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# 1 Project background and objectives

## 1.1 Introduction

It is important to understand the geomorphic processes and subsequent response to any flood relief scheme arising to the direct impact that they can have on altering flood capacity and changing flood risk levels. It is also important in terms of maintaining or improving biotic and hydromorphological health through the creation and development of ecological habitats impacting on water body hydro-geomorphological status which is a fundamental component of the European Water Framework Directive (WFD).

The Glashaboy River FRS study aims to assess and develop a viable, cost-effective and sustainable flood alleviation scheme. This scheme must consider potential system dynamics and associated issues linked to changing patterns of erosion and deposition, ensuring that any depositional sites are minimised and that where sediment is predicted to accumulate that it does not compromise the flood capacity of the scheme. Geomorphological issues linked to erosion and deposition can be efficiently investigated through a desk and site based fluvial audit. The process based knowledge gained from the exercise will inform the development of a conceptual model of system dynamics predicting likely patterns of channel change.

This report is provided in the following layout:

- Main body of the report summarises the hydromorphic audit which involved a catchment baseline survey, a summary of system function (past, present, and future geomorphic processes), and assessed the options for the FRS at a high level.
- Appendix A (Geomorphology Addendum 2016) provides a geomorphic assessment of the outline design of the Glashaboy Flood Relief Scheme, which informed the EIAR for the scheme when it was submitted for planning permission in 2018.
- Appendix B (Geomorphic Impact Assessment 2020) provides a geomorphic assessment of the detailed design in response to further detail requested in an RFI received by the Department of Public Expenditure and Reform. Appendix B provides the most detailed assessment of the proposed scheme measures and predicted impact on sediment transport and should be considered in response to the RFI. This addendum informs the EIAR addendum submitted for Further Information in 2020.

## 1.2 Assessment Methodology

### 1.2.1 Overview

The existing geomorphological processes have been assessed through a high level hydromorphic audit involving a catchment baseline survey and local fluvial audit to determine the historic, current and likely future dynamics of the river, paying particular attention to the sediment transport regime (coarse and fine) and associated patterns of erosion and deposition. The audit has concentrated on the Glashaboy River but has also considered wider system response to disrupted / altered flow and transport processes.

The findings of the audit have been used to develop a conceptual model of the form and dynamics of the interacting watercourses allowing predictions of system response to be made regarding potential flood works throughout the catchment. This model will be key in ensuring a sustainable, Water Framework Directive (WFD) compliant solution to the flooding problems is found that minimises hydromorphic impact elsewhere.

### 1.2.2 Sub-catchment baseline survey

This is a process based audit of the Glashaboy River catchment and tributary channels, providing a clear and simple qualitative understanding of how the river system functions. The audit required a walkover survey associated with a review of online archival sources (aerial photographic evidence, historic flow data, archive planform change information from OS maps and previous studies of the regional geomorphology where available) together with any information provided by the client.

### 1.2.3 Fluvial audit

The fluvial audit includes a field based survey reviewing the present state of the watercourse morphology and active processes. It identifies key locations where erosion and deposition are impacting on the river and links this to the wider sediment delivery, transport and storage regime to assist in sustainable scheme design and minimise future maintenance requirements.

### 1.2.4 Development of regional channel change models

The baseline and audit information have been utilised to construct a larger scale cascading model of sediment flux through the catchment and drainage network based on local channel character with channel segments responding to adjacent and upstream sediment inputs. The model also predicts potential channel evolution to altered flow and catchment conditions in the catchment and locally, potentially allowing targeted action at sediment source areas which will reduce erosion and deposition problems through the scheme.

# 2 Existing Catchment Conditions

## 2.1 Overview

The Glashaboy River rises in the Nagles Mountains to the North of Cork and flows in a southerly direction entering the Upper Cork Harbour downstream of Glenmire. The upper reaches are predominantly rural, however, the catchment becomes more urbanised in its lower reaches.

The geology of the catchment is predominantly sandstone till overlain by a cover of acid brown earth soils offering free drainage. The lower reaches are underlain by limestone. Low hills dominate the catchment with steeper sloping valleys located to the north.

The Glashaboy catchment is drained by a number of watercourses, the main one being the River Glashaboy which drains land to the west of the catchment. The Butlerstown River and Glenmore River join the Glashaboy at Genmore and drain land to the east.

The lower reaches of the Glashaboy are tidally influenced (up to Glanmire). The fine sediment dynamics of the Cork estuary result in deposition of extensive mud flats through Lough Mahon. However, there is no significant deposition of tidally derived silts along the Glashaboy, suggesting that depositional processes are largely controlled by fluvial processes.

## 2.2 Water Framework Directive status

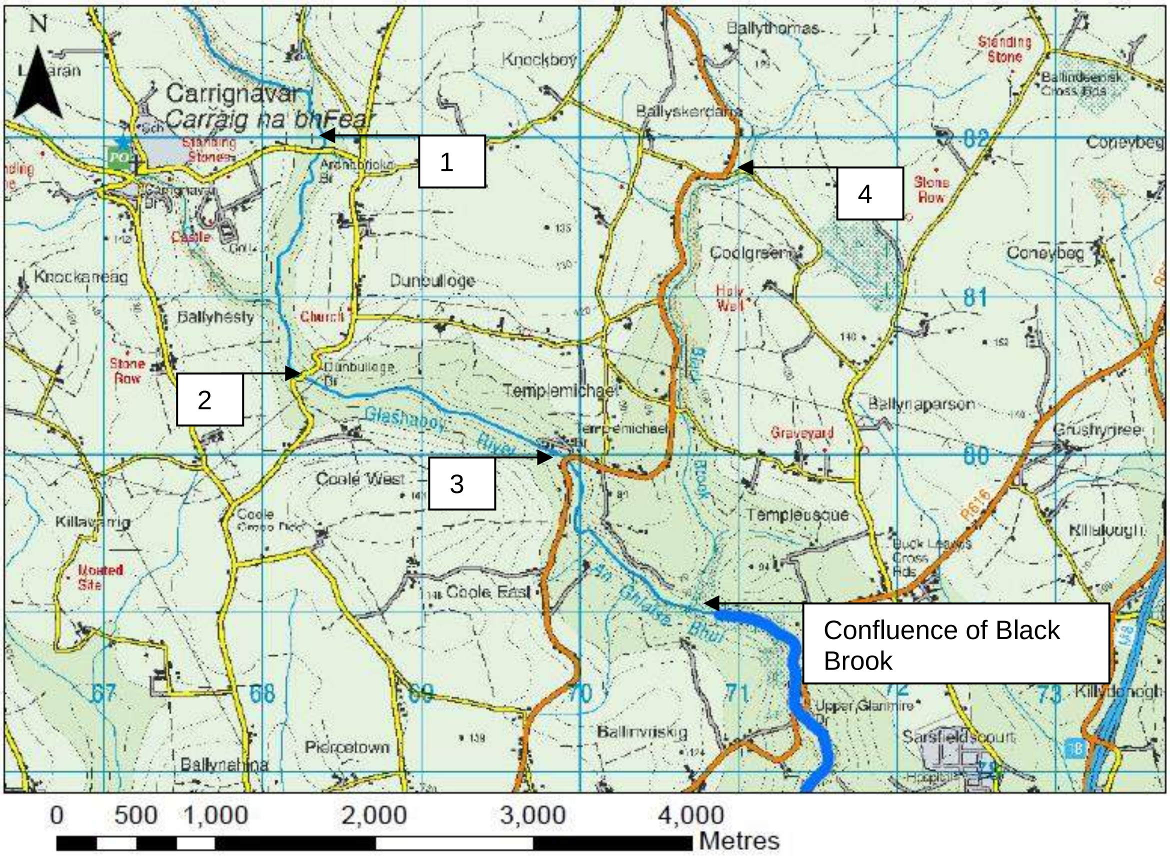
The Glashaboy River is currently classed as being at a Moderate status, whilst its tributaries the Glenmore River and Butlerstown River are classed as being at Good status (with the upper reaches of the Butlerstown river classed as moderate status). All reaches need to achieve 'Good Ecological Status' by 2027.

# 3 Fluvial Audit

This section of the report summarises the qualitative findings of the geomorphological / fluvial audit conducted on the Glashaboy River and the lower sections of the Butlerstown River and Glenmore River during April 2014 and August 2016, following the large flood events of 2015. Tidal reaches were visited at low tide to maximise the opportunity to view the bed conditions within the watercourse / estuary.

## 3.1 Carringnavar to Upper Glanmire Bridge

Figure 3-1 Survey Reach Overview



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The upper sections of the Glashaboy between Carringnavar to Upper Glanmire Bridge (1 to 2 on Figure 3-1) are predominantly rural. The floodplain in most locations is narrow and dominated by farmland and woodland. The channel exhibits a pool-riffle morphology which is dominated by a cobble and gravel bed, with little evidence of significant transport of cobble and gravel sized material given the amount of bed algae present across this sediment (Figure 3-2). Limited large accumulations of gravel as bar features were noted even in areas where the gradient was reduced. This suggests a limited upstream supply of gravels and/or the ability of the channel to flush sediment downstream during higher flow events.

Stable vegetated bars were common throughout the reach (Figure 3-5) along with small pockets of fine sediment deposition along the lateral edges of the channel, mainly from localised bank erosion. Small areas of deposition like this are often an indication of the channel naturally attempting to narrow as a result of historic intervention, such as over widening. Several low weirs exist (see example in Figure 3-2), which cause limited upstream impoundment, but act to cause increased fine sediment deposition within their impoundment zones. Limited evidence was noted of weirs restricting movement of gravels.

Evidence within the reach of historic channel management exists, including old dredging embankments (Figure 3-3) and channel straightening. Channel straightening and dredging has led to some disconnection of the channel from its floodplain in certain areas (although this is not excessive in the upper reaches). Modifications to the channel such as dredging and straightening concentrates in-channel energy, due to reduced stream length. This may also explain the lack of gravel deposition seen in some areas.

Opportunities exist to improve connection through embankment removal and re-grading (Figure 3-5). This should act to improve floodplain storage in these upper reaches and act to reduce downstream flood risk.

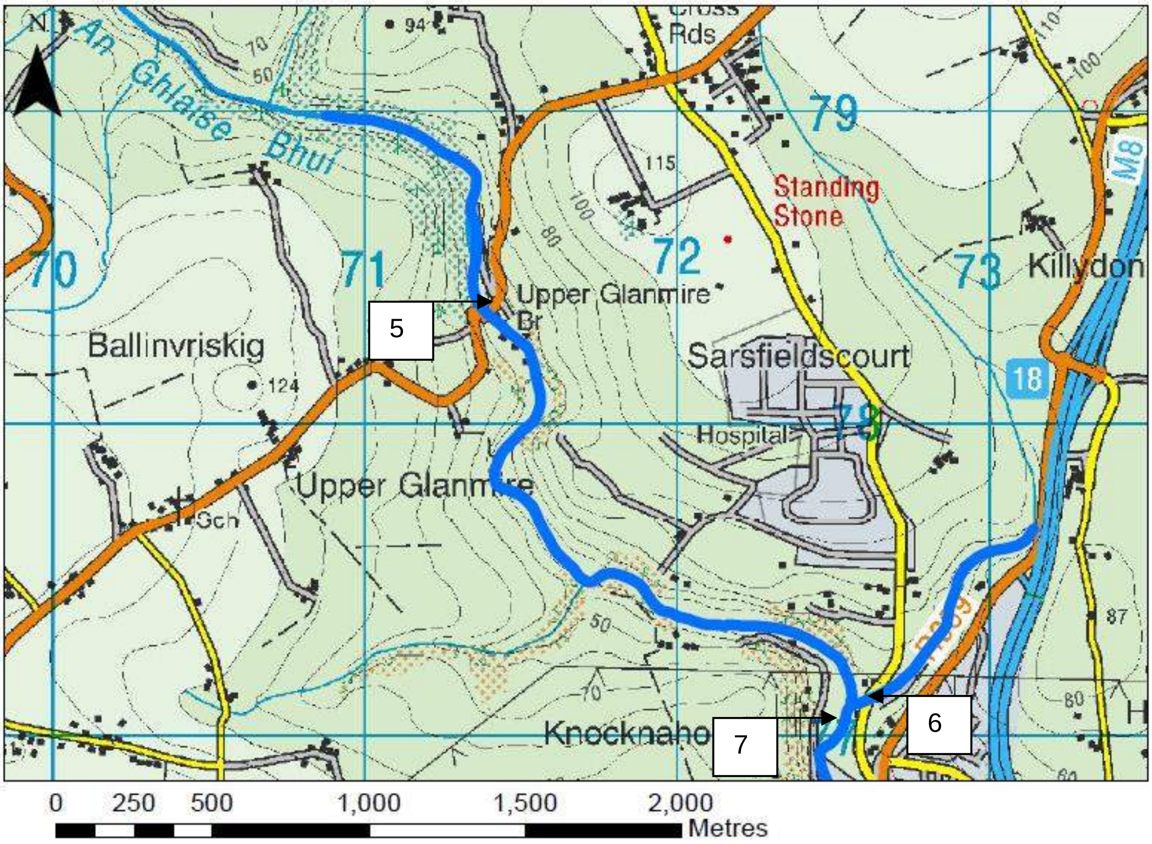
Figure 3-2 Ardnabricka Bridge (Point 1)

Figure 3-3 Dunbulloge Bridge (Point 2)

Figure 3-4 Templemichael Bridge (Point 3)

Figure 3-5 Upstream of Ballyskerdane Bridge (Point 4)

## 3.2 Upper Glanmire Bridge to Knocknahorgan



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In the reach between Upper Glanmire Bridge and Knocknahorgan the river valley narrows which results in a confined floodplain. At Upper Glanmire Bridge a weir is leading to local bank erosion (Figure 3-6), due to the direction of flows passing under the bridge. Banks have been reinforced using gabion baskets, however, in the long term the river may undercut these baskets.

Downstream of Upper Glanmire Bridge, flow energy in the channel reduces and areas of gravel and small cobble deposition occur (sizes of gravels range from 4cm to 40cm). Gravel splays occur at tributary confluence points (Figure 3-6) along this section, suggesting an active supply of gravels is present from the steep tributaries joining the river (Figure 3-7).

Figure 3-6 Upper Glanmire Bridge (Point 5)

Like the upper sections above Glanmire, bankside vegetation remains dense in many places which acts to improve bank stability through cohesive root networks. In areas where vegetation was less dense small pockets of erosion were noted, but this was certainly not widespread.

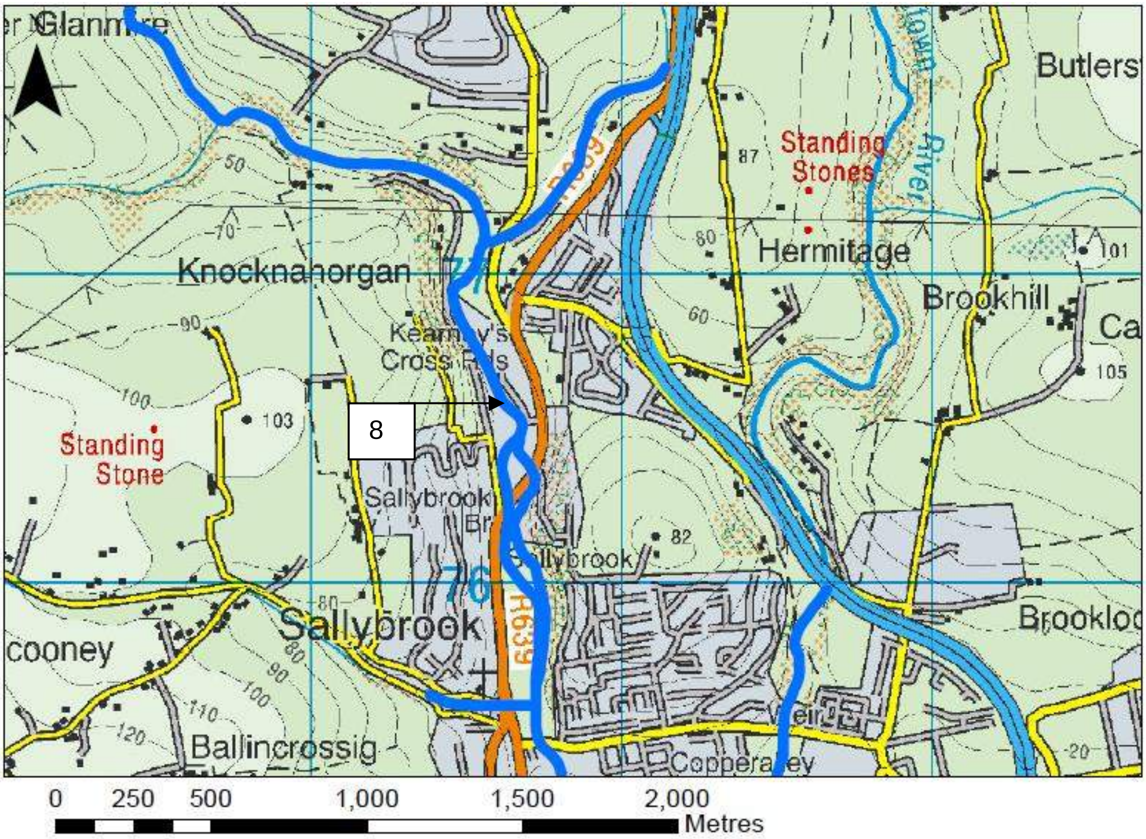
Figure 3-7 Knocknahorgan tributary (Point 6)

Figure 3-8 Knocknahorgan (Point 7)

The channel bed throughout this reach is again dominated by gravels and cobbles, in a plane bed and pool riffle morphology. Less algae was seen on the more gravelly sections on the bed which suggests a more active supply and movement of gravels through this reach (Figure 3-8).

## 3.3 Knocknahorgan to Sallybrook

Figure 3-9 Reach overview



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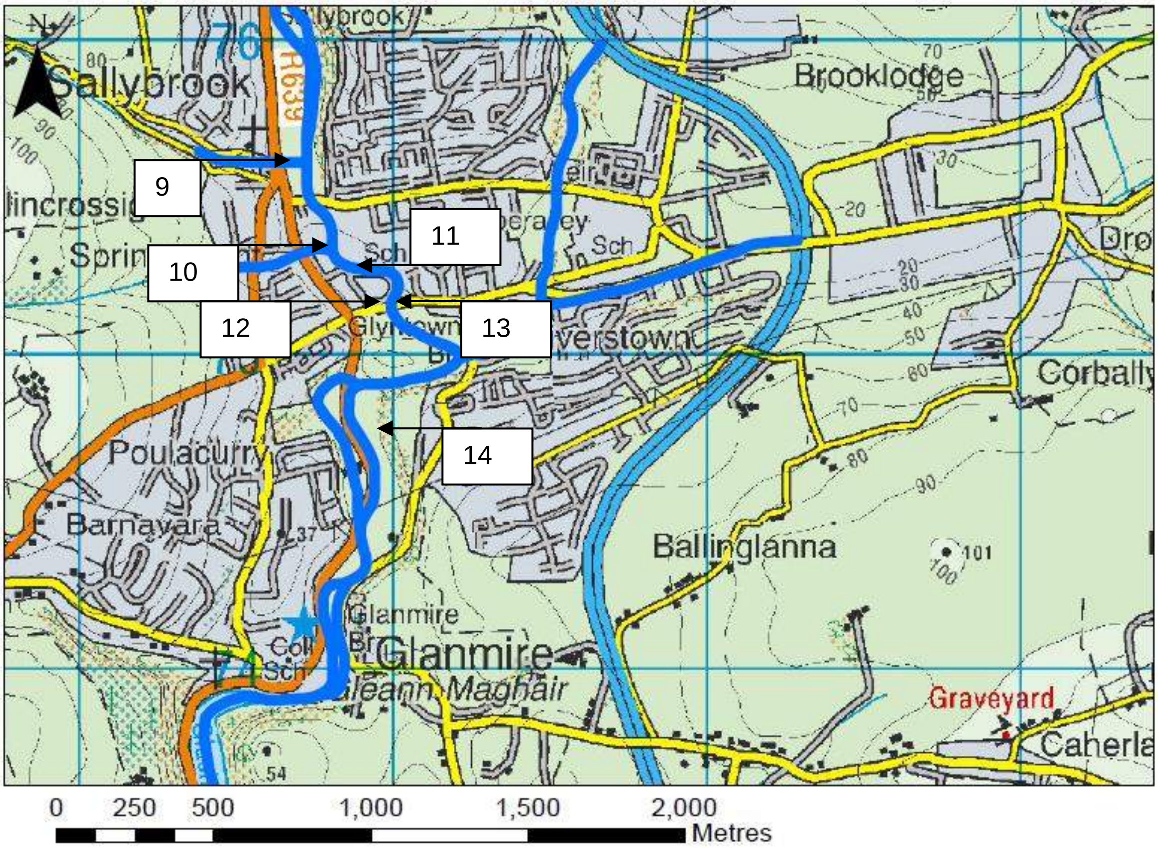
As the river approaches Sallybrook the channel and its floodplain become subject to greater urban influences including embankments, weirs and limited floodplain connectivity due to the presence of flood embankments.

