Appendix F
Drainage Design Options

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1.1 Introduction

This report is to outline the drainage options available for the treatment of the surface water runoff generated from the proposed Bus Connects Galway: Dublin Road Project. This report relates to the treatment for the surface water from Drainage Networks 7 and 8 only (between approx. Mainline Chainage 2+170 to 3+883), which is henceforth referred to as the 'Study Area'.

As the preliminary design of the Bus Connects project progressed, it became apparent that between mainline chainage 2+170 and 3+883 there was no watercourses or drainage networks which could be utilised as outfalls for a road drainage system, and that the drainage of the existing road was via an informal over the edge drainage system, whereby surface water from the road pavement was shed onto private lands adjacent to the road. This runoff then infiltrated through the soil adjacent to the road. This form of system is common and is how most rural roads in Ireland are drained. As the proposed works involve the provision of a cycle track and footpath which incorporate kerbing, the existing over the edge drainage system cannot be utilised.

The purpose of this report is to outline the different options for draining this section of carriageway, so that an informed decision can be made on which option should be adopted for the Preliminary Design.

The options presented takes cognizance of the relevant constraints regarding landownership and environmental requirements amongst others.

1.2 The Study Area

The Study Area extends from Chainage 2+170, which is the start of Drainage Network 7 to Chainage 3+883 at the tie-in point of the development (Doughiska Junction). Refer to Figure 1, on which a longitudinal section along the proposed road alignment is depicted along with the alignment low points. Within the Study Area, no suitable watercourses or existing drainage networks have been identified.

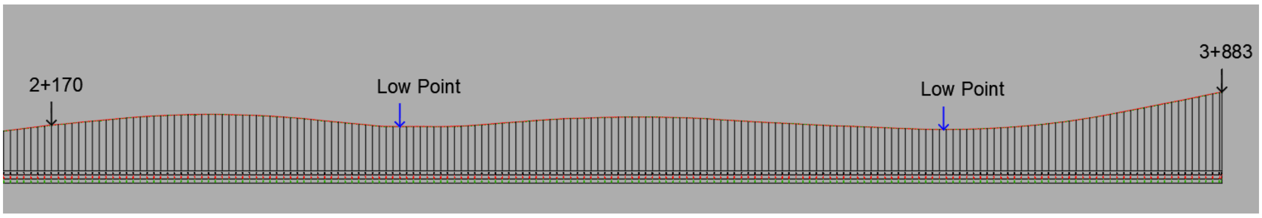

Figure 1:Long Section along Dublin Road (2+170 to 3+883)

1.3 Proposed Works

The proposed works involve the widening of the existing road to incorporate bus lanes, cycle lanes and pedestrian footpaths. The bus lanes will be separated from the cycleways and pedestrian footpaths by kerbing. The typical road cross sectional width comprising the proposed road, bus lanes, cycleway and footpaths are within the range of 20m to 24m. The width of the existing road and footpaths between the entrance to Merlin Park Hospital and the Doughiska Junction is within the region of 13-17m, meaning there is an increase in the hardstand area. A typical section through the proposed road is indicated in Figure 2.

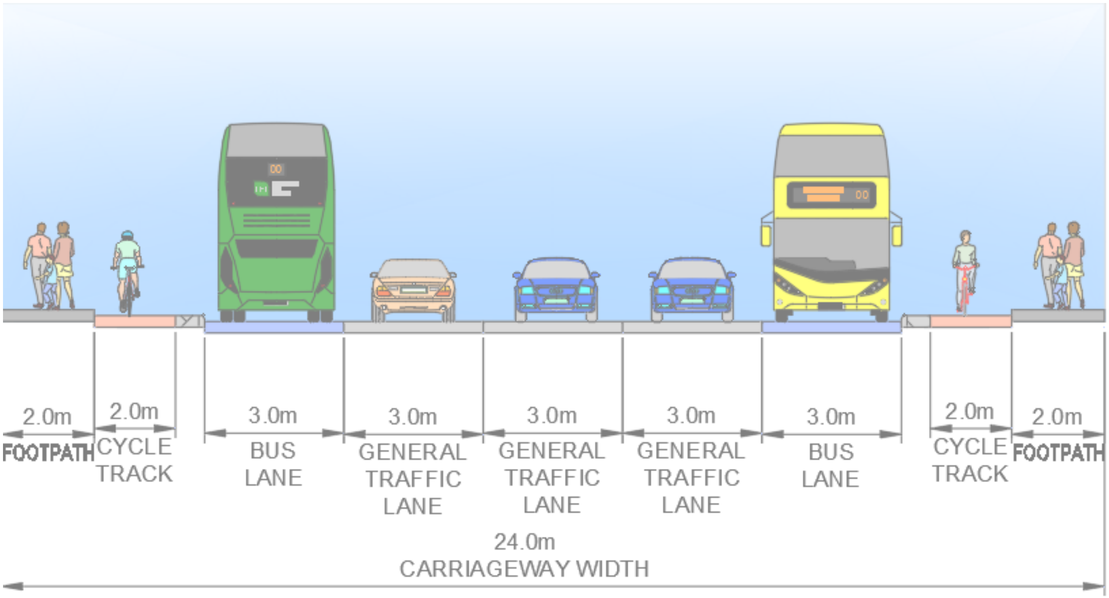

Figure 2: Proposed Road Cross Section

1.4 Surface Water Runoff from Roadways

TII document *Road Drainage and the Water Environment March 2015*, gives guidance on assessing the impact from road runoff on the receiving environment. Research conducted by TII, and related bodies have found that surface runoff from paved surfaces subject to vehicular traffic overrun can contain traces of zinc, copper, and hydrocarbons, amongst others. While these are only present in trace quantities, the concentrations are proportionate to the traffic levels (AADT's), and with time can accumulate in topsoil. The receiving environment within the study area is currently at risk from the two types of runoff/pollution;

Acute Pollution*: occurs as a result of a severe, usually transient, impact. For road runoff, these impacts usually result from a spillage of pollutants, but can result from routine runoff. High loads of suspended solids may have similar effects in certain circumstances. The impacts are generally associated with readily dissolved forms of the pollutants which, on discharge into the water environment, are sufficiently toxic above certain concentrations to result in the death of organisms over a relatively short period of time (usually hours/days).*

Chronic Pollution: *is the result of on-going low levels of pollution which may result in the accumulation of sediment-bound pollutants over a longer period of time (months/years). These low levels of pollutants can result in non-lethal effects, such as reduced feeding, growth rates and reproduction, or may result in the death of organisms. Sediment can also have indirect effects on ecosystems such as the burial of spawning beds and the changing of a gravel dominated substrate to a substrate dominated by finer sediments.*

The above definitions are taken from the TII document; *Road Drainage and the Water Environment March 2015*. As surface water from the existing road runs over the edge into grassed areas this can result in *Chronic Pollution* within the soils and grasses. As this runoff is uncontrolled, a pollution spillage from a tanker or fuel tank rupture will be difficult to contain and will drain to the adjacent grasslands and groundwater. Some of the options provided below address the issues of Chronic and Acute pollution within the study area, meaning that post development, the polluting effects on the receiving environment will have reduced.

1.5 Existing environment.

A number of environmental sensitivities within the study area include:

- The grassland to the north of the existing road between approximate Chainages 2+235 and 3+250 is being treated as a mosaic of an Annex I grassland habitat.
- The ground to the south of Chainage 2+700 to 3+300 is classified as an area of geological heritage. Refer to Figures 3 to 9 below, which indicate GSI's notes and the extents of the geological heritage region.

