Appendix 17.2

Flood Risk Assessment

N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT

Flood Risk Assessment

MDT0806-RPS-00-XX-RP-D-RP0100
Flood Risk Assessment
A1.C01
June 2023

Contents

Tables

Figures

Appendices

1 INTRODUCTION

RPS was appointed by Meath County Council (MCC) as multidisciplinary consultants for the proposed bypass route of the N2 carriageway around the village of Slane in County Meath. The project scope includes for traffic management and public realm improvements within Slane village. The RPS remit included for the preparation of a Flood Risk Assessment (FRA) to inform the design process, which is to be submitted as part of a planning application for the proposed bypass route corridor.

This FRA was completed in accordance with the Office of Public Works (OPW) FRA guidelines titled "The Planning System and Flood Risk Management – Guidelines for Planning Authorities" Department of Environment, Heritage and Local Government, (DOEHLG), 2009 and Circular PL2/2014 Flooding Guidelines.

2 SITE DESCRIPTION

2.1 Existing Site

The Proposed Bypass Route runs to the east of Slane Village and is circa 3.4km in length as indicated in **Figure 2-1**. The Proposed Bypass Route diverts from the existing N2, in a north easterly direction, from a location approximately 500m north of McGruder's crossroads in the townland of Johnstown. It continues in a north-north easterly direction, through Fennor and Crewbane townlands. This route crosses the River Boyne approximately 630m east of the existing Slane Bridge. It traverses the existing N51 approximately 1.1km east of the N2/N51 junction in the centre of Slane Village. It then proceeds in a north westerly direction, through the townlands of Cashel and Mooretown, before tying in with the existing N2, approximately 415m north of the entrance to the Grassland Agro plant.

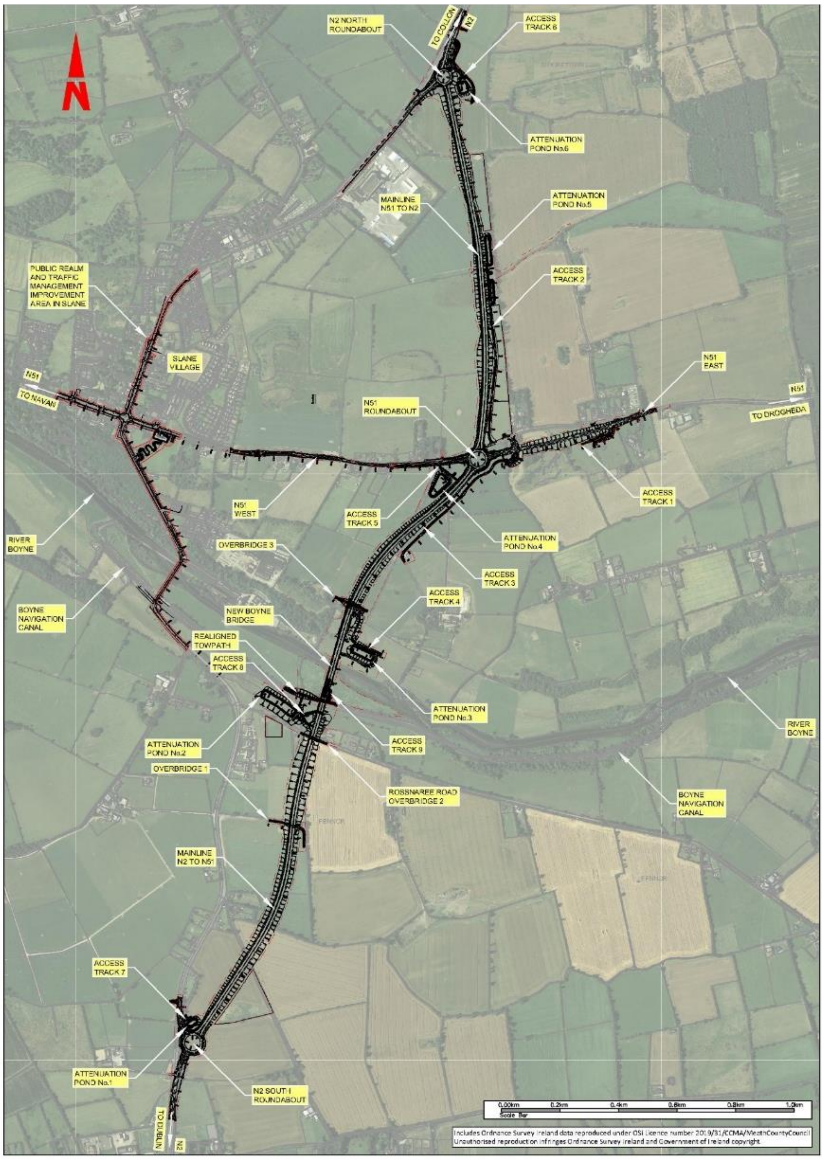


Figure 2-1 Proposed Scheme

2.2 Existing Topography

The existing ground within the Proposed Bypass Route typically slopes towards the River Boyne. The ground elevation to the south of the River Boyne ranges from approximately 15m AOD to 60m AOD and is moderately sloping while the ground to the north is shallow to steep sloping from approximately the same level range.

2.3 Local Hydrology

The most notable hydrological feature in the vicinity of the Proposed Bypass Route is the River Boyne. The River Boyne and its associated tributaries upstream of Slane Bridge drain a catchment area of approximately 2,490 km^2, flowing eastwards from the midlands discharging to the Irish Sea, just to the east of Drogheda. The River Boyne in the vicinity of the Proposed Bypass Route is under tidal influence from the Irish Sea. The River Boyne, at the location of the Proposed Bypass Route, forms part of the Boyne Navigation Channel which includes a series of canals. There is an existing weir within the River Boyne immediately upstream of the Slane Bridge. This causes river flow to be retained within the channel upstream and also flow to be routed to 2no. canals upstream of the weir. The first canal runs through an old flour mill and returns to the River Boyne approximately 0.3 km upstream of the Proposed Bypass Route. The old flour mill has long since decommissioned.

The 2nd canal starts from a lock on the right bank of the River Boyne approximately 60 metres upstream of the existing weir and extends for approximately 3 km until it returns to the River Boyne downstream of the proposed bridge location (See **Figure 2-2**). The canal was observed to be heavily vegetated and in poor repair. Hence the canal does not appear to be in use any longer.

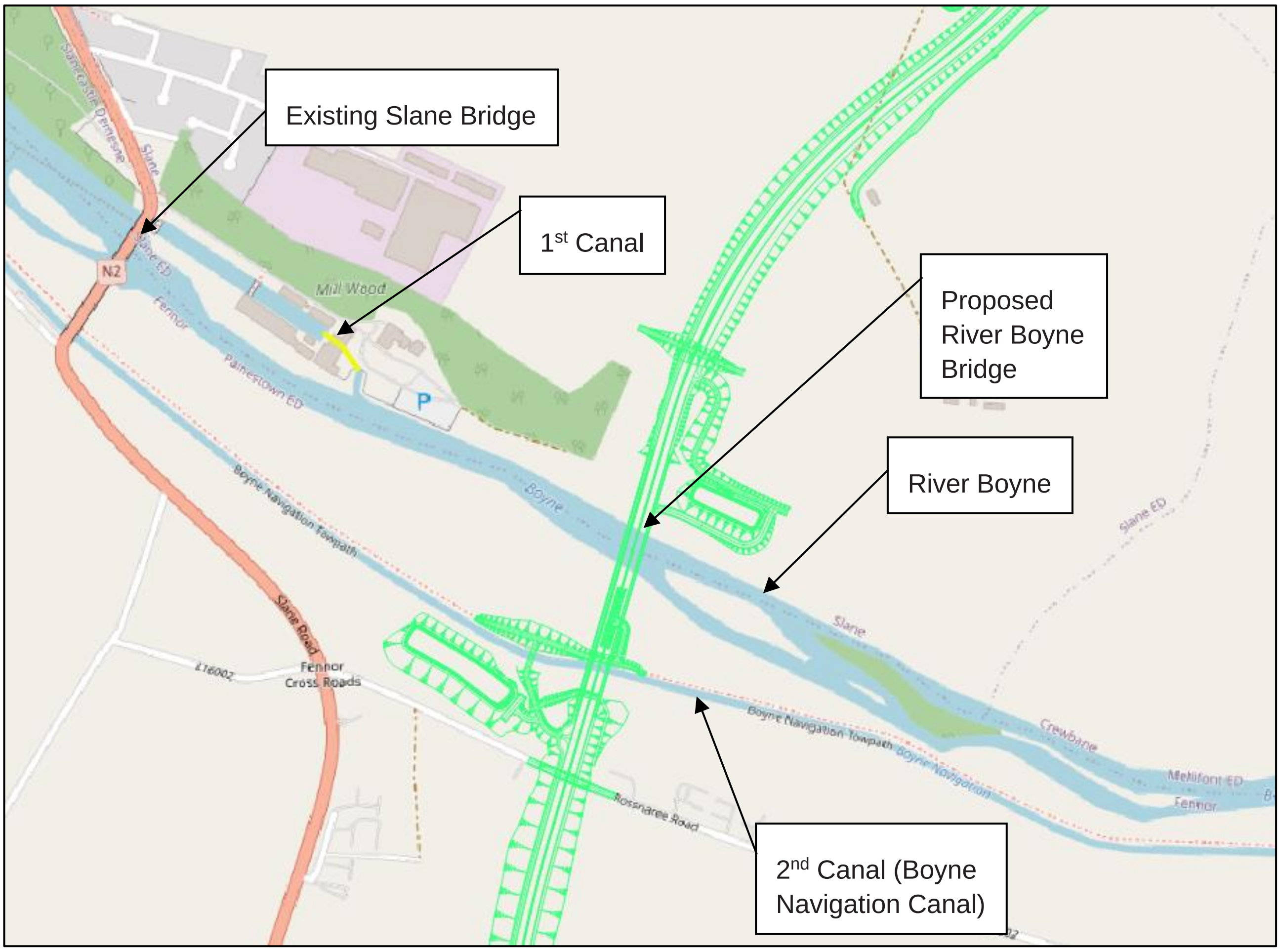


Figure 2-2 The Proposed Bridge Location on the River Boyne

The Proposed Bypass Route intersects with the Mattock (Mooretown) Stream at the north roundabout prior to tying in with the existing N2, approximately 415m north of the entrance to the Grassland Agro plant. The Mattock (Mooretown) Stream has a catchment area of approximately 1.4km^2, flowing from the west/north-west and drains predominantly agricultural lands. The Mattock (Mooretown) Stream is culverted underneath the existing N2 road prior to intersecting with the Proposed Bypass Route at the North Roundabout as shown in **Figure 2-3**.

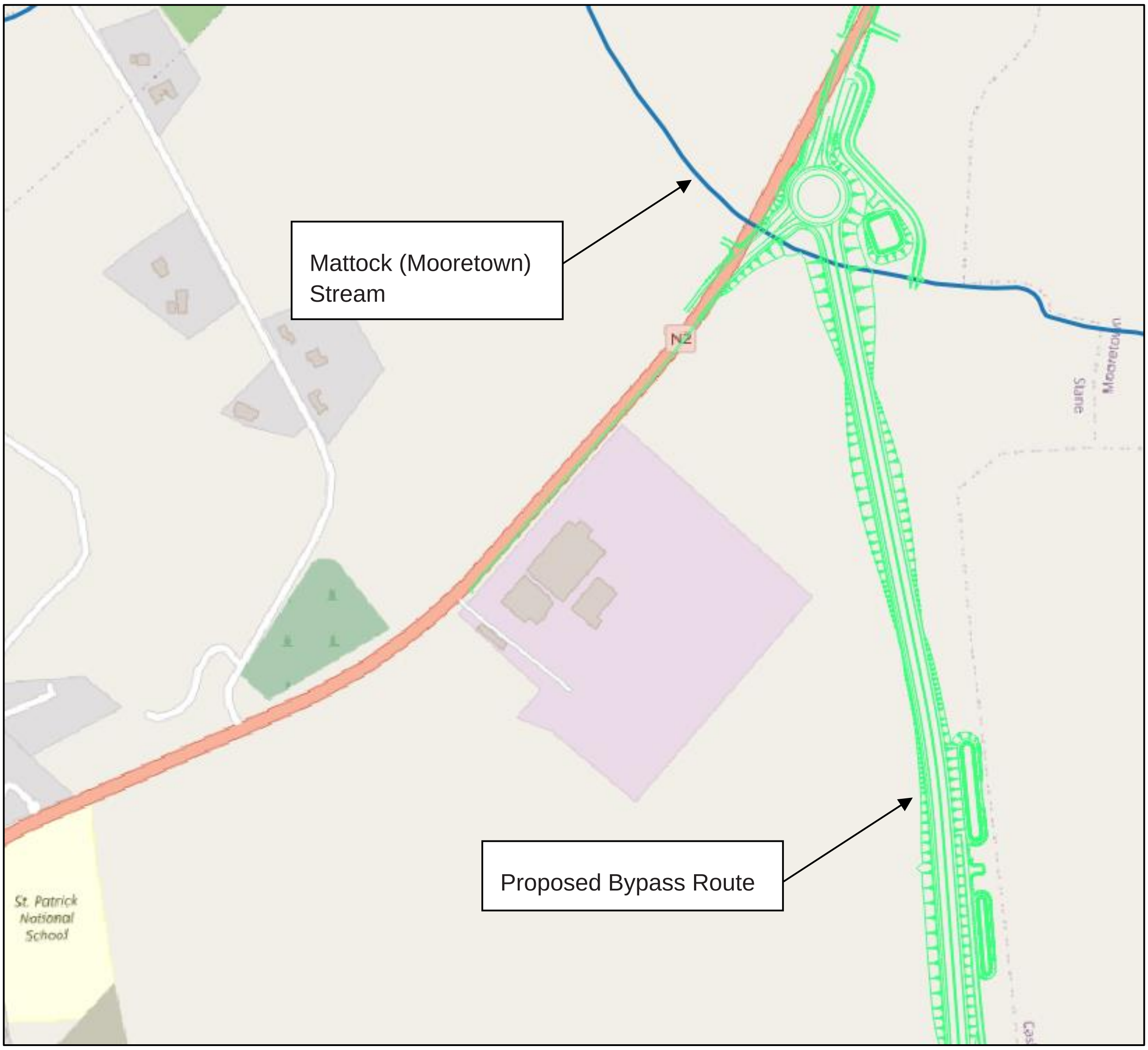


Figure 2-3 Proposed Bypass Route intersection with Mattock (Mooretown) Stream

There are land drains serving greenfield and agricultural lands up to 0.5km^2 that transverse the Proposed Bypass Route. The existing land drains are proposed to be accommodated within the road drainage system design.

2.4 Proposed Scheme

The Proposed Scheme consists of the Proposed Bypass Route and also traffic management and public realm improvements within Slane village. The Proposed Bypass Route is to consist of a 3.5km dual carriageway, a bridge across the River Boyne, 3no. culvert on the Mattock (Mooretown) Stream, three road junctions, three overbridge structures and associated infrastructure.