Figure 3-10 Channel upstream of Sallybrook (Point 8)

As the channel approaches Sallybrook the valley widens and becomes less confined. The wider floodplain along this reach has been developed / built upon which acts to constrict the channel. In some areas informal flood embankments have been constructed. In other areas active bank erosion is occurring as the channel attempts to naturally adjust within is confined channel. This is exacerbated by the higher energies during flood conditions as a result of the channel constriction. Hard measures, such as walls have been constructed to reduce the erosional impact of the river (particularly on the outside of bends) and some of these are now failing (such as adjacent to the petrol station). The erosion of banks acts as a strong sediment supply of gravels and fine materials. Deposition is also common through this reach, with several gravel bars (which are unvegetated, signalling frequent movement ) being present. However, in the lower portions of the reach the channel becomes incised as a result of the influence of old mill leats and weirs (some existing and some now removed). As a result of these structures the channel is disconnected by over 1m from the floodplain (due to the channel eroding downwards in an attempt to adjust its bed gradient) and deposition is minimal, due to floodplain disconnection and high in channel energy levels. The channel in this lower section is dominated by coarser cobbles.

## 3.4 Sallybrook to Glanmire

Figure 3-11 Reach overview



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Downstream of Sallybrook the channel flows through a narrow urban corridor. The channel remains slightly incised, possibly due to historic straightening due to protected river banks. Sediment is delivered to this reach via several steep tributaries.

Figure 3-12 Downstream of Sallybrook (Point 9)

Figure 3-13 Adjacent to the Glanmire shopping centre (Point 10a)

Figure 3-14 Adjacent to the lower area of the Glanmire shopping centre (Point 10b)

At the Glanmire shopping centre several areas of bank instability exist (Figure 3-13 and Figure 3-14). The channel at this point is confined and relatively narrow compared to reaches upstream. There is limited deposition due to the steepness in some sections and disruption from upstream to the sediment transport process. The channel banks are high in most locations due to land raising and embankments. As a result, during flood conditions all energy is concentrated within the channel which is leading to bank erosion and instability. In many places existing bank protection has been undermined and has collapsed into the river. This section appears to be starved of sediment, suggesting upstream structures, such as the old weirs are influencing in-channel processes. As a result, the channel has excess stream power leading to the erosion processes along the beds and bank. In order to reduce the flood impact and erosion within this section various options could be investigated including flood storage options upstream and also improving the in-channel morphology which is currently degraded, to manage the existing high energy conditions.

Downstream of the shopping centre the channel widens slightly. Flood defences exist, which protect an adjacent housing estate. The defences act as a constraint to the channel in terms of its floodplain connection. The wider nature (Figure 3-15) of the channel here has allowed for the deposition of some sediment (dominated by fines). In the majority of cases the depositional features are vegetated which suggests that the channel has reacted following past intervention (i.e. it has adjusted to a more natural narrow channel), probably as a result of the construction of the flood defences. This indicates that if any future maintenance of this section occurs (such as sediment removal or flood defence improvements) deposition of this nature will continue to occur.

Figure 3-15 Defences downstream of the Glanmire shopping centre, adjacent to the housing estate (Point 11)

Downstream of the housing estate the channel enters a parkland area and connection to the floodplain is improved. In areas of the channel where flows are reduced fine sediment deposition is occurring (Figure 3-16) and in some areas small pockets of gravels (Figure 3-17) have been deposited, however, gravel deposition is not widespread. If sediment is removed as part of any future maintenance works, it should be expected that sedimentation will re-establish itself naturally.

Figure 3-16 Upstream of the park (Point 12)

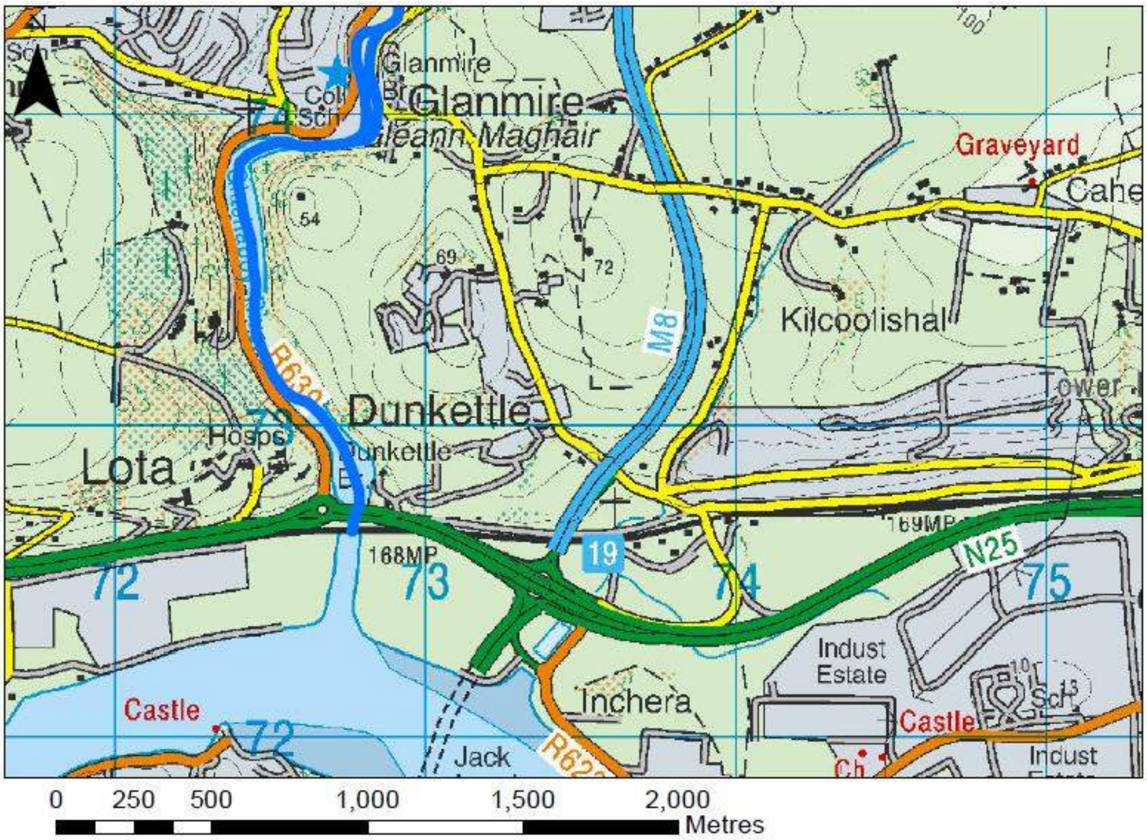
Figure 3-17 Parkland area (Point 13)

In the downstream section of the park a weir exists, which historically was used to feed a mill leat (which is still active). This causes upstream impoundment through the park increasing fine sediment deposition (Figure 3-18). Downstream of the weir some minor scour has occurred along with a small area of gravel deposition, in a classic weir pool morphology. The channel then enters a canalised section with steep walls on both banks which act to prevent any channel migration. As a result, flows within this section have the ability to transport gravels downstream resulting in little deposition apart from coarser sediment at the edges of the channel through this section.

Figure 3-18 Impoundment (Point 14)

## 3.5 Glanmire to Lough Mahon

Figure 3-19 Reach overview



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At Glanmire bridge, deposition of gravels is occurring on the left bank (Figure 3-20). Downstream of the bridge the river gradually becomes wider and eventually is influenced by the tidal regime. This influences water levels and flow conditions downstream of Glanmire, resulting in some deposition of tidally derived muds and silts. The deposition of this sediment appears low therefore there is little risk of increased sedimentation in this section.

Figure 3-20 Sections downstream of Glanmire

## 3.6 Summary of system function

The upper sections of the Glashaboy are generally steep and well connected to the floodplain. The upper sections of the channel are generally stable with a stable armoured bed (vegetated in parts). Fine sediment being delivered from upstream is generally at a low level and this material appears to be moving through the upper part of the system rather than accumulating as bar deposits. However, more evidence of fine sediment deposition was noted in the lower, more modified reaches of the channel. Gravel inputs from upstream appear limited, however several steep tributaries deliver gravels into the system at regular points along the reach.

In the lower reaches, the channel is sensitive to surrounding urban land use and past historic modifications. In some modified sections the channel has become degraded (i.e. a lack of flow has resulted in excessive fine sediment deposition) and in other sections in channel measures to modify the channel are not working with in-channel processes (such as deposition and transportation). As a result, several significant areas of bank erosion and instability exist. These influence local sediment supply and deposition. In most cases ad-hoc bank protection has been used, but evidence suggests after several years this will fail and / or require maintenance.

Tidal fine sediment inputs are similarly very low. The deposition of this sediment appears low (i.e. no large accumulations) therefore there is little risk of increased sedimentation in this section.

# 4 Flood Relief Options Review

## 4.1 Introduction

Due to the iterative nature of design of a flood relief scheme, outline designs of the major works were assessed from a geomorphic perspective. These initial findings are discussed in Appendix A and have been used in the detailed design of the scheme. Further review of the final scheme design is provided in Appendix B.

## 4.2 Sallybrook Industrial Estate

### 4.2.1 Option 1A

Figure 4-1 Typical conditions upstream of the industrial estate

This is a moderately active section of the channel upstream of the mill leat with a gravel / cobble bed that is partly mobilised during higher flows. The river is disconnected from its floodplain in several locations through this reach as a result of informal flood defences. This elevates in-channel energy levels during higher flows, preventing formation of significant gravel features. Under existing conditions, flow velocities vary between 1.0-2.4m/s for bankfull flows upstream of the mill leat, that are capable of moving medium to large gravels. Downstream of the old mill, the channel is moderately incised and the channel bed is dominated by cobbles. Bankfull flow velocities through this section range from 0.2-2.2m/s.

The proposed works for this reach appear to be formalising the existing flood embankments and creating a flood defence wall that ranges between 0.6-1.1m above existing ground levels and tying into existing embankments at one location. As the channel is already moderately disconnected form the floodplain as a result of incision and the informal flood embankments, there is a moderate impact on existing flow hydraulics for the Q100 and Q2 event, with flow velocities increasing by 0.1-0.2m/s. This is unlikely to significantly change the sediment regime through this reach.

As a result, there may be a low level increase in delivery of sediment to downstream reaches as a result of the elevated energy levels created by the increase in length of flood defence embankment.

## 4.3 Hazelwood Shopping Centre

Figure 4-2 Typical conditions adjacent to the shopping centre

This reach is an active section of the river, with bank erosion common. Bank erosion is particularly occurring on the bend upstream of the confluence. There is a decent supply of sediment from upstream and adjoining steep tributaries. Historic straightening, possible dredging, informal flood embankments and bank protection works all act to increase energy levels during the channel during elevated flows as a result of the disconnected floodplain, loss of channel length through straightening and restriction of lateral processes. The channel is also relatively narrow through this section when compared to upstream reaches which again increases in-channel energy levels during elevated flows. This means there are few depositional features on the channel bed despite the strong supply of sediment to the reach.

### 4.3.1 Option 2A Direct defences (with conveyance improvements on Cois na Gleann Stream)

The set-back defences in the upper part of this reach for this option still allow some connectivity to the floodplain and are therefore unlikely to significantly influence the existing flow and sediment regime at this point. Through the section where new flood walls and embankments are proposed, velocities for the Q100 event increase by 0.2-0.3m/s. Existing velocities of up to 2.4m/s for a Q2 flow are capable of moving large gravels and the increases in velocities as a result of the proposed works will still fall within this mobility range. This quantifies the existing erosion witnessed through this reach.

The proposed works will result in some change to the existing dynamics through the reach as a result in the increase in length of online flood embankments. These are unlikely to help the river reach WFD status objectives although they are unlikely to result in significant deterioration (small risk of change from current).

### 4.3.2 Option 2B Conveyance improvements (dredging)

Dredging of this reach will increase the carrying capacity of the channel which is achieved through increasing the depth of the channel. The banks through this reach are already steep and unstable and would become even more unstable as a result of the overdeepening created by the dredging. In combination with the high velocities through the reach, bank failure and erosion is likely to increase unless significant protection works are undertaken. There is a strong supply of sediment to the reach from upstream reaches and adjoining tributaries, therefore dredged material will soon be replaced. Removing the sediment from the channel will put the reach into a state of disequilibrium, meaning the channel will seek to redress the sediment balance by increased erosion immediately upstream (risking propagation of incision upstream) and increased local bank erosion.

This option is unlikely to be WFD compliant due to negative impacts on geomorphological conditions locally and upstream.

### 4.3.3 Option 2C, 2D and 2E Combination of direct defences and conveyance improvements (Arrangement 1, 2 and 3)

This option is likely to have similar impacts to option 2A as the online flood walls and embankments in the downstream section of the reach are proposed. However, the proposed wider bridge will improve flow and sediment conveyance to downstream reaches, reducing the impacts on the sediment processes here during higher flows and therefore improving sediment continuity as a result of the reduced impounding effect associated to the existing structure.

For option 2D, the localised channel widening could encourage some localised deposition of gravel. The modelling shows a 0.1-0.2m/s reduction in flow velocities at this point, however, the velocities are still energetic enough to transport small to medium gravels.

For option 2E, the new flood relief culvert alongside the bridge is unlikely to achieve significant benefit in reducing energy levels and encouraging deposition of gravel locally as option 2D. The replacement of the downstream bridge will improve flow and sediment conveyance to downstream reaches as a result of the single span footbridge that is proposed. There is a 0.3m/s increase in the Q100 flow velocity immediately upstream of the proposed footbridge that supports this conclusion.

The proposed works will result in some change to the existing dynamics through the reach as a result in the increase in length of online flood embankments. These are unlikely to result in significant deterioration in WFD status (small risk of change from current).

## 4.4 Meadowbrook Housing Estate

### 4.4.1 Option 3A Direct Defences (with conveyance improvements on Springmount Stream)

Figure 4-3 Typical conditions adjacent to Meadowbrook Housing Estate

In the section of the river downstream of the shopping centre the channel widens slightly. Flood defences exist on the right bank, which protect an adjacent housing estate. The defences act as a constraint to the channel in terms of its floodplain connection. The wider nature of the channel here has allowed for the deposition of some sediment (dominated by fines). In the majority of cases the depositional features are vegetated which suggests that the channel has reacted following past intervention (i.e. it has adjusted to a more natural narrow channel), probably as a result of the construction of the flood defences and disconnected floodplain over the right bank.

The replacement and building of the flood wall through this reach increases the Q100 flow velocities by 0.1-0.2m/s. These flows are capable of mobilising medium to large gravels. The increase in velocities for flows impacted by the flood walls will result in more sediment being mobilised and transferred to downstream reaches compared to existing conditions.

The proposed works will result in some change to the existing dynamics through the reach as a result in the increase in length of online flood embankments. These are unlikely to result in significant deterioration in WFD status (small risk of change from current).

## 4.5 Butlerstown / Glenmore

### 4.5.1 Option 4A Conveyance improvements

This reach of the river is moderately active and has been historically straightened that has acted to increase in channel energy levels during high flows. This prevents formation of any significant morphological features on the channel bed. The structures on the Butlerstown Stream provide a constriction that is likely to impact the flow and sediment regime at higher flows.

The proposed works aim to improve the conveyance through inclusion of flood relief culverts, a new flood embankment and works to existing walls.

The new flood embankment is likely to increase in channel energy levels that may result in erosion and transport of sediment on the channel bed. For the Q100 event, velocities increase by up to 0.5m/s from a maximum of 2.0-2.1m/s within the reach where the new embankment is proposed on the Glenmore Stream. This is a significant increase and could change the channel morphology within this reach as larger gravels will be able to be transported with the higher velocities.

Replacement of the culvert upstream of the M8 on the Glenmore stream will alter the sediment regime as the new culvert will be larger and laid at a suitably slacker gradient. Regrading of the upstream and downstream channel to accommodate the new culvert will cause a local change in geomorphological conditions, and this may alter the sediment dynamics downstream. Use of appropriate mitigation measures for new culverts, as detailed in the CIRIA C689 Culvert Design and Operation Guide and IFI (2016) Guidelines on Protection of Fisheries During Construction Works in and Adjacent of Waters will be required. Introduction of some pools and riffle sequences should be considered in this reach.

The potential impacts on the flow and sediment dynamics through the reach along Glenmore Stream may change the geomorphological condition of the channel. Monitoring and appropriate mitigation measures should be used to offset this potential change.

### 4.5.2 Option 4B Combination of direct defences and conveyance improvements

This option is similar to option 4A with the addition of a flood defence embankment that is to be set back from the channel over the right bank. As the embankment is to be set back on the Butlerstown Stream, there is limited impact on the hydraulics through this reach for the majority of flows. Otherwise, similar impacts to those described above will be experienced.

## 4.6 O'Callaghan Park to Glanmire Bridge

### 4.6.1 Option 5A Direct Defences

Figure 4-4 Typical conditions through O'Callaghan Park

This reach is characterised by a moderately active channel with some deposition of gravel and fines and some embryonic riffle pool sequencing. There is an impounded section of watercourse within this reach as a result of the large weir downstream, this creates elevated levels of fine sediment deposition on the channel bed. There is some evidence of bank erosion outside of the impounded area.

Of the works proposed here, the majority are set back flood defences that are relatively minor and protect localised areas that are unlikely to significantly impact the geomorphological processes of this reach. The only section that may result in elevated in channel energy levels for higher flows is the option for a new flood defence wall at St Patricks Mill. This was predicted to increase flood disconnection, and containment of flows in the channel, elevating energy levels that may promote increased erosion of the channel bed and banks. It would have also result in more flow and sediment being conveyed downstream. As a result, the option was discounted in favour of individual property protection.

# 5 Conclusions and next steps

The geomorphological audit has shown that the Glashaboy is presently not actively transporting much gravel sized material. The river in its upper reaches has good floodplain connectivity, but in its lower reaches, as the urban influences encroach into the channel and floodplain and confine the river corridor, instabilities in the channel occur and erosional processes increase.

Sediment deposition is generally at a low level. The main supply of sediment into the system is from bank erosion, steep tributaries and glacial sediment re-working (in the very upper reaches). Run off from agricultural areas also inputs fine sediment in to the system with limited buffer strips due to a poor quality riparian zone in many locations. Where sediment accumulation issues exist within the system these tend to be as a result of modifications to the channel which has acted to disrupt the natural river system processes. This includes impoundment disrupting the downstream transport of sediment, over widening which reduces channels velocity (increasing sedimentation), channel narrowing increasing velocities (decreasing sedimentation and increasing bank erosion) and poor placement of in channel features and structures.

In relation to potential flood management solutions, opportunities exist to improve floodplain connectivity in several areas upstream of urban locations. This could help reduce flow energy causing erosion in key areas such as adjacent to the shopping centre. However, the steepness of the banks adjacent to the shopping centre and the limited easement between the top of bank and buildings means careful consideration should be given to bank stability, as the current ad-hoc method of bank protection could lead to long term issues. On the tributaries culvert replacement works are planned, and sediment transport processes will be temporarily impacted. The mitigation measures detailed in CIRIA C689 Culvert Design and Operation Guide and IFI (2016) Guidelines on Protection of Fisheries During Construction Works in and Adjacent of Waters will be required for culverts and for fish passage will be required to reduce the long term impact of these works. A review of the effectiveness of these measures should be undertaken towards the end of the construction programme and any adjustments made to manage any potential erosion activity adjacent to new culverts and bank works.

# A Appendix A: Geomorphology Addendum (August 2016)

## A.1 C09_B01: Replace existing twin 0.9m dia. culverts with new 1.6m by 1.2m high rect. culvert

Bleach Hill Stream at this location is entrenched (overly deep). As a result there is little floodplain connectivity except when flood water backs up behind the structure. The stream is dominated by a gravel and cobble bed which appears partially mobile (i.e. limited evidence of armouring). During flood conditions it is likely that this sediment will be mobilised and transported downstream, whilst new sediment will be delivered from upstream reaches. Due to the existing small culverts some sediment has accumulated upstream of the bridge. Whilst the existing culverts appear to be capable of allowing sediment to move downstream, it is likely that the culverts frequently become blocked with trash and debris which will hinder sediment continuity to downstream reaches.