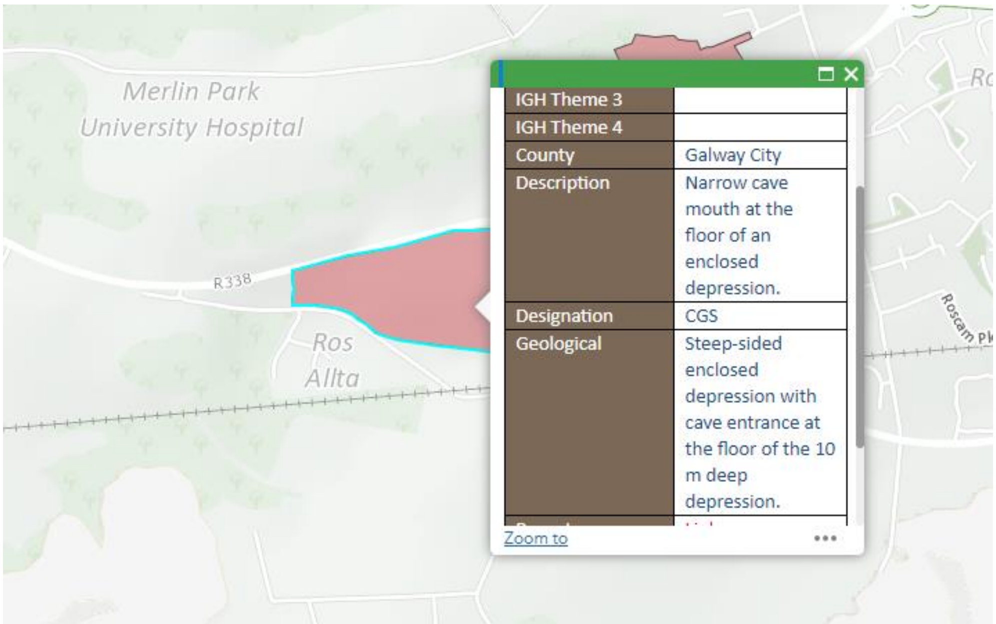

Figure 3: Geological Heritage Area Notes

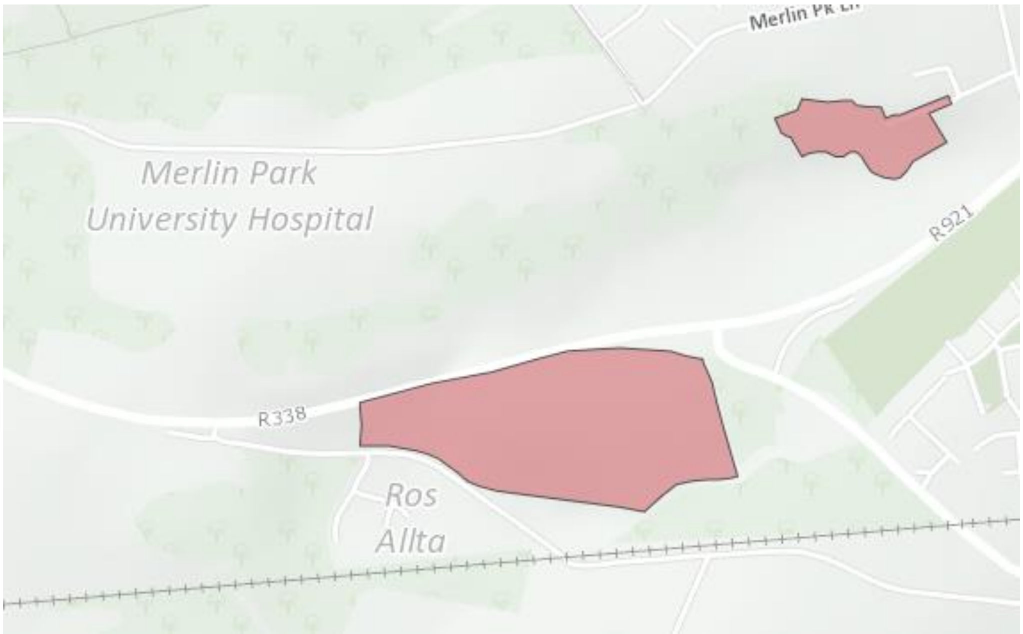

Figure 4: Geological Heritage Extents

- The aquifer/groundwater in the region has a vulnerability of E (Extreme) or X, which are the highest vulnerability ratings. Where the overburden is thin or non-existent and bedrock is close to or at the surface, this can act as a pathway to groundwater for pollutants. In this case, the bedrock is limestone, which is vulnerable to karstification, meaning there is the potential for voids and pathways within the rock which can act as a conduit between pollutants at ground level and the aquifer. Refer to Figures 5 and 6 below.
- The bedrock is KaRck which is karstified bedrock outcrop or subcrop.
- The aquifer in the region is classified as regionally important.