The proposed drainage for the Proposed Bypass Route is to consist of the following elements:

- Kerb and Gully Drainage / Surface Water Channels to intercept and collect run-off from road surfaces;
- Filter Drains to collect run-off from road cuttings;
- Interceptor Ditches and Culverts to intercept and maintain greenfield runoff flow paths and land drains that transverse the Proposed Bypass Route;

- Attenuation Ponds to store run-off from road drainage with outfall to receiving watercourses with peak discharges limited to greenfield run-off rate as per TII Drainage Standard; and
- Class 1 Petrol/Oil Interceptor to treat run-off prior to discharge on incoming pipes to attenuation ponds.

The proposed bridge is to span approximately 260m across the River Boyne, the Boyne Navigation Canal and its associated tow-path. It is to be located 630m downstream of the existing multi-arch masonry Slane Bridge. The bridge is to consist of two abutments and three piers, as shown in drawing numbers MDT0806-RPS-ST01-N2-DR-D-BR0210-01 included in **Appendix A** of this report. An exclusion zone, which consist of a 10m set back from left and right banks of the River Boyne, is incorporated into the bridge design to ensure no permanent and temporary works within these zones. The bridge piers each consist of 5no. 1.5m diameter columns. The bridge alignment across the River Boyne is proposed to be inclined from the right to left bank. The bridge soffit levels are proposed to vary from 18.765m AOD to 25.567m AOD.

The proposed River Boyne Bridge includes for the following;

- An access track extending from tow-path to greenfield adjacent to River Boyne right bank at the bridge location.
- Provision of combined footway/cycleway facilities, including a pedestrian/cyclist link to the existing Boyne Canal tow-path.

The Proposed Bypass Route includes for 3 no. culverts on the Mattock (Mooretown) Stream at the North Roundabout as shown in **Figure 2-4**. The locations and dimensions for the culverts proposed are listed in **Table 2-1**. The works will require realignment of the Mattock (Mooretown) Stream between Culvert 6A and 6B, to accommodate the embankment for the North Roundabout. The culverts include for a 0.5m embedment as per Inland Fisheries Ireland requirements. The proposed works includes for the removal of an existing culvert at the North Roundabout immediately upstream of Culvert 6A to improve the hydromorphology and fish-bearing potential of the Mattock (Mooretown) Stream. Further details on the proposed culverts and channel realignment are shown on drawings **MDT0806-RPS-01-N2-DR-C-DR2001** and **2002** included in **Appendix A** of this report.

The traffic management and public realm improvements within Slane village as part of the Proposed Scheme includes for the following:

a. Removal of traffic signals and left turn slips at the existing junction.
b. Provision of necessary signage and road markings so that the junction becomes a priority junction with the east-west N51 forming the major arms and the northern and southern approaches giving way.
c. Realignment of kerb lines to narrow the carriageway widths on approach to the junction and allow widening of the road verge and footway.
d. Provision of verge areas for suitable on-street planting.
e. Provision of raised pedestrian / cyclist crossing ramps on each arm of the junction with signalised crossings on the N51 arms and zebra crossings on the N2 arms.
f. Enhanced pedestrian / cyclist accessibility from the centre of Slane to the Existing River Boyne bridge and river amenity area.
g. New off-street parking area.

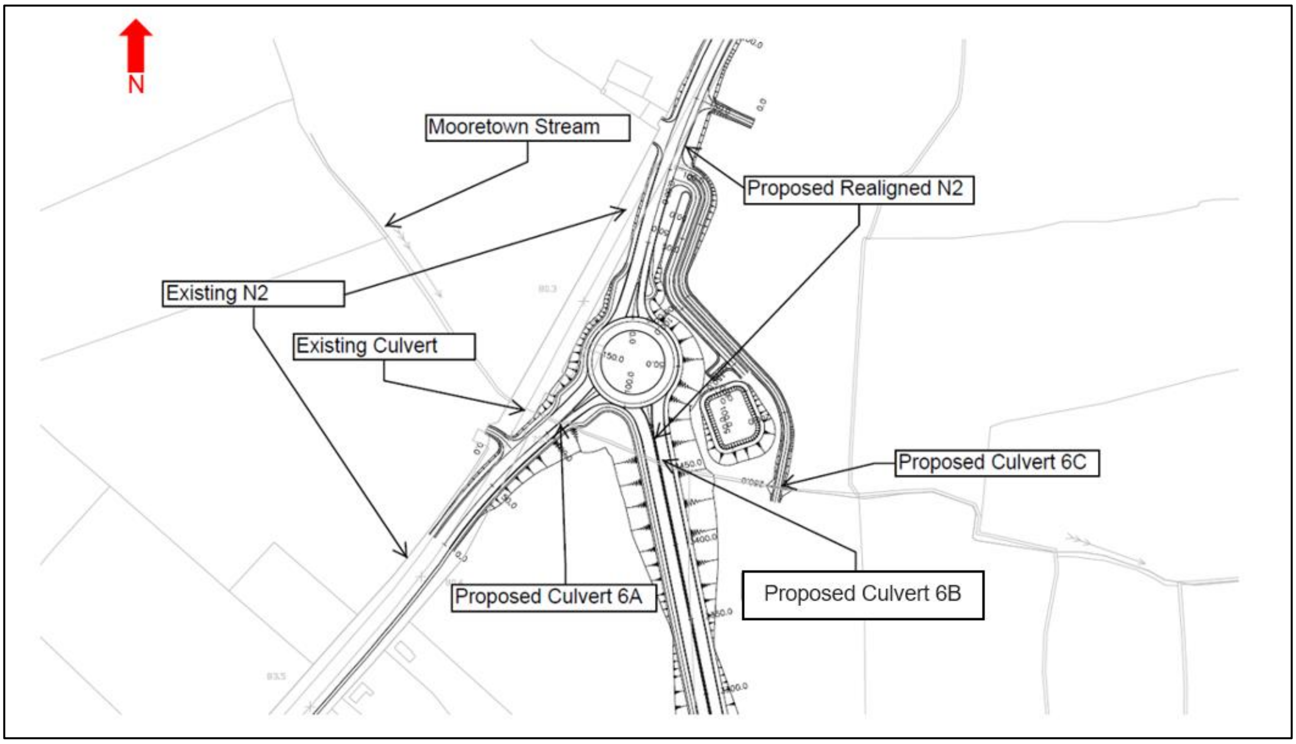


Figure 2-4 Proposed North Roundabout

Table 2-1 Proposed Mattock (Mooretown) Stream Culvert Information

Culvert Ref.	Location	Type	Length	Size (m)	Embedment (m)
6A	North Roundabout Exit to Slane	Box	32.6	2.4mx2.4m	0.5
6B	N51 to N2 Mainline	Box	55.73	1.8mx1.5m	0.5
6C	Access Track 6	Box	9.66	1.8mx1.5m	0.5

Also included in the scheme are substantial temporary works associated with the construction of the River Boyne bridge. The project includes for both the construction and decommissioning of these temporary works.

To construct the River Boyne bridge, it will be necessary to incorporate considerable temporary works and it will be removed following completion of the bridge construction. These include temporary access roads and temporary working platforms to support the plant necessary to carry out the construction. The general arrangements for the proposed working platforms are illustrated on Drawings MDT0806-RPS-01- N2-DR-C-GA5000 to 5005 contained in **Appendix A** of this report. The working platforms consist of the following;

- WP1 – Working Platform for south abutment construction.
- WP2 – Working Platform for works on the south side of the river.
- WP3 – Working Platform for works on the north side of the river.
- WP4 - Working Platform for north abutment works.

WP2 and WP3 will include 3no. cofferdams around the proposed bridge pier locations to provide an almost watertight working environment preventing waters from entering so that the piers can be constructed safely.

3 STAGE 1 – FLOOD RISK IDENTIFICATION

3.1 Overview

The purpose of this section is to establish the level of flood risk for the Proposed Scheme, and to collate and assess existing current and historical information and data which may indicate if there are any flood risk issues at the development site. The following sections detail information and data collated as part of the Stage 1 Flood Risk Identification carried out for the Proposed Scheme.

3.2 Flood Risk & Flood Studies Information

Relevant information was reviewed and collated from the following sources:

- Flood Risk Assessment and Management Plan for Meath County Development Plan, 2020-2026;
- Eastern Catchment Flood Risk Assessment and Management Study Predicted Flood Maps;
- Office of Public Works National Flood Hazard Mapping Website;
- Meath County Council GIS and PFRA Flood Mapping; and
- National Indicative Fluvial Mapping (NIFM).

3.3 Flood History

3.3.1 OPW Flood Hazard Mapping Website

The OPW Flood Hazard Mapping website (www.floodmaps.ie) was consulted to determine whether there was any evidence of previous flooding within the Proposed Scheme area.

There were previous flooding incidents from the River Boyne in the vicinity of the Proposed Bypass Route in February 1990 and in November 2002. These incidents were documented with photographic records of the events and minutes from meeting with Meath County Council Area Engineer for Slane. A description of these records is presented below in **Table 3-1**.

Table 3-1 Past Flood Event Records Provided on the OPW-Floods Map Website

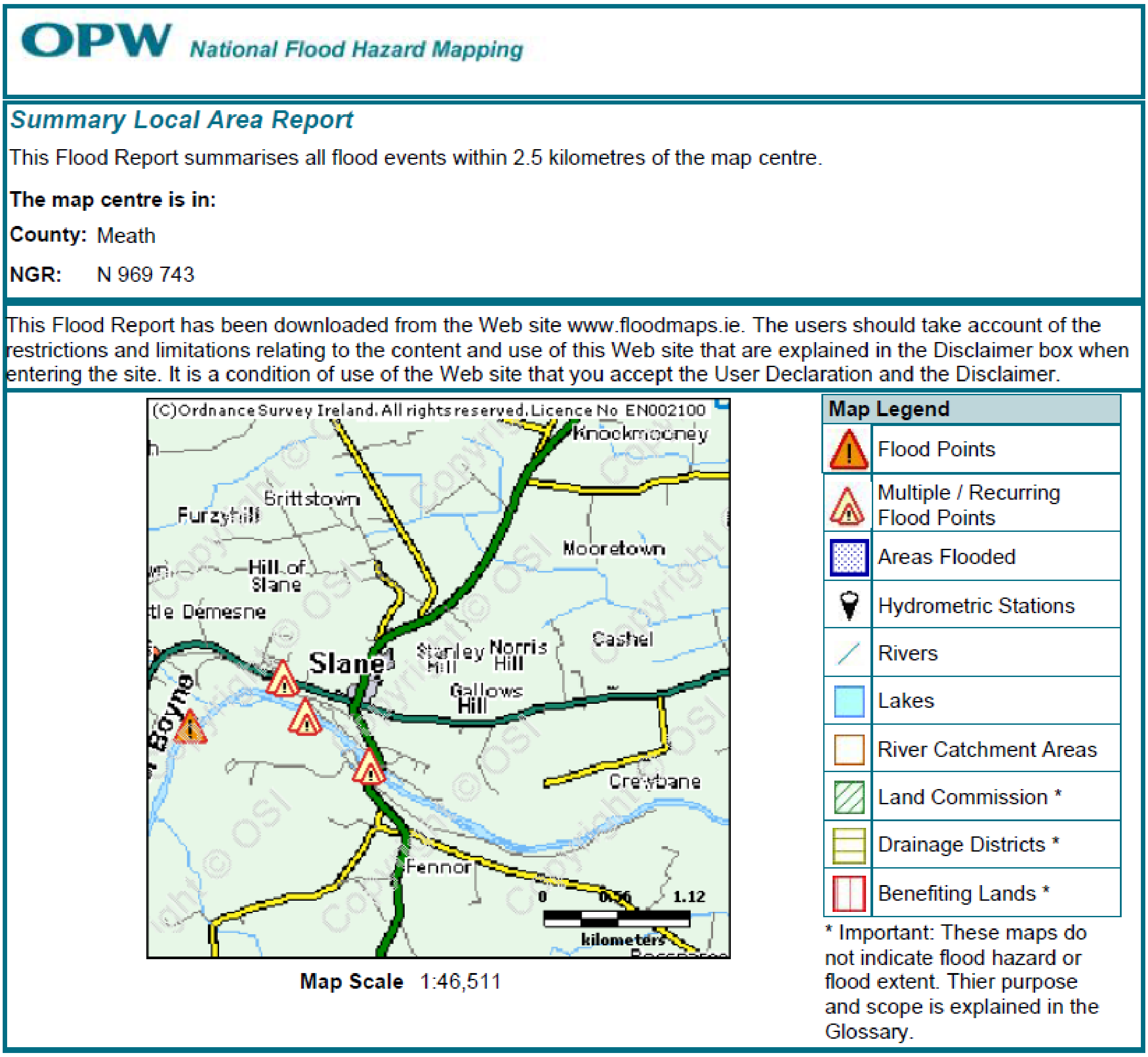
Document Type, Title, Date	Description	Notes
OPW Flood Hazard Mapping – Phase 1 Meeting with Area Engineer Minutes dated 17th January 2006	Outline of areas that are or were prone to flooding	4no. stretches of the River Boyne floodplains between Slane & Drogheda prone to flooding once or twice a year Section of N51 carriageway at Patrick Terrance in Slane floods after heavy rainfall due to inadequate town drainage
Photos dated February 1990 and November 2002	Illustrations of previous high-water marks from River Boyne at Slane Bridge. The photo closest to the Proposed Bypass Route was taken from Slane Bridge facing upstream and downstream as shown in **Figure 3-1** to **Figure 3-3**.	Flooding from River Boyne noted to be contained within low lying areas adjacent to River Boyne upstream and downstream of Slane Bridge

Figure 3-1 1990 Flood Event (taken from existing Slane Bridge facing upstream)

Figure 3-2 1990 Flood Event (taken from right bank adjacent to existing Slane Bridge facing downstream)

Figure 3-3 1990 Flood Event (taken from existing Slane Bridge facing downstream)

The locations of the flooding experienced in previous events are illustrated in **Figure 3-4**.



OPW *National Flood Hazard Mapping*

Summary Local Area Report

This Flood Report summarises all flood events within 2.5 kilometres of the map centre.

The map centre is in:

County: Meath

NGR: N 969 743

This Flood Report has been downloaded from the Web site www.floodmaps.ie. The users should take account of the restrictions and limitations relating to the content and use of this Web site that are explained in the Disclaimer box when entering the site. It is a condition of use of the Web site that you accept the User Declaration and the Disclaimer.

Map Scale 1:46,511

Map Legend

- Flood Points
- Multiple / Recurring Flood Points
- Areas Flooded
- Hydrometric Stations
- Rivers
- Lakes
- River Catchment Areas
- Land Commission *
- Drainage Districts *
- Benefiting Lands *

* Important: These maps do not indicate flood hazard or flood extent. Thier purpose and scope is explained in the Glossary.

Figure 3-4 OPW National Flood Hazard Mapping – Previous Events Flood Locations

3.3.2 Gauging Station Data

The nearest gauging station to the Proposed Bypass Route is Slane Castle Gauging Station (Ref: 07012) on the River Slane approximately 2km upstream as shown in **Figure 3-5**.