The proposed larger culvert will improve sediment continuity through the system. The existing bed material should be maintained and matched where possible, however, any disturbance to the bed will quickly be rectified during subsequent high flow events. High flows event will be capable of transporting sediment to the structure from upstream reaches and the bed will quickly re stabilise.

## A.2 C01_L01: Concrete flood defence (Old weir at Petrol Stn North of Sallybrook)

There is an impounded reach upstream of an old weir adjacent to the petrol station. The weir is partially collapsed and appears unmaintained. The reach upstream of the weir exhibits low velocities due to the impoundment impacts. The weir has also, over time acted to trap sediment upstream which in turn has elevated the upstream channel bed level.

The main flow route over the weir is towards the left bank (outside bed) at the weir site. The steep gradient of the weir acts to elevate velocities and this has caused outer bank erosion problems.

Measures to protect the banks from erosion have been implemented using boulders and concrete which appear to be working in the short term.

In the long term there is a risk that the existing bank protection measures could fail due to their ad-hoc nature and the old weir structure could fail. If this occurs the existing river bed upstream of the weir will naturally lower as the trapped sediment is released. There may be a case for further investigation to determine the impact of the failure of this old weir structure on both the bed and bank upstream. Works are planned on the left hand bank, and this will stabilise this bank.

Any future failure would release trapped sediment downstream (which may impact structures) and cause upstream bank instability (which may impact the existing and future flood defences and erosion protection measures depending on foundation depth). This issue should be monitored and action taken if conditions deteriorate.

## A.3 C08_700: Silted mill race

The redundant weir (noted above) feeds into the mill race shown in the photographs above. This is heavily silted due to the low velocities and limited variation in flow. Limited change is expected in this area following the construction of the new flood defences.

## A.4 Cols na Gleann Stream: Replace existing culvert with a new 2m wide by 0.9m high rectangular culvert

The Cols na Gleann Stream is a small steep channel dominated by cobbles and gravels, which appear to readily transported downstream. The channel is very narrow and it is likely that it has been straightened historically. Such modifications act to elevate in channel velocities. Sediment has accumulated upstream of the culvert. Downstream of the culvert the channel gradient reduces and smaller gravels have been deposited (due to the reduced velocities associated with the reduced gradient). Within this area gravels dominate the channel bed and less cobbles are present. The existing culvert appears to disrupt the downstream continuity of sediment due to blockages at the small trash screen and the undersized nature of the bridge.

The proposals at this location should improve sediment continuity downstream. Care will be required to ensure large cobbles do not become trapped against the upstream trash screen (if one is to be constructed) as the high energy conditions will still be present.

## A.5 C01_C01, B02, C02: Proposed flood relief channel and culvert

The existing channel at this location is dominated by cobbles and gravels. The bed is partially armoured (evidenced by the moss over some of the larger cobbles) which suggests limited large sediment delivery. However, site conditions suggest higher velocity flows frequently transport smaller gravels through this reach. The construction of a flood relief channel is unlikely to significantly alter existing morphological conditions. However, the invert of the flood relief channel should be set at a point as to not decrease velocity as this could lead to an increase in deposition if in channel velocities are reduced significantly.

The existing bed material should be maintained and matched where possible. High flows event will be capable of transporting sediment; however, several flood events may need to pass through the system before the bed re-stabilises.

## A.6 C01_B03: Replace bridge

The channel at this location is currently over wide which acts to influence morphological processes. As a consequence, depositional zones are noted within this reach. (i.e. the over wide nature of the channel may lead to lower velocities which in turn may encourage deposition). The proposed new bridge should not change the existing morphological regime, as the channel width is remaining the same.

Upstream and downstream of this bridge some channel erosion is evident. In particular, downstream of the bridge, existing gabion basket protection has begun to fail on the outside of the bend. An alternative solution to bank protection is recommended at this location.

The existing bed material should be maintained and matched where possible. High flow events will be capable of transporting sediment, however several flood events may need to pass through the system before the bed destabilises.

## A.7 C06_B01: Replace existing twin 0.4m dia culverts with a new 1.8m wide by 0.9m high rect culvert

No safe access could be sought to see this culvert on the Springmount stream. However, extensive gravels and sands were present downstream. A wooden weir structure is also in place downstream which acts to impound water upstream for an unspecified distance. This appears to have collected a substantial amount of sediment. If this weir fails it could impact the stability of the channel upstream in the short term. Further investigation should be sought to see if this weir influences flow conditions at the upstream culvert.

## A.8 C01_C03: Bridge arch to be cleared by removing vegetation

Sediment was in the process of being removed from the channel during the site visit on the 03/07/16. Sediment was being removed several hundred metres upstream and downstream of the bridge. Some banks remain steeply profiled and could be subject to erosion until vegetation re-establishes.

Nevertheless, it is expected that the channel will quickly recover and new gravel bars will reform and the river attempts to re-establish a sediment equilibrium.

## A.9 C09_C01 (channel deepening), C05_B01 (replace culverts), C05_C02 (channel widening), C05_C03 (widening)

Deepening and increasing the culvert size will increase conveyance through the bridge.  There will be limited impact on the channel morphology.  The weir downstream of the bridge acts to trap some sediment.

The delivery of sediment within this reach appears to be lower than over reaches.  This means that the channel may take longer to recover following any in channel works.

# B Appendix 2: Geomorphic Impact Assessment (September 2020)

## B.1 Purpose of this addendum

This addendum report provides a review of the detailed design, which considers recommendations from the catchment Fluvial Audit and Addendum report (which provided initial scope of restoration measures in light of the outline design) to further refine the design, and inform further restoration and mitigation options for the Glashaboy FRS.

The purpose of this report is to provide a baseline of geomorphic change to the catchment in question as well as changes observed since the initial site visits taken in 2014 and 2016. This baseline is used to highlight the long-term impact of the scheme design on geomorphic processes which may result in future maintenance requirements, and to inform secondary impacts on fisheries.

The main parts of the scheme are described below, as well as the existing geomorphological conditions and predicted impacts once the scheme is constructed and operational.

## B.2 Area 1 - Sallybrook Industrial Estate

### B.2.1 Cúil Chluthair culvert (C01_B01)

#### Design proposal

A new culvert is proposed in a confined valley section within the Bleach Hill Stream at the entrance to the Cúil Chluthair housing estate. The structure will be enlarged to 2.6m in height and width, with a length of approximately 12.5m.

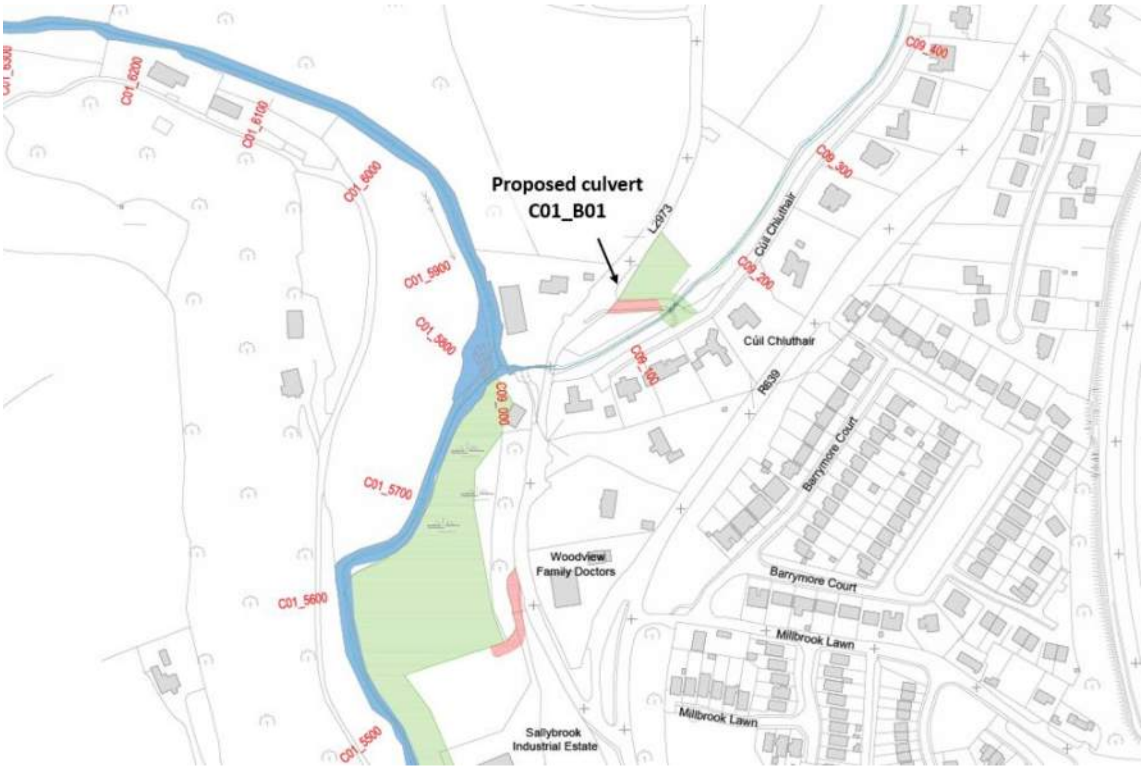

Figure 5-1. Location of proposed culvert upgrade in Cúil Chluthair housing estate (from drawing ref. GR_501)

The new culvert has been designed with the invert depressed into the river bed, to allow long-term resilience of the structure by allowing movement of gravels and delivery to the downstream reach, as well as allowing fish passage through the structure. A double layer of rip rap (Dn50 = 300mm) will be inserted into the bed at the downstream and upstream ends of the structure to prevent scour. This design measure is based on modelled flows in the post-scheme scenario.

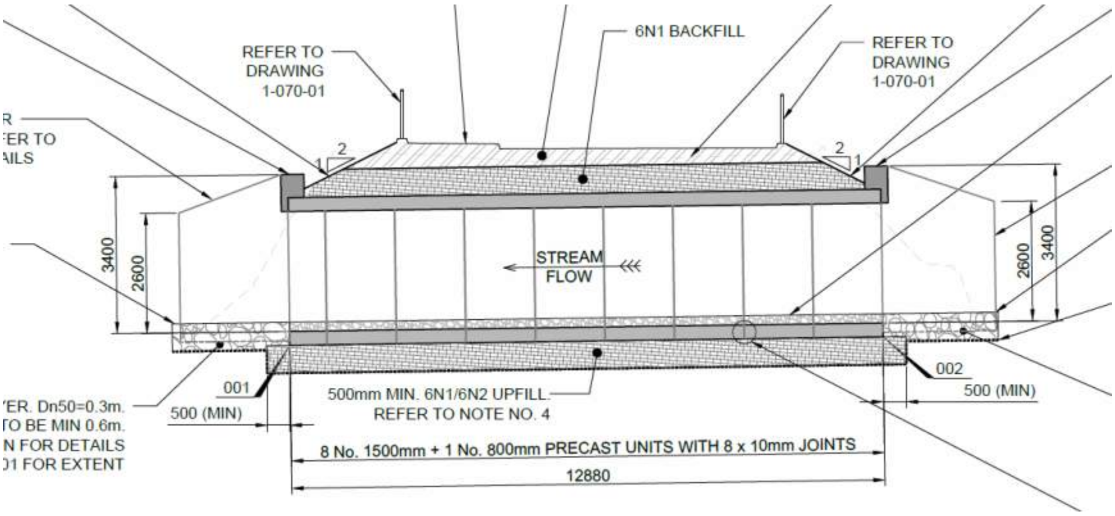

Figure 5-2. Cuil Chluthair proposed new culvert

### Existing geomorphic conditions

The bed in this section is gravel, cobble, and sand with little to no fine sediment. Active sediment transport in this area, with a build-up of gravel and sand noted at the existing culvert due to blockage by woody debris and under-sizing of the culvert. A small amount of undercutting was noted on both banks, indicating that the river in this section is sourcing some sediments from the lower banks and transporting it downstream. This is consistent with observations in the previous audit which suggested that this reach is overly deep/entrenched, which has contributed to armouring of the bed and little to no connectivity with the floodplain.

Figure 5-3. Cúil Chluthair culvert location (Left: looking upstream, right: looking downstream at existing culvert)

### Impact assessment

As noted in the previous assessment, the proposed larger culvert will improve sediment continuity through the system.  Any disturbance to the bed will quickly be rectified during subsequent high flow events.  High flows event will be capable of transporting sediment to the structure from upstream reaches and the bed will quickly re stabilise.

The increased size of the culvert should prevent blockages by branches and cobbles (as observed in the current culvert), however will allow greater flow velocities to pass through. The flows through this reach are only expected to change at the Q100 flood level, increasing by 0.2m/s, however this change is not great enough to impact sediment transport processes significantly.

It is not expected that the proposed culvert will significantly impact sediment transport on the bed downstream of the structure, and that the proposed rip-rap at the transition of the culvert will be sufficient to protect the bed and dissipate flows in the downstream reach. Therefore, no further mitigation is proposed.

### B.2.2 Sallybrook RC and sheet pile walls (C01_L01)

#### Design proposal

The existing culvert which feeds the mill race behind Grandon car sales is to be retained. Both RC walls and sheet pile walls are proposed on top of existing concrete/rock armour defences, on high ground at the top of the riverbank. Space constraints for this reach do not allow defences to be set back to allow connection with floodplain on the left bank. There is, however, good floodplain connectivity on the right bank.

At the Mill Race, a penstock is to be constructed to the proposed RC flood defence wall opening. The purpose of the penstock is to facilitate future routine maintenance to dewater the mill race at Grandon's. The mill race will be maintained by dredging of fine sediments and vegetation removal on a scheduled basis.

#### Existing geomorphic conditions

This reach is a plane bed (i.e., homogenous width and depth, very little riffle and pool formation) composed of gravel and cobble with little to no fine sediment, suggesting that the weir causes impoundment of gravel materials while fine sediments are transported downstream. The river in this area is connected to the floodplain on the right bank, opposite the industrial estate. An existing weir is noted which is the likely cause of limited morphology upstream throughout the estate due to the effects of weir impoundment.

There are existing ad-hoc defences (rock armour and various concrete defences) on the left bank which are in various states of repair. The rock armour noted in Figure 5-4 (photo on the right) is shown to be unstable, while adjacent to it (photo on the top left) concrete defences remain in place.

Figure 5-4. Location of proposed RC walls and sheet pile walls at the Sallybrook Industrial Estate

#### Impact assessment

The proposed RC and sheet pile walls will improve the stability of the banks, which currently contain ad-hoc defences that are at risk of failure. The proposed walls will retain the channelised nature of this reach, however will not degrade the overall morphology further compared with present conditions. The existing weir which feeds the mill race may be targeted by Inland Fisheries Ireland (IFI) for future fisheries improvement works to remove the barrier to fish passage. If the weir was to be removed completely, it would impact the geomorphology of this reach, potentially causing lowering of the bed upstream of the structure and compromising of the foundations of flood defence walls if removed in an uncontrolled way. Further study would be required to assess this impact if future weir removal was considered, with a plan to mitigate geomorphological change and impacts on the flood defences. Minor fisheries improvements such as installation of a fish pass structure would not impact overall geomorphology, but would be less effective in terms of improving overall WFD status of the river.

Installation of the pen stock at the entrance to the mill race will cause a build-up of fine sediment, which will require regular maintenance throughout the life of the scheme.

## B.3 Area 2 - Hazelwood and Meadowbrook

### B.3.3 Cois na Gleann culvert (C07_B01)

#### Design proposal

The proposed structure is one closed box culvert, approximately 27m in length and set at a gradient of 4.6%. In comparison, the existing culvert is a series of stepped structures, which dissipate flow energy through higher drops and act as barriers to sediment transport. The new culvert is likely to increase stream power within the culvert, with a change the sediment transport regime within the culvert and the downstream reach.

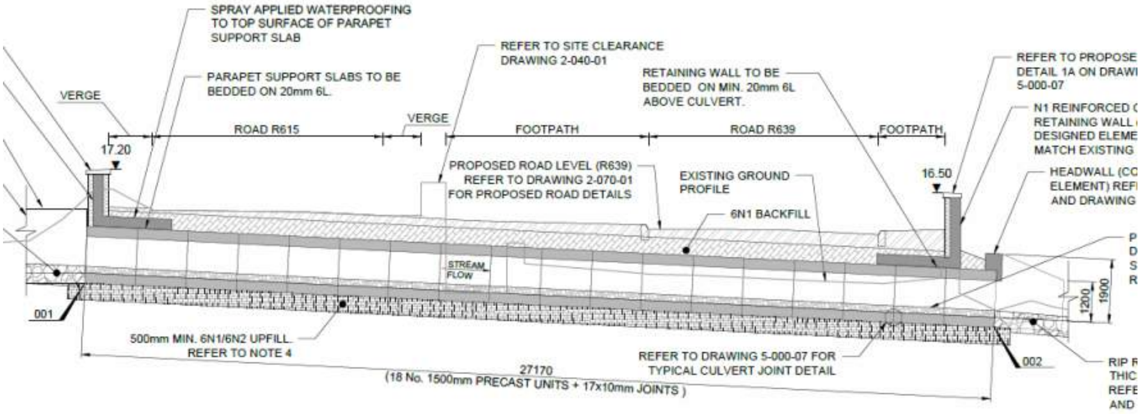

Figure 5-5. Proposed culvert at Cois na Gleann (C07_B01)

Inclusion of rip rap armour layer on the stream bed (Dn50 = 0.3m, min. thickness of 0.6m, length of 2.5m) at the transition out of the culvert has been included in the design to protect against the creation of a scour pool. Rock armour has also been included in the design to protect downstream banks against erosion. Additionally, the proposed bed of the culvert is rock slabs which should act to dissipate flow velocity to some degree within the culvert.

#### Existing geomorphic conditions

Deposition of sand, gravel and sandstone shale-like material observed throughout existing multiple levels of culvert system. Gravel, cobble, sands observed deposited at upstream and throughout stepped culverts suggest that the existing culverts act as a barrier to sediment transport. No scouring of concrete walls or historic culvert was observed.

This tributary has been artificially straightened which increases the ability of this tributary to transport sediment due to increased flow energy in the system, however the existing culverts act as a barrier to sediment movement. The downstream reach is moderately armoured with cobble and gravels which further support that the culvert acts as a barrier to sediment transport. Downstream of the culvert the channel gradient reduces and smaller gravels have been deposited and there is little to no cobble sized material.

Figure 5-6. Existing culvert system at Cois na Gleann (Left: upstream end of culvert, right: downstream reach)

### Impact assessment

This new structure has the potential to increase stream power during low flow and flood flows, increasing sediment transport capacity within and downstream of the structure. This will allow sediments to move through the culvert to the downstream reach, potentially mitigating further armouring/incision**.** However, this increases the risk of the creation of a scour pool at the downstream end. Rip-rap and rock armour have been included in the design to mitigate against the creation of a scour pool. Therefore, the structure and the design should have positive benefits to sediment transport throughout this reach with low risk of scour.

## B.3.4 Hazelwood flood relief culvert (C01_B02)

### Design proposal

A flood relief culvert is proposed adjacent to the existing Hazelwood Bridge, to take flood flows only. The invert of the new flood relief culvert is placed at or slightly above the existing river bed to ensure the river continues to flow under the Hazelwood Bridge during low flows, and is only used when flows exceed bankfull conditions. Rip rap is proposed at the transition at the upstream and downstream of the proposed flood relief culvert (Dn50 = 0.3m, min. thickness of 0.6m), with sizing of the rock armour designed to withstand the 100-year modelled flood event. Rock armour is proposed at the toes of both banks, further discussed in Section B.3.**5**.

### Existing geomorphic conditions

Fine sediment deposition was observed at the upstream of the existing bridge, however undercutting and bank failure was observed at both banks at the downstream end, consistent with the previous geomorphology audit. The bed is armoured with gravel and cobble. This suggests that the reach is over-widened, in that banks erode during high flows but sediments deposit at low flows, particularly where the presence of instream structures encourage deposition.

Figure 5-7. Location where new flood relief culvert to tie into existing bridge (left: bank failures observed at downstream,

right: fine sediment deposition observed upstream of bridge)

### Impact assessment

The proposed rip-rap upstream and downstream of the flood relief culvert should be sufficient to protect the structure against undermining and/or creation of scour pool at the downstream end. As a low-flow channel will be maintained under the existing bridge, it is unlikely that the proposed culvert will result in further widening of this reach. **T**he downstream rock armour will protect banks from further erosion and instability.

## B.3.5 Hazelwood RC walls (C01_L03)

### Design proposal

All existing masonry walls on right bank will be removed and replaced by new RC flood walls, with gravels being reinstated on the bed post-construction. The toe of both banks will be lined with rock armour to prevent further widening and bank erosion, and sizing of the rock armour has been designed to remain in place under the Q100 flood event.

