATION

The ground investigation works at Letterkenny General Hospital commenced on 15th August 2013, and was undertaken by Irish Drilling Ltd. The investigation involved rotary drilling of boreholes and the excavation of trial pits on the western side of the hospital site. Rotary drilling took place at seven locations while a total of eight trial pits were excavated.

During the works, interim data was submitted to TOBIN in the form of data sheets showing all trial pit information along with data sheets showing information from two of the rotary drilling locations. The information from the rotary drilling reveals the presence of quartzite rock at a depth of approximately 5.0m below the top of the embankment close to the Psychiatric Unit. The ground investigation works were completed on 23rd August 2013. Irish Drilling Ltd have also employed AGEC geotechnical engineering consultants as a sub-contractor to carry out the required slope stability analysis of the existing embankment at the Psychiatric Unit to ensure that the ground at that location is suitable for the works.

The results of the ground investigation have informed the design of the new culvert.

3.3 PLANNING PERMISSION

Following discussions with Donegal County Council Planning Department, it became apparent that the construction of the proposed culvert would require planning permission. This application was lodged on Friday 13th September 2013. The statutory display period for this application runs to Friday 18th October 2013, following which Donegal County Council have a three weeks to assess the application. Following this assessment and assuming that Further Information is not requested, a period of four weeks is required before a Grant of Permission can be issued by the Planning Authority.

3.4 SCREEN DESIGN

Given that the on 26th July 2013 a significant amount of debris from the Sprackburn Tributary catchment arrived at the screen protecting the culvert entrance, and that the blockage of the screen caused by this debris was the most likely cause of the flooding of the hospital, it is prudent to review the design of these existing screens and consider alternative screening arrangements that would reduce the risk of a recurrence of similar screen blockage. Consequently, we are currently carrying out such a review against various guidance documents for trash and security screens, including UK Environment Agency's Trash and Security Screen Guide, 2009.

3.5 SELECTION OF WORKS CONTRACTORS

We have identified three contractors who we believe have the skills and capacity to undertake the proposed works in the timeframe envisaged in the programme. We have initiated discussions with these contractors regarding their methodologies for carrying out the works.

3.6 NEXT STEPS

We now seek agreement on the proposed engineering solution at the hospital site, and we propose to proceed with the procurement of a competent contractor to construct the necessary works.

Appendix A

Estimation of the Design Flood – Key Parameters

The following catchment descriptors were used in the assessment of the design flood for the catchment upstream of the culvert at the hospital site.

Table A1 Catchment Descriptors

Descriptor	Value
Catchment Area	1.63 km^2
Main Stream Length (MSL)	1.72 km
Gradient of the river between 10% and 85% of MSL u/s of the site (S1085)	65.76 m/km
Annual Average Rainfall (SAAR)	1,469 mm
Fraction of urban catchment (URBAN)	0.2
Soil Moisture Deficit (SMD)	4.00 mm
Soil Index (SOIL)	0.40

In relation to the SOIL index used, Figure A1 shows the principal soil types in the Letterkenny area. The Podzolic nature of the soil is of average permeability and for this reason we have assigned a SOIL index of 0.4 to the calculations.

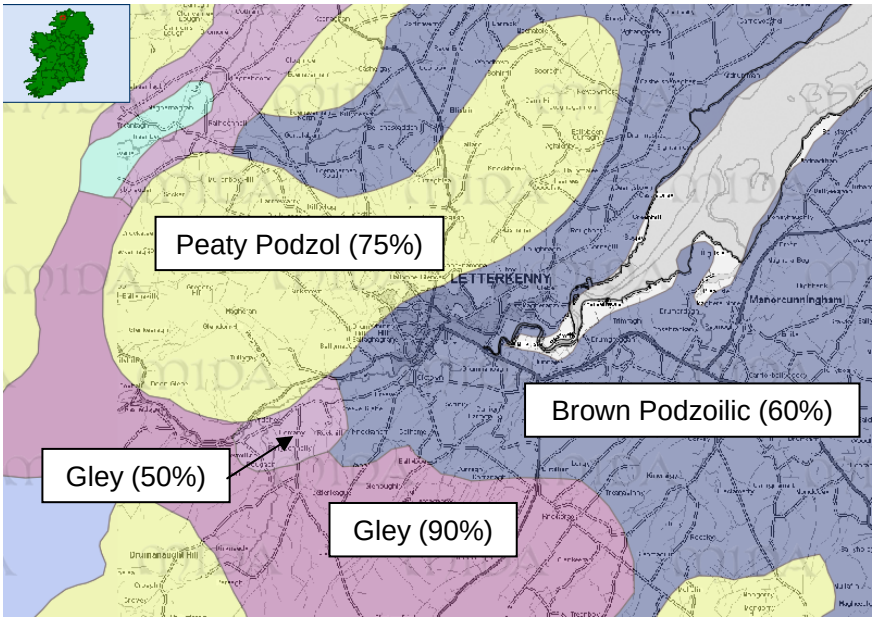


Figure A1 Soil Classification

Other key parameters used were:

- 2 day rainfall total with a return period of 5 year (2DM5) = 65.5mm (ref: www.met.ie)
- R = 30% (Wilson 1990).

The UK Flood Studies Report (1975) and Flood Estimation Handbook (1999) both recommend the use of a triangular Unit Hydrograph with the following formula for Time to Peak (T_p) in terms of catchment length and channel slope:

$$T_p = 46.6\, S^{-0.38} {R_{smd}}^{-0.4} (1+U)^{-1.99} L^{0.14}\ hours$$

$$Q_p = \frac{220}{Tp} cumec/100km^2$$

$$T_B = 2.52\ T_p$$

From this a synthetic Unit Hydrograph was developed for the catchment (Figure A2 below). This represents the quick response runoff resulting from 1cm of rain which falls uniformly over the catchment for one hour. Rainfall values were taken from the Flood Study Report, as shown in Table A2.