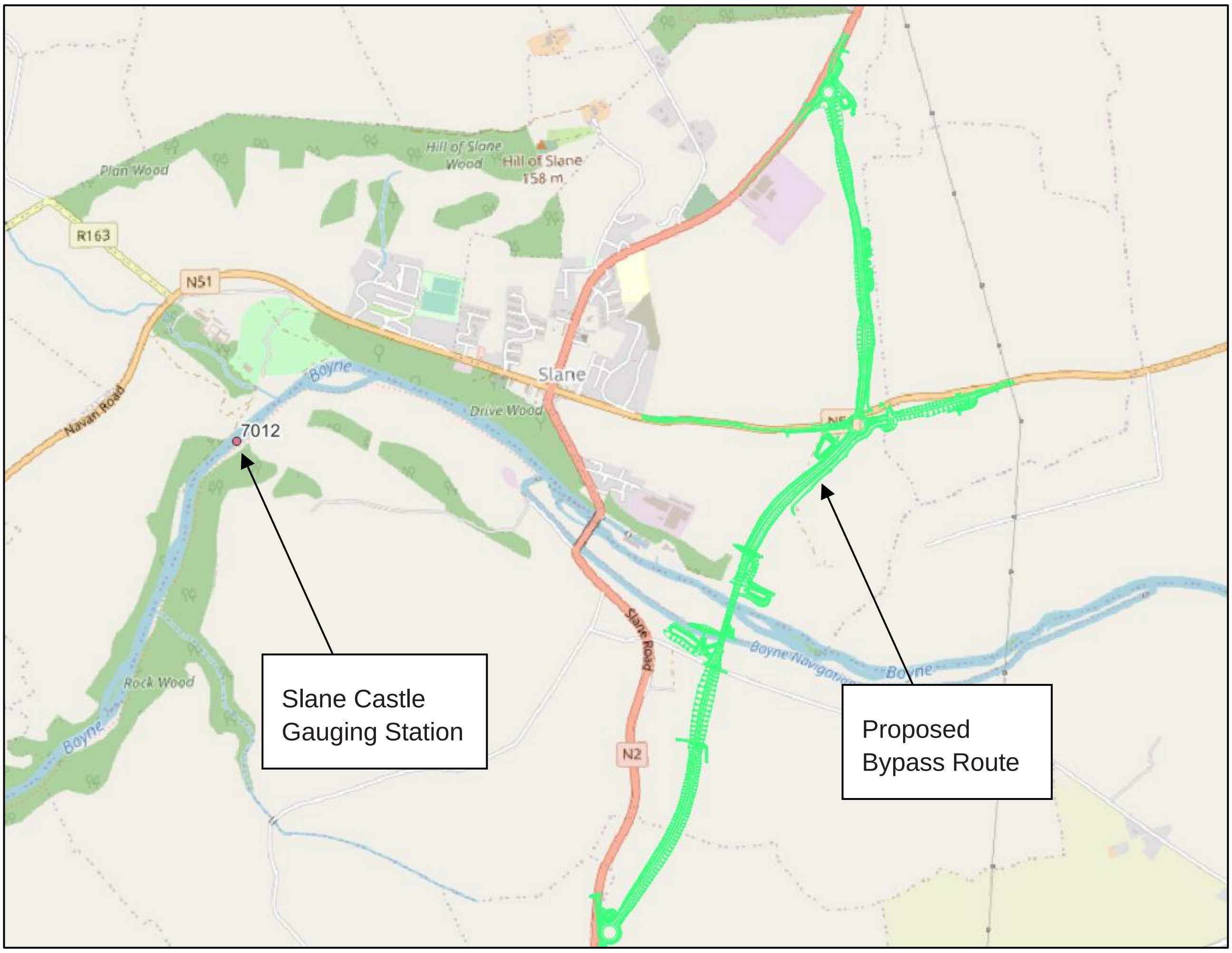


Figure 3-5 Slane Castle Gauging Station Location

The annual maximum (Amax) flow record for the gauging station for the record period (1986 to 2019) is shown in **Figure 3-6**. The highest flow (425.25m^3/s) and the 2nd highest flow (417.90m^3/s) for the period was observed in November 2000 and February 2020 respectively. The median flow for the catchment at Slane Castle Gauging Station is calculated at 269.10 m^3/s.

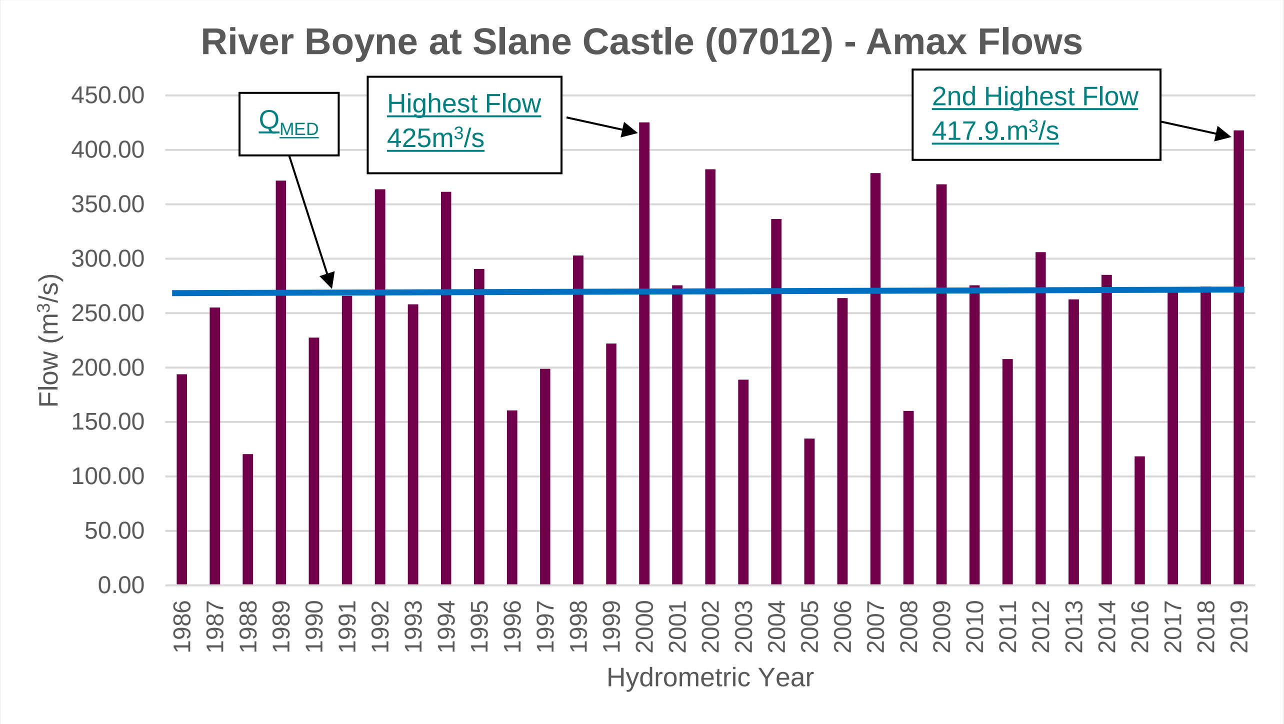


Figure 3-6 Slane Castle (07012) - Amax Record

3.4 Eastern CFRAM Predicted Flood Mapping

The Eastern Catchment Flood Risk Assessment and Management (ECFRAM) Study provided an assessment of the extent and degree of flood risk for critical locations identified from the flood hazard mapping referred to above. The flood hazard areas had been identified as being potentially at risk from significant flooding, including areas that have experienced significant flooding in the past. The Proposed Scheme fall within the ECFRAM Study.

This study produced present day fluvial and coastal predicted flood maps which are shown in **Figure 3-7** and **Figure 3-8** respectively. The maps indicate modelled flood extents for a range of annual exceedance probabilities (AEP). Both figures indicate that the Proposed Bypass Route to intersect predicted flood extents for fluvial and coastal sources from the River Boyne. However, it is noted that the predicted flood extents are contained within the low-lying areas adjacent to the banks of the River Boyne. The 1% and 0.1% predicted flood extents are marginally larger than the 10% predicted flood extents at the Proposed Bypass Route crossing location.

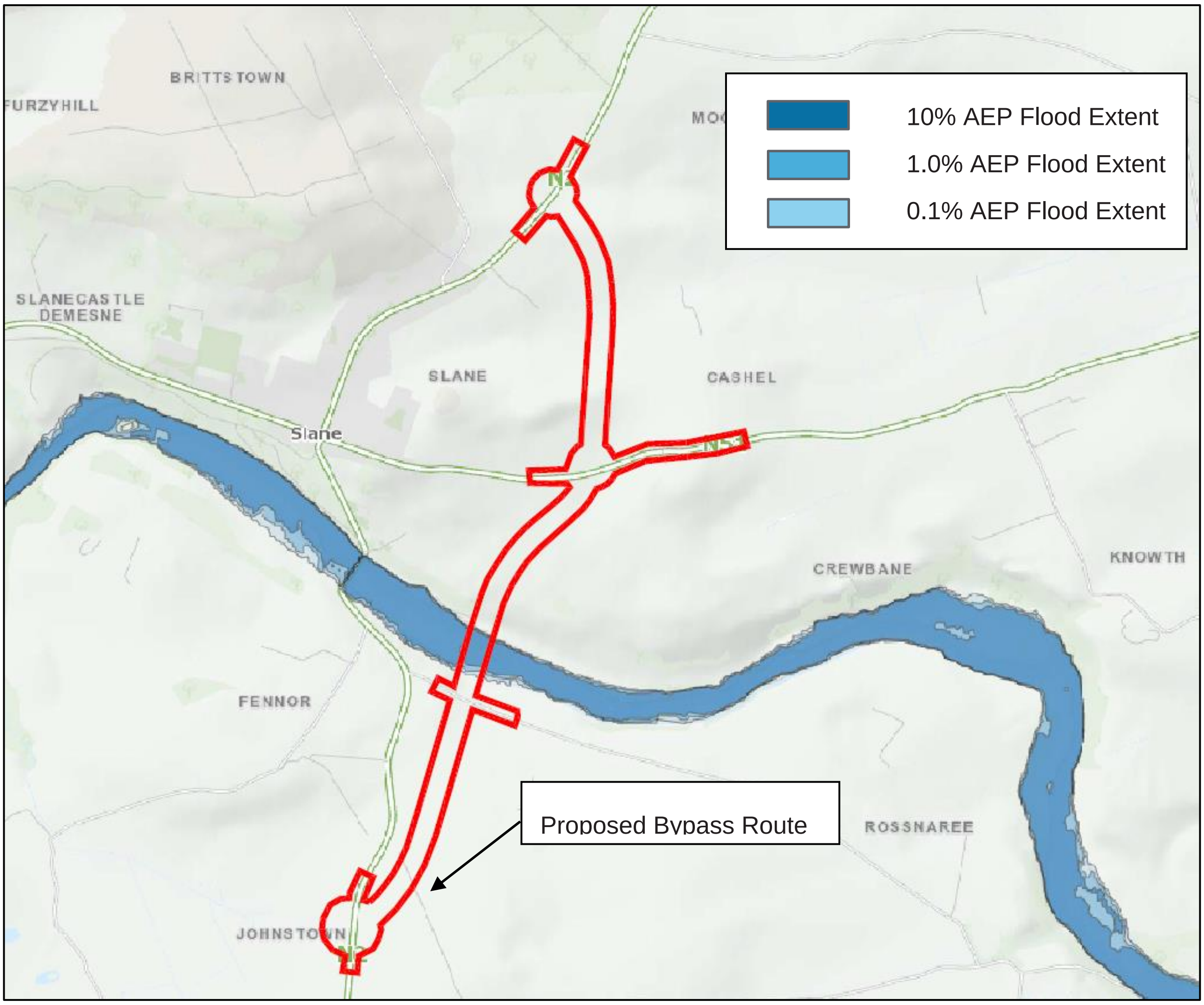


Figure 3-7 CFRAM Fluvial Predicted Flood Extents – Present Condition (source: www.floodinfo.ie)

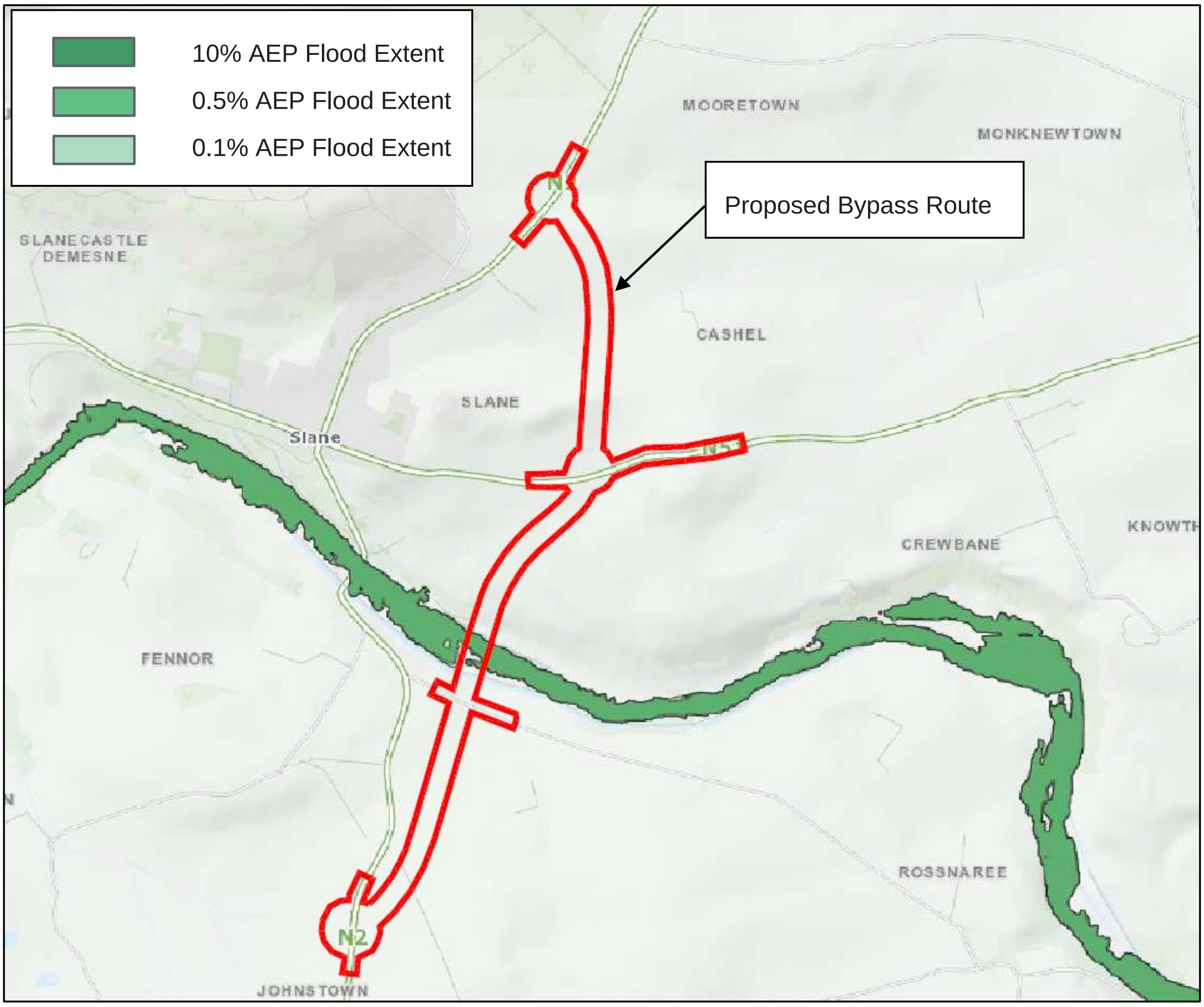


Figure 3-8 CFRAM Coastal Predicted Flood Extents (source: www.floodinfo.ie)

3.5 Meath County Council GIS and PFRA Flood Mapping Records

The Meath County Council GIS and PFRA Flood Mapping (2019/MAP/290/A Rev 0) records were made available for the purpose of this Flood Risk Assessment. The predicted flood extent indicated in the vicinity of the Proposed Scheme from GIS and PFRA Flood Mapping is shown in **Figure 3-9** and **Figure 3-10** respectively. Both maps indicate the Proposed Bypass Route to intersect flooding from the River Boyne and the Mattock (Mooretown) Stream. The PFRA Flood Mapping shows pluvial flooding at a low point within existing greenfield.