### Existing geomorphic conditions

Through this reach, the right bank contained undermined rock armour falling into channel, consistent with instability noted in previous geomorphology audit. As noted above, this reach is over-widened, with limited instream morphology.

Figure 5-8. Existing retaining wall and rock armour to be replaced by RC walls (looking downstream at right bank)

### Impact assessment

Observations of bank instability on both banks indicate that this reach is experiencing adjustment via widening during high flows. Bank protection via rock armour will prevent further over-widening and stabilise banks, preventing future bank failures. In the post-scheme modelling scenario, flow velocity is expected to decrease slightly as a result of the introduction of the new flood relief culvert in the Q5, Q10, and Q100 flood flows, therefore no significant change to sediment transport is predicted through this reach.

## B.3.6 C01_Hazelwood shopping centre bridge (C01_B03) and Hazelwood RC walls (C01_L04)

### Design proposal

A replacement bridge is proposed, which will increase conveyance through this reach. Bridge footings are proposed below the existing bed level, which will provide protection against future bed lowering (caused by future high flows and/or increased runoff due to urbanisation of the catchment) and allow sediment to transport freely through this reach. Proposed concrete abutments will prevent further localised scouring, a trend which is already being observed particularly on the left bank of the channel.

Reinforced concrete walls are proposed on the right bank, to be set back from the river's edge. No works are proposed on the left bank.

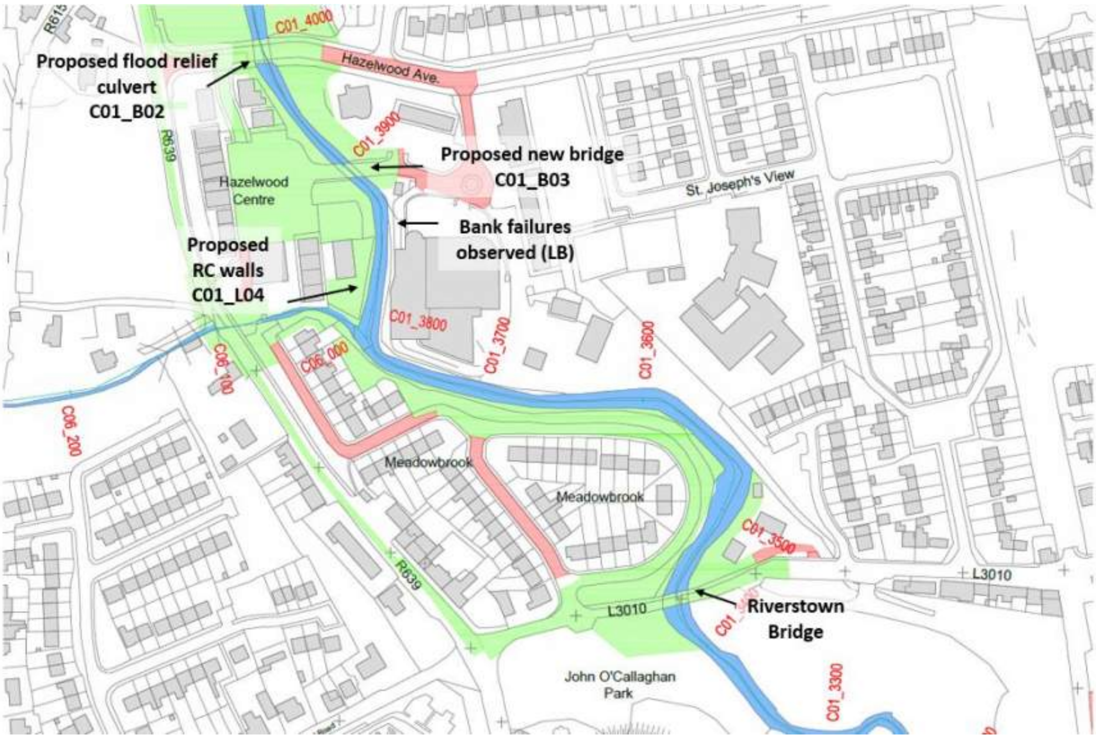

Figure 5-9. Proposed RC flood wall on right bank, no works proposed on left bank (clipped from drawing ref. GR-502, where green = indicative extent of works)

### Existing geomorphic conditions

Bank instability and undercutting was observed both upstream and downstream of the existing bridge, shown in Figure 5-10. This is due to over-widening of the channel as well as the effects of urbanised stream corridor which over time have increased the quantity and velocity of flow through this reach.

Figure 5-10. Bank instability noted around existing Hazelwood shopping centre bridge at downstream (left) and upstream (right)

Lowering of the bed and channel widening was observed through evidence including undermining of ad hoc defence structures on left bank and undercutting of banks on both banks, shown in Figure 5-11. These observations were also noted in the previous geomorphology audit. Despite this observed widening, instream geomorphic units (riffles/pools) and meander pattern are maintained – i.e., deposition of gravels on inside bends, erosion outside bends, indicating that sediment transport is active through this reach.

Erosion and undermining of banks is likely to be due to the historic narrowing of the floodplain through ad-hoc defences, poor placement of defences, and historic straightening of the river in upstream reaches resulting in high flows and channel widening.

Figure 5-11. Undermining of ad-hoc defence structures observed on left bank

Deposition of gravels was observed on inside of meander bends, and in-channel riffle-pool morphology observed through reach, indicating that a good upstream sediment supply is available this reach. Fine sediment deposition observed at confluence of Springmount and Glashaboy Rivers (Figure 3-9).

Figure 5-12. In-channel morphology contains point bars (left) and erosion at meander bends. Sediment input from Springmount Stream (right)

### Impact assessment

Observed bank instability within this reach indicate that flood flows will continue to contribute to erosion and instability, particularly on the left bank adjoining the Supervalu. Post-scheme modelling indicates that average channel velocities will not increase substantially post-construction, as they are not expected to change during the Q5 and Q10 flood events, but will increase from 2.4m/s to 2.7m/s during the Q100 event. Natural channel evolution will continue to progress, with migration toward the outside of the meander where the Supervalu is located, shown in Figure 5-13. Post-scheme flows will be able to transport only slightly larger gravels. Therefore only Q100 flows will impact morphology to a slight degree, with natural channel evolution in this reach likely to enhance bank degradation on the left bank in the future. It is likely that future maintenance will be required to maintain/repair the gabion baskets and/or alternative erosion protection solution could be sought on the left bank.

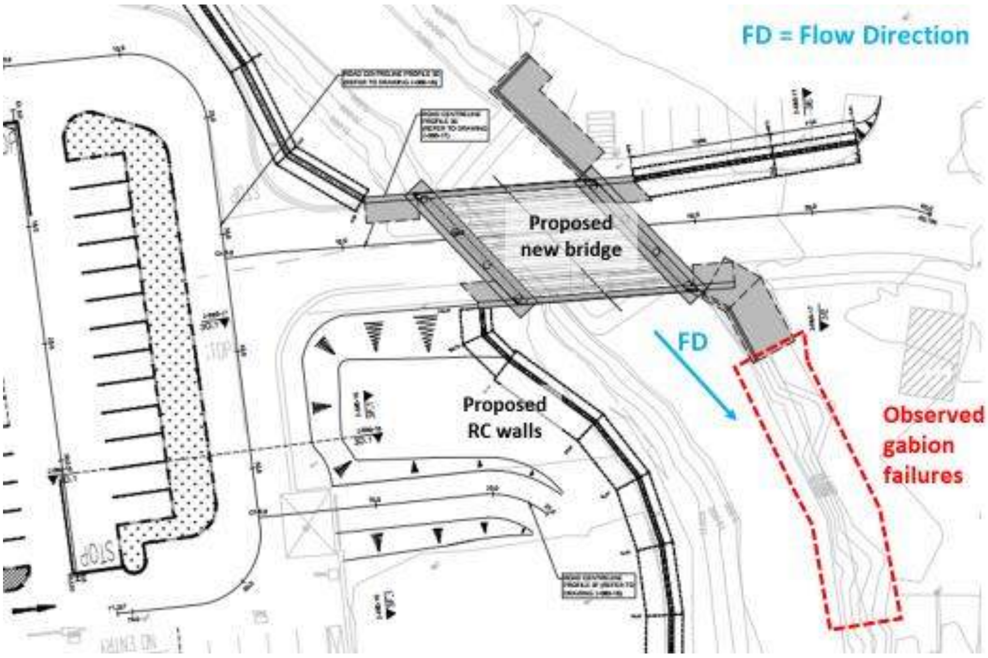

Figure 5-13. Observed bank failure relative to proposed elements of scheme (including new Hazelwood Shopping Centre bridge and RC walls)

### B.3.7 Meadowbrook RC and sheet pile walls (C01_L05) and works at Riverstown Bridge

#### Design proposal

Flood defence walls including RC walls (left bank) and sheet pile walls (right bank upstream of Riverstown Bridge) are proposed in this area.

In addition, works are proposed at Riverstown Bridge by removing fine sediment from outside arches and lowering of the bed at the middle arches to increase conveyance through this area.

#### Existing geomorphic conditions

The riffle/pool morphology and meander pattern are maintained through the Meadowbrook area. Here, the floodplain widens, less undercutting observed, however the banks were heavily vegetated. Bed is gravel with little to no fine sediments.

Mid-channel gravel bars and vegetated bars were observed around Riverstown bridge, with clean, shifting gravels through the middle 3 arches, and fine sediment deposition observed in the 2 outside arches. Fine sediment was observed to a lesser degree than was noted in the previous geomorphology report, due to maintenance occurring to clear bridge arches of fine sediments. Fine sediments deposit here due to over-widening of the channel in this location.

Further downstream through John O'Callaghan Park, sediment deposition was observed at the larger meander bend at the confluence of the Butlerstown and Glashaboy rivers.

Figure 5-14. Deposition at Riverstown Bridge is primarily mid-channel gravel bars, with some fine sediments downstream of the east bank arch where outfalls are located and backwatering likely occurs during higher flows

Figure 5-15. Fine sediment deposition observed at meander bend in John O'Callaghan Park

### Impact assessment

Presence of clean gravel deposits through three centre bridge arches indicate that this reach is able to deposit gravel material, but only deposits finer materials at the outside two arches and further downstream during high flows due to over-widening of the channel at the bridge. The widening of the channel through sediment removal and deepening through bed lowering through outside arches of Riverstown Bridge is predicted to reduce flood velocities through this reach, and will degrade morphology, requiring regular maintenance interventions.

Post-scheme, fine sediments are likely to continue to deposit at the outside arches, requiring regular maintenance (annual and post-flood maintenance walkover checks will be required to determine the frequency of maintenance). Downstream of this bridge, deposition increases through the John O'Callaghan Park, particularly at the meander bend at the confluence of Butlerstown and Glashaboy Rivers where fine sediment deposition is already observed at the existing pool. Fine sediment maintenance will be required through this area.

## B.3.8 Springmount culvert (C06_B01)

### Design proposal

The Springmount Stream is currently culverted (twin culverts) beneath the R639. It is proposed to replace the existing twin 0.4m diameter culverts with a new 32m long, 1.75m wide by 0.9m high, rectangular culvert. Clearance works are proposed to be undertaken within the existing Springmount Stream channel, including removal of an existing timber weir approximately 0.4m high by 2m long.

### Existing geomorphic conditions

This stream was not visited again in 2020, however previous observations suggested that extensive gravels and sands were present downstream of the existing culvert. A wooden weir structure is also in place downstream which acts to impound water upstream for an unspecified distance, and has collected a substantial amount of sediment.

### Impact assessment

Removal of the wooden weir has the potential to release sediment if unmanaged. Managed removal will require excavation of built up sediments prior to removal of the wooden structure to prevent substantial sediment release downstream.

# B.4 Area 3 - Butlerstown and Glenmore

## B.4.9 Brooklodge Grove culvert (C05_B01) and Brooklodge Walls (C05_L11)

### Design proposal

An overview of works proposed through this section of Glenmore stream is shown in Figure 5-16, which include bridge upgrade at Copper Valley Vue bridge, upgrade of the existing three culverts to double box culverts, regrading of the channel along a 105 meter length of channel, as well as removal of a small weir upstream of the proposed culverts.

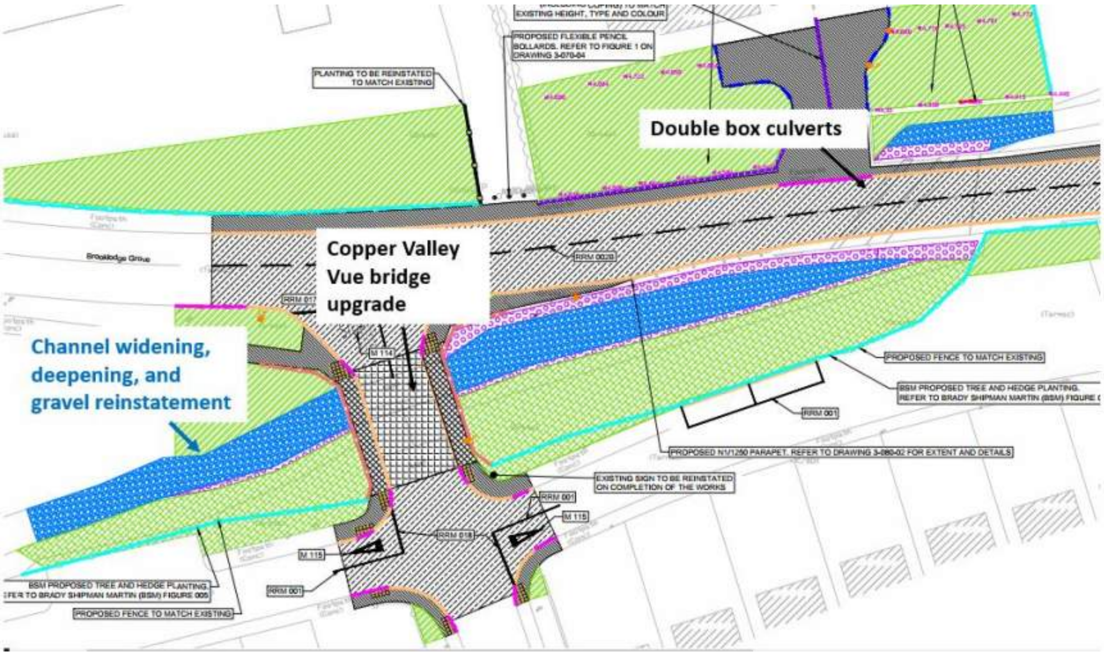

Figure 5-16. Proposed channel works at Brooklodge Grove

It is proposed to replace the three existing culverts, (2.32m span arch culvert, 2.95m wide by 0.68m high culvert and 2.95m wide by 0.67m high culvert) with two rectangular precast culverts each 5m wide by 1.95m high. The two culverts are shown in Figure 5-17: one to convey the low-flow channel, and one to convey flood flows. The invert of both culverts will be placed 30 to 50 cm below the existing bed level, and the bed will be filled with natural gravel material, with one culvert bed higher than the other. The flood relief culvert is proposed slightly above the low flow channel to ensure flows and fish passage are maintained through one culvert and not dispersed. This will ensure continuous transport of gravels through the culvert to downstream reaches, and prevention of future culvert perching given observed incision of the bed. Proposed rip-rap on the bed upstream and downstream transitions should ensure protection against future perching.

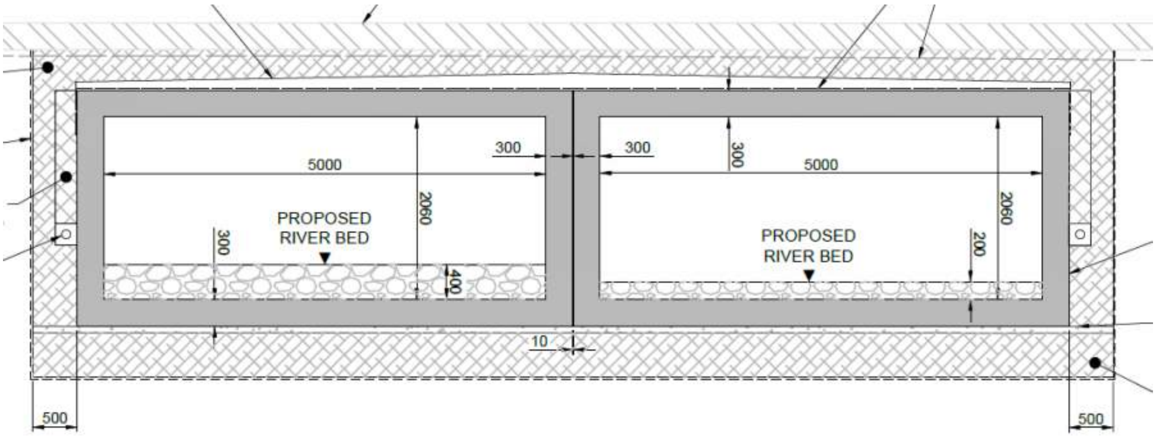

Figure 5-17. Cross-section of proposed double box culverts at Brooklodge

Downstream of the proposed culvert outlet, regrading of the river channel is proposed over an approximate 105m stretch with an average drop in bed level of 0.3-0.4m within the centre of the river over this extent. This will effectively be a two-stage channel but will activate at or above low/moderate flows in the river. The bed lowering (0.3-0.4m typical) is along the main river channel (approx. 0.246m deep at the point the cross section is drawn but varies over the extent of 105m), with the low flow channel to remain the same width as existing.

Along the left bank, a larger cut is proposed (approx. 1.3m) but will be out of the existing main river channel. The left bank of the river is proposed to be cut and constructed with engineered side slopes with erosion protection matting and rock armour placed to ensure stability of the riverbank, thereby creating a 2-stage channel, shown in Figure 5-18.

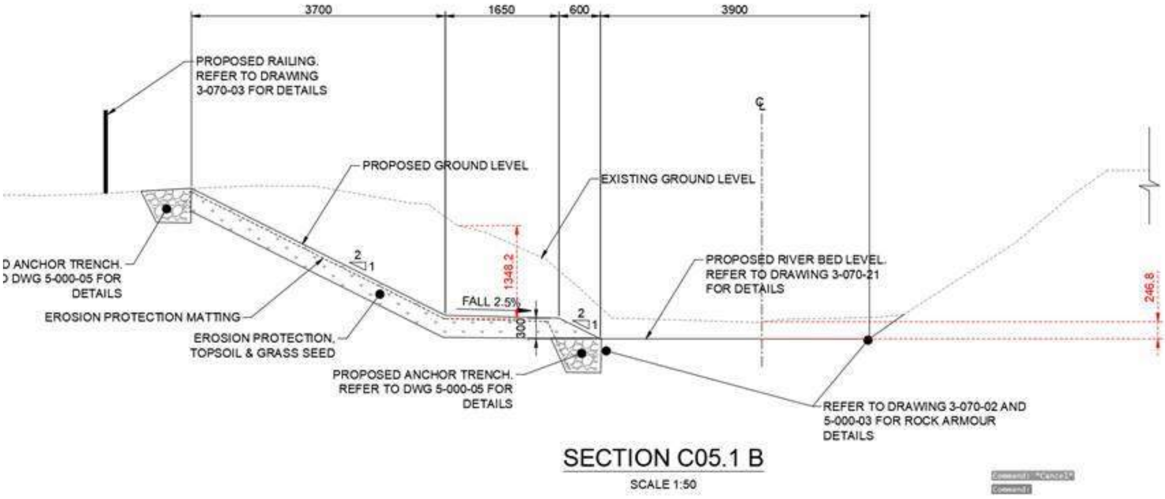

Figure 5-18. Cross-section of proposed river lowering and widening. Lowering will occur through the existing channel thalweg, and widening to introduce a 2-stage channel only to be wetted during flood flows

### Existing geomorphic conditions

Upstream of the existing Brooklodge culvert entrance, scour was observed on the bed at the transition to the base of the culvert at and downstream of the small weir. Banks are presently lined with rock and concrete. This reach of Butlerstown River, particularly the areas around the existing Brooklodge Grove culvert, showed signs of incision including undercut banks, perching of the existing culvert, concrete wall foundations perched above bed (in this reach and further upstream by the New Line Bridge and M8 culvert), and armouring of the bed material (no fine material, gravel/cobble dominated). This indicates that the sediment supply to this reach is limited, and flows are regularly high enough to erode the bed and banks. This is likely caused by historic straightening of this reach.

Figure 5-19. Observed small weir structure at location where Brooklodge walls are proposed (to be removed as part of the works)

Figure 5-20. Observed downcutting at existing section of channel between Brooklodge Grove Culvert and Copper Valley Vue bridge, where bed lowering and widening is proposed

### Impact assessment

The small weir upstream of the existing Brooklodge culverts will be removed as part of the proposed development. This intervention will dually benefit sediment transport and fish passage through this reach. Removal of this weir and bed lowering downstream together have the potential to create a knickpoint which can migrate upstream if unmanaged, particularly because the downstream reach is proposed to be deepened. Mitigation measures can be introduced to the design of the channel bed to prevent creation of such a point, including the creation of low stepped pools on the channel bed to aid in gradient readjustment.