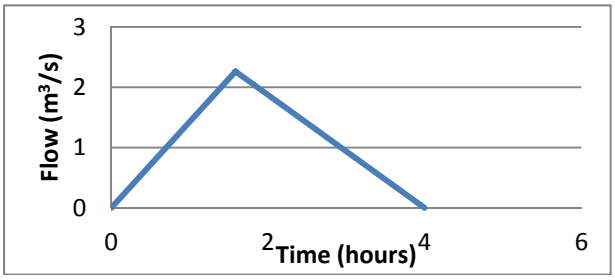


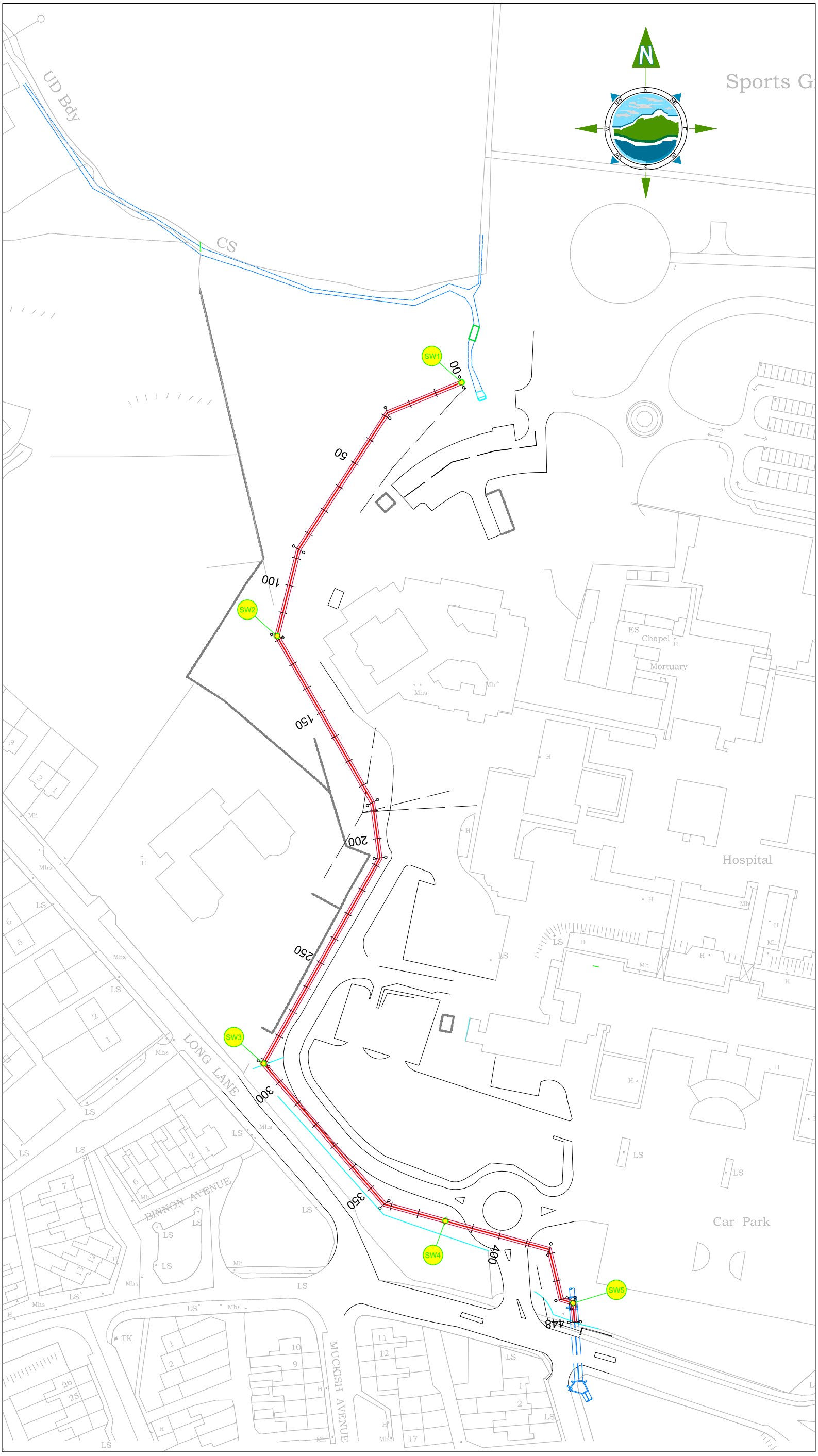
Figure A2 Synthetic 1-hr Unit Hydrograph

Table A2 Rainfall Values (source: FSR)

Time (min)	5 year rainfall (cm)	140 year rainfall (cm)	1000 year rainfall (cm)
0	0.02	0.05	0.08
20	0.04	0.08	0.13
40	0.05	0.11	0.18
60	0.08	0.16	0.27
80	0.13	0.26	0.44
100	0.19	0.40	0.66
120	0.08	0.17	0.29
140	0.08	0.17	0.29
160	0.19	0.40	0.66
180	0.13	0.26	0.44
200	0.08	0.16	0.27
220	0.05	0.11	0.18
240	0.04	0.08	0.13
260	0.02	0.05	0.08
280	0.02	0.05	0.08

Appendix B

Drawing Showing Route of Proposed New Culvert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