The predicted flood extents shown on MCC GIS Flood Mapping were produced from a JBA developed software (JFLOW@). The accuracy of the predicted flood extent was stated to be directly correlated to the Digital Terrain Model (DTM) available and does not account for individual flow structures such as bridges or culverts. Hence the predicted flooding shown is indicative.

The Preliminary Flood Risk Assessment (PFRA) mapping was completed by the OPW in 2012 based on available and readily derivable information. The mapping does not account for channel or drainage structures and is indicative at best.

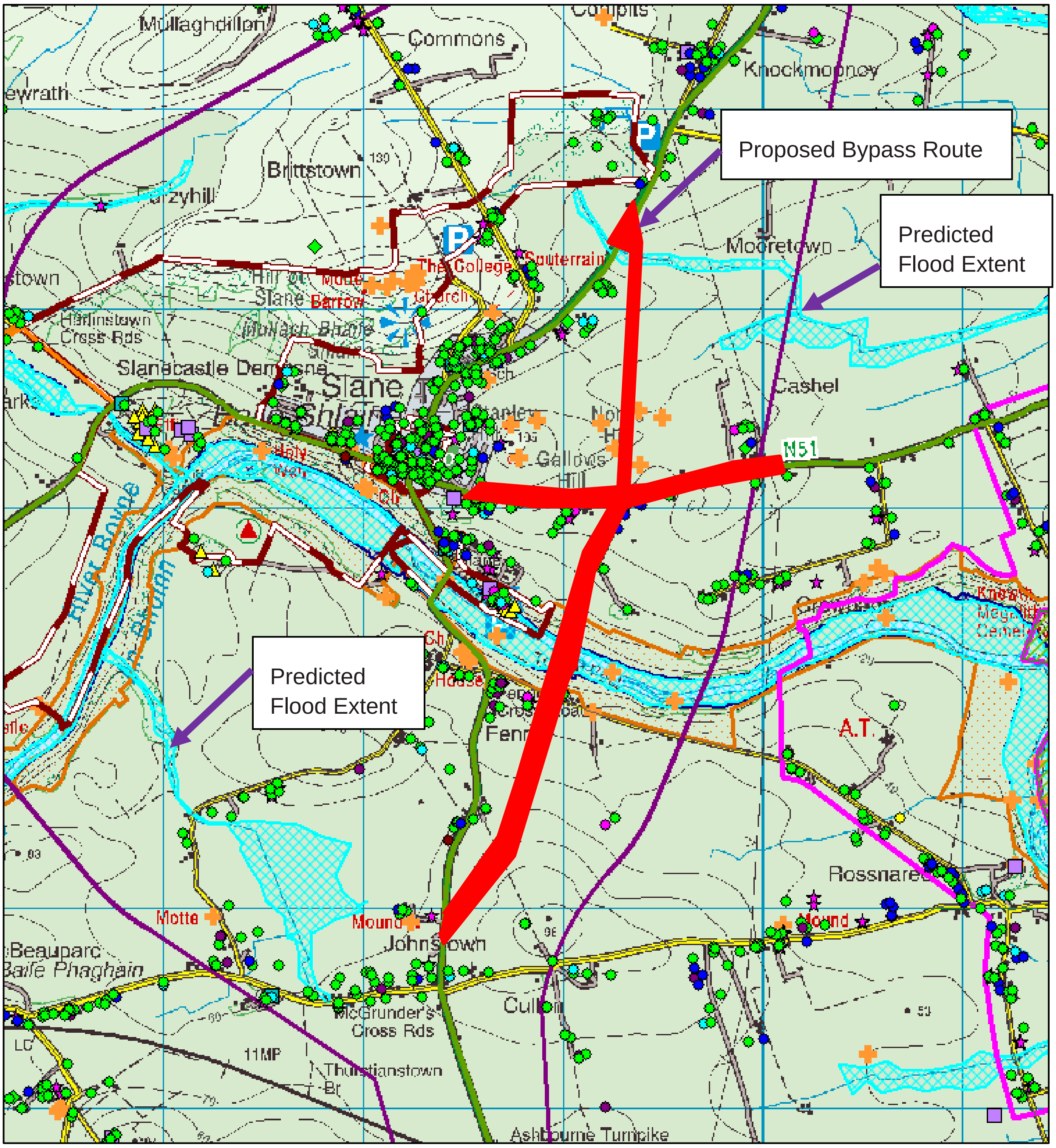


Figure 3-9 Meath County Council GIS Flood Mapping

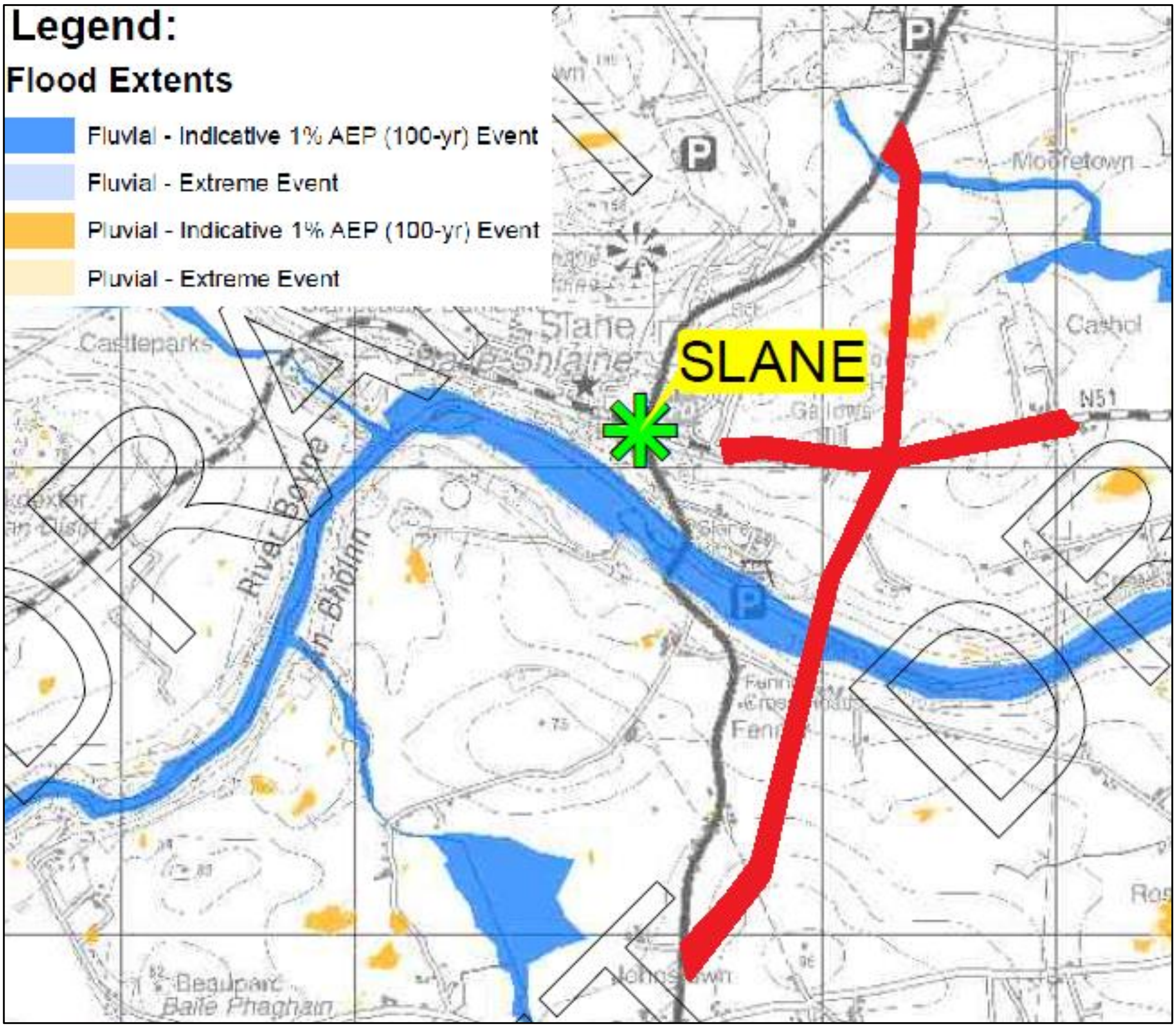


Figure 3-10 MCC PFRA Flood Mapping

3.6 National Indicative Fluvial Mapping (NIFM)

The National Indicative Fluvial Mapping (NIFM) Project was commissioned to provide updated predictive flood mapping for river catchments greater than 5km^2 not covered as part of the CFRAM studies. The NIFM predictive flood mapping superseded the Preliminary Flood Risk Assessment (PFRA) predicted flood maps for river catchments. The NIFM predictive flood mapping similar to the PFRA maps are noted to be indicative and is recommended to only be used to identify potential flooding areas that require further assessment.

The NIFM Project does not cover any watercourse that intersects the Proposed Bypass Route as the Mattock (Mooretown) Stream and other smaller watercourses have catchments less than 5 km^2. The nearest watercourses included in the NIFM Project are the Castleparks Stream and the Devlin stream located 2km to the west and to the north respectively. The predictive flood extents for these watercourses does not interact with the Proposed Bypass Route (see **Figure 3-11**).

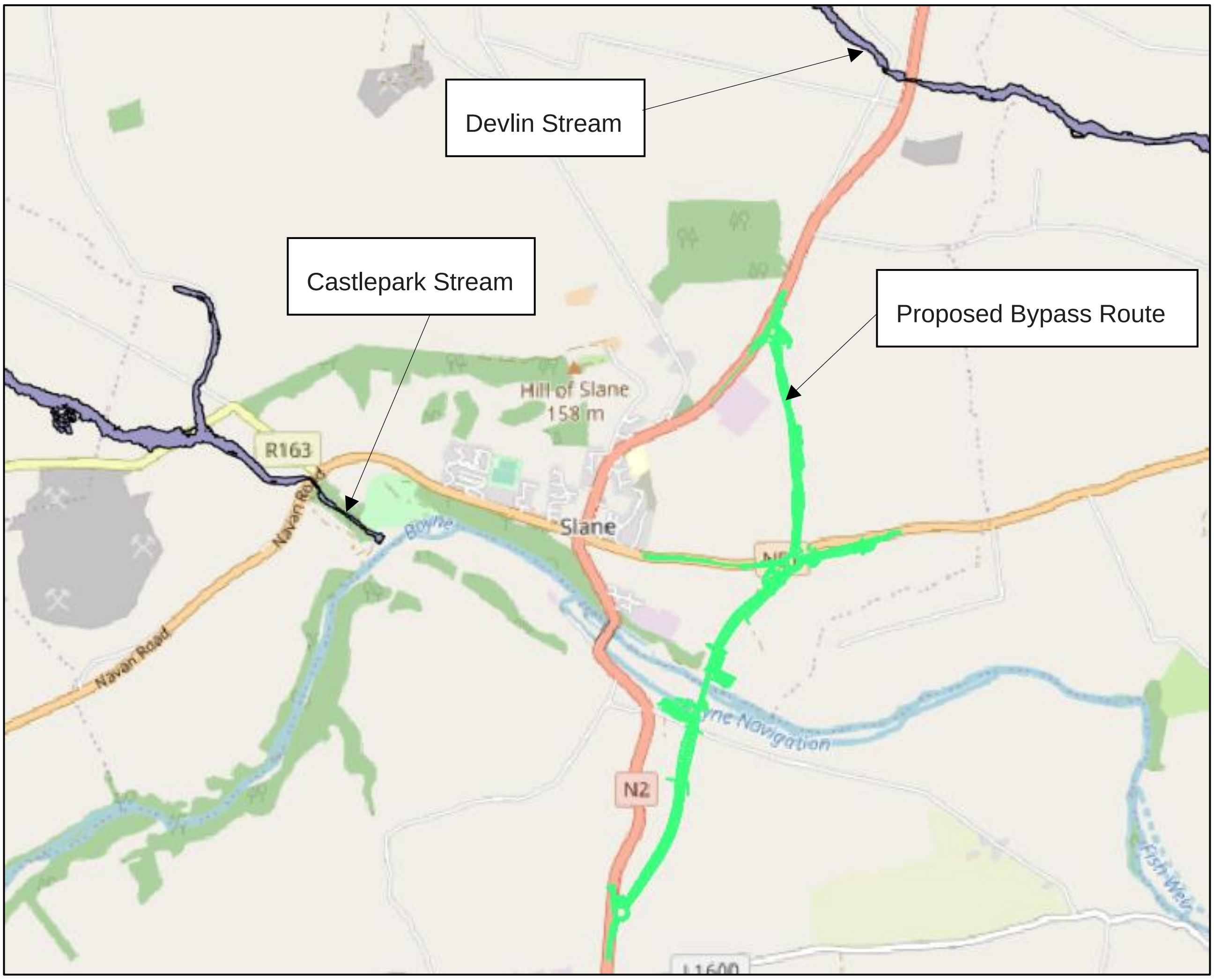


Figure 3-11 NIFM Predictive Flood Mapping in vicinity of Proposed Bypass Route

3.7 Conclusion of Stage 1 – Flood Risk Identification

Records of historical flooding, MCC GIS and PFRA Flood Mapping and the Eastern CFRAM predicted flood extent indicated that the Proposed Bypass Route may be at risk from a fluvial and coastal flooding and to a lesser extent from pluvial flooding. Therefore, the FRA was progressed to Stage 2 – Initial Flood Risk Assessment for the Proposed Bypass Route.

The 'Stage 1 – Flood Risk Identification' assessment concluded the traffic management and public realm improvement works proposed within Slane village not to be at risk of flooding. Hence the FRA is not required to progress to Stage 2 – Initial Flood Risk Assessment for this proposed element of works.

4 STAGE 2 – INITIAL FLOOD RISK ASSESSMENT

4.1 Overview

The purpose of the Initial FRA is to appraise the availability and adequacy of the identified flood risk information, to qualitatively appraise the flood risk posed to the site and potential impacts on flood risk elsewhere and recommend possible mitigation measures to reduce the risk to acceptable level. A Source-Pathway-Receptor model is used to summarise the possible sources of floodwater, the pathway and the receptors that could be affected by potential flooding.

4.2 Source-Pathway-Receptor Model

In the first instance, an assessment of the probability, magnitude, response of pathways and consequences of a flood event in the Proposed Bypass Route were appraised. The analysis was aimed at identifying high risk elements as summarised in **Table 4-1**.