Velocities through this section of channel will increase by 0.4m/s for the Q5 and Q10 events, and 0.3m/s for the Q100 event. Greater conveyance through this bridge and the upstream and downstream reach will increase the ability of the channel to transport sediments, therefore increasing its erosive capacity. This change will be sufficient to change the sediment transport regime for the area, transporting larger gravels at high flows.

To prevent further degradation of the bed as a result of deepening of the channel and increased shear stress applied to the bed, features can be included within the channel to dissipate energy. This could include further stepped pools throughout the reach, which would have a localised impact on reducing velocity and providing areas for fish refuge through this reach. This would add flow diversity/dissipation to this reach, and keep the effective bed gradient the same as in present conditions, with the overall result of limiting further downcutting.

With regards to channel widening, proposed geotextiles will be sufficient to protect against future bank erosion, however monitoring will be required to ensure that bank stability is maintained throughout the lifetime of the scheme.

Monitoring will be required to assess scour and potential fine sediment build up around structures, and to address potential impacts through maintenance of the scheme.

## B.4.10 Copper Valley Vue Bridge (C05_B02)

### Design proposal

Proposed measures including replacement of the existing bridge with a new reinforced concrete clear span bridge (C05_B02) to improve conveyance capacity. **C**hannel deepening and widening through the bridge and the downstream reach will also take place, as described above and shown in Figure 5-16.

### Existing geomorphic conditions

Around this structure, observations included armoured bed of gravel and cobble, with no undercutting or scour observed. Undercutting and incision of the bed in the upstream reach between Copper Valley Vue bridge and Grove Lodge culverts are provided above.

### Impact assessment

Greater conveyance through this bridge and the upstream and downstream reach will increase the ability of the channel to transport sediments. As above, velocities through this section of channel are expected to increase by 0.4m/s for the Q5 and Q10 events, and 0.3m/s for the Q100 event. Maintenance will likely be required under this bridge to clear fine sediments that deposit during low flows through this over-widened section.

## B.4.11 New Line Bridge (C05_B03)

### Design proposal

The proposed works include removal of the existing culvert including concrete bottom, which is presently set at a steep gradient, and replacement with a span bridge. The new bridge structure design proposes bridge footings buried beneath existing bed level.

### Existing geomorphic conditions

Scour observed on bed, where the invert of the existing culvert is exposed and scouring immediately upstream, shown in Figure 3-14.

Fast flow through culvert indicating that reach is transport/erosion dominated, i.e., bed materials cannot be deposited through this reach, and are being transported through the culvert, as well as eroded from upstream of the structure.

Figure 5-21. High gradient of culvert has resulted in bed scour at inlet of structure

### Impact assessment

The change in gradient through this reach as a result of the culvert removal and changes to the bed level will alter sediment transport and create a knick-point upstream of the new bridge if unmanaged. Instream works through this reach could include rock weirs or riffles upstream and downstream of the structure to control the gradient so that future geomorphological change can be managed. The post-scheme modelling results suggest that velocities will increase throughout this section from 1.6 and 1.7m/s in the Q5 and Q10 floods to 2.1 and 2.2 m/s respectively, and from 1.7 to 2.4 m/s in the Q100 flood. These increases will be sufficient to transport larger cobble material and erode gravels.

Instream flow dissipation structures made of boulders of appropriate sizing and/or spacing should be included in the detailed design, upstream of the new bridge. This should resemble a rock weir, riffles, or stepped pools. Re-instatement of gravel and cobble material under the new bridge should be completed during construction of the new bridge. These measures would ensure that such a structure is optimised for fish habitat and reduce the risk of creation of a knick-point in the upstream reach.

## B.5 Area 4 - The Grove

### Design proposal

RC flood walls are proposed to be set back from the channel edge through this section. No in-channel works or modification to the river banks are proposed.

### Existing geomorphic conditions

This reach contains in-channel morphological units such as riffles and pools, with fine sediment deposition increasing as the river approaches the estuary. Some undercutting observed on low banks due to incision of the channel, attributed to increased stream power within this section of river due to the presence of heightened flows and high in-channel energy during flood events.

Figure 5-22. Observations included the presence of riffles and pools, low undercutting, and fine sediment deposition on the bed

### Impact assessment

Proposed defences are set back from river and will allow the river to maintain connection with the floodplain. It is unlikely that the scheme will cause any impact to the morphology of this reach.

## B.6 Detailed design recommendations

The following recommendations are provided in order to enhance river morphology and ensure sediment transport is maintained through the proposed scheme area.

Table 1. Recommendations at detailed design stage based on geomorphology observations

| Structure | Overview impacts of scheme and recommendations |
|---|---|
| C01_B01 Cuil Chluthair Culvert | • Post-scheme, conveyance will improve through the culvert, delivering faster and higher flows out of the culvert to the downstream reach.<br>• The detailed design has provided rip-rap on the bed of the channel upstream and downstream of the new structure. The sizing and area/length is sufficient to protect the downstream reach against the creation of a scour pool.<br>• No further recommendations. |

| | |
|---|---|
| C01_L01 Sallybrook RC and sheet pile walls | • Impacts to this reach include potential siltation at the proposed penstock and mill race, which will be regularly maintained.<br>• This reach is presently impacted by the existing weir, which affects morphology upstream and downstream of it. Minor fisheries improvement works such as the provision of a fish pass would be feasible after the scheme is completed and would not be prevented as a result of the scheme. |
| C06_B01 Springmount culvert | • A substantial amount of gravel has accumulated between the reach downstream of the existing culvert and a timber weir structure.<br>• Removal of the timber weir should be carefully managed to include excavation of built-up sediments prior to removal of the structure. |
| C07_B01 Cois na Gleann culvert | • The detailed design has provided rip-rap on the bed of the channel upstream and downstream of the new structure. The sizing and area/length is sufficient to protect the downstream reach against the creation of a scour pool.<br>• In addition, measures to dissipate flow are included within the detailed design of the culvert bottom (rock slab base).<br>• No further recommendations. |
| C01_B02 Hazelwood flood relief culvert | • The design includes rock armour which should be sufficient to protect the downstream reach against undermining and/or creation of scour pool.<br>• Measures to increase flow diversity downstream of this structure should be considered. |
| C01_B03 Hazelwood shopping centre bridge | • The proposed bridge footings are buried at a sufficient depth to protect against scour. A level of bank protection is provided on the left bank (where previous failures are noted) which will prevent further slope failure.<br>• No further recommendations. |
| C01_L03, C01_L04 Hazelwood flood relief walls | • Future channel evolution will likely result in the thalweg moving towards the left bank, where failure of existing ad-hoc gabion and concrete structures has been observed.<br>• Existing structures in the river may degrade over time, and should be monitored in the maintenance regime of the scheme. |
| C01_L05 Meadowbrook walls and Riverstown Bridge | • Fine sediment management/maintenance will be required at the outside arches of Riverstown Bridge due to channel widening in this area. The channel in this area is capable of transporting gravels, which will re-establish quickly following maintenance activities.<br>• Monitoring of sediment accumulation will be required annually, as well as post-flood, to inform timing of maintenance. |
| C05_B01 Brooklodge grove culvert | • A 2-stage channel is included in the design to allow maintenance of a low-flow channel.<br>• Removal of the small weir upstream of Brooklodge grove culvert should include coinciding measures taken to balance the gradient through this reach, including step-pools from the high channel bed behind the weir, which step down into the proposed lowered channel.<br>• In-channel mitigation measures should be provided in the detailed design of the deepened low-flow channel to provide opportunities for energy dissipation, which may have further benefits to fish habitat through this reach. The preferred measure is to provide stepped pools on the channel bed.<br>• Fine sediment maintenance will be required through this section, as the channel around Copper Valley Vue bridge is likely to accumulate fine sediments during low flows due to |
| C05_L11 Brooklodge walls | |
| C05_B02 Copper valley vue bridge | |

| | |
|---|---|
| | over-widening. |
| C05_B03 New Line bridge | • The change in gradient through this reach as a result of the culvert removal and changes to the bed level may alter sediment transport and create a knick-point that may lead to uncontrolled scour upstream of the new bridge if unmanaged.<br>• Instream works through this reach should include rock weirs or riffles upstream of the new bridge to control the gradient and dissipate flows through the bridge so that future geomorphological change can be managed.<br>• Such structures should be built using boulders of sufficient sizing to not be transported downstream during flow events, and sized/spaced accordingly to allow fish migration upstream. |
| Grove RC walls | • RC walls are set back from the channel in this reach.<br>• No recommendations. |

## B.7 Maintenance

The following areas are likely to be subject to future maintenance (fine sediment removal) following completion of the scheme:

- Riverstown Bridge - outside arches of existing bridge
- Meander bends downstream of John O'Callaghan Park and at the confluence of Butlerstown Stream and Glashaboy River.
- Glenmore Stream where channel is to be deepened and widened, particularly through the low-flow culvert, and through the upgraded Copper Vue Valley bridge

In addition, maintenance of scour will be required at the following areas:

- Banks around Hazelwood shopping centre, adjacent to proposed flood relief measures, including areas where historic bank protection structures exist but will not be replaced as part of the proposed scheme.
- New Line Bridge, monitoring will be required to assess post-flood sediment transport and monitor scour as a result of increased velocities and altered gradient throughout this reach.
- Glenmore Stream upstream and downstream of the Brooklodge Grove culvert, monitoring of the channel bed after channel deepening and removal of the small weir

## B.8 Recommendations for post-scheme monitoring

Geomorphic monitoring should take place post-construction to monitor river recovery following the construction of flood defence measures. This should be completed after 2 years initially, and then every 5 years, and/or after a large flood, to monitor long-term impacts. Through the geomorphic assessment of the scheme design, all areas of the scheme that will require maintenance works within the stream have been identified. However, rivers can react to changes within the catchment, such as altered land use practices which change the sediment supply. A subsequent number of flood events within each flood season could also accelerate sediment supply processes both upstream and within the scheme area. These are difficult to predict, but if changes to the sediment transport regime are noted, instream measures can be provided to enhance sediment transport throughout the catchment (which can also act to deliver enhancement for fish movement). The probable location of these works has been identified in this assessment, and will tend to be local and require the use standard techniques and machinery and hence have been assessed within the EIAR and NIS.

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# Appendix G

## Tree Removal Report & Drawings (EIAR (2018) Appendix 3.2)

# Appendix 3.2

## Tree Removal Report

## GLASHABOY RIVER (GLANMORE/SALLYBROOK) DRAINAGE SCHEME EIAR

## PROPOSED TREES TO BE REMOVED

### Introduction

DixonBrosnan were commissioned to carry out a tree survey as part of the assessment procedure for the Glanmire Flood Relief scheme. The survey was carried out along the lower reaches of the Glashaboy River and tributaries within the proposed works area. The total length of the survey area was 9,041m. The purpose of the survey for the EIAR assessment was as follows:

- Within the main works area there is very little scope to retain trees and therefore the focus in this area for the survey was to assess the number and type of trees affected. The majority of trees were tagged and described. The survey identified trees within 10m of the works area which could be potentially affected. Management recommendations were provided where required. This covered a length of 3,700m.

Following the results of the survey, the Arup environmental and engineering teams modified the design where possible to avoid trees where feasible. The drawings and table presented in this Appendix show just the trees which are proposed to be removed to facilitate the drainage scheme.

### Survey Methodology

The survey was carried out from September 5-15, 2016. All trees are recorded on work areas with the exception of the some areas where unrecorded trees were low risk (C) of failure. The tree survey was also carried out within a 10 metre zone from the area within which construction works will be carried out. This was to assess the possible impacts on trees which lie on the periphery of the works area and which could be inadvertently damaged. All trees in excess of 150mm, at approximately 1.3metres height, were included in the survey. Recorded trees were numbered with plastic tags. Where possible the tag was placed at the downstream side of the tree at 1-2metres height. GPS Co-ordinates were recorded for each tree and where trees form natural groups, readings were taken from the middle of the group. All individual trees and groups are recorded on tree condition record forms and marked on drawings. Recommendations were made to fell, monitor or retain the trees and this information assisted the environmental and engineering teams to modify the design to try to avoid trees which were recommended to be retained. The survey key utilised for the survey, which is based on the guidelines outlined in the British Standard *BS 5837:2012 Trees in relation to design, demolition and construction – Recommendations* as detailed below in **Table 1.**

### Statement of authority

Carl Dixon M.Sc. is senior ecologist who has experience in ecological and woodland surveys. Mark Donnelly holds a BSc. (Hons) in Forestry from Bangor University, Wales and is a member of the Institute of chartered Foresters Society of Irish Foresters and is a registered Forester with the Irish Forest Service. He worked as an arboriculture consultant for The National Trust in Wales for 22 years and has worked as a lecturer in Forest Ecology at Bangor University. In Ireland he has undertaken a range of arboriculture and ecological surveys for projects including windfarms, quarries, housing developments, roads and pipelines.

**Cork County Council – Ongoing River Maintenance Project**

It is noted that Cork County Council (CCC), as part of its responsibilities for ongoing river maintenance and flood prevention (which includes removing degrading, unstable and unsafe trees on the river edge) will be undertaking distinct separate works along the Glashaboy river and its tributaries between December 2017 until February 2018 and possibly December 2018 until February 2019. The proposed works will comprise the removal (and/or crowning) of trees by suitably qualified personnel along the Glashaboy River and its tributaries, with the Glashaboy Catchment. Some (of those trees identified for removal as part of those separate CCC works are also required to be removed to facilitate the Glashaboy Drainage scheme – these trees are marked with an asterix * and the row is shaded in blue below.

**Table 1: Survey Key**

| Attribute | Description |
|---|---|
| **Location** | The river side location for each tree or group of trees is recorded looking downstream as either Left (L) or Right (R). GPS Co-ordinates |
| **Species** | Recorded as common name. A full list is in **Appendix 1.** |
| **Age** | IM - An immature tree greater than 150mm diameter but regarded as a sapling<br>SM - Semi mature tree – A young tree but less than 50% of its ultimate size.<br>M - Mature – A tree having attained dimensions typical of a fully grown specimen of its species.<br>OM – Over mature – An old specimen of a species showing signs of decline in health. Usual symptoms include crown starting to break up and decreasing in size. |
| **Girth** | Measured in mm. An average diameter was recorded for multi-stemmed stools and number of stems recorded |
| **Height** | Approximate tree height in metres. |
| **Spread** | Approximate tree canopy diameter in meters. Where a crown is unbalanced, approximate dimensions for the crown are given for North, East, South and West directions. |
| **Condition:** | Good : Full healthy canopy with good form and health<br>Fair: A specimen whose overall condition is typical of the site and may exhibit slightly reduced leaf cover/minor deadwood or maybe predisposed to defects e.g. Coppice re-growth, but otherwise in good health.<br>Poor: A specimen which through defect or disease has a limited longevity, dead or may be un-safe. |
| **Risk code - Risk Assessment (Adapted from International Society of Arboriculture (*ISA)*Tree Risk Accepted Methodology)** | **A:** High Risk – Failure likely to, or very likely to occur with severe consequences/impacts on people and or property.<br>**B:** Medium risk – Failure could occur but is unlikely during normal weather conditions within short to medium term (0-5yrs). Regular monitoring is necessary.<br>**C:** Low Risk – Failure unlikely during Short- Medium term (0-5 years). Regular monitoring is necessary. |

## PROPOSED TREES TO BE REMOVED WHICH ARE LOCATED WITHIN THE WORKS AREAS

### SALLYBROOK – UNNAMED CHANNEL Read in conjunction with Figure 1 (Appendix 3.2b)

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | | E | S | W | | | |
| | 359 | 515652<br>4 | 0823960 | Alder | SM | 200 | 15 | | | 8 | | | Good | C | Group of 30 trees. |
| L | 368 | 51 56<br>581 | 08 23 912 | Sweet Chestnut | M | 850 | 12 | | | 12 | | | Good | C | Pollarded |
| L | 369 | 51 56<br>583 | 08 23 903 | Sweet Chestnut | M | 1,200 | 15 | | | 10 | | | Good | C | Adjacent to road, pollarded |

### SALLYBROOK – GLASHABOY RIVER Read in conjunction with Figure 1 (Appendix 3.2b)

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | | |
| L | 391 | 51 56 689 | 08 24 037 | Oak | SM | 350 | 12 | | | | | 10 | Good | A | Over run |
| L | 390 | 51 56 689 | 08 24 037 | Sycamore | SM | 250 | 10 | | | | | 12 | Good | A | Over the river |
| L | 389 | 51 56 673 | 08 24 057 | Alder | M | 800 | 12 | | | | | 10 | Fair | A | 2 stems in river |
| L | 388 | 51 56 672 | 08 24 060 | Ash | M | 380 | 20 | | | | | 10 | Fair | A | Over river |
| L | 386* | 51 56 641 | 08 24 073 | Ash | M | 450 | 20 | | | | | 15 | Poor | A | 3 stems over river |
| L | 385 | 51 56 634 | 08 24 065 | Sycamore | M | 400 | 18 | | | | | 10 | Good | A | 3 stems |
| L | 384 | 51 56 628 | 08 24 065 | Alder | M | 350 | 15 | | | | | 10 | Good | A | Over river |
| L | 383 | 51 56 621 | 08 24 061 | Alder | SM | 280 | 12 | | | | | 12 | Good | A | Over river |
| L | 382* | 604 - | 042 - | Elm | SM | 280 | 15 | | | | | 10 | Poor | A | In river. Dead |
| L | 381* | 51 56 602 | 08 24 042 | Elm | SM | 220 | 15 | | | | | 10 | Poor | A | In river |
| L | 380* | 51 56 595 | 08 24 036 | Ash | M | 410 | 18 | | | | | 10 | Good | A | 1 limb only |
| L | 378* | 51 56 584 | 08 24 029 | Ash | M | 350 | 18 | | | | | 10 | Good | A | Over river 3 stems |
| L | 379* | 51 56 581 | 08 24 031 | Hawthorn | M | 150 | 10 | | | | | 5 | Good | A | Over river |
| L | 375* | 039 | 772 | Ash | M | 300 | | | | | | | Poor | A | In channel |
| L | 372* | 51 56 537 | 08 23 974 | Sycamore | M | 350 | 18 | | | | | 10 | Good | A | Over river |
| L | 371* | 51 56 534 | 08 23 972 | Ash | M | 370 | 18 | | | | | 10 | Good | A | 4 stems |
| L | 350* | 51 56 473 | 08 23 931 | Sycamore | SM | 360 | 15 | | | | | 10 | Fair | A | 2 stems Rot |
| L | 348* | 51 56 464 | 08 23 914 | Alder | M | 500 | 15 | | | | | 10 | | A | Undermined |

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | | |
| L | 346* | 51 56 462 | 08 23 908 | Sycamore | M | 500 | 18 | | | | | 10 | Good | A | Leaning over channel |
| L | 344* | 51 56 457 | 08 23 900 | Elm | M | 380 | 15 | | | | | 10 | Good | A | |
| L | 339* | 51 56 459 | 08 23 890 | Alder | M | 550 | 18 | | | | | 10 | Fair | A | 2 stems. Undermined |
| L | 338* | 51 56 453 | 08 23 887 | Sycamore | M | 400 | 18 | | | | | 10 | Fair | A | Undermined |
| L | 336* | 51 56 414 | 08 23 878 | Crack Willow | SM | 160 | 8 | | | 5 | | | Poor | A | 8 stems group – damaged |

## SALLYBROOK – GLASHABOY RIVER

**Read in conjunction with Figure 2 (Appendix 3.2b)**

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | | |
| L | 323 | 51 56 328 | 08 23 923 | Sycamore | SM | 220 | 18 | | | | | 10 | Good | B | 3 stems |
| L | 322 | 51 56 326 | 08 23 922 | Sycamore | SM | 250 | 18 | | | | | 10 | Good | B | 2 stems |
| L | 321* | 51 56 322 | 08 23 921 | Sycamore | SM | 350 | 18 | | | | | 10 | Fair | A | 2 stools rot 7 stems |