Figure 5: Groundwater Vulnerability 1

Figure 6: Groundwater Vulnerability 2

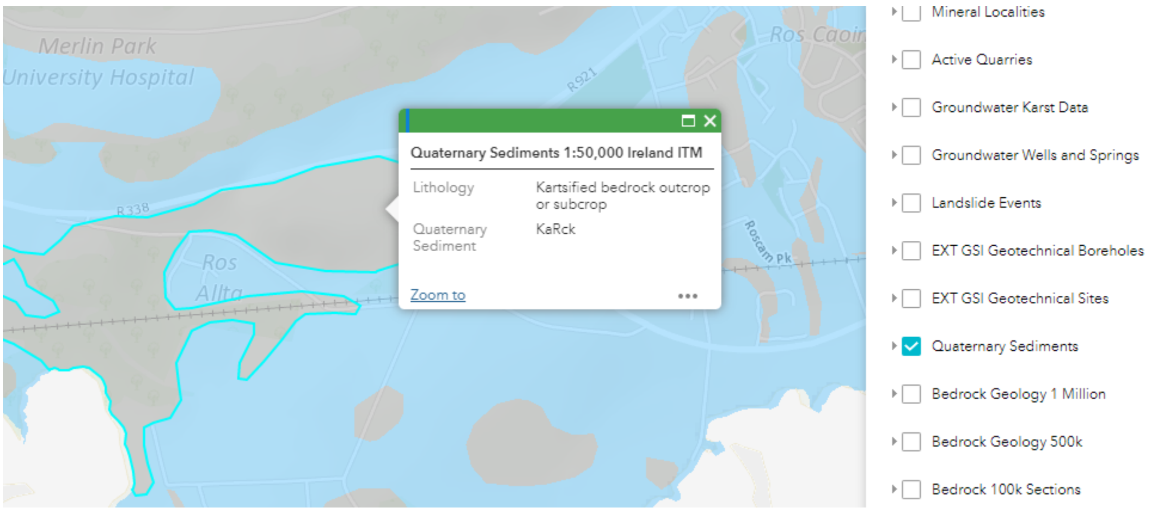

Figure 7: Quaternary Sediments (Overburden) classification

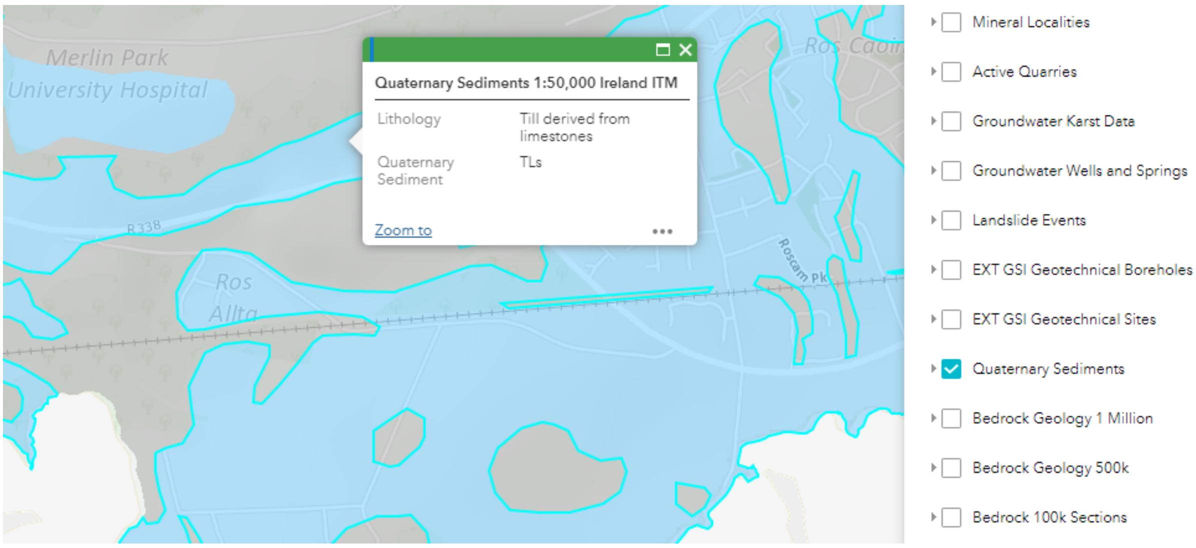

Figure 8:Bedrock Classification

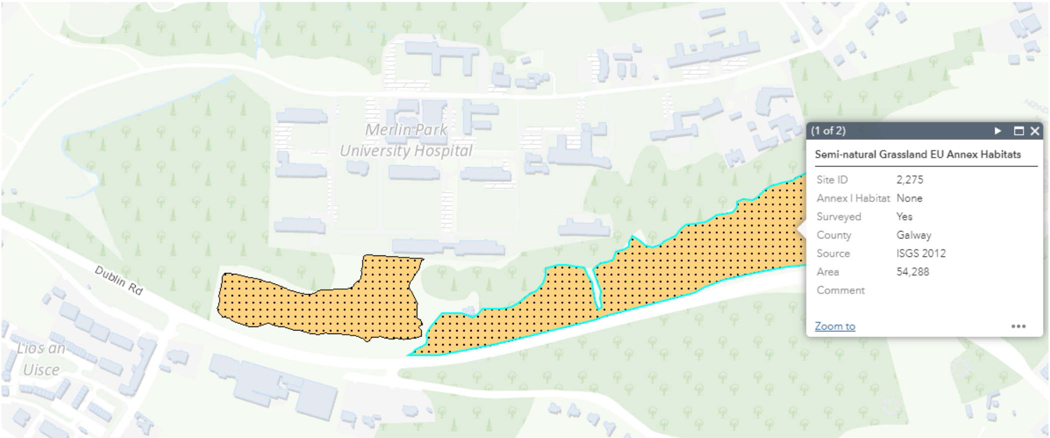

Figure 9: Extents of Semi-Natural Grassland

1.6 Drainage Design Options

Further to assessing the various constraints within the Study Area, ten potential engineering options were developed to facilitate the disposal of the surface water generated by the existing and additional hardstand areas. Impacts on the environmentally sensitive areas in the region were important factors in the selection and assessment for each option. Where infiltration-based options are proposed, there is the potential of aquifer contamination by road pollutants or spillage events. This is unavoidable but can be mitigated through design. The current road drainage presents a risk to the aquifer, which can now be mitigated through the Galway BusConnects: Dublin Road project.

With respect to the infiltration options, these will be provided within a region where the bedrock is limestone with thin overburden and where there is the potential for karstification. Barry Transportation / J.B.Barry previously completed the detailed design on the northern section of the N17/N18 Gort to Tuam PPP scheme, which is between approximately 10-20 kilometres to the west of the Galway BusConnects: Dublin Road project. As part of the Gort to Tuam scheme, specific infiltration details were developed for use within karstified regions, and it is the intention to propose similar details on this project and assess if appropriate. One of the problems with providing infiltration trenches on top of porous rock such as karstified limestone, is that if the infiltration trench is resting on expose rock, a direct route to the aquifer is provided. On the Gort to Tuam project, this was mitigated by providing 1m of slower draining material beneath the infiltration trench or infiltration pond, which would slow the flow rate to the aquifer, and act as a trap for pollutants. If required, something similar would be proposed for the Galway BusConnects: Dublin Road project.

The Options are as follows:

1.6.1 Option 1: Lateral Infiltration Trenches.

Option 1 will involve the provision of lateral infiltration trenches at the back of the proposed footpaths (Figure 10). The infiltration trenches shall be kept relatively narrow (1-2m) and shallow (1-1.5m). Surface water will be collected from the road pavement and footpaths / cycleways via gullies or drainage kerbs (ACO). These gullies or ACO kerbs will either connect directly to the infiltration trench, or connect into a collection network, which will then outfall to the infiltration trench. The infiltration trenches will be filled with a granular material which typically has a void ratio of 0.3, which will provide attenuation. The trench will be finished with geotextile and topsoil, so it is not incongruous with the surrounding landscape. The main advantages and disadvantages of this system are listed below. Indicative locations of the narrow infiltration trenches shown in Figure 10 as N.I.T (Narrow Infiltration Trench).

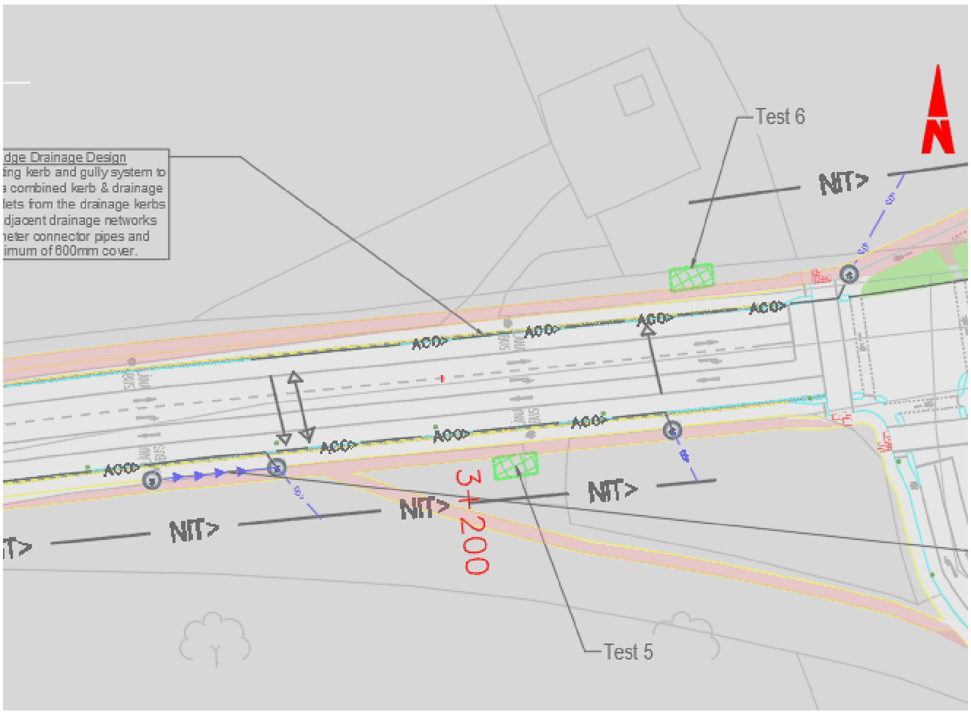

Figure 10: Option 1 - ACO Drains connecting to narrow infiltration trenches.

Advantages:

- Providing a continuous infiltration system in parallel with the carriageway is similar to the pre-development over the edge drainage system and is compatible with a nature based 'SuDS' form of drainage system.
- System is in keeping with the circular economy and does not require extensive network of concrete pipes and manholes to convey water to a singular outfall.

Disadvantages:

- Extra land required for infiltration trench.
- If system is not maintained, infiltration trenches can become silted up meaning they may need to be excavated and replaced with fresh granular material.
- The aquifer is vulnerable to a large fuel spillage event.
- Approximately four locations will require infiltration testing if this approach is to be adopted for the preliminary design.

- Between chainage 2+520 and 2+980 on the southern side, infiltration trench will be through a wooded area of geological heritage.
- This option is contingent on site investigation works and determination of permeability rates, bedrock depth and groundwater depth.
- Difficult to provide pollution control and petrol interceptors as this option consists of numerous small outfalls from gullies and ACO kerbs to a long infiltration trench.

1.6.2 Option 2: Lateral Infiltration Trenches between the Proposed Footpaths.

A change in the positioning of the infiltration trenches to beneath the proposed footpaths rather than to the back of is the main difference between Option 2 and Option 1 above. While this gives Option 2 an advantage over Option 1, by removing the requirement for additional land take, footpaths could potentially be susceptible to subsidence. In addition, the footpaths would need to be excavated if the infiltration trenches were not maintained or became silted up.

1.6.3 Option 3: Infiltration Basin / Pond.

Option 3 proposes a standard gravity storm network to convey surface water from the proposed road and footpaths / cycleways and transfer to alignment low points at Chainage 2+670 (Network 7) and 3+475 (Network 8) approx. At the low points, infiltration basins would be provided (Figure 11) to allow infiltration of surface water. A drainage system such as this was successfully used on the M17/M18 Gort to Tuam project. This project had similar sensitivities and constraints i.e., presence of sensitive karstified limestone bedrock situated close to the surface and outfall constraints due to lack of watercourse availability.