Table 4-1 Possible Flood Mechanisms

Source	Pathway	Receptor	Likelihood (Remote, possible, likely)	Consequences (low, medium, high)	Risk (low, medium, high)	Comment/ Reason
Fluvial	Increased river levels overtopping riverbanks	Proposed Bypass Route and adjacent properties	Possible	Medium	Medium	The route corridor is proposed to cross the River Boyne and the existing canal, and the Mattock (Mooretown) Stream. Hence it has potential to increase risk of out of bank flooding if the soffit for the proposed bridge for River Boyne is too low or if the proposed culvert for Mattock (Mooretown) Stream does not have sufficient capacity or if the route intersects with a floodplain. The bridge piers proposed within the predicted floodplain has the potential to obstruct out-of-bank flooding flow which may have an impact on flood risk elsewhere.
Tidal/ Coastal	Increased river levels overtopping existing riverbanks	Proposed Bypass Route and adjacent properties	Possible	Medium	Medium	The River Boyne at the location of the Proposed Bypass Route is subject to tidal influence, hence coastal flooding may be a possibility.
Pluvial	Overland Flow from Elevated Lands or Water logging	Proposed Bypass Route and adjacent properties	Possible	Medium	Medium	The surrounding topography slopes towards the river. Hilly areas do slope towards the site. Water logging could occur due to highly saturated soil.
Blockage	Increased river level overtopping existing riverbanks	Proposed Bypass Route and adjacent properties	Remote	High	Low	There are no bridges within the River Boyne downstream of the Proposed Bypass Route. The Mattock (Mooretown) Stream is culverted underneath existing N2 road but is located upstream of the Proposed Bypass Route. There are no existing culverts within the

Source	Pathway	Receptor	Likelihood (Remote, possible, likely)	Consequences (low, medium, high)	Risk (low, medium, high)	Comment/ Reason
						Mattock (Mooretown) Stream immediately downstream of the Proposed Bypass Route. Blockage of the proposed culvert on the Mattock (Mooretown) Stream can increase flood risk if not designed appropriately.
Groundwater	Rising Ground Water Level	Proposed Bypass Route and adjacent properties	Remote	High	Low	There are no records of ground water flooding in the area.
Human or Mechanical	Attenuation or Pipework failure	Proposed Bypass Route and adjacent properties	Remote	Medium	Low	The Proposed Bypass Route drainage system will be subjected to regular maintenance and checks. This should avoid any issues of this nature.

The primary source of flood risk to the Proposed Bypass Route may be attributed to fluvial and coastal flooding largely from the tidally influenced River Boyne. Secondary risks may arise from pluvial flooding due to potential contribution of runoff from elevated land surrounding the Proposed Bypass Route.

In consideration of the above assessment, the primary flood risk to the study area was narrowed down to:

- Fluvial – Medium Risk.
- Coastal – Medium Risk.
- Pluvial (overland flow) – Medium Risk.

4.3 Fluvial Flooding

Section 3.3 outlines a brief history of the previous flood events from the River Boyne. The low-lying areas adjacent to the banks of the River Boyne within the Proposed Bypass Route have been subjected to flooding during previous events.

The 1-in-100-year predicted flood extent Meath County Council (MCC) GIS and PFRA mapping show the Proposed Bypass Route to intersect flooding from the River Boyne and the Mattock (Mooretown) Stream. The predicted flood extent shown on both GIS and PFRA mapping does not account for individual flow structures and is noted to be indicative.

4.3.1 River Boyne Crossing

4.3.1.1 ECFRAM Study

Detailed hydraulic modelling was carried out for the River Boyne as part of the Eastern CFRAM study as discussed in **Section 3.4** and the extent of the model is shown in **Figure 4-1**. The River Boyne at the vicinity of the Proposed Bypass Route was modelled in 1-dimension only and was not part of the Area for Further Assessment (AFA) recommended for more detailed analysis as part of the ECFRAM study.

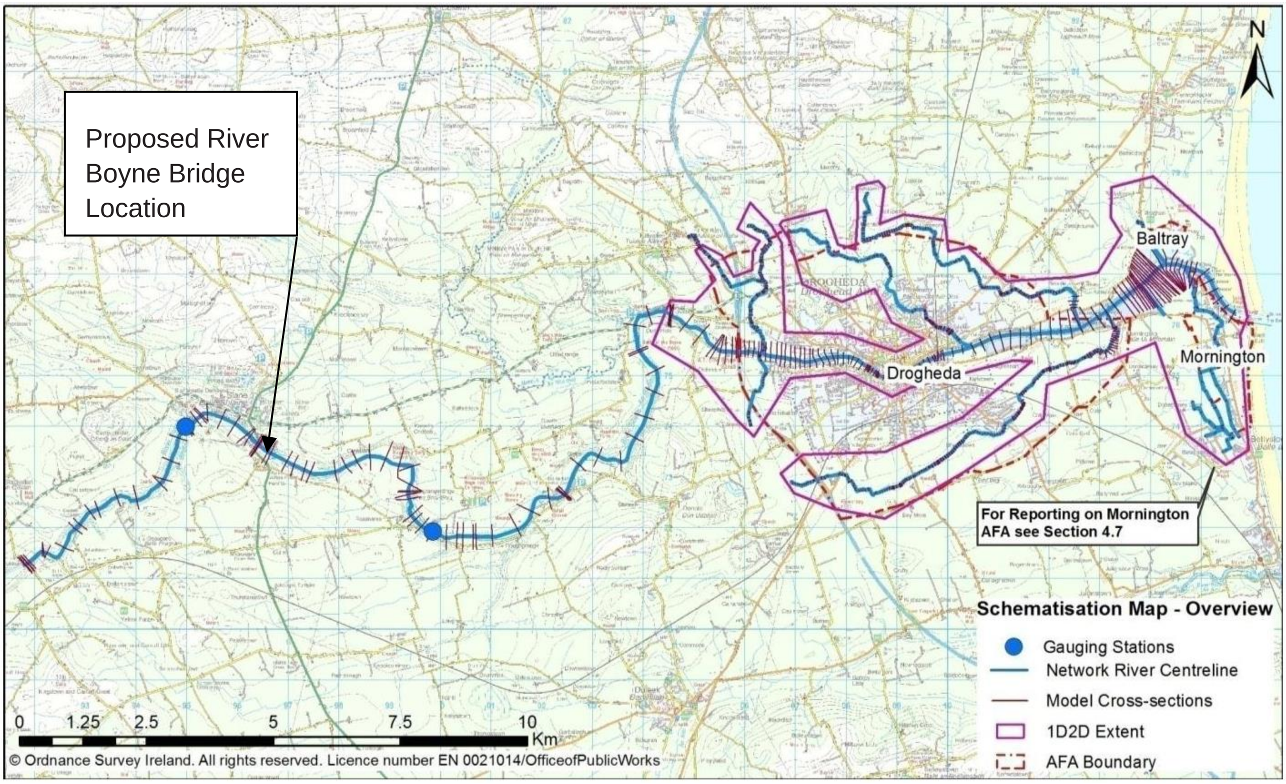


Figure 4-1 ECFRAM Hydraulic Model Extent

The predicted flood extents from ECFRAM model for the River Boyne in the vicinity of the Proposed Bypass Route is shown in **Figure 3-7**. The figure indicates the predicted flooding for up to the 0.1% AEP event to be contained within localised low-lying areas adjacent to the banks of the River Boyne.

The predicted ECFRAM 1% and 0.1% AEP flows and flood levels for the River Boyne for the current and climate change scenarios (i.e. mid-range future scenario and high-end future scenario) was requested from the Office of Public Works for the purpose of this flood risk assessment.

The climate change scenarios consist of the following increases in peak flows for extreme flood events:

- Mid-Range Future Scenario – 20%
- High-End Future Scenario – 30%

The predicted CFRAM 1% and 0.1% AEP fluvial flood levels for the River Boyne just upstream of the Proposed Bypass Route, as shown in **Figure 4-2**, are listed in **Table 4-2**.

Figure 4-2 Fluvial Flood Node Location

Table 4-2 Predicted CFRAM Fluvial Levels just upstream of Proposed Bypass Route

Scenarios	Predicted 1.0% AEP Fluvial Level (m.AD)	Predicted 0.1% AEP Fluvial Level (m.AD)
Current Scenario	14.50	14.95
Mid-Range Future Scenario	14.98	15.52
High-End Future Scenario	15.83	16.53

4.3.1.2 Proposed River Boyne Bridge Permanent Works

The proposed bridge piers, access track and abutments are to be situated at a minimum distance of 10 metres from the banks of the river. The extent of the predicted flooding within the proposed River Boyne Bridge for the ECFRAM 1% AEP and 0.1% AEP current scenario is shown in **Figure 4-3**.

The proposed three piers and access track are within the ECFRAM predicted 1% AEP and 0.1% AEP flood extents. The proposed abutments are proposed outside the predicted ECFRAM 1% AEP and 0.1% AEP flood extents. Hence further assessment is required to assess the impact of the proposed three piers and access track on flood risk to the Proposed Bypass Route and elsewhere.

The existing canal, which forms part of the River Boyne Navigation, intersects with the Proposed Bypass Route approximately 130 metres to the south of the River Boyne right bank. The canal is noted to appear in poor maintenance and the CFRAM predicted flood extents does not appear to consider additional capacity of the existing canal to convey out-of-bank flooding flow. Hence the existing canal does not have an influence on the flooding from the River Boyne.

The other existing canal, which runs through the old flour mill, discharges flow from the River Boyne upstream of the existing Slane Road Bridge to the main channel approximately 0.3km upstream of the Proposed Bypass Route. Hence the canal is active and contribute to the capacity of the River Boyne to convey flows.

The lowest soffit level proposed for the bridge is 18.765m AOD and is approximately 3.765 metres above the predicted 1% AEP predicted flood level for the mid-range future scenario as shown in **Figure 4-4**. It is also approximately 2.2 metres above the predicted 0.1% AEP predicted flood level for the high-end climate change scenario. Hence the proposed bridge has more than adequate freeboard and will not contribute to surcharging during extreme flood events.

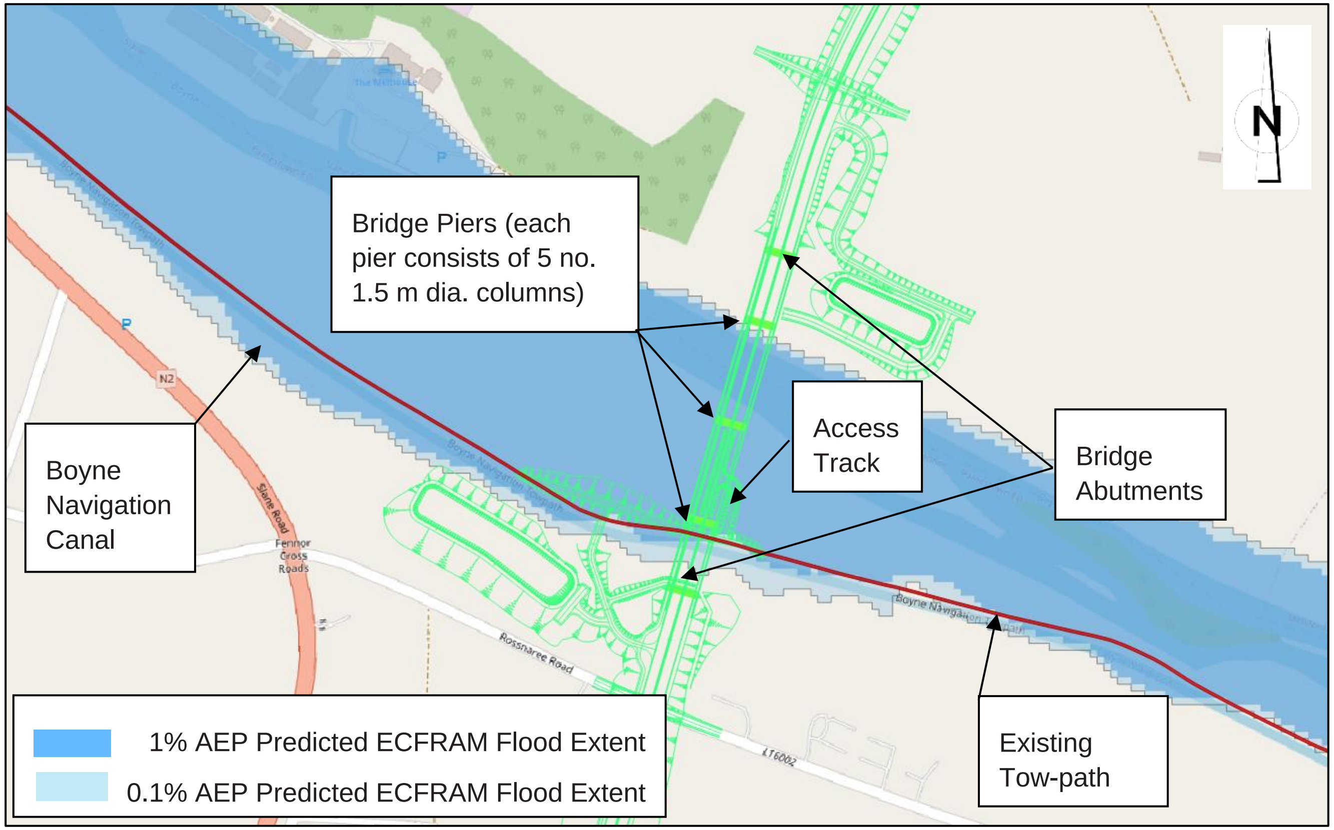


Figure 4-3 Proposed Bridge Permanent Works - 1% & 0.1% AEP ECFRAM Predicted Flood Extents

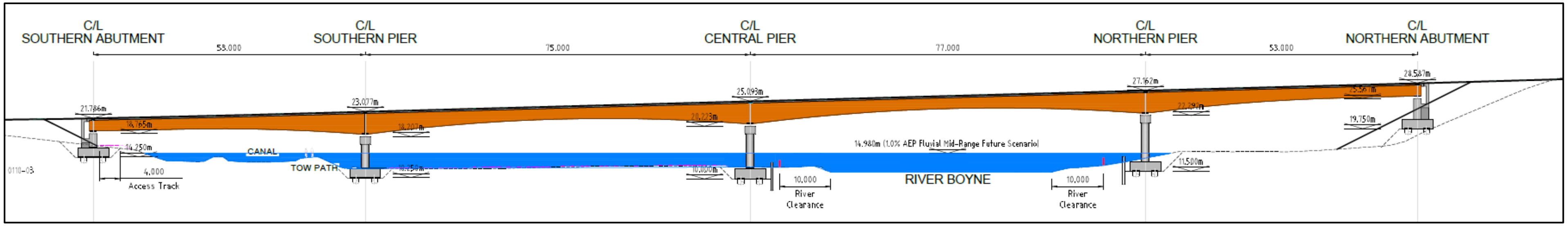


Figure 4-4 Proposed Bridge - 1% AEP mid-range future scenario - Section

4.3.1.3 Temporary Works within the Floodplain

The construction of the proposed River Boyne Bridge includes for a temporary works platform (WP2) and cofferdams to be erected within the 1% AEP and 0.1% AEP floodplain as shown in **Figure 4-5**.