## GLASHABOY RIVER – NORTH OF HAZELWOOD AVENUE BRIDGE

**Read in conjunction with Figure 3 (Appendix 3.2b)**

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | |
| L | 008* | 5153 924 | 0823 843 | Elm | SM | 300 | 14 | | | | 5 | Good | B | Over river |
| L | 007* | 5153918 | 0823841 | Sycamore | SM | 280 | 20 | | | | 10 | Good | A | 2 stems over river |
| L | 006* | 5153 909 | 0823838 | Elm | SM | 400 | 12 | | 6 | | | Poor | A | Dead |
| L | 003 | 902 | 839 | Sycamore | M | 540 | 23 | | 15 | | | Good | B | 2 trees undermined |
| L | 005* | 5153 907 | 0823839 | Willow | M | 340 | 10 | 5 | | | | Poor | A | Decay at base |
| L | 004* | 5153 898 | 0823838 | Sycamore | M | 540 | 25 | | 15 | | | Poor | A | Multistemmed. Decay at base |
| L | 015 | 51 55 892 | 08 23 345 | Elm | SM | | 8 | | | | 5 | Good | C | |
| R | 014 | 51 55 887 | 08 23 840 | Willow | M | 180 | 6 | 8 | | | | Fair | C | Multistemmed |
| R | 013 | 51 55 887 | 08 23 839 | Alder | SM | 220 | 6 | | 4 | | | Good | C | Multistemmed |

## IN FIELD NEXT TO R639 NORTH OF HAZELWOOD AVENUE BRIDGE

**Read in conjunction with Figure 3 (Appendix 3.2b)**

| River Side | No. | GPS coordinates N | W | Species | Age Class | Girth (mm) | Height (m) | Spread (m) N | E | S | | W | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In Field next to R639 | 006 | 51 55 917 | 08 23 892 | Elm | SM | 600 | 7 | | | 3 | | | Poor | C | Pollarded, Elm Disease |
| | 007 | 51 55 916 | 08 23 893 | Sycamore | SM | 300 | 7 | | | 3 | | | Fair | C | 3 Stems, Pollarded |
| | 008 | 51 55 910 | 08 23 891 | Elm | SM | 350 | 7 | | | 3 | | | Poor | C | Pollarded, Elm Disease |
| | 009 | 51 55 901 | 08 23 881 | Elm | SM | 350 | 5 | | | 3 | | | Dead | C | Dead |
| | 010 | 51 55 897 | 08 23 885 | Sycamore | SM | 350 | 5 | | | 3 | | | Poor | C | Pollarded, Multistemmed |
| | 011 | 51 55 888 | 08 23 871 | Ash | IM | 270 | 8 | | | 8 | | | Fair | C | Multistemmed |
| | 012 | 51 55 888 | 08 23 852 | Ash | SM | 470 | 9 | | | 8 | | | Good | C | Multistemmed |

## GLASHABOY RIVER SOUTH OF HAZELWOOD AVENUE BRIDGE including MEADOWBROOK & RIVERSTOWN BRIDGE

**Read in conjunction with Figure 3 (Appendix 3.2b)**

| River Side | No. | GPS coordinates N | W | Species | Age Class | Girth (mm) | Height (m) | Spread (m) N | E | S | W | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roadside | 133 | 51 55 880 | 08 23 840 | Alder | | 220 | 12 | | 7 | | | Good | C | 2 Stems |
| R | 281 | 51 55 874 | 08 23 814 | Alder | SM | 250 | 18 | | 10 | | | Good | C | 8 Stem, 1 Sycamore |
| L | 21 | 51 55 872 | 08 23 819 | Willow | M | 250 | 5 | | | | 5 | Fair | B | Leaning over river |
| L | 20 | 51 55 875 | 08 23 827 | Alder | SM | 210 | 10 | | 8 | | | Good | C | 4 Stems |
| L | 22 | 51 55 871 | 08 23 820 | Alder | SM | 350 | 12 | | | | 12 | Good | B | |
| L | 23 | 51 55 873 | 08 23 815 | Elm | SM | 350 | 15 | | 8 | | | Good | B | Healthy |
| R | 283 | 51 55 859 | 08 23 811 | Alder | SM | 220 | 15 | | 10 | | | Good | C | Undermined,2Trees, Hawthorn |
| L | 24 | 51 55 873 | 08 23 815 | Sycamore | SM | 350 | 15 | | 8 | | | Good | C | |
| L | 25 | 51 55 871 | 08 23 815 | Alder | SM | 350 | 15 | | 12 | | | Good | C | 4 Stems |
| L | 26 | 51 55 866 | 08 23 809 | Willow | M | 350 | 8 | | 8 | | | Fair | A | |
| R | 31 | 51 55 852 | 08 23 798 | Alder | SM | 400 | 15 | | 8 | | | Fair | C | 3 stem |
| R | 32 | 51 55 850 | 08 23 794 | Beech | M | 1000 | 20 | | 15 | | | Good | B | Poor Form |
| L | 41 | 51 55 820 | 08 23 764 | Willow | M | 310 | 10 | | | 15 | | Poor | A | 3 stems, 1 sycamore |
| L | 42 | 51 55 812 | 08 23 764 | Sycamore | SM | 280 | 10 | | | 8 | | Good | C | 4 stems |

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | |
| L | 43 | 129 | 832 | Sycamore | M | 650 | 23 | | | | 12 | Good | B | Over river |
| R | 290 | 51 55 803 | 08 23 768 | Alder | SM | 240 | 15 | | 5 | | | Fair | C | +Ash |
| R | 292 | 792 | 776 | Ash | SM | 260 | 18 | | | 10 | | Good | C | 3 stems |
| R | 52 | 51 55 783 | 08 23 763 | Ash | IM | 280 | 12 | | | 8 | | Good | C | 1 tree |

**SPRINGMOUNT STREAM** **Read in conjunction with Figure 3 (Appendix 3.2b)**

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | |
| R | 95* | 51 55 793 | 08 23 794 | Hawthorn | M | 260 | 8 | | 15 | | | Poor | A | 6 Stems |
| R | 96 | 51 55 794 | 08 23 800 | Ash | SM | 300 | 15 | | 10 | | | Fair | C | 2 Stems |
| R | 97 | 51 55 774 | 08 23 817 | Sycamore | SM | 320 | 15 | | 10 | | | Good | C | |
| R | 98 | 51 55 793 | 08 23 823 | Ash | SM | 340 | 15 | | 10 | | | Good | C | 3 Stems |
| R | 99 | 51 55 789 | 08 23 829 | Sycamore | M | 500 | 13 | | 10 | | | Good | C | 8 Stems |
| R | 100* | 51 55 789 | 08 23 825 | Elm | SM | 470 | 15 | | 10 | | | Poor | A | Dead 3 Trees |
| R | 48* | 51 55 794 | 08 23 781 | Sycamore | SM | 460 | 18 | | 12 | | | Good | A | 2 Stools, 3 Stems, In river |
| R | 50* | 51 55 790 | 08 23 780 | Elm | IM | 310 | 15 | 5 | | | | Poor | A | Dead |

**GLASHBOY RIVER – SOUTH OF SPRINGMOUNT STREAM** **Read in conjunction with Figure 3 (Appendix 3.2b)**

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | |
| R | 53 | 51 55 778 | 08 23 738 | Alder | IM | 230 | 12 | | | 12 | | Good | C | 5 Stems ( 1Ash) |
| R | 293 | 51 55 789 | 08 23 773 | Cypress | M | 500 | 18 | | | 10 | | Poor | B | In Garden |
| R | 295 | 51 55 784 | 08 23 754 | Ash | SM | 320 | 16 | | | 8 | | Good | C | |
| R | 54* | 51 55 780 | 08 23 752 | Elm | IM | 240 | 12 | | 8 | | | Good | A | Leaning over river |
| R | 294 | 51 55 789 | 08 23 773 | Sycamore | M | 280 | 15 | | | 10 | | Good | C | 2 Stem |

**GLASHABOY RIVER AT MEADOWBROOK AND RIVERSTOWN** **Read in conjunction with Figure 3 (Appendix 3.2b)**

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | S | W | | | |
| L | 85 | 51 55 746 | 08 23 577 | Ash | SM | 600 | 25 | | | | 10 | Good | B | 3 ash Stems |
| L | 86* | 51 55 743 | 08 23 575 | Ash | M | 240 | 23 | | | | 10 | Good | A | 2 ash Stems, over river |
| L | 306 | 51 55 740 | 08 23 573 | Alder | M | 190 | 20 | | | 10 | | Poor | B | Over river |
| L | 307 | 51 55 740 | 08 23 573 | Ash | SM | 150 | 20 | | | | 10 | Poor | B | Over river |
| L | 87* | 51 55 737 | 08 23 575 | Sycamore | SM | 450 | 20 | | | | 10 | Good | A | 3 Stems in river |
| L | 88 | 51 55 736 | 08 23 575 | Sycamore | M | 440 | 20 | | | | 10 | Good | B | |
| L | 89 | 51 55 732 | 08 23 578 | Beech | M | 1300 | 30 | | 25 | | | Poor | A | Rot in Crown – reduce by 30%, Bat Survey required |
| L | 90 | 51 55 731 | 08 23 581 | Ash | SM | 220 | 20 | | 10 | | | Good | C | |
| L | 308* | 51 55 727 | 08 23 577 | Ash | M | 330 | 20 | | | 8 | | Good | A | 2 Stems |
| L | 91* | 51 55 729 | 08 23 581 | Beech | M | 800 | 20 | | 25 | | | Good | A | Multi-stemmed |
| L | 92 | 51 55 725 | 08 23 584 | Alder | IM | 210 | 25 | | 8 | | | Good | C | |
| L | 93 | 51 55 720 | 08 23 589 | Sycamore | M | 410 | 18 | | 15 | | | Good | C | 3 Stems |
| L | 94 | 51 55 713 | 08 23 595 | Ash | SM | 430 | 18 | | 5 | | | Good | A | 2 Stems |
| PUBLIC AREA (LEFT BANK) | 309* | 51 55 709 | 08 23 594 | Ash | M | 350 | 20 | | | 15 | | Good | A | |
| | 310 | 51 55 708 | 08 23 620 | Cherry | M | 300 | 9 | | 6 | | | Poor | B | |
| | 311 | 51 55 702 | 08 23 639 | Norway Maple | M | 420 | 15 | | 10 | | | Fair | A | |
| | 312 | 51 55 706 | 08 23 641 | Lime | M | 840 | 18 | | | 12 | | Good | B | |
| | 313 | 51 55 706 | 08 23 643 | Norway Maple | M | 520 | 18 | | 10 | | | Good | B | |
| | 314 | 51 55 706 | 08 23 650 | Lime | M | 450 | 18 | | | 12 | | Fair | B | Poor branching form |
| | 315 | 51 55 705 | 08 23 653 | Rowan | M | 430 | 9 | | 8 | | | Fair | B | |
| | 316 | 51 55 696 | 08 23 621 | Birch | M | 320 | 9 | | 10 | | | Good | B | |

## GLENMORE STREAM AT COPPER VALLEY VUE ESTATE **Read in conjunction with Figure 4 (Appendix 3.2b)**

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | | S | W | | | |
| R | 176* | 788 | 698 | Elm | M | 350 | 10 | 15 | | | | | Good | B | 2 stems |
| R | 179 | 793 | 674 | Alder | M | 400 | 15 | | | 15 | | | Good | B | Multiple stems |
| L | 180 | 794 | 674 | Alder | M | 450 | 18 | | | 10 | | | Good | C | Good form |
| L | 182 | 792 | 672 | Turkey Oak | M | 600 | 18 | | | 15 | | | Good | C | Good form |
| L | 183 | 795 | 663 | Alder | M | 430 | 15 | 10 | | | | | Good | B | 2 stems |
| | 195 | 788 | 668 | Birch | SM | 200 | 10 | | | 7 | | | Good | C | Amenity Planting |
| | 198 | 788 | 676 | Beech | SM | 210 | 12 | | | 8 | | | Good | C | Amenity Planting |
| | 200 | 783 | 690 | Willow | SM | 150 | 8 | | | 10 | | | Good | C | |
| | 113 | 784 | 692 | Beech | SM | 150 | 12 | | | 8 | | | Good | C | |
| L | 191 | 807 | 617 | Alder | SM | 230 | 12 | | | | | | Fair | B | On roadside 8 trees |
| L | 189 | 798 | 641 | Alder | SM | 280 | 10 | | 10 | | | | | B | 7 stems |
| L | 188 | 798 | 644 | Alder | M | 280 | 10 | | 4 | | | | Poor | B | Dead |
| L | 187 | 798 | 644 | Alder | M | 350 | 15 | | 10 | | | | Good | B | 3 stems |
| L | 186 | 796 | 660 | Willow | M | 390 | 10 | | 12 | | | | Good | B | |
| | 133 | 796 | 637 | Birch | SM | 200 | 10 | | | 7 | | | Good | C | Amenity Planting |
| | 192 | 796 | 630 | Birch | SM | 200 | 10 | | | 7 | | | Good | C | Amenity Planting |
| | 193 | 794 | 643 | Birch | SM | 200 | 10 | | | 7 | | | Good | C | Amenity Planting |

**Note:** Trees may need to be removed in the east of Brooklodge Grove, information not available.

## GLASHABOY RIVER – NORTH OF GLANMIRE BRIDGE **Read in conjunction with Figure 5 (Appendix 3.2b)**

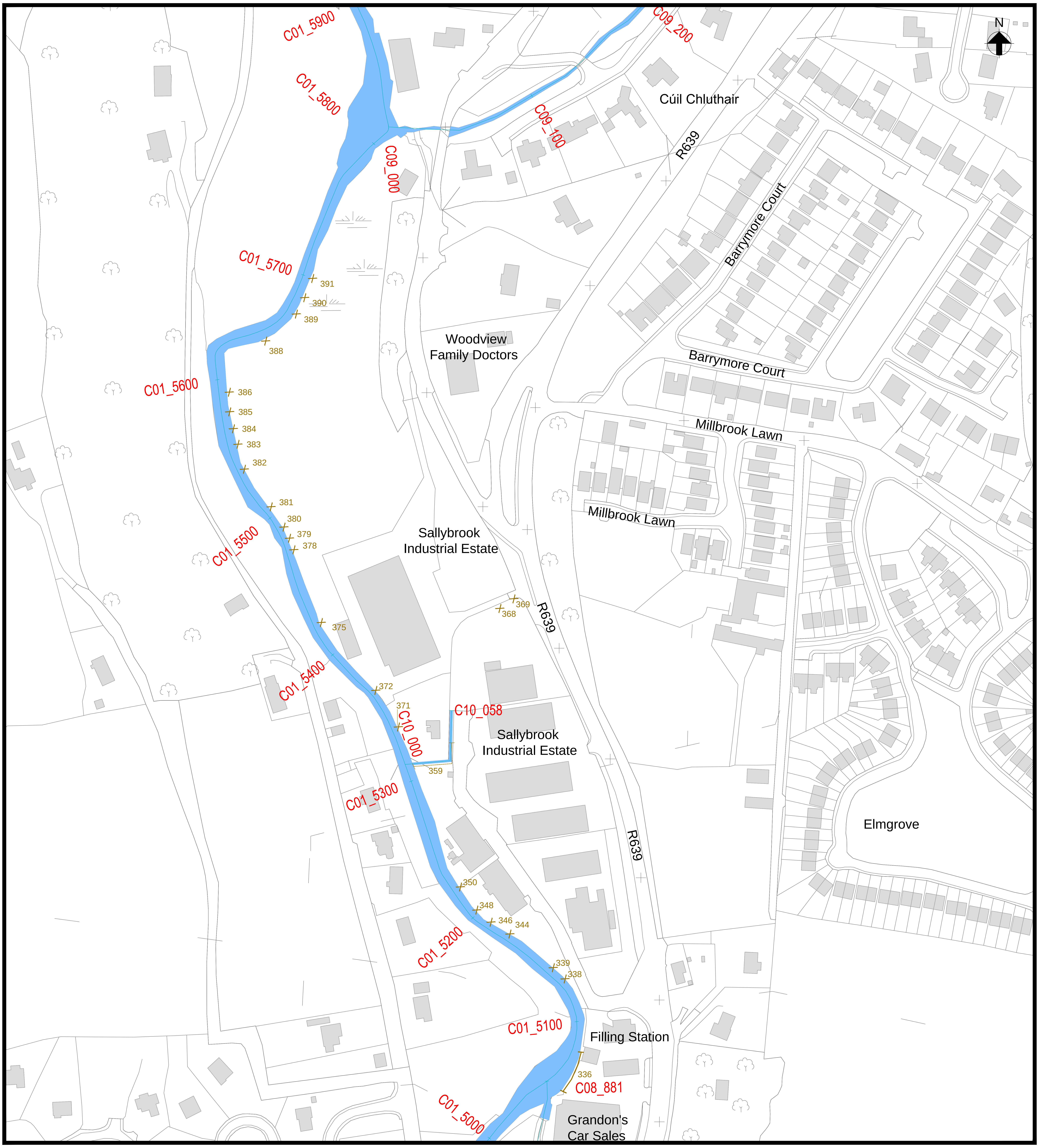
| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | | S | W | | | |
| | 141* | 51 55 196 | 08 23 793 | Sycamore | | | | | | | | | | | Group growing in retaining wall above river |
| | 141* | 51 55 196 | 08 23 793 | Elm | SM | 205 | 15 | | 8 | | | | Fair | A | |
| | 141* | 51 55 196 | 08 23 793 | Fig tree | | | | | | | | | | | 41 metre |
| | 141* | 51 55 196 | 08 23 793 | Alder | | | | | | | | | | | |
| | 142 | 51 55 222 | 08 23 782 | Alder | SM | 180 | 15 | | | 12 | | | Good | C | 4 stems, poor form |
| | 143 | 51 55 222 | 08 23 781 | Sycamore | M | 360 | 18 | | | 12 | | | Good | C | |

| River Side | No. | GPS coordinates | | Species | Age Class | Girth (mm) | Height (m) | Spread (m) | | | | | Condition | Risk Code | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | W | | | | | N | E | | S | W | | | |
| Above river | 144 | 51 55 221 | 08 23 780 | Ash | SM | 320 | 118 | | | 15 | | | Good | C | 5 stems, poor form |
| | 145 | 51 55 225 | 08 23 777 | Sycamore | M | 520 | 20 | | | 15 | | | Good | C | |
| | 146* | 51 55 228 | 08 23 780 | Sycamore | M | 840 | 20 | | | 15 | | | Fair | C | Poor form |
| | 147* | 51 55 235 | 08 23 772 | Ash | M | 820 | 17 | | | 15 | | | Fair | C | Poor form |

# Appendix 3.2

## Tree Removal Drawings

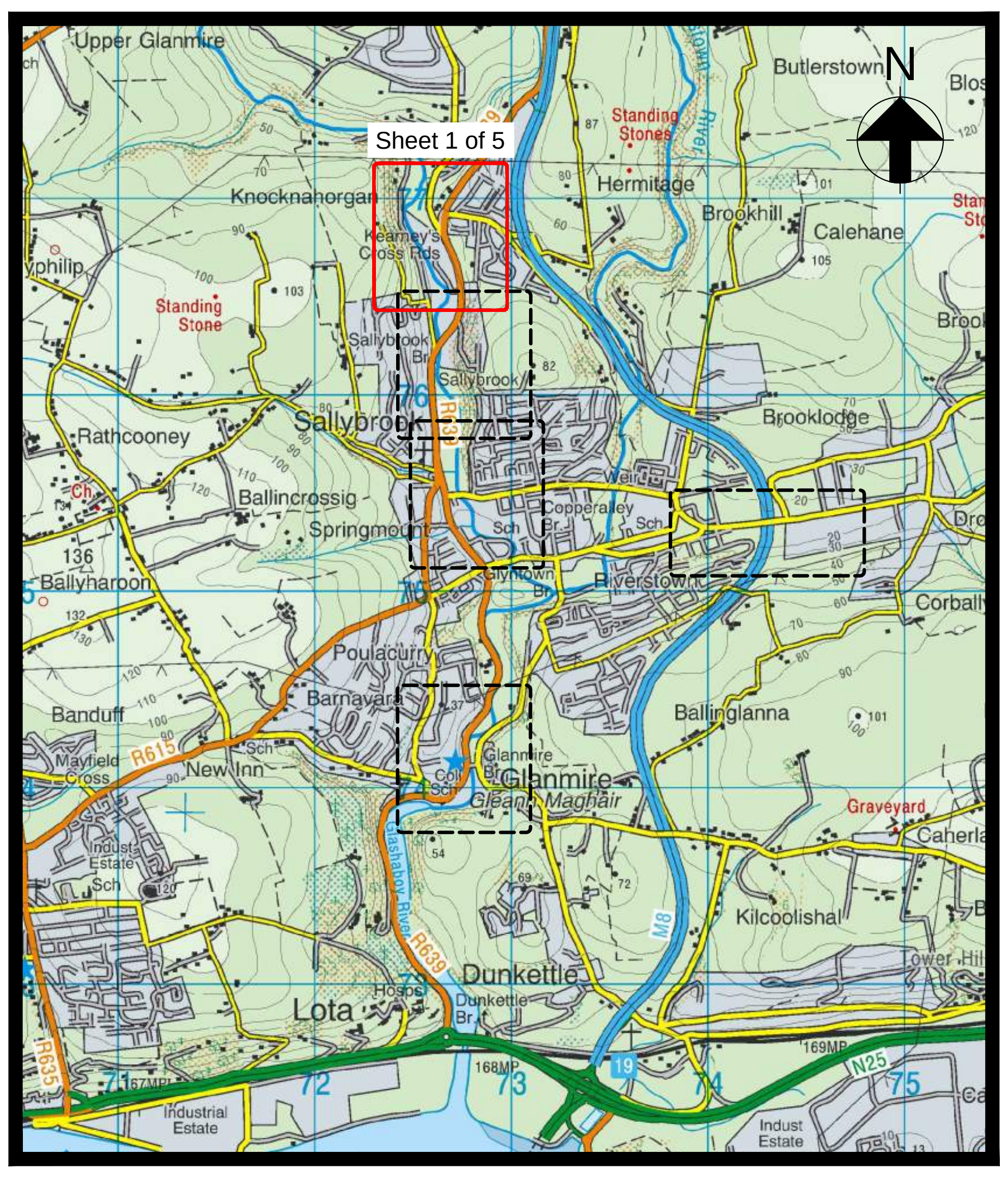
# Glashaboy River (Glanmire/Sallybrook) Drainage Scheme



Location Plan

25m SCALE 1:1250

Scale 1:1,250 at A1
Scale 1:2,500 at A3



Key Plan

Notes:
1. Do not scale from drawing.
2. Proposed works geometry and extents are subject to detailed design.
3. This drawing should be read in conjunction with all other Glashaboy River (Glanmire/Sallybrook) Drainage Scheme Confirmation Drawings and Schedules.