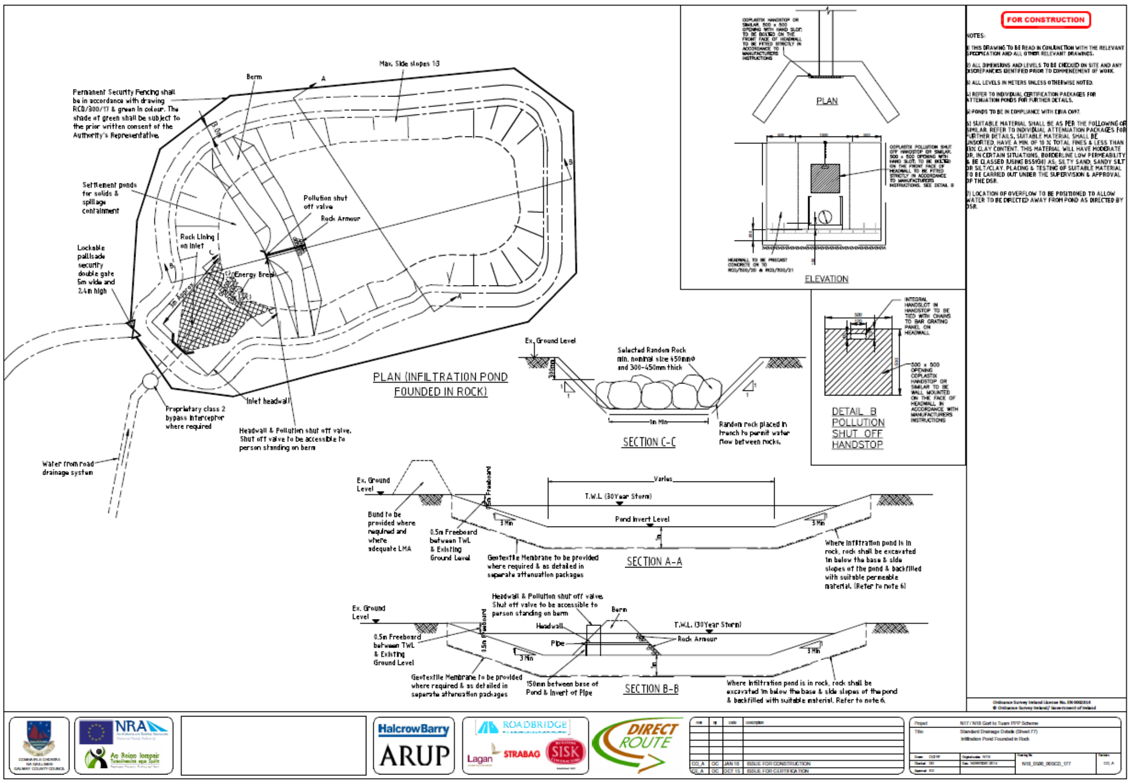

Figure 11: Option 3 - Drawing of Infiltration Basin as used on N17/N18 Gort to Tuam PPP Scheme

The advantages and disadvantages for Option 3 are as follows:

Advantages:

- Infiltration occurs at a singular location in an open-air infiltration basin, simplifying desilting maintenance works.
- As the footpaths and road drainage is collected by a conventional piped system, pollution control in the event of a spillage event is easier, reducing the risk of aquifer contamination.
- Infiltration basin can be landscaped and add aesthetic / recreational amenity to the development.
- Landtake only required at pond/basin location, and not continuous strip as is the case with Options 1 and 2.
- Petrol interceptors can be provided as required.

Disadvantages:

- Infiltration is restricted to pond footprint and if poor infiltration is present at the network low point, the pond may not provide sufficient infiltration.
- The proposed system is different to the current system. This option brings surface water to two local low points, which is different to the current scenario where road drains to the adjacent lands along the full length of the road.
- Larger local land take required for pond.

- Pond has the potential to hold a depth of water during extreme flood events, which may be a potential hazard.
- Pond requires overflow if a 1 in a 100-year flood event is exceeded. As there are no adjacent watercourses, overflows will extend across private lands.
- Tree clearance will be required at low point at Chainage 2+700 to facilitate pond / basin.
- Network 8 pond / basin would be in an area of geological heritage.
- Pond could cause odours from stagnated undrained water, leading to potential maintenance issues.

As a piped system is required to transfer surface water from the road and footpaths to the location of the infiltration basin, this option requires more pipes and manholes. Furthermore, it does not align with the promotion of circular economy principles compared to Options 1 and 2.

1.6.4 Option 4: Online storage outfalling to infiltration basin at low point

Option 4 follows a similar infiltration outfall approach as Option 3 but is supported by the addition of an online storage system. The online storage or attenuation system will be in the form of oversized pipes situated upstream of the infiltration trenches at alignment low points (Figure 12).

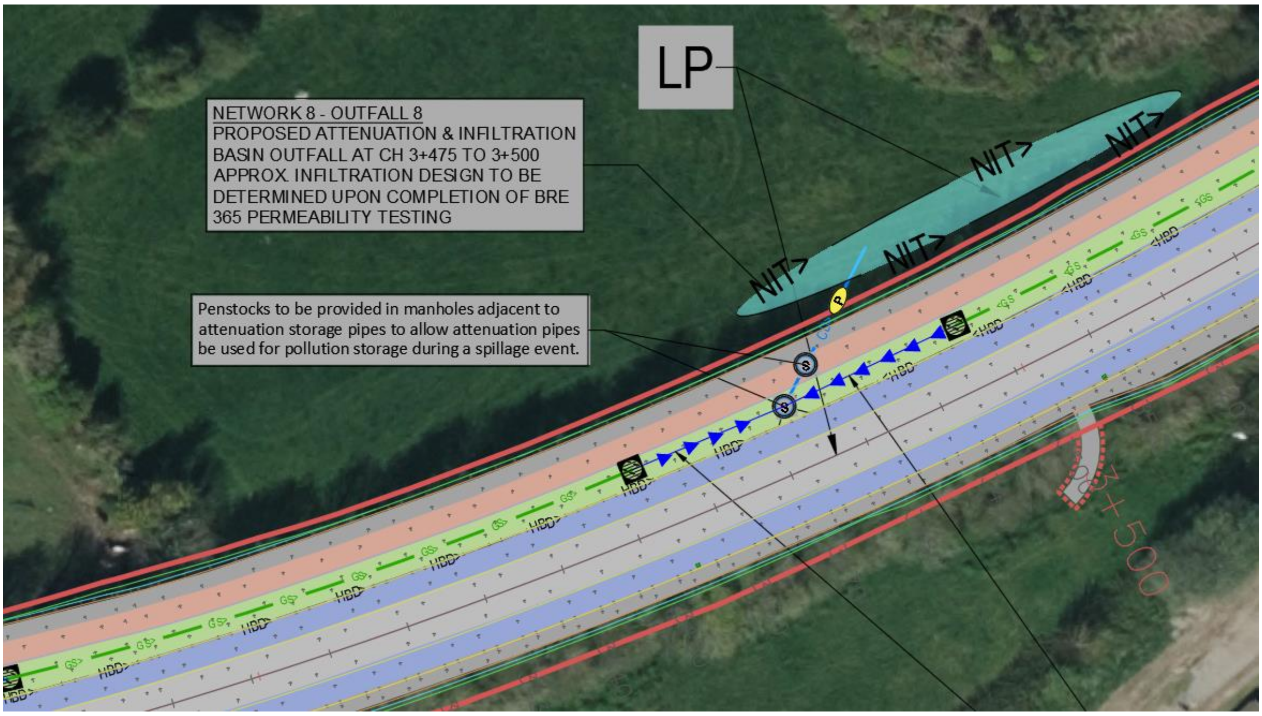

Figure 12: Option 4 - Online Attenuation- Infiltration Basin System

Advantages

- Reduced land take along the development corridor. Online pipes can be provided beneath footpaths. Infiltration trenches at low points will have a much smaller footprint compared to Option 3 due to the presence of flow controls within the online attenuation pipes restricting flows.
- As the footpaths and road drainage is collected by a conventional piped system, pollution control in the event of a spillage event is easier, reducing the risk of aquifer contamination.

- As surface water passes through a pipe system incorporating catchpit manholes and other silt trapping measures prior to outfalling to the infiltration trench, the risk of the infiltration trench silting up over time is reduced.
- Petrol interceptors can be provided as required.

Disadvantages

- Use of pipes and manholes not in keeping with SuDS or circular economy principles.
- Proposed system is different to the existing drainage system. This option brings surface water to two local low points, which is different to the current scenario where road drains to the adjacent lands along the full length of the road.

1.6.5 Option 5: New surface water gravity main, connecting to the existing surface water network.

Further to assessing the existing surface water infrastructure in the region, an existing surface water pipe was identified near Galway Irish Crystal along Murrough Avenue Sideroad (Mainline Ch 2+170). Previously installed as part of the Galway Main Drainage Works, the existing storm sewer was confirmed as 1500mm diameter with a depth to invert of 7.41m.

Figure 13 to Figure 15 below provide details of the depths and extents of the gravity main with the range of impacted Networks 7 and 8. The proposed surface sewers are indicated in blue, with suggested manholes indicated in yellow. The proposed gravity sewer as indicated by the blue line will have a diameter of 450mm. Attenuation will be provided upstream of the connection points, to minimise the flows in the 450mm pipe.

Prior to connecting to the existing 1500mm diameter pipe at Chainage 2+170, the surface waters from networks 7 and 8 will be attenuated to limit the flow to the 1500mm pipe.