The temporary working platform (WP2) and cofferdams has the potential to reduce the available flood water storage volume/ conveyance leading to increased flooding elsewhere. Detailed hydraulic modelling will be required to establish the potential impact of the platform and cofferdams on flood risk elsewhere during the 1% AEP and 0.1% AEP events and, if required, detail the mitigation measures to ensure minimal or impact.

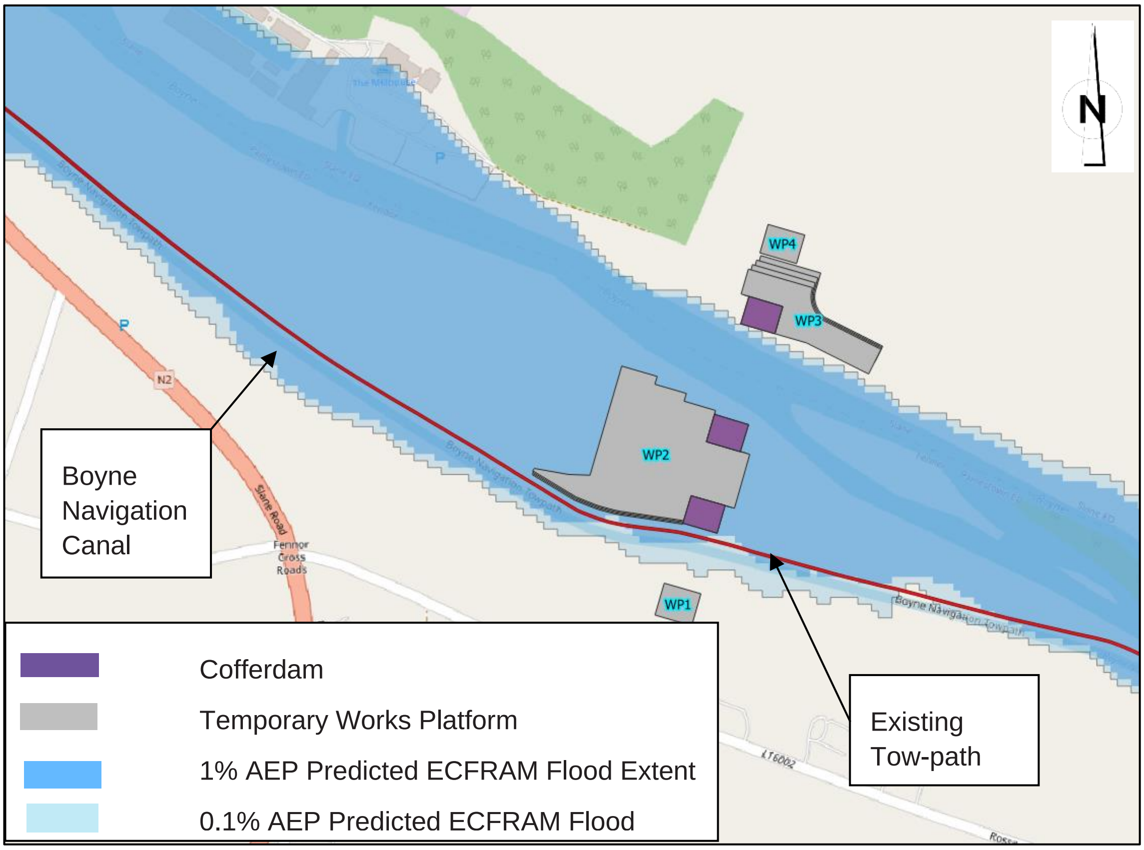


Figure 4-5 Proposed Bridge Temporary Works - 1% & 0.1% AEP ECFRAM Predicted Flood Extents

4.3.2 Mattock (Mooretown) Stream Crossing

The Mattock (Mooretown) Stream is culverted underneath the existing N2 road just upstream of the intersection with the Proposed Bypass Route. The Meath County Council GIS mapping records also indicate localised flooding from the Mattock (Mooretown) Stream at the location of the Proposed Bypass Route and downstream (see **Figure 3-9**). The flooding appears to be due to insufficient channel capacity.

The proposed culverts for the Mattock (Mooretown) Stream (6A, 6B and 6C) were sized to accommodate the 1-in-100-year flow taking into account 20% allowance for climate change and 0.5 m freeboard to ensure compliance with Section 50 of the 1945 Arterial Drainage Act. The proposed works includes for channel re-alignment between Culvert 6A and 6B (Chainage 308.81 to 245.82) to accommodate the North Roundabout Embankment as shown in **Figure 4-6**.

A hydraulic model was developed using HEC-RAS software to assess the impact of the culverts proposed for the Mattock (Mooretown) Stream. The model was assessed for the 1-in-100-year flow plus 20% allowance for climate change (Q100+CC). This gave a flowrate of 1.59m^3/s, based on the OPW Flood Studies Update (FSU) method, for the Mattock (Mooretown) Stream at North Roundabout. The predicted Q100+CC water levels for the Mattock (Mooretown) Stream, taking into account the proposed culverts, are listed in **Table 4-3**. The water level chainages are shown on **Figure 4-6**. Future details on the flow calculation and HEC-RAS model is provided in Section 50 report included in **Appendix B** of this report.

The results of the hydraulic analysis showed no increase in predicted water levels upstream of Culvert 6A and downstream of Culvert 6C resulting from the proposed culverts. The predicted water levels for the Mattock (Mooretown) Stream were reviewed in comparison with the ground levels for the following properties (shown on **Figure 4-6**) to assess flood risk impact;

- Existing N2 road level at the North Roundabout – 77.5 mAD.
- Lowest Ground Level at residential property located to the south – 81.0 mAD.
- Lowest Ground Level at commercial property located to the south – 81.1 mAD.

The lowest ground level for the adjacent infrastructure (77.5 mAD) is at least 2.5 m above the predicted Q100+CC water level for the Mattock (Mooretown) Stream, taking into account the proposed culverts. Hence the Proposed Bypass Route does not increase flood risk elsewhere from the Mattock (Mooretown) Stream. Section 50 approval was obtained from the Office of Public Works for the proposed Mattock (Mooretown) Stream Culverts.

Table 4-3 Proposed Q100+CC Fluvial Levels (m.AD) - Mattock (Mooretown) Stream

Chainage	Predicted Q100+CC Water Level (mAD)
360.00	74.97
340.00	74.78
337.42	74.73
266.22	72.92
250.69	72.76
245.82 to 237	Proposed Culvert 6B
176.81	69.99
147.48	69.14
144.51 to 133.85	Proposed Culvert 6C
130.25	68.63
120.00	68.43
100.00	67.96
86.19	67.79

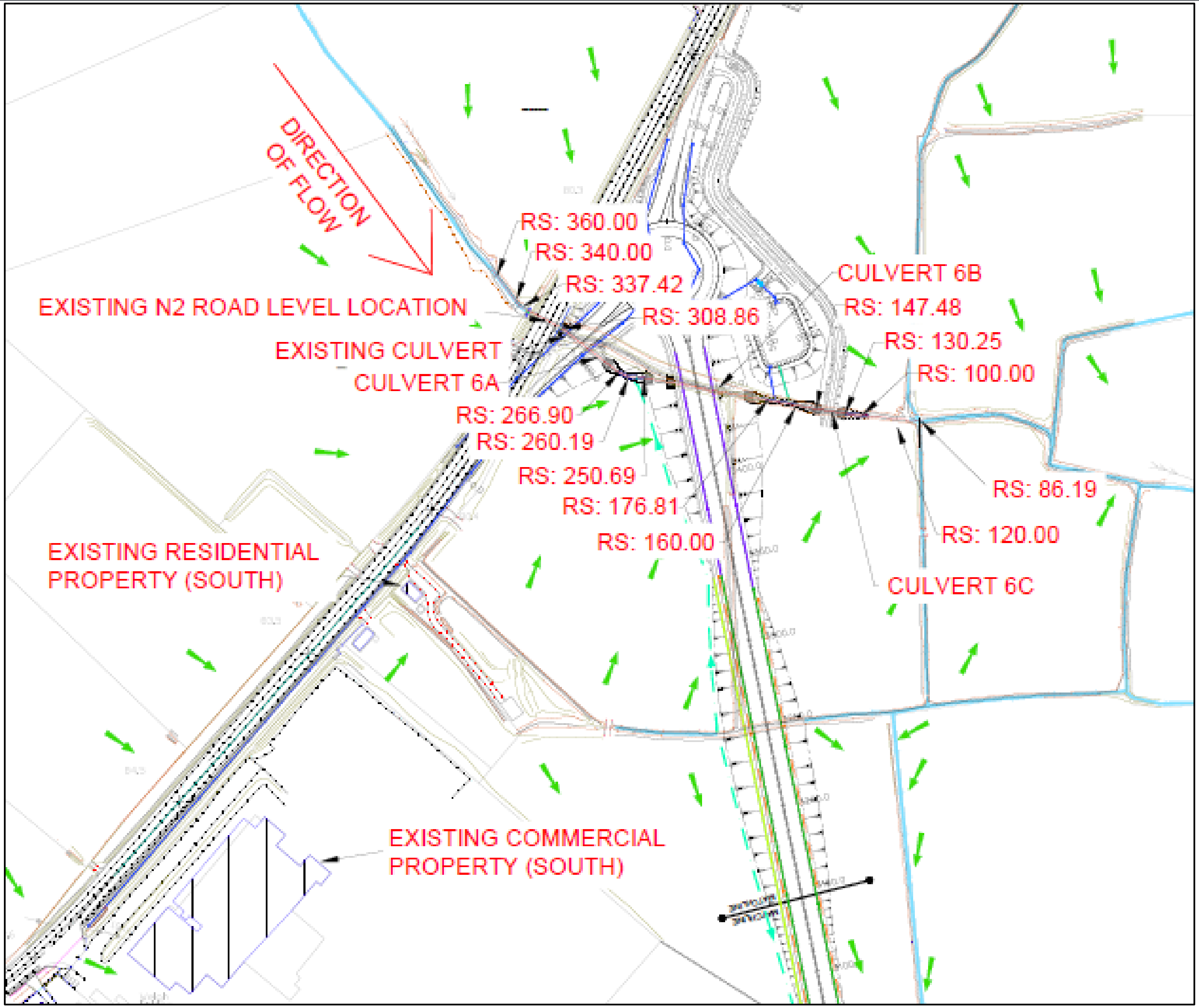


Figure 4-6 Mattock (Mooretown) Stream Cross Section Locations

4.3.3 Other Watercourses

There are no other known watercourses with significant contributing catchment area (i.e. greater than 1km^2) that will be intercepted by the Proposed Bypass Route. However, there are several land drains that will traverse the Proposed Bypass Route. The existing land drains and overland flow paths from greenfield are proposed to be captured by the interceptor drains which will run along both sides of the Proposed Bypass Route as appropriate. The existing land drain routes are proposed to be maintained using culverts crossing the Proposed Bypass Route. The existing land drains are not noted on the OSI historical 6-inch and 25-inch maps. Hence these land drains are not deemed to be historical land drains. Therefore, the culverting of these land drains within the Proposed Bypass Route does not require Section 50 approval. The proposed interceptor drains and culverts to accommodate the land drains are to be sized to cater for the 1-in-75 year flow from catchments contributing to the land drains as per Transport Infrastructure Ireland standard (Ref: DN-DNG-03064-02) titled "*Drainage of Run-off from Natural Catchment*". Hence the Proposed Bypass Route will not increase flood risk elsewhere from the land drains.

4.4 Coastal Flooding

The River Boyne in the vicinity of the Proposed Bypass Route is subjected to tidal influence. A detailed analysis was carried out as part of the Eastern CFRAM study to establish potential impact on coastal flood risk from the River Boyne for up to the 0.1% AEP event. The predicted coastal flood extent map produced from this study shown in **Figure 3-8** indicate potential flooding confined within low-lying areas adjacent to the River Boyne.

The proposed bridge is the only element of the route corridor to interact with the predicted coastal flood extent.

There were no predicted CFRAM 0.5% and 0.1% AEP coastal flood levels for the River Boyne at the Proposed Bypass Route location. The most upstream predicted coastal water levels provided for the River Boyne is approximately 17.5km downstream within the town centre of Drogheda as shown in **Figure 4-7**. The predicted CFRAM coastal levels are listed in **Table 4-4**.

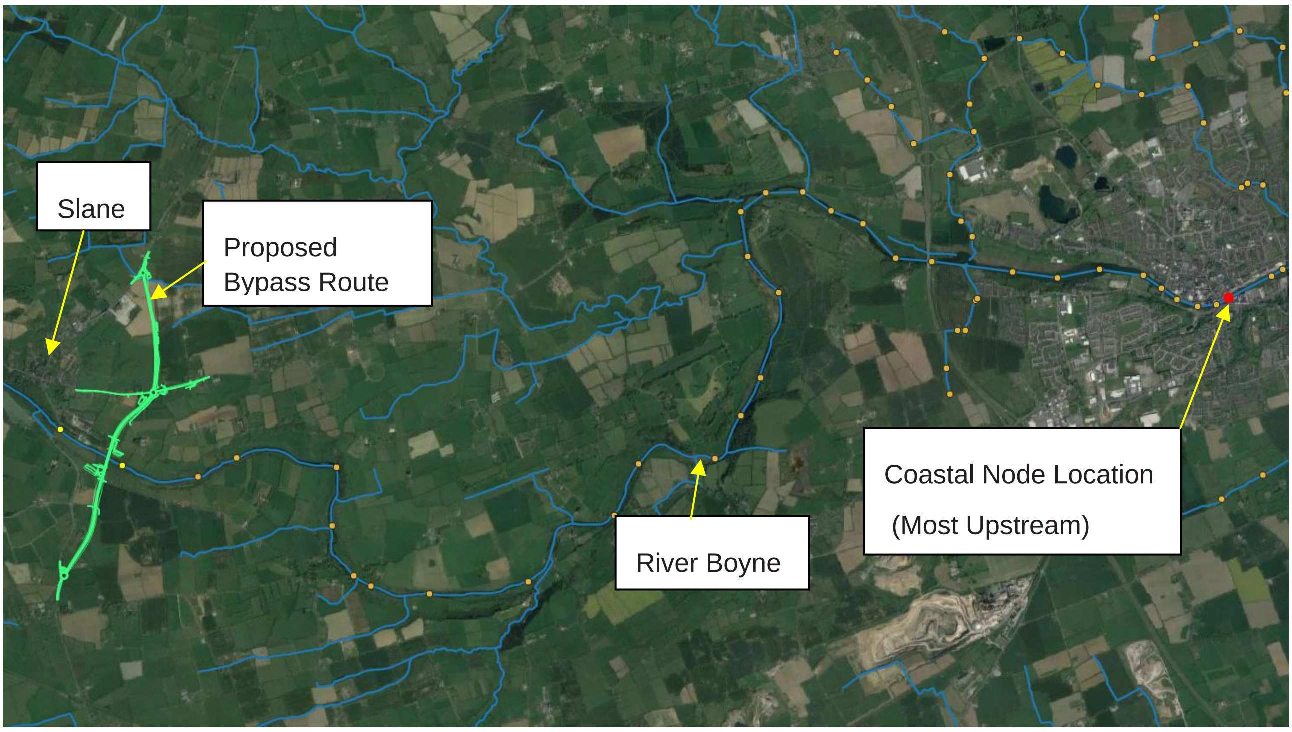


Figure 4-7 Predicted CFRAM Coastal Node Location

Table 4-4 Predicted CFRAM Coastal Levels - Drogheda

Scenarios	Predicted 0.5% AEP Coastal Level (m.AD)	Predicted 0.1% AEP Coastal Level (mAD)
Current Scenario	3.56	3.77
Mid-Range Future Scenario	4.08	4.28
High-End Future Scenario	4.58	4.79

The highest predicted CFRAM coastal level (4.79 mAD) is below the River Boyne river bed level at the intersection with the Proposed Bypass Route. Hence the Proposed Bypass Route is not at risk from coastal flooding.