Key to Plan

| | |
|---|---|
| ## ## | Trees to be Removed |
| C06_300 | Channel Centreline, Reference (C06) and Chainage (300m) |

## Figure 1 (Appendix 3.2b) Proposed Trees to be removed Plan Layout (Sheet 1 of 5)

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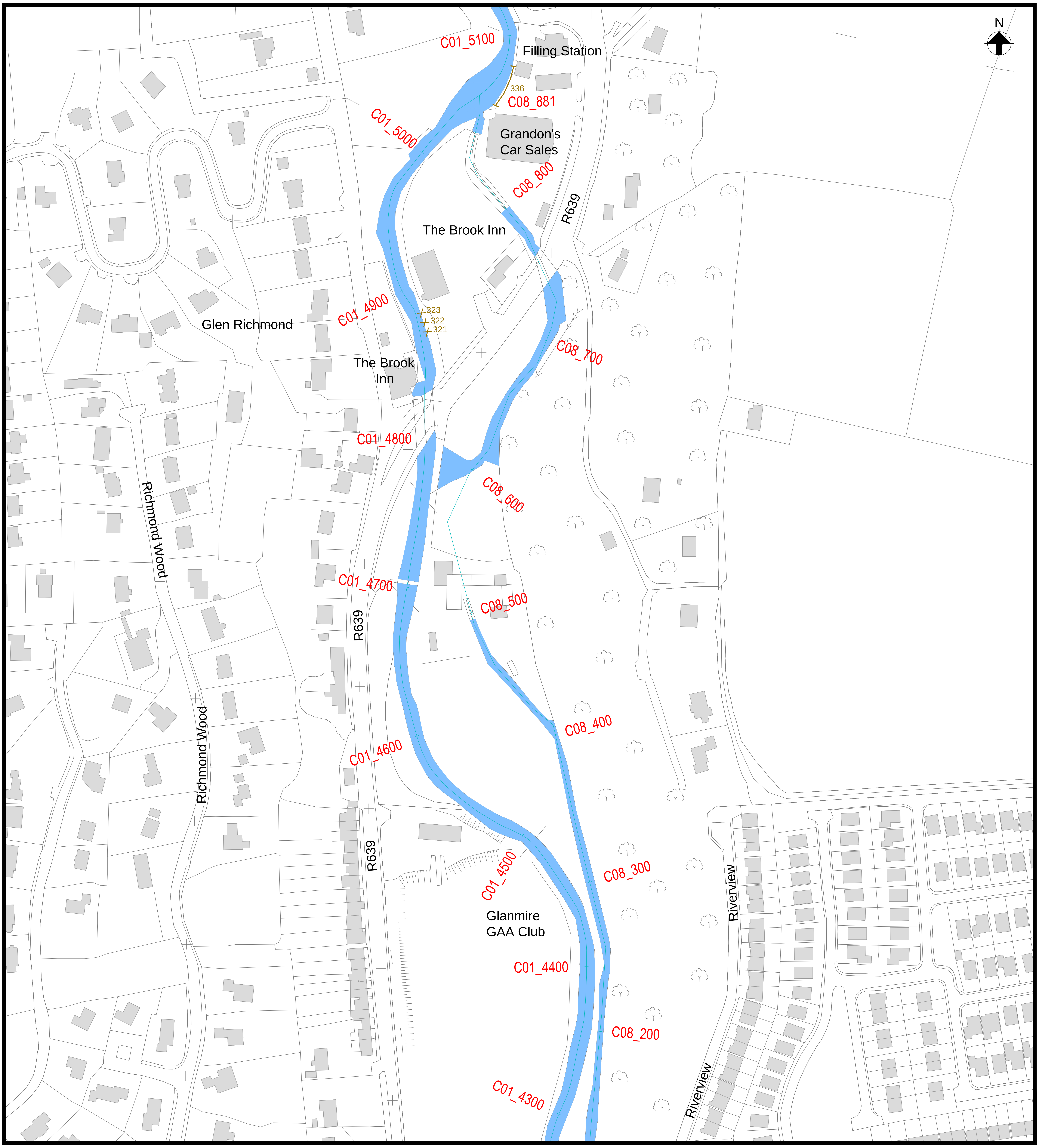
Fax +353 (0) 1 661 0747

# Glashaboy River (Glanmire/Sallybrook) Drainage Scheme



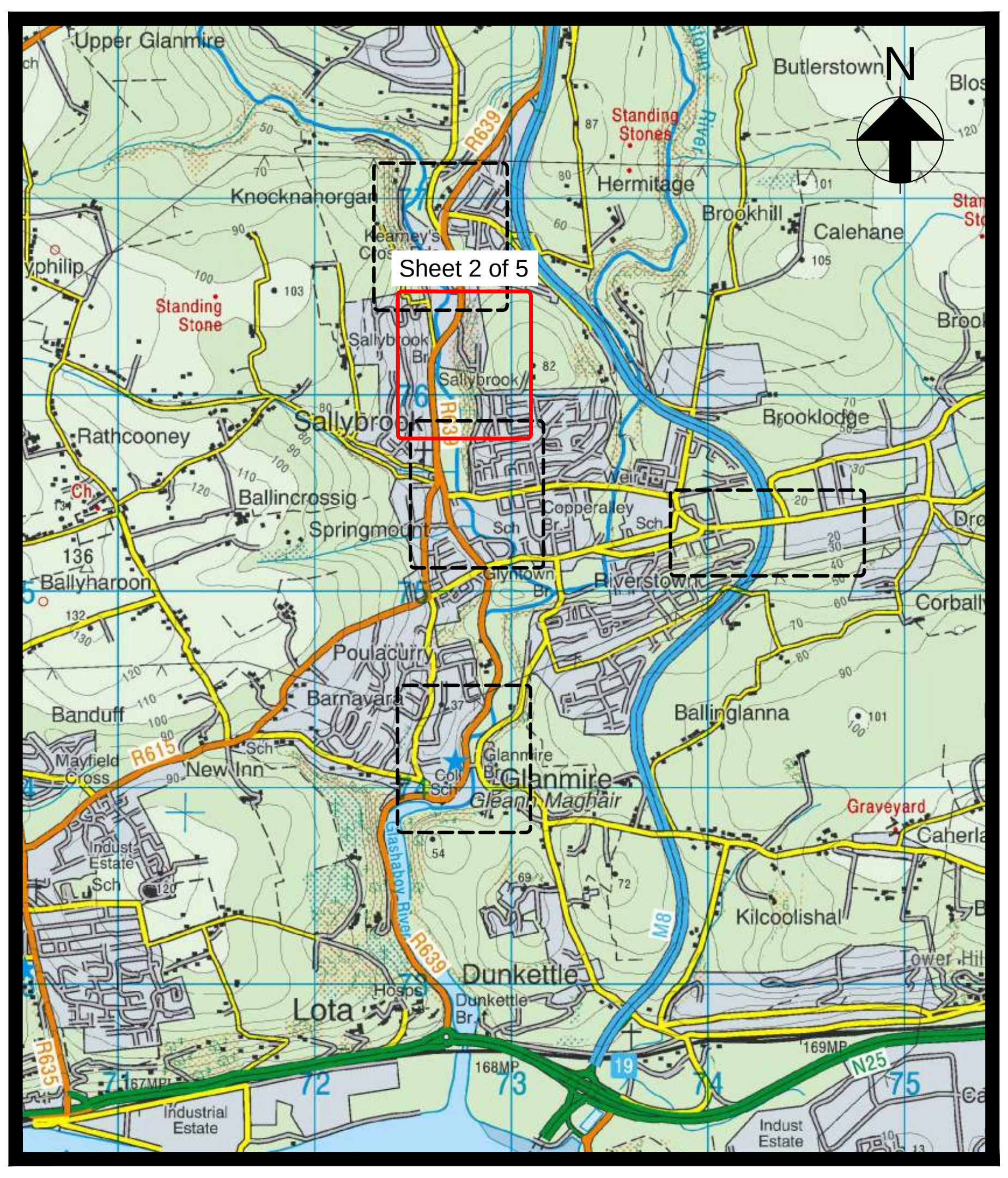
Location Plan

25m SCALE 1:1250

Scale 1:1,250 at A1
Scale 1:2,500 at A3

Notes:

1. Do not scale from drawing.
2. Proposed works geometry and extents are subject to detailed design.
3. This drawing should be read in conjunction with all other Glashaboy River (Glanmire/Sallybrook) Drainage Scheme Confirmation Drawings and Schedules.



Key Plan

## Key to Plan

| | |
|---|---|
| ## ## | Trees to be Removed |
| C06_300 | Channel Centreline, Reference (C06) and Chainage (300m) |

Figure 2 (Appendix 3.2b) Proposed Trees to be removed
Plan Layout (Sheet 2 of 5)

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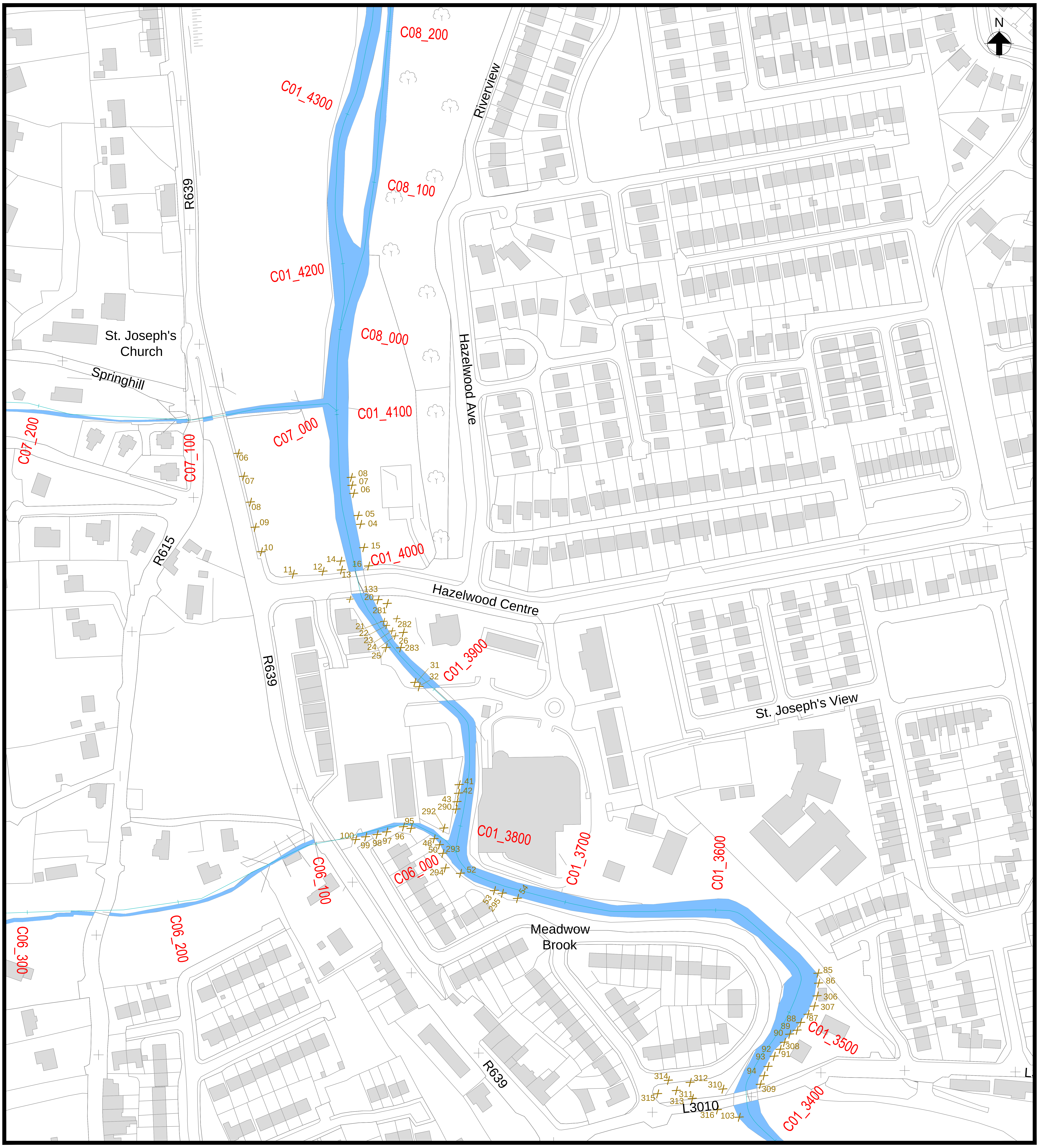
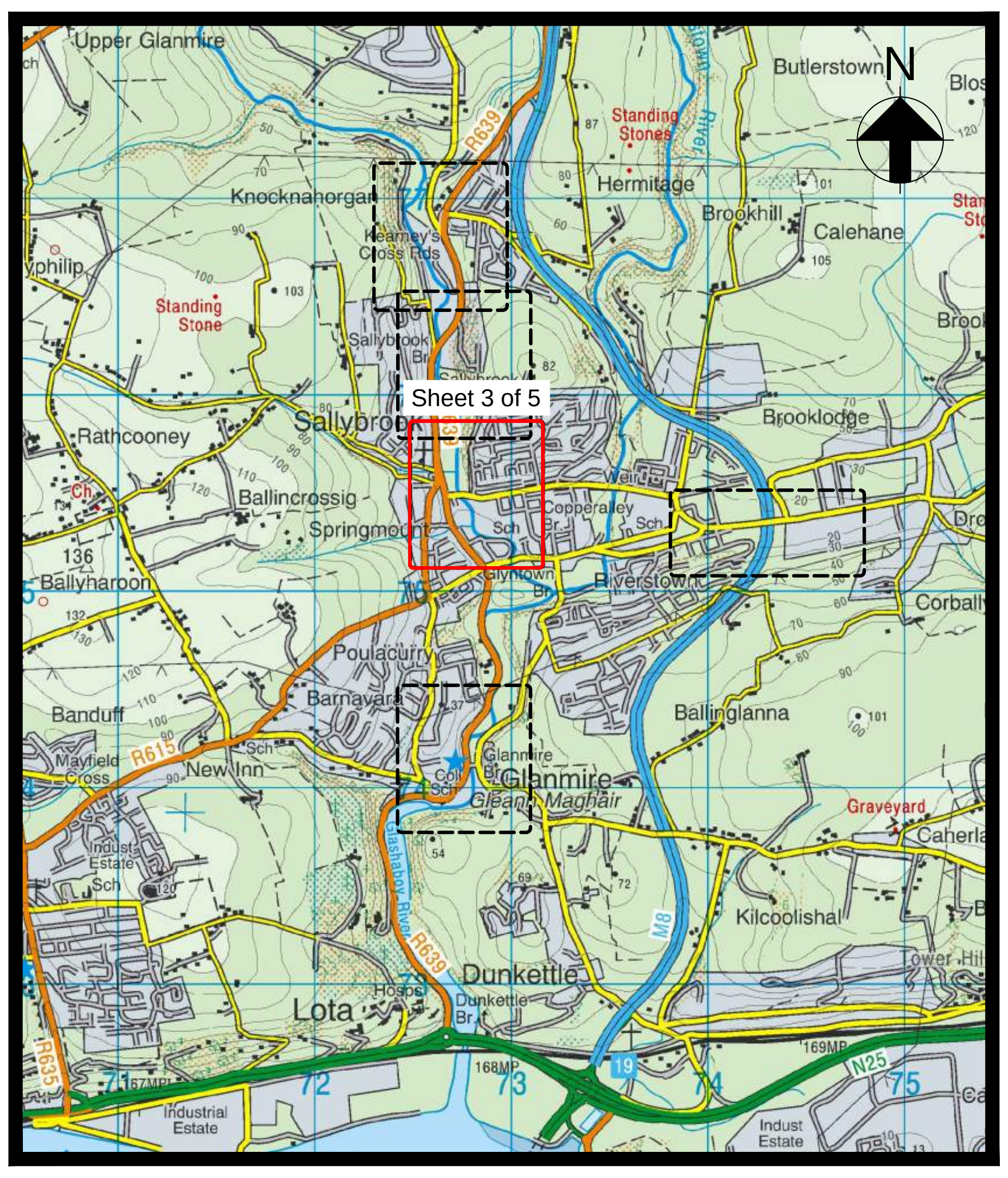
# Glashaboy River (Glanmire/Sallybrook) Drainage Scheme



Location Plan

25m SCALE 1:1250

Scale 1:1,250 at A1
Scale 1:2,500 at A3



Key Plan

Notes:
1. Do not scale from drawing.
2. Proposed works geometry and extents are subject to detailed design.
3. This drawing should be read in conjunction with all other Glashaboy River (Glanmire/Sallybrook) Drainage Scheme Confirmation Drawings and Schedules.

Key to Plan

| | |
|---|---|
| ## | Trees to be Removed |
| C06_300 | Channel Centreline, Reference (C06) and Chainage (300m) |

## Figure 3 (Appendix 3.2b) Proposed Trees to be removed
## Plan Layout (Sheet 3 of 5)

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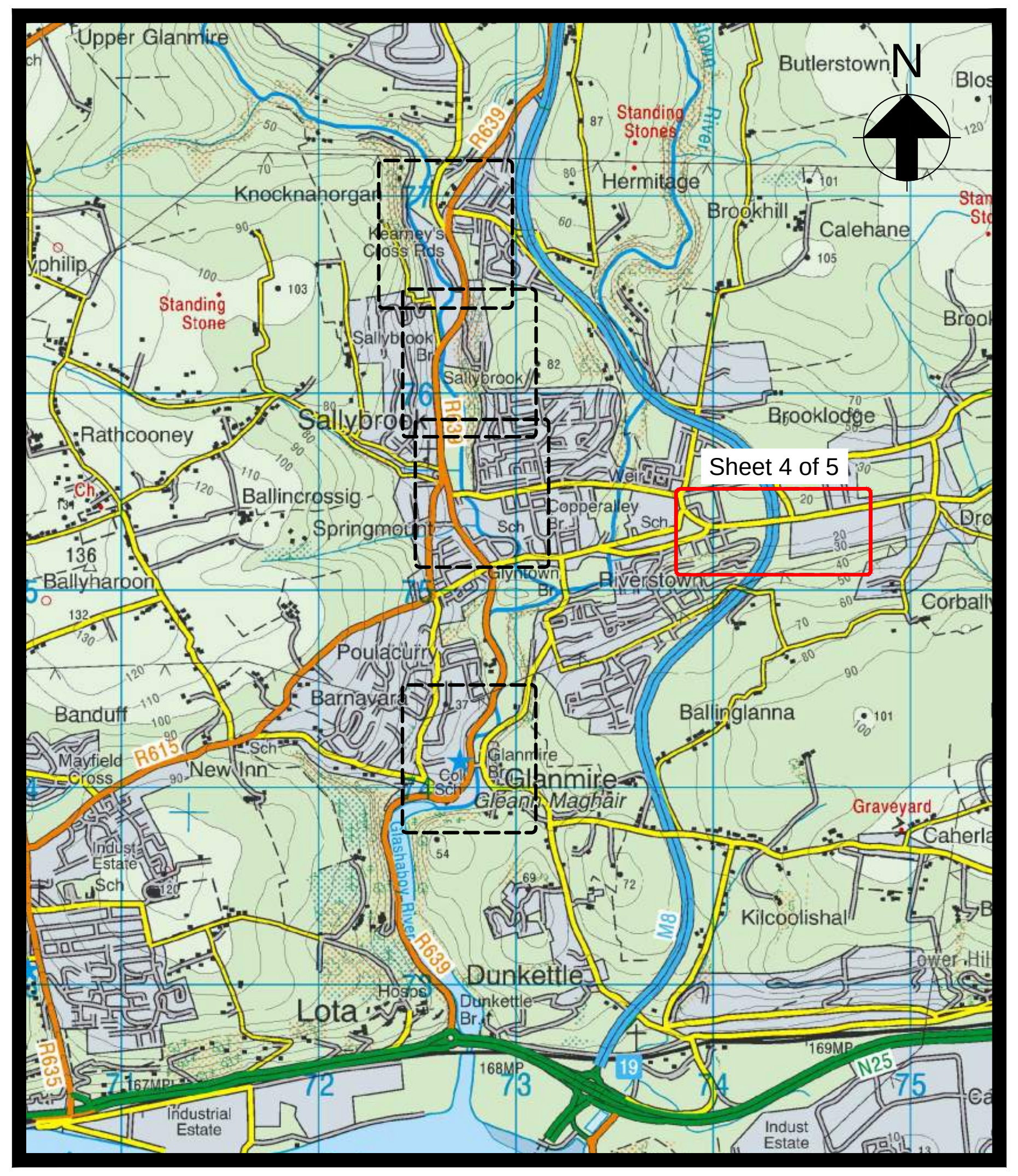
# Glashaboy River (Glanmire/Sallybrook) Drainage Scheme

Location Plan



Key Plan

25m SCALE 1:1250

Scale 1:1,250 at A1
Scale 1:2,500 at A3

Notes:
1. Do not scale from drawing.
2. Proposed works geometry and extents are subject to detailed design.
3. This drawing should be read in conjunction with all other Glashaboy River (Glanmire/Sallybrook) Drainage Scheme Confirmation Drawings and Schedules.