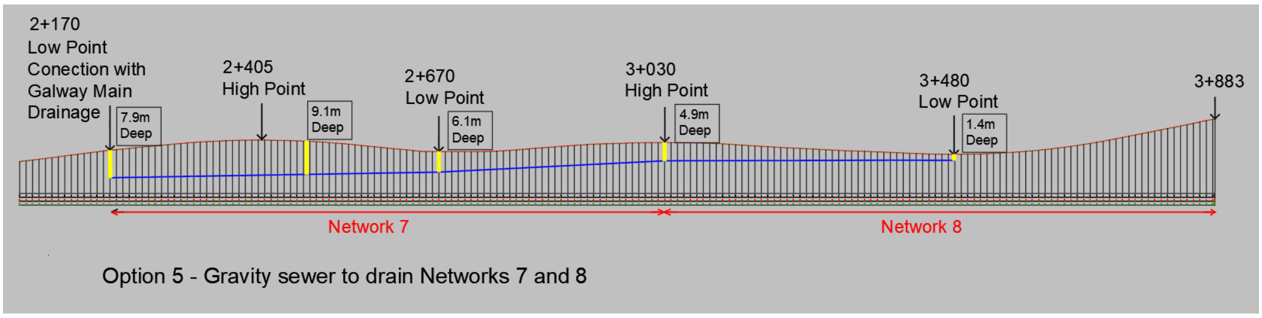

Figure 13: Option 5 – Gravity Surface Water Main Cross Section

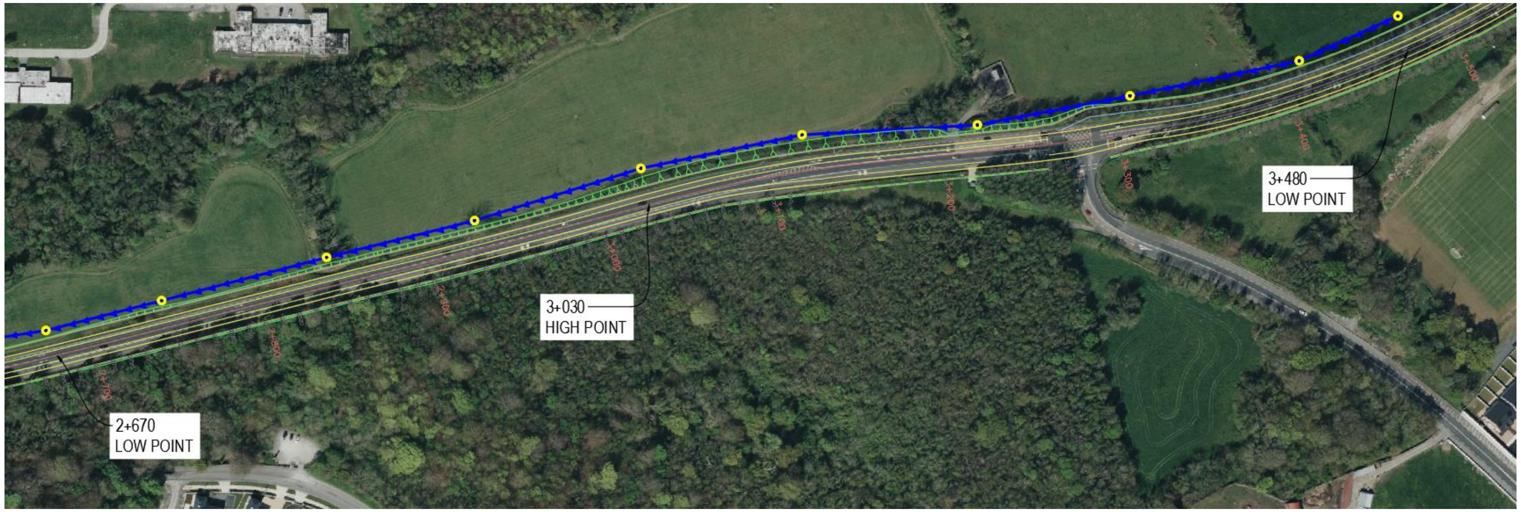

Figure 14: Option 5 - Gravity Surface Water Main Layout

Figure 15: Option 5 - Gravity Surface Water Main Layout (Towards existing 1500mm main)

Advantages:

- **Environmental:** As this option is completely sealed, contaminated road runoff will no longer drain over the edge onto the adjacent grasslands, meaning the post development impact on the grasslands and aquifer will be improved from the predevelopment impact.
- **Environmental:** The adjacent grasslands will no longer be vulnerable to a large-scale fuel spillage event.
- As there are no infiltration features, the risk of long-term silting up is removed.

Disadvantages:

- **Health and Safety (Operational Phase):** More onerous long term maintenance regime due to the depth of the pipe and manholes. Specially trained operatives with specialist equipment may be required.
- **Health and Safety (Construction Phase):** Depth of trench is a risk to construction personnel**.**
- **Environmental:** Depth of trench may impact on the aquifer during the Construction and Operational Phases. Deep trenches can result in dewatering of the adjacent aquifer.
- **Environmental:** Depending on the ground conditions, significant rock excavation may be required.
- **Construction Complexity:** Deep trench within constrained land take will require detailed method statements that address all constraints and risks.
- **Cost:** It is considered this option will add a significant amount to the projects overall Construction Cost due to the complexity of installing a pipe at the required depths.
- Attenuation pond or subsurface cellular attenuation will be required to limit flows.
- Proposal will not be in keeping with SuDS or the circular economy.
- Additional land take to allow construction of and maintenance of any pipework between the proposed road drainage system and the receiving drainage network.

1.6.6 Option 6: Gravity pipe for Network 7, combined with infiltration trench at Network 8.

Option 6 consists of a combination of the drainage approaches discussed in Option 5 (gravity) and Option 4 (infiltration) above, where a gravity sewer will be applied across the extents of Network 7 and an infiltration approach for Network 8.

The benefits of using a gravity sewer for Network 7 will prevent polluted surface water from the road draining over the edge onto the Annex 1 grasslands. Furthermore, in the case of Option 6 the Network 7 gravity sewer will be shallower than Option 5, with overall trench depths reduced by a minimum of 4m (Figure 16).The advantages and disadvantages for the gravity sewer and the infiltration trench/pond will be similar to those listed for Options 4 and 5 respectively.

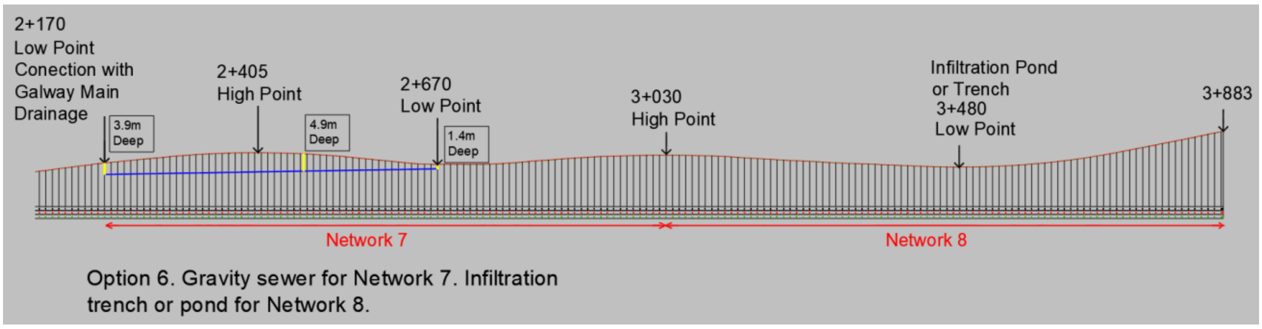

Figure 16: Option 6 – Combined Gravity Surface Water Main & Infiltration Cross Section

1.6.7 Option 7: 2 No. Surface water pumps at low points.

This option will entail the provision of two surface water pumping stations at Chainages 2+670 and 3+480. A gravity collection system will bring surface water from Network 8 to the low point at 3+480. From here it will be pumped via a rising main to 2+670, where it will outfall into a wet well. Collected surface water from Network 7 will also drain into this wet well. A second pump at Chainage 2+670 will pump the waters from the wet well to the existing 1500mm pipe at Chainage 2+170.

As this proposal will be dependent on the pumps, flood overflows and contingencies will need to be considered as part of the design.