4.5 Climate Change Sensitivity

The predicted ECFRAM fluvial flood maps for the River Boyne at the Proposed Bypass Route crossing were reviewed to assess the sensitivity of the predicted flood extents due to increased flows or increased tidal levels as a result of climate change.

The comparison between the predicted ECFRAM 1% and 0.1% fluvial flood levels for the current and mid-range future scenario showed an average difference of approximately 0.5 m.

The proposed bridge soffit levels will be in excess of 3m above the 1% AEP fluvial flood level for the mid-range future scenario. Thus, the proposed bridge will have sufficient freeboard to cater for increased flows as a result of climate change. Further assessment is required to assess the potential offsets of the bridge piers proposed within floodplain for the 1% AEP and 0.1% AEP events.

4.6 Pluvial Flooding

There are no recorded incidents of pluvial flooding in the vicinity of the Proposed Bypass Route. The nearest recorded instance of pluvial flooding was on the N51 approximately 1.5 km west of the Proposed Bypass Route. This flooding was reported to be as a result of inadequate local drainage system. The potential impact of the Proposed Bypass Route on the flood risk at this location is deemed minimal due to the proximity between the two locations.

The route corridor is surrounded by elevated lands and has the potential to impede or interfere with the natural drainage flow paths, potentially contributing to a build-up of run-off and hence flooding. The PFRA flood mapping indicates potential pluvial flooding on a greenfield which intersects with the Proposed Bypass Route as shown on **Figure 3-10**. The extent of the pluvial flooding is localised at a low point and is a direct result of a build-up of run-off contributing to the flooding. The proposed drainage design for the route corridor includes for interceptor drains along the verge to intercept existing drainage paths from the surrounding elevated lands, and to cater for same within the system. This includes the predicted pluvial flooding location. The interceptor drains will be sized using the Transport Infrastructure Ireland (TII) drainage design standard as appropriate. Hence the Proposed Bypass Route will improve the existing pluvial flood risk at this location.

The existing road drainage pipes to be intercepted by the proposed drainage system will also be catered for and accommodated in the design appropriately.

Drainage discharge to the receiving watercourse is via petrol interceptors and attenuation ponds. Attenuation is designed to cater for run-off from the Proposed Bypass Route for up to the 1% AEP event taking account of climate change. The discharges from the attenuation ponds to receiving watercourses will be limited to greenfield run-off rate as recommended in the TII and Greater Dublin Strategic Drainage Study (GDSDS) guidelines. Hence the Proposed Bypass Route is considered to have no detrimental impact on the pluvial flood risk elsewhere.

4.7 Conclusion of Stage 2 – Initial Flood Risk Assessment

The potential impact of the Proposed Bypass Route on fluvial, coastal, climate change sensitivity and pluvial flooding was reviewed. The proposed bridge, located across the River Boyne, will have piers and the associated access track within the predicted ECFRAM 1% AEP and 0.1% AEP floodplain. The ECFRAM predicted flood extents indicate the proposed bridge abutments will be located outside the 1% AEP and 0.1% AEP floodplain. The proposed bridge will have a freeboard above the predicted flood levels (in excess of 3 metres) hence it will have adequate flood protection. The construction of the proposed River Boyne Bridge includes for a temporary works platform and cofferdams to be erected within the predicted ECFRAM 1% AEP and 0.1% AEP floodplain. Further assessment is required to assess the impact of the proposed River Boyne permanent works (bridge piers and access track) and temporary works (platform and cofferdams) on flood risk elsewhere during the 1% AEP and 0.1% AEP events.

The flood risk for the culverts proposed for the Mattock (Mooretown) Stream adjacent to the North Roundabout was assessed. The assessment concluded that the proposed Mattock (Mooretown) Stream Culverts does not pose a flood risk to Proposed Bypass Route and does not increase flood risk elsewhere.

The existing drainage and overland flow paths intercepted by the Proposed Bypass Route will be intercepted and catered for within the drainage system design. The surface water run-off discharge from the drainage system to receiving watercourses will be attenuated and limited to greenfield run-off rate using 7 No. attenuation ponds. Class 1 Petrol/Oil Interceptor to treat run-off prior to discharge on incoming pipes to attenuation ponds will also be provided. Hence the Proposed Bypass Route will not have a detrimental impact on pluvial flood risk elsewhere.

This FRA is required to progress to Stage 3 - Detailed Flood Risk Assessment to ascertain the impact of the proposed River Boyne bridge piers and temporary works platform on flood risk elsewhere.

5 STAGE 3 – DETAILED FLOOD RISK ASSESSMENT

5.1 Hydrology

The Flood Studies Update (FSU) method was used to estimate the 1% and 0.1% Annual Exceedance Probability (AEP) flows for the River Boyne upstream and downstream of the Proposed Bypass Route at Hydrological Estimation Points (HEPs) shown in **Figure 5-1**.

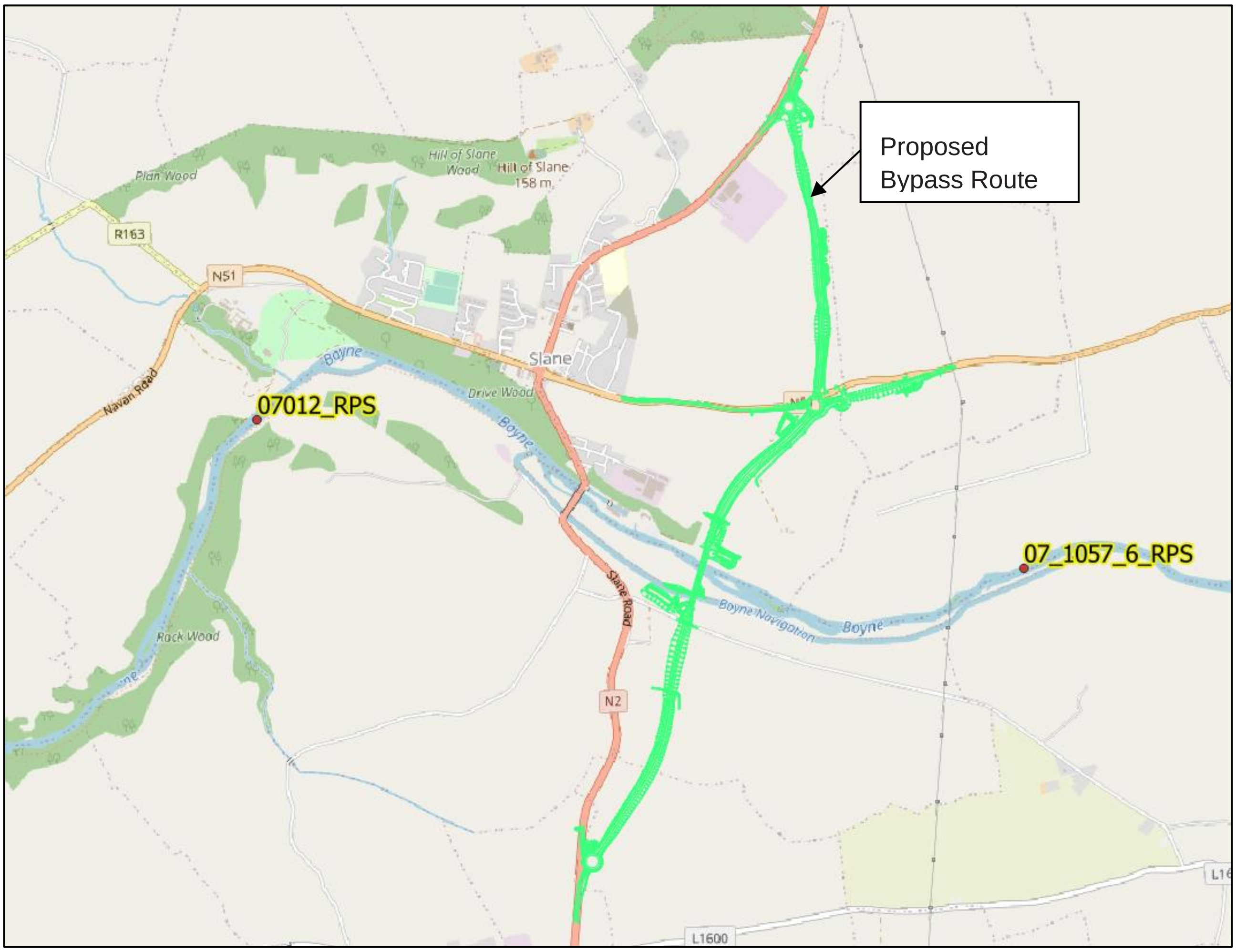


Figure 5-1 HEP Locations

5.1.1 Index Flood Estimation

The first step in determining the 1% and 0.1% AEP flows will be the estimation of the Index-flood (Q_{MED}) at each Hydrological Estimation Point (HEP). The Index-flood is a crucial flood statistic as it can be robustly determined from suitable gauged locations with a significant record length (more than 14 years). For the ungauged river catchments, it is generally estimated using the catchment PCD-based regression equation. Estimation of the index-flood for the ungauged catchments in their rural form, referred to henceforth as $Q_{MED-RURAL}$.

$Q_{MED-RURAL}$ for ungauged catchments determined using FSU 7-variable equation outlined below:

$$Q_{med\ rural} = 1.237 * 10^{-5} * Area^{-0.937} * BFI_{soil}^{-0.922} * SAAR^{1.306} * FARL^{2.217} * DRAIND^{0.341} * S1085^{0.185} * (1 + ARTDRAIN2)^{0.408}$$

The FSU 7-variable Q_{MED} equation was derived through regression analysis and has a Factorial Standard Error (FSE) of 1.37. This equation is recommended only for catchment areas larger than 25 km^2.

The relevant physical catchment descriptors are obtained from the FSU datasets and are listed in **Table 5-1** for each HEP. The ungauged Q_{MED_RURAL} estimates for each HEP are outlined in **Table 5-2**.

Table 5-1 HEPs Catchment Descriptors

Parameter	Units	07012_RPS	07_1057_6_RPS
Area	km^2	2447.58	2477.95
BFISOIL	-	0.678	0.680
SAAR	mm	890.06	889.87
FARL	-	0.965	0.965
DRAIN	km/km^2	0.872	0.874
S1085	m/km	0.697	0.688
ARTDRAIN2	-	0.606	0.603

Table 5-2 HEPs Ungauged Q_{MED_RURAL} Estimates

HEP	Ungauged $Q_{MED-RURAL}$ (m^3/s)
07012_RPS	188.7
07_1057_6_RPS	189.7

5.1.2 Urban Adjustment

This $Q_{MED-RURAL}$ value does not consider the effects of urbanisation which is considered separately through an Urban Adjustment Factor (UAF) calculated as follows:

$$UAF = (1 + URBEXT)^{1.482}$$

The final Q_{MED} which considers the effect of urbanisation is then calculated:

$$Q_{MED} = UAF * Q_{MED\ RURAL}$$

The urban adjustment values and ungauged Q_{MED} for each HEP are outlined in **Table 5-3**.

Table 5-3 Urban Adjustment Values & Ungauged Q_{MED}

HEP	URBEXT	UAF	Ungauged Q_{MED} (m^3/s)
07012_RPS	0.0091	1.0135	191.3
07_1057_6_RPS	0.0090	1.0134	192.2

5.1.3 Pivotal Site Adjustment

The FSU method recommend that the ungauged Q_{MED} estimates are adjusted where there is appropriate observed data available from a gauged catchment. The catchment descriptor equation has the potential to over or under-estimate ungauged Q_{MED} estimates for catchments, which can be adjusted based on gauged catchment observed data.

The gauged catchment from where this adjustment is derived is referred to as a ‘pivotal site’ and it may refer to a gauging station upstream or downstream or a gauging station from a different catchment which is hydrologically similar. Preference can be given to hydrologically similar gauges that are geographically close to the area of interest.

The ungauged Q_{MED} estimates for the River Boyne HEPs were adjusted based on the observed Q_{MED} for Slane Castle Gauging Station. This gauging station is the closet to the Proposed Bypass Route and is also the same location for the upstream HEP (07012_RPS). The details from this gauging station used in the hydrological analysis are outlined in **Table 5-4**.

Table 5-4 Hydrometric Gauging station record considered for hydrological analysis

Station No.	Station Name	Catchment Area (km^2)	Operator	Record Length	Record End	Data	Gauge Rating
07012	Slane Castle	2447.58	OPW	33 Years (1986 – 2019)	2019	Water Level & Flow	A1 (OPW Rating)

The observed Q_{MED} computed for Slane Castle Gauging Station location based on the Amax flows is 269.10 m^3/s and has an adjustment factor of 1.407. The adjusted Q_{MED} values for each HEP are listed in **Table 5-5**.

Table 5-5 Adjusted Q_{MED} Values

HEP	Q_{MED} (m3/s)
07012_RPS	269.1
07_1057_6_RPS	270.1

5.1.4 Growth Curve Estimation

A growth curve defines the relationship between the index-flood flow Q_{MED} and the various event probability peak flows (i.e. 1% AEP and 0.1% AEP flows). A growth curve can be defined from Amax data from a single site, such as for Slane Castle Gauging Station on the River Boyne and is defined by the at site flood frequency curve. However, this approach is not recommended for defining flood events with a return period more than twice the number of Amax years available. In this case pooled analysis is undertaken based on the FSU methodologies to determine growth factors for a range of range of design events.

The choice of final growth factors for design flow estimation considers the confidence in the ratings following rating reviews, the length of record, and the return period (T) under consideration amongst other things. **Table 5-6** below, adapted from Volume 3, Table 8-2 of the UK Flood Estimation Handbook (FEH), outlines the preferred decision framework in selecting the method.

Table 5-6 Selection of At-Site or Pooled Growth Factors / Curves

Record Length	At-Site Analysis	Pooled Analysis	Preferred Method
<T/2 or 14 years	No	Yes	Pooled
T/2 to T years	For confirmation	Yes	Pooled
T to 2T years	Yes	Yes	Joint
> 2T years	Yes	For confirmation	At-Site

The Amax flows dataset for all stations (up to the hydrometric year 2019/2020) comprising the possible pooling groups for all HEPs have been obtained from OPW, EPA and NI Rivers Authority and used in the pooling analysis.

At-site flood frequency analysis and pooled frequency analysis was performed on this record to estimate the growth factors to calculate 1% AEP and 0.1% AEP flows from Q_{MED}. A number of flood-like distributions were fitted to the Amax data as part of the flood frequency analysis and the Generalised Logistic (GLO) distribution was found to be the best fit. The CFRAM growth factors was reviewed for comparison with the At-Site and Pooled GLO growth factors which are listed in **Table 5-7**.The Pooled Growth Factors are more conservative than the At Site Growth Factors and is also comparable to CFRAM Growth Factors. The Pooled Growth Factors are applied to the Q_{MED} flows to calculate 1% and 0.1% AEP flows.