## Key to Plan

| | |
|---|---|
| ## + <br> ⊢ ## | Trees to be Removed |
| C06_300 | Channel Centreline, Reference (C06) and Chainage (300m) |

Figure 4 (Appendix 3.2b) Proposed Trees to be removed
Plan Layout (Sheet 4 of 5)

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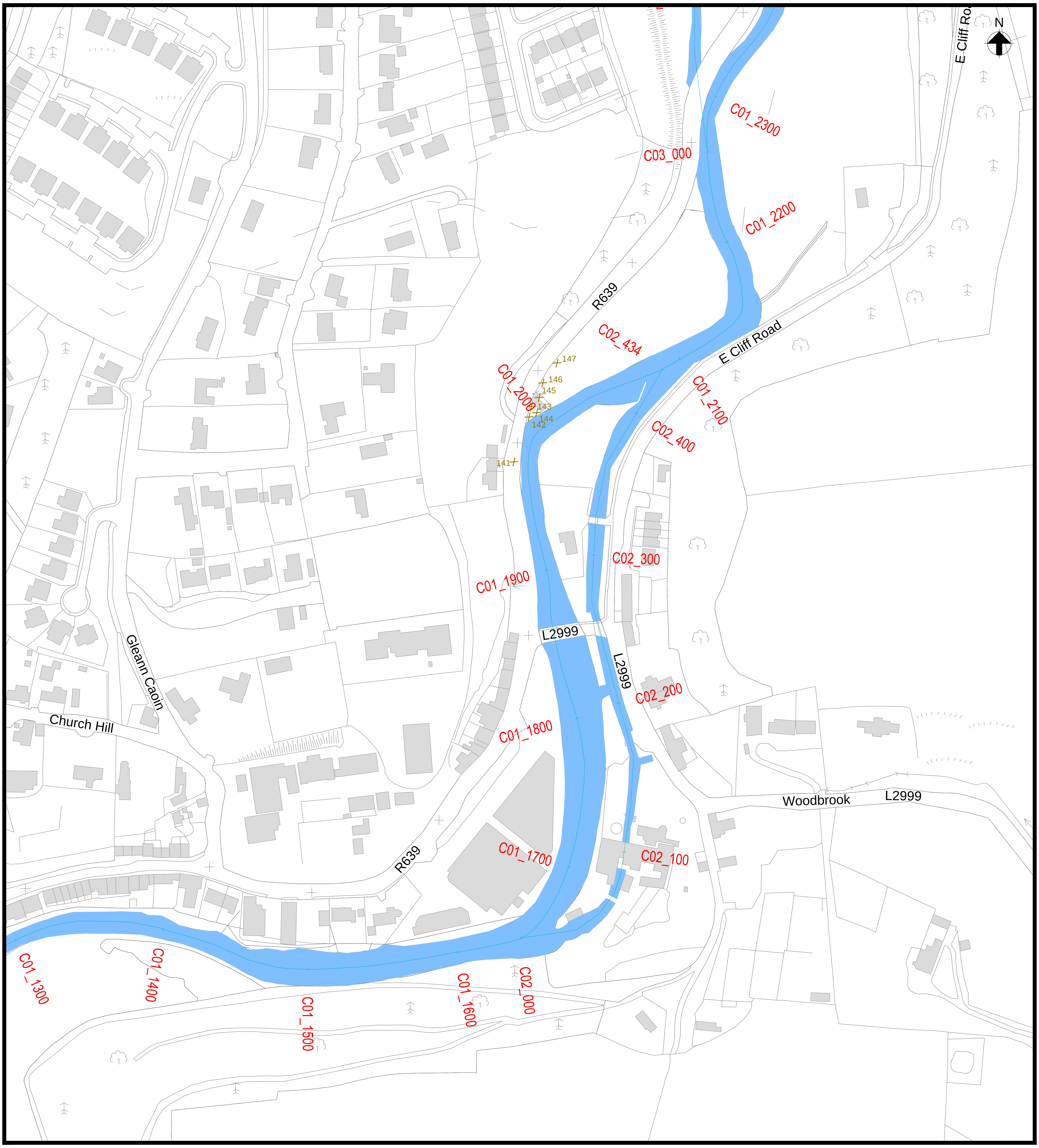
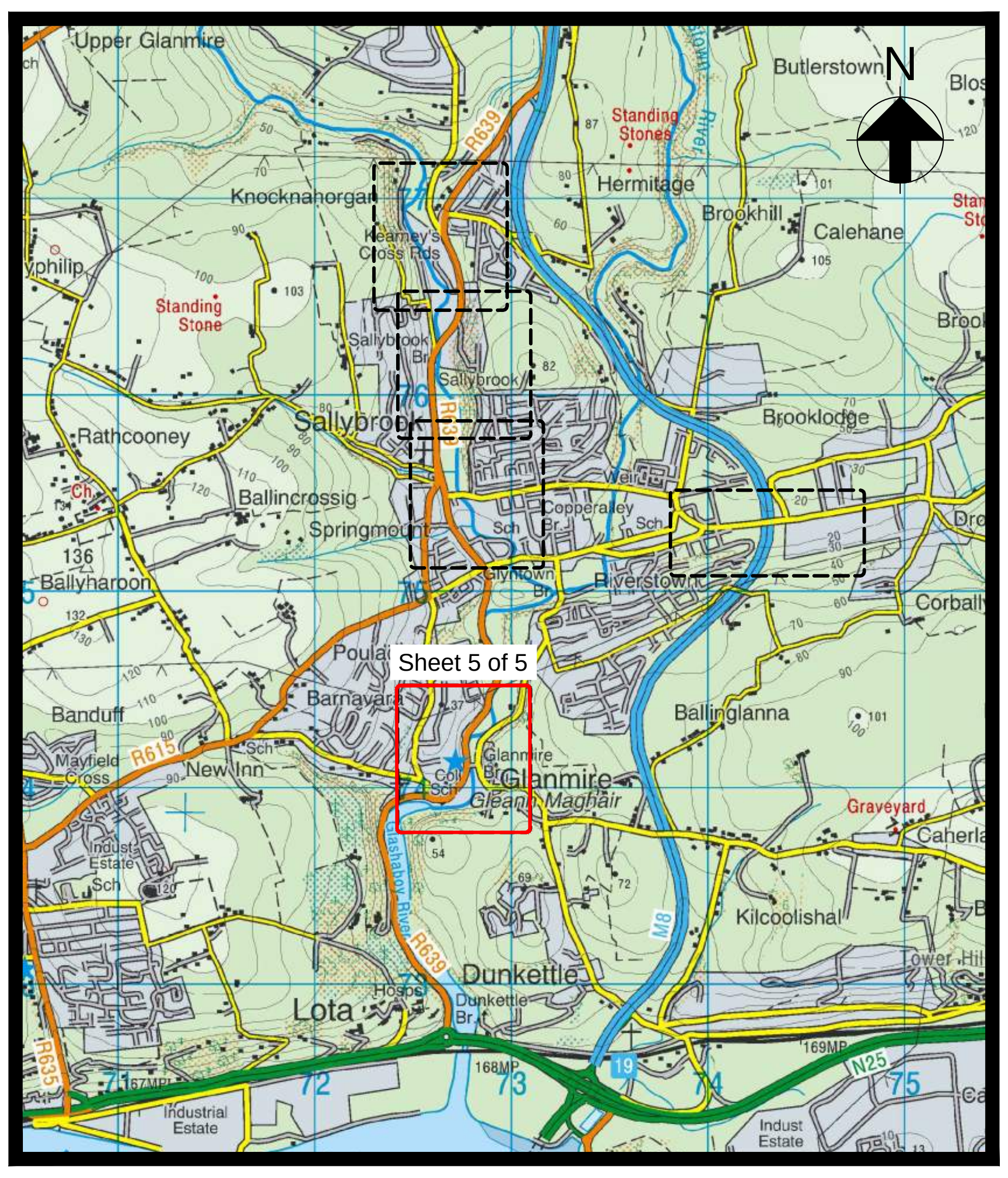
# Glashaboy River (Glanmire/Sallybrook) Drainage Scheme



Location Plan

25m SCALE 1:1250

Scale 1:1,250 at A1
Scale 1:2,500 at A3



Key Plan

Notes:
1. Do not scale from drawing.
2. Proposed works geometry and extents are subject to detailed design.
3. This drawing should be read in conjunction with all other Glashaboy River (Glanmire/Sallybrook) Drainage Scheme Confirmation Drawings and Schedules.

Key to Plan

| | |
|---|---|
| ## ✗ | Trees to be Removed |
| C06_300 | Channel Centreline, Reference (C06) and Chainage (300m) |

Figure 5 (Appendix 3.2b) Proposed Trees to be removed
Plan Layout (Sheet 5 of 5)

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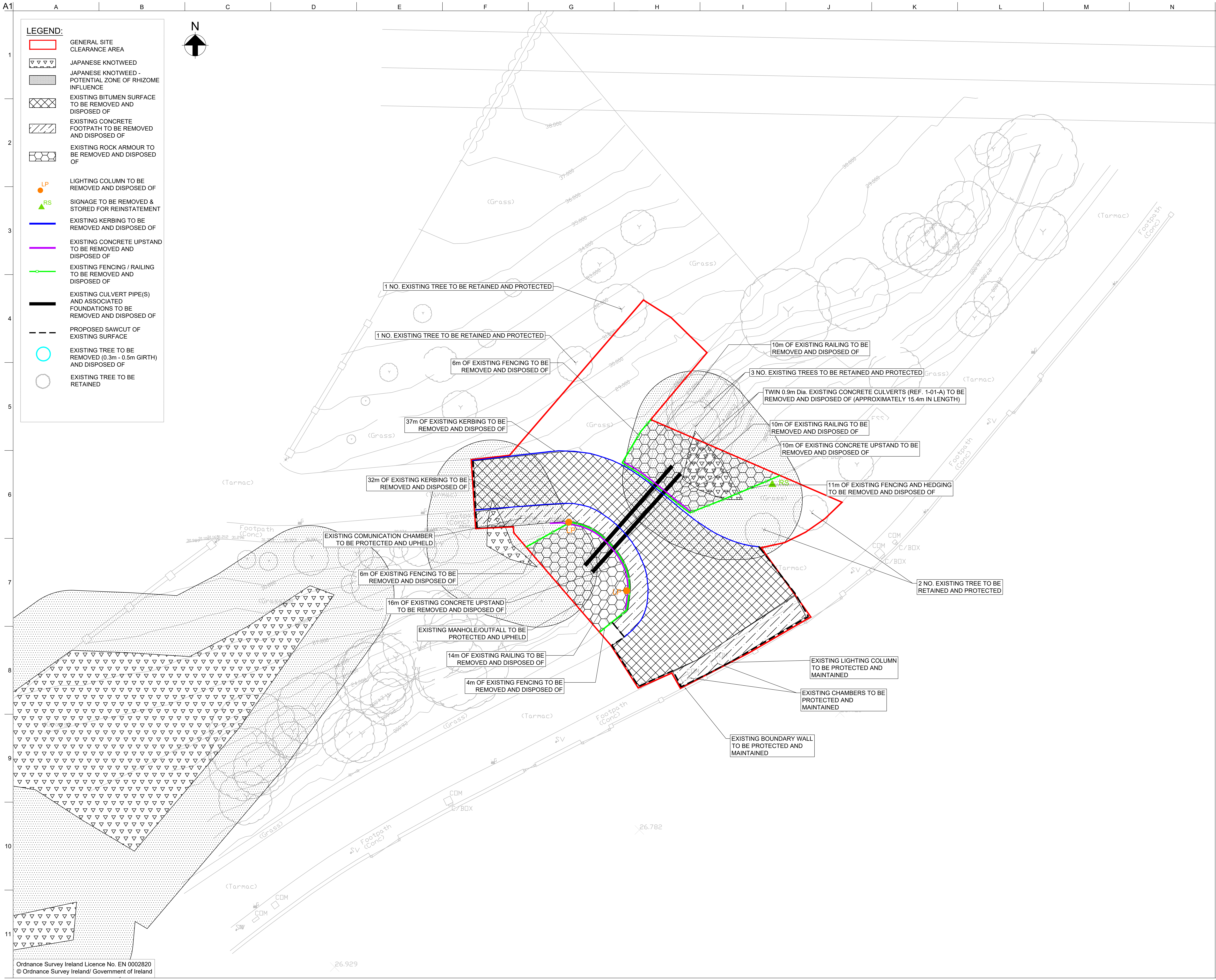
# Appendix H

## Revised Tree Removal Drawings (XX-040-XX)



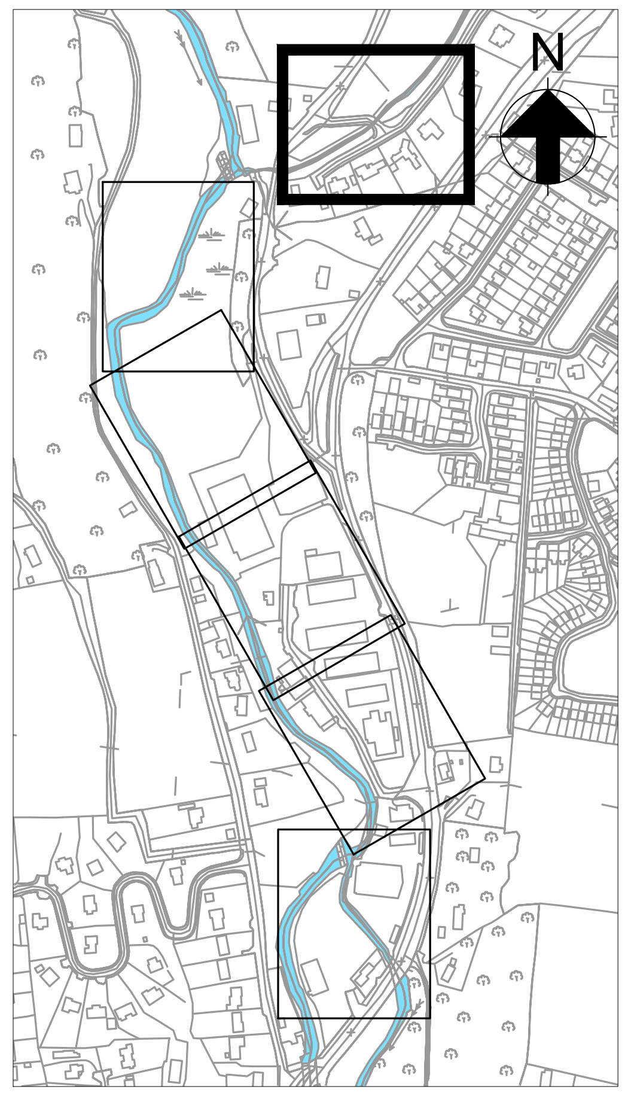
## LEGEND:

| | |
|---|---|
| ▭ | GENERAL SITE CLEARANCE AREA |
| ▽▽▽▽ | JAPANESE KNOTWEED |
| ▒ | JAPANESE KNOTWEED - POTENTIAL ZONE OF RHIZOME INFLUENCE |
| ▩ | EXISTING BITUMEN SURFACE TO BE REMOVED AND DISPOSED OF |
| ▨ | EXISTING CONCRETE FOOTPATH TO BE REMOVED AND DISPOSED OF |
| ⬡ | EXISTING ROCK ARMOUR TO BE REMOVED AND DISPOSED OF |
| ● LP | LIGHTING COLUMN TO BE REMOVED AND DISPOSED OF |
| ▲ RS | SIGNAGE TO BE REMOVED & STORED FOR REINSTATEMENT |
| — | EXISTING KERBING TO BE REMOVED AND DISPOSED OF |
| — | EXISTING CONCRETE UPSTAND TO BE REMOVED AND DISPOSED OF |
| —□— | EXISTING FENCING / RAILING TO BE REMOVED AND DISPOSED OF |
| ━ | EXISTING CULVERT PIPE(S) AND ASSOCIATED FOUNDATIONS TO BE REMOVED AND DISPOSED OF |
| — — — | PROPOSED SAWCUT OF EXISTING SURFACE |
| ○ | EXISTING TREE TO BE REMOVED (0.3m - 0.5m GIRTH) AND DISPOSED OF |
| ○ | EXISTING TREE TO BE RETAINED |

Do not scale

## NOTES:

1. FOR GENERAL NOTES, REFER TO DRAWING 5-000-00.
2. THIS DRAWING IS ONLY TO BE USED FOR THE DESIGN ELEMENT IDENTIFIED IN THE TITLE BOX. ALL OTHER INFORMATION SHOW ON THE DRAWING IS TO BE CONSIDERED INDICATIVE ONLY.
3. UNLESS OTHERWISE NOTED, ALL REMOVED/DEMOLISHED MATERIALS ARE TO BE REMOVED FROM SITE AND DISPOSED OF TO AN APPROPRIATELY LICENSED WASTE DISPOSAL SITE.
4. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER CONTRACT DRAWINGS AND THE CONTRACT SPECIFICATION (APPENDIX 2/1). REFER TO DRAWING SERIES 1-080 AND 1-090 FOR PROPOSED CIVIL/STRUCTURAL WORKS.
5. REFER TO WORKS REQUIREMENTS FOR DETAILS OF EXISTING TREES.
6. REFER TO DRAWING 1-070-01 FOR FURTHER DETAIL ON POSSIBLE REUSE OF EXISTING ROCK ARMOUR.
7. UNLESS OTHERWISE NOTED, ALL ITEMS ARE TO BE PROTECTED AND UPHELD.
8. UNLESS OTHERWISE NOTED, ALL ITEMS TO BE REMOVED/DEMOLISHED ARE TO INCLUDE ASSOCIATED FOUNDATIONS.



KEY PLAN

| Rev | Date | By | Chkd | Appd |
|---|---|---|---|---|
| T3 | 16/12/22 | SW | SW | KL |
| T2 | 22/12/21 | AG | SW | KL |
| T1 | 19/07/21 | AG | KOS | RK |
| P4 | 23/07/20 | SB | DR | RK |
| P3 | 21/02/20 | SB | DR | RK |
| P2 | 26/04/19 | SB | RK | KL |
| P1 | 15/03/19 | SB | RK | KL |

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Client

OPW

Project Title

Glashaboy River
(Glanmire/Sallybrook)
Drainage Scheme

Drawing Title

Area 1
Site Clearance & Demolition
Sheet 1 of 6

Scale at A1 1:200

Role Civil Structures

Suitability Tender

Arup Job No
**234334-00**

Rev
**T3**

Name
**1-040-01**