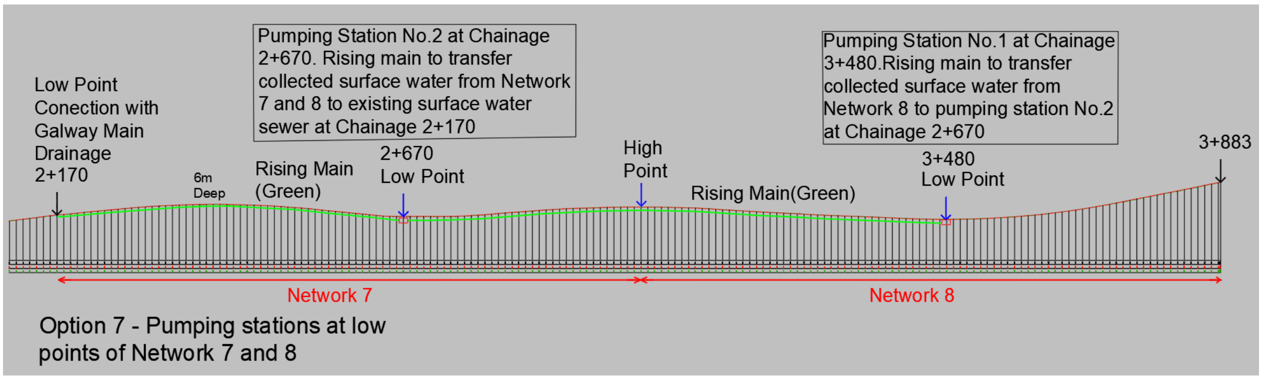

Figure 17: Option 7 – Surface Water Rising Main Pump Cross Section

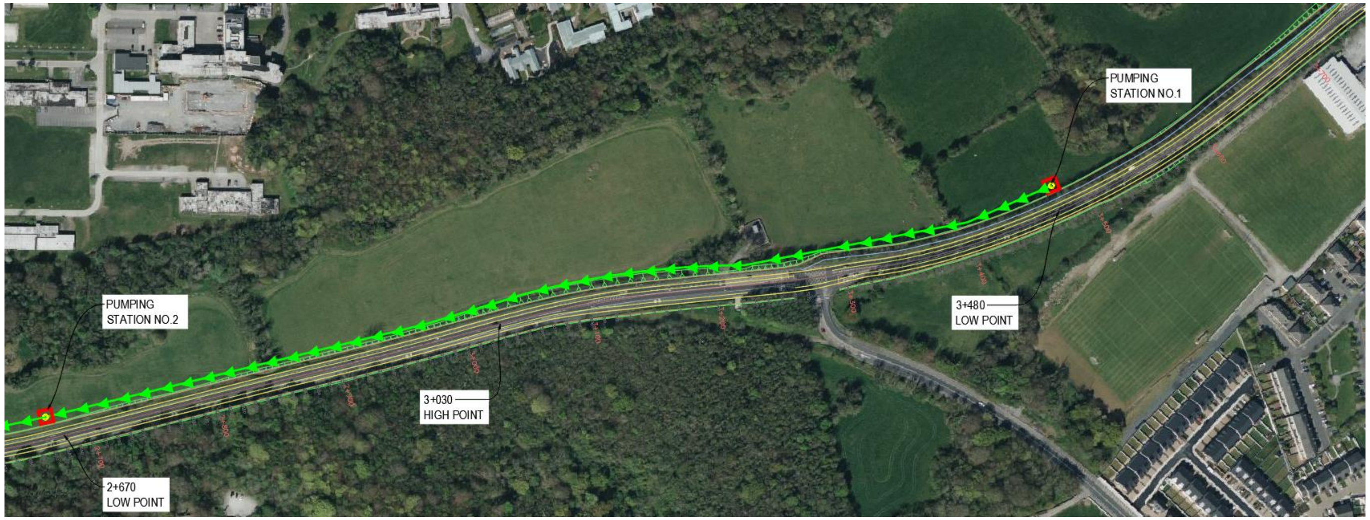

Figure 18: Option 7 – Surface Water Rising Main Pump Layout

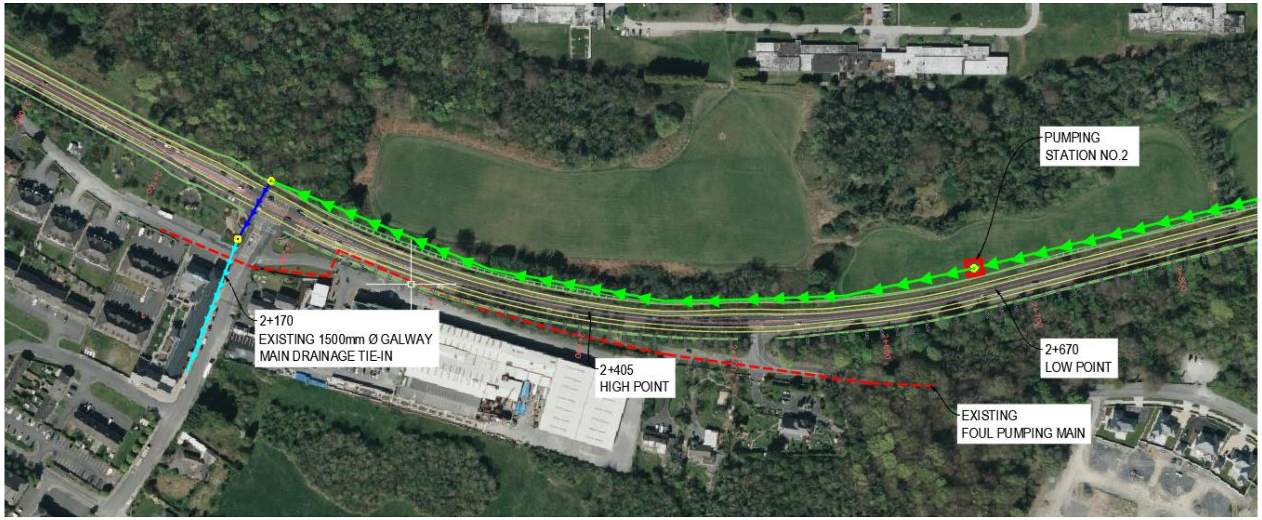

Figure 19: Option 7 – Surface Water Rising Main Pump Layout (Towards existing 1500mm main)

Advantages:

- **Environmental:** As this option is completely sealed, contaminated road runoff will no longer drain over the edge onto the adjacent grasslands. Meaning the post development impact on the grasslands and aquifer will be improved from the predevelopment impact.
- **Environmental:** The adjacent grasslands will no longer be vulnerable to a large-scale fuel spillage event.
- With no infiltration features provided, the risk of long-term silting up is removed.
- No deep excavation required.

Disadvantages:

- Cost of long term maintenance.
- System is at risk from power outages, meaning overflow mechanisms will need to be provided in the event of pump failure.

1.6.8 Option 8: Pumping Station and gravity main combination.

Option 8 resembles Option 6 by adopting a combined system approach. However, while Option 6 combines infiltration and gravity main drainage, Option 8 employs a combined rising main and gravity main approach. The pumping station will transfer flows to the head of the new gravity main at Chainage 2+670 from where they will flow by gravity to the existing 1500mm surface water sewer at Chainage 2+160 (Figure 20).

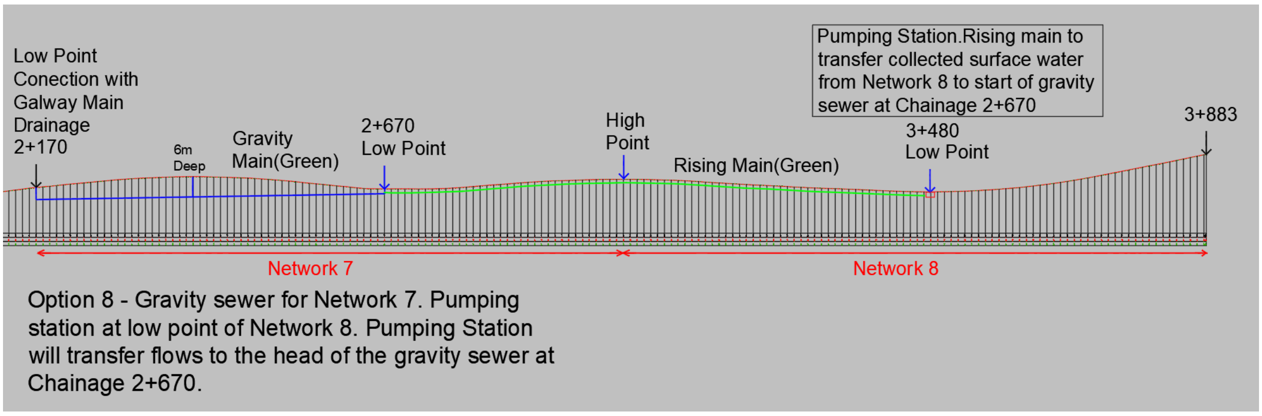

Figure 20: Option 8 – Combined Surface Water Rising Main Pump & Gravity Main Cross Section

Advantages:

- As outlined above as per Option 7. Road runoff will no longer drain to the protected grassland or the aquifer.

Disadvantages:

- As outlined above for Options 6 and 7 the pumping station will require long term maintenance. The installation of deep pipes will need to be carefully considered from a Health and Safety perspective. Maintenance of deep pipes will also be more onerous from a Health and Safety perspective.

- Installation of deep pipes may require extensive and prolonged periods of rock breaking. This will be confirmed when the site investigations are complete.

1.6.9 Option 9: Connect with existing drainage networks.

For Network 8, whilst there are no existing drainage network connections in the immediate vicinity of the development, a potential connection maybe available at a proposed housing development to the south of the development at the Coast Rd-Dublin Rd junction (Figure 21). The planning documentation indicates that this development will have a soakaway infiltration trench to allow disposal of surface water runoff. Although, it may be possible to connect to the proposed development surface water network, attenuation would need to be provided upstream, as it is considered the infiltration trench servicing the housing estate would not have the capacity to receive the unattenuated flows from Network 8.

Another housing estate is positioned to the south of Network 7 low point at Ch 2+670. Surface water in this housing estate will be collected by a surface water network, that will outfall into an infiltration trench. There is a possibility that the road drainage for Network 7 could be connected into this infiltration trench, but the Network 7 flows would need to be attenuated. The image provided shows this housing estate to be under construction, but it is understood this housing estate is now complete.

In both cases, an assessment of the infiltration trenches existing capacity would also need to be carried out. It is understood this is a private development and is not under the maintenance regime of Galway City Council at present. Therefore, any connections from the public road would need to be agreed with the Developer.

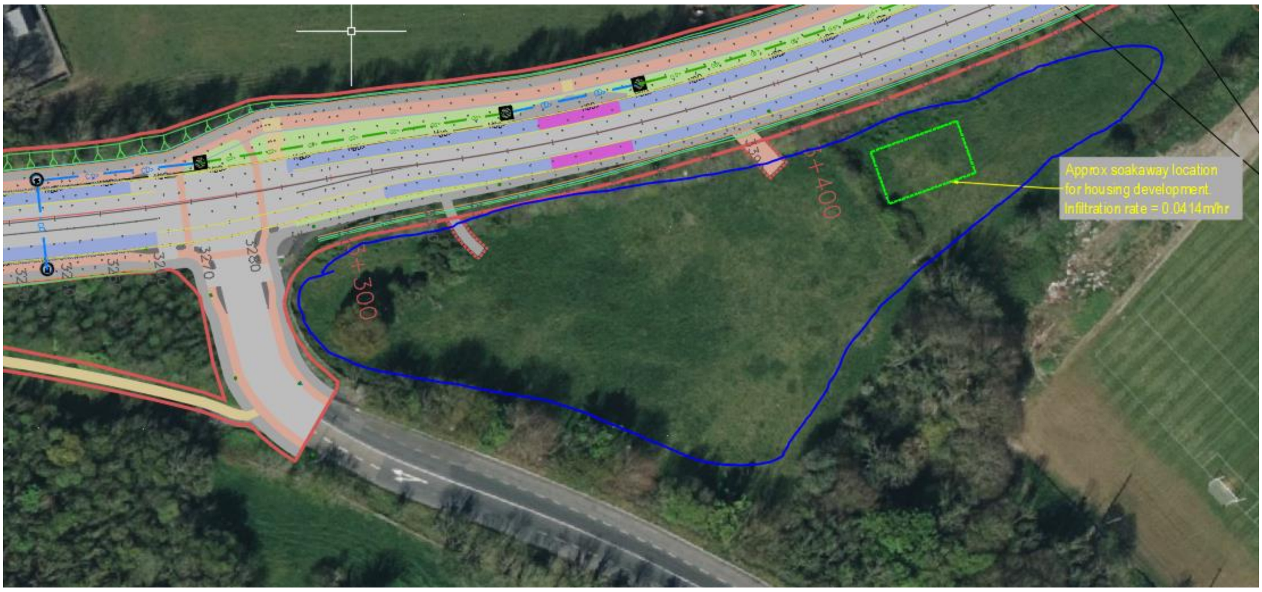

Figure 21: Location of proposed housing development along Coast Rd (Network 8 Ch 3+480)

Figure 22 Existing houses and houses under construction to the south of Dublin Road nearby Roshill Park Woods.

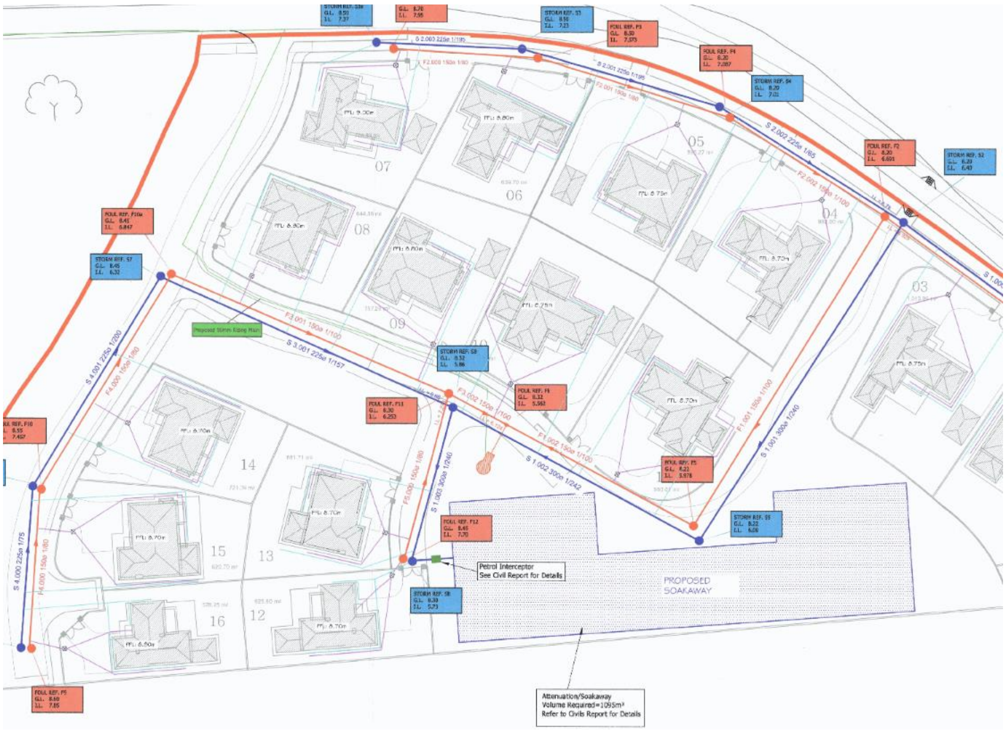

Figure 23 Layout plan of houses to the south of Dublin Road nearby Roshill Park Woods.

Advantages:

- Existing infiltration trenches can be utilised.

Disadvantages:

- Network 8: Uncertainty as to capacities of the drainage networks which service the existing housing estates, meaning additional surveys and assessments will be required to determine if this option is feasible.
- Network 7 and 8: Attenuation Pond or subsurface cellular attenuation will be required to limit flows to receiving networks.
- Network 7 and 8: Additional land take to allow construction of and maintenance of any pipework between the proposed road drainage system and the receiving drainage network or infiltration trench.
- Network 7: Existing infiltration has limited capacity and any connections or future maintenance agreements would need to be agreed with the Housing Estates Developer.

1.6.10 Option 10: Connect with existing foul pumping station at Chainage 3+240

There is an option of connecting the surface water from Drainage Network 8 to the existing foul pumping station, Merlin Park No.3 Wastewater Pumping Station. This pumping station is at Chainage 3+240. This option has not been assessed in detail, as it is understood that in principle it will not be acceptable to use a foul pumping station for pumping surface water. Refer to Figure 24 below, on which the location of this pumping station has been indicated.

Figure 24: **Merlin Park No.3 Wastewater Pumping Station**

1.7 Conclusions

This assessment outlined 10 potential design options to replace the existing and now unsuitable over the edge surface water drainage system along the Old Dublin Road (R338) between Mainline Chainage 2+170 to 3+883 of the Bus Connects Galway: Dublin Road development. It is considered that each option falls within one or more of the following drainage categories:

- Infiltration — Option 1, Option 2, Option 3, Option 4, Option 6
- Deep gravity pipe — Option 4, Option 5, Option 6, Option 8
- Pumping / Rising Main — Option 7, Option 8, Option 10,
- Existing drainage connections — Option 9, Option 10

1.7.1 Infiltration:

As noted above, infiltration is considered the predominant drainage method for several of the proposed options. While there is no historical evidence of flooding or drainage issues within the adjoining lands of the study area, the suitability of the infiltration options and their viability cannot be assessed until the site investigation works are complete. Evidence made available from open-source data like GSI indicate high to extreme groundwater vulnerability levels within the region and, the presence of karst landforms e.g. swallow hole at Ch 3+240. The TII document '*Drainage and the Water Environment March 2015',* indicates that the use of infiltration trenches in this type of landscape (i.e., Karst with shallow overburden) is not recommended.

Due to the unpredictable nature of karst features and the vulnerability of the aquifer at this location, it is also considered that the existing road runoff is resulting in some contamination of the aquifer. Research conducted by TII, and related bodies have found that surface runoff from paved surfaces subject to vehicular traffic can contain traces of zinc, copper, and hydrocarbons amongst others. While only present in trace quantities, the concentrations are proportionate to the traffic levels (AADT's), and with time can accumulate in topsoil. With no apparent pollution controls provided along the existing Old Dublin Road, the risk from large fuel spillage could result in significant contamination of the aquifer that may impact upon sensitive grassland habitats e.g., at Merlin Park Meadows.

Until groundwater levels, subsoil/rock composition and infiltration rates are determined, it will not be possible to establish the viability of all infiltration options. While site investigation records will help inform the design of any infiltration trenches or ponds, due to a finite period of groundwater monitoring, i.e., 6 months to 1 year, there is a risk that groundwater levels could rise higher during the operational phase of the road. If groundwater levels were to rise above the base of any infiltration trenches or ponds, there would be no attenuation, resulting in road runoff effectively discharging direct to groundwater.

In summary, notwithstanding the delay relating to site investigation works, it is considered that the use of infiltration trenches/ponds presents a number of risks and unknowns.

1.7.2 Deep Gravity Pipe

Site investigations which will determine the makeup of the ground in the region are ongoing. Based on the information available from the GSI website, it would appear excavations deeper than 2-3 metres will be present within the limestone rock including the potential of karstified limestone. Therefore, installing gravity pipes at depths of 6-9 metres, will require very deep trenches through solid rock, which will be time consuming and will result in significant disruption in a built-up urbanised area. It is considered that the deep gravity pipes can be constructed and maintained in a safe manner subject to suitable design and maintenance regime protocols, but the option will add a considerable cost to the project.

In addition to the issues outlined above the installation of deep trenches have the potential to impact the groundwater flow regime in the vicinity. Deep trenches can act as a form of groundwater cut-off and can also add as a flow conduit. This effect can occur during the construction and operational phases of the project. Whilst mitigation measures can be provided e.g., longitudinal flow barriers placed within the trench, the effectiveness of these measures can be subjective, and it is not possible to guarantee that the installation of deep trenches will not impact the groundwater regime within the region. As the deep pipes will be adjacent to the Annex I Grassland, any change in the groundwater flow regime has the potential to impact surface vegetation, meaning the sensitive grasslands could be impacted.

In summary, whilst the use of gravity pipes has some benefits, it is considered this option will add a significant cost to the project and will result in a lot of disruption to traffic in the region. It is also very difficult to predict the long-term impact this option will have on groundwater in the region, which could in turn affect the Annex I Grasslands.

1.7.3 Surface Water pumping

Regarding the pumping of surface water as described in the options above, there is precedent for the use of a rising main / pump to manage surface water in Galway City. When the Lough Atalia Bridge Road was lowered a sag point was created in the re-aligned road which required a pumping station (Figure 25) to allow drainage of the road. Whilst pumping of surface water is not common practice, when maintained correctly, it can function successfully. From assessing the study area, it would appear a pumping option would work in this instance.

In summary, while a pumping option will have long term operational and maintenance costs, this option has no significant unknowns, and therefore is of low risk provided it is designed and maintained correctly.

1.7.4 Connecting to existing surface water infiltration system or sewer.

Whilst there is some benefit in using existing surface water infrastructure in the form of surface water networks or infiltration trenches, several uncertainties need to be considered. Notwithstanding the likely hydraulic capacity constraints of the existing drainage system, there are also maintenance and legal constraints to be considered. In the case of connecting to an existing infiltration system, similar issues highlighted in Section 1.7.1 need to be considered.

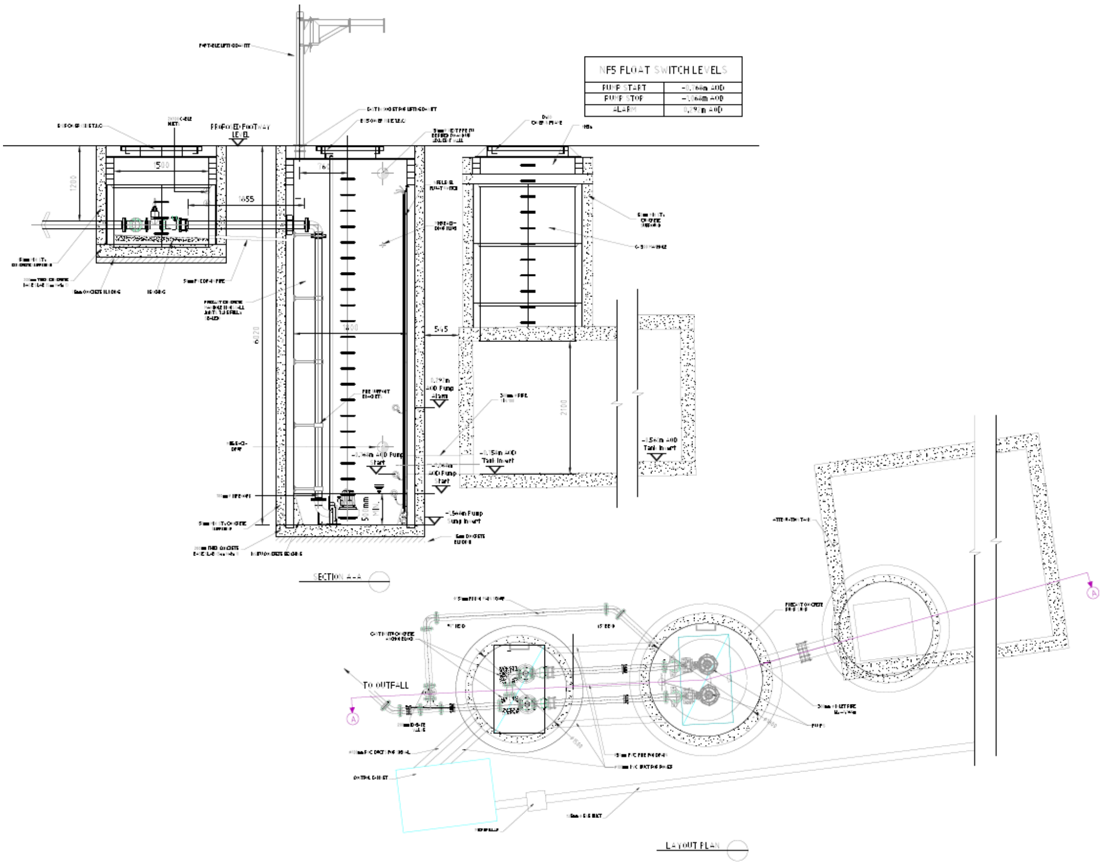

Figure 25: Detail of pumping station provided along Lough Atalia Bridge Road

1.8 Summary

When considering all the above Options 1-10, it is considered that there are a number of unknowns, which will not only apply added risks to the project but also have the potential to impact the adjacent / receiving environment. These unknowns also have the potential to impact how the drainage system will successfully function during the service life of the road. Whilst on-site investigation works and modelling exercises can in some way quantify these unknowns, it will be difficult to eliminate them completely through on-site testing and design mitigations. The most significant unknowns are as follows.

- The upper and lower range of groundwater levels within the region. This will impact upon the infiltration and gravity pipe options.
- The infiltration rates of the subsoil through the region.
- The impacts from deep trench excavation on groundwater levels, and the larger receiving environment within the region.
- The suitability of existing privately maintained surface water networks or infiltration trenches for use as at an outfall for public road drainage.

- How infiltration trenches will function in a region where the bedrock is of karstified limestone. In accordance with TII guidance, the use of infiltration trenches in ground conditions such as these, should be avoided.

When all the unknowns are considered, it would appear that Option 7, in which the collected surface water is pumped to the existing 1500mm diameter public surface water sewer at Chainage 2+130 has the least amount of unknowns and on balance of advantages and disadvantages is the recommended as the preferred option.