Table 5-7 At-Site & Pooled Growth Factors

AEP	Growth Factors - Pooled	Growth Factors - At Site	CFRAM Growth Factors
50%	1.00	1.02	1.00
20%	1.25	1.29	1.25
10%	1.41	1.41	1.41

AEP	Growth Factors - Pooled	Growth Factors - At Site	CFRAM Growth Factors
5%	1.58	1.49	1.58
2%	1.80	1.57	1.81
1%	1.99	1.62	2.01
0.10%	2.69	1.70	2.76

5.1.5 Peak Flow Estimation

The peak 1% and 0.1% AEP flows are listed in **Table 5-8**. The 1% AEP plus climate change was computed based on 20% uplift recommended in OPW National Climate Change Adaptation Plan for Mid-Range Future Scenario (MRFS).

Table 5-8 1% & 0.1% AEP Peak Flows

HEP	1% AEP (m3/s)	1% AEP+cc (m3/s)	0.1% AEP (m3/s)
07012_RPS	535.51	642.61	723.88
07_1057_6_RPS	537.51	645.02	726.59

5.1.6 Design Hydrographs

Once the design peak flow is estimated, the next step is to determine the characteristic hydrograph shape to ensure it is a true representation of the catchment in question under a flood flow. The method adopted for this study is the Hydrograph Width Analysis (HWA) approach as discussed in the Technical Research Report Volume III[1]. This method is similar in principle to the estimation of the index flood in that it uses catchment descriptors to arrive at an initial estimate of the characteristic hydrograph shape, defined in three parameters, and then uses a pivotal site to adjust the shape based on observed data.

The HWA approach considers all the observed hydrographs represented within the AMAX series for a pivotal site. At the ungauged HEPs the characteristic hydrograph shape parameters were estimated based on physical catchment descriptors and then adjusted based on the appropriate pivotal site.

Slane Castle Gauging Station was deemed the most appropriate pivotal site and the hydrographs for all HEPs were adjusted using the observed flood hydrographs from this gauging station.

The flood hydrograph associated with any AEP has been estimated by scaling up the characteristic hydrograph ordinates by the relevant peak flow. **Figure 5-2** illustrates the flood hydrograph scaled up for the 5% AEP event for Slane Castle Gauging Station location and the observed hydrograph for the November 2000 event recorded at Slane Castle Gauging Station for comparison. Both hydrographs have similar peak flows. The comparison indicates the predicted flood hydrograph to be conservative. The predicted flood hydrograph for the 1% AEP event at Slane Castle Gauging Station location is shown in **Figure 5-3**.

[1] https://opw.hydronet.com/data/files/Technical%20Research%20Report%20-%20Volume%20III%20-%20Hydrograph%20Analysis(1).pdf

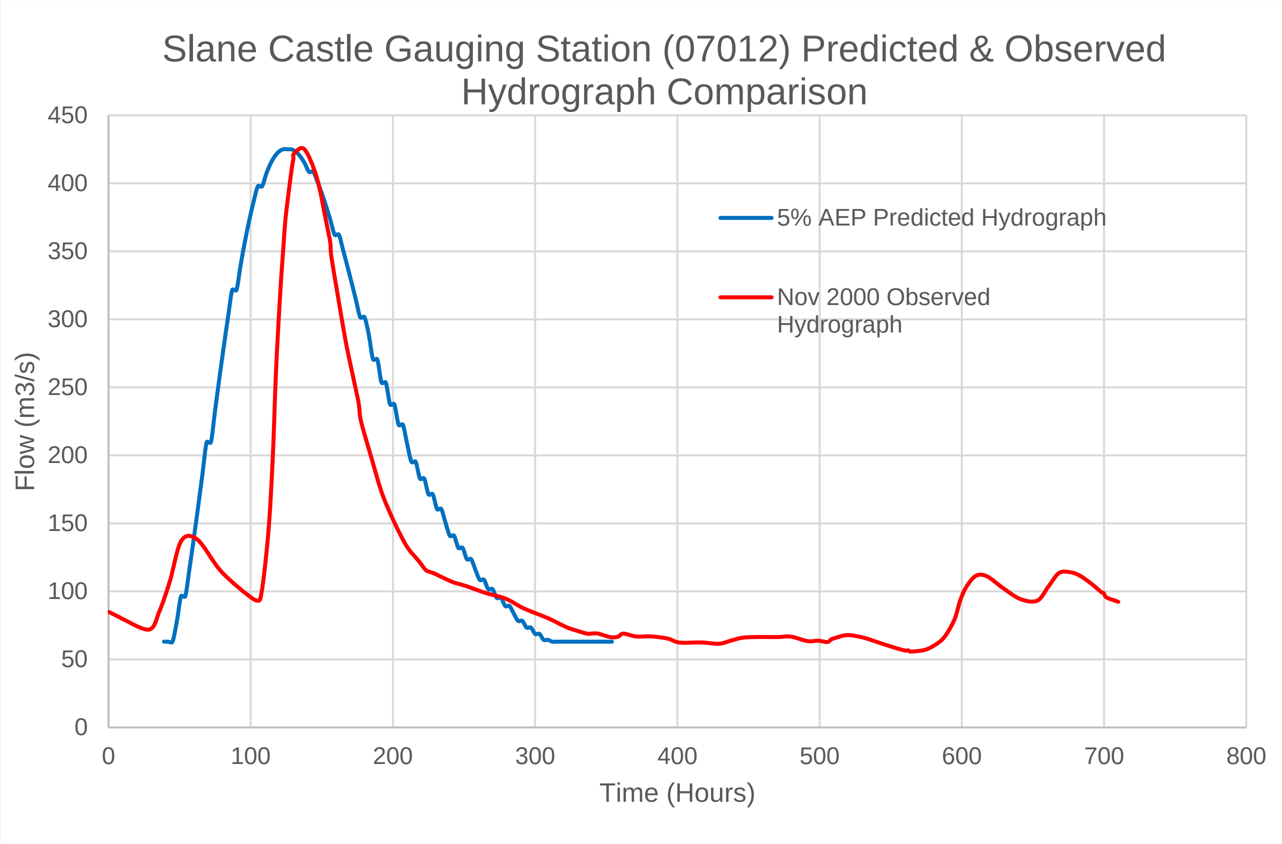


Figure 5-2 5% AEP Predicted & November 2000 Observed Hydrographs Comparison

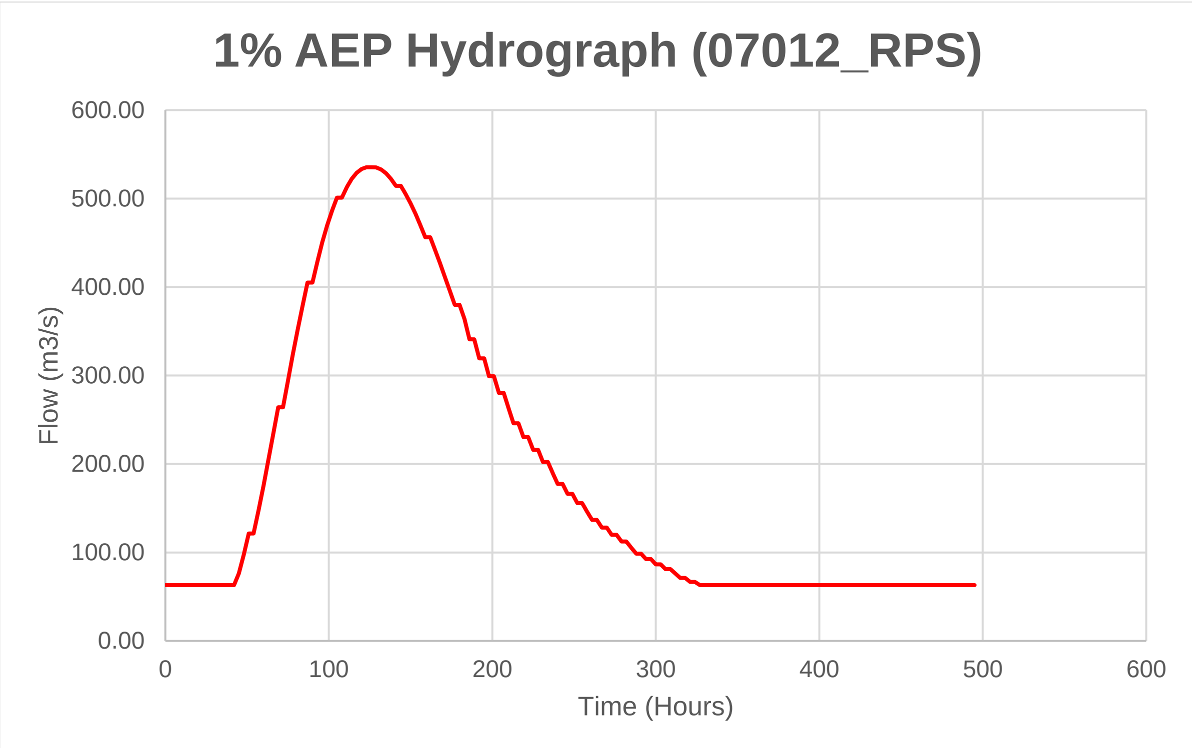


Figure 5-3 Slane Castle Gauging Station Location 1% AEP Predicted Hydrograph

5.2 Hydraulic Modelling

This section provides details of the hydraulic analysis and modelling undertaken to assess the flood risk for the Proposed Bypass Route and elsewhere.

The primary objectives of the hydraulic modelling were:

- To build and calibrate a robust 1D/2D hydraulic model to study the hydraulic characteristics and out of bank flow paths of the River Boyne modelled for the Proposed Bypass Route.
- To use the hydraulic model to estimate water levels, out of bank flow paths and flood outlines, for up to 0.1% AEP flow event.

5.2.1 Hydraulic Modelling Software

RPS used InfoWorks ICM (version 10.5) to undertake the numerical modelling of the River Boyne. InfoWorks ICM is an integrated hydrological and hydraulic modelling package developed by Innovyze, and includes full solution modelling of open channels, floodplains, embankments and hydraulic structures. Additionally, the 2-dimensional areas within InfoWorks ICM are modelled through a triangular flexible mesh which allows for high levels of detail in specific areas (for example at riverbanks and around buildings) and a broader approach in other areas (for example open floodplains).

5.2.2 Survey Data

5.2.2.1 Cross Section & Hydraulic Structures Data

The cross section and hydraulic structures data for the River Boyne was provided by the OPW from the ECFRAM Study. The extent of the cross sections and hydraulic structures built into the InfoWorks ICM model is shown in **Figure 5-4**. The total number of CFRAM features (i.e. cross sections, bridges/ culverts and areas) inputted into the hydraulic model are detailed in **Table 5-9**

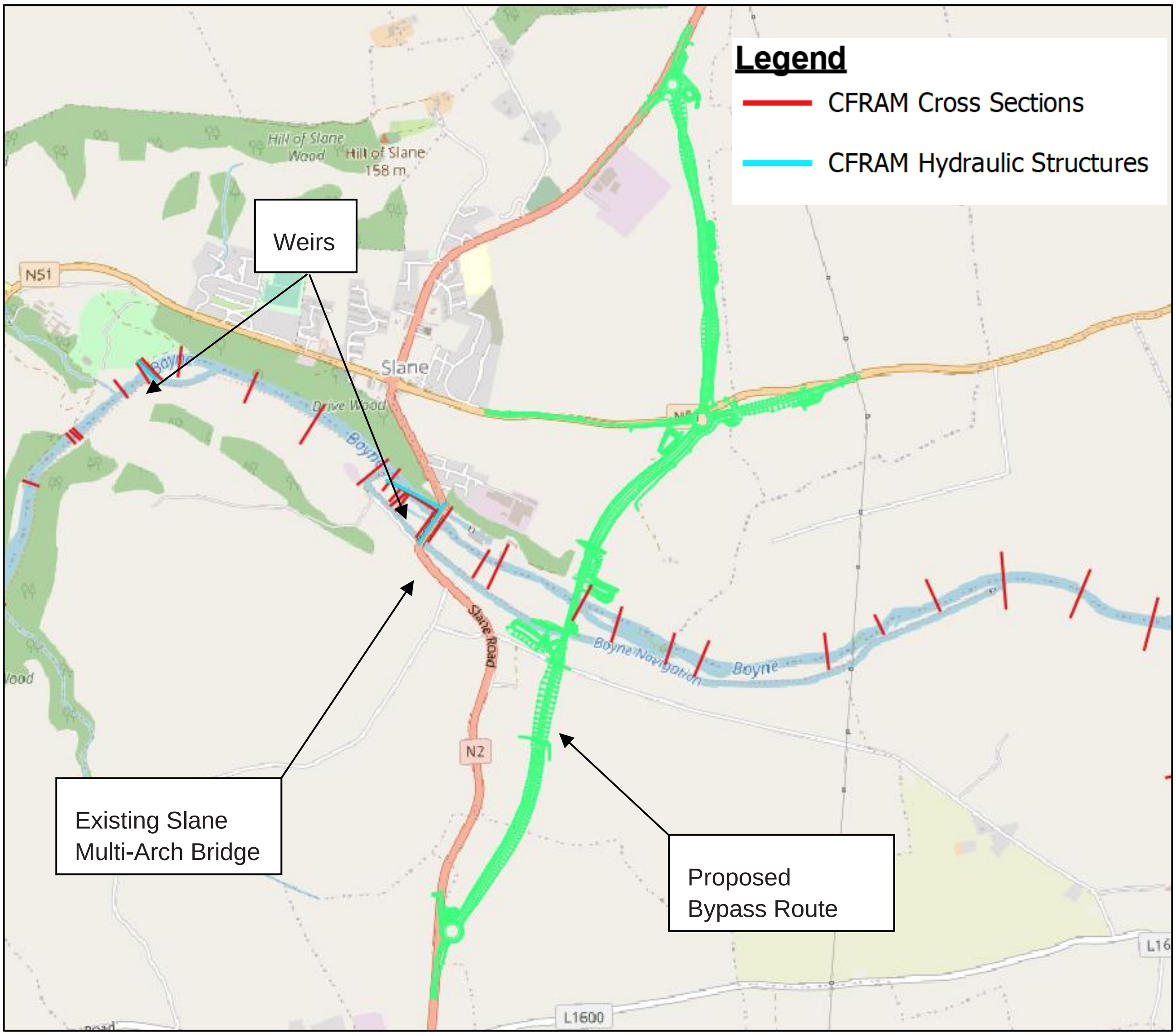


Figure 5-4 CFRAM Cross Section & Hydraulic Structures Locations

The total number of features (i.e. cross sections, bridges/ culverts and areas) surveyed are detailed in **Table 5-9.**

Table 5-9 CFRAM Cross Sections & Hydraulic Structures Quantities

Features	Units	Quantity
Cross Sections	No.	36
Bridges/ Culverts	No.	1
Weir	No.	2

5.2.2.2 OSI Digital Elevation Model

A Digital Elevation Model (DEM) developed using the ground elevation data obtained from the following surveys carried out for the purpose of Proposed Bypass Route design;

- Drone Survey (Elevations obtained in a grid format with less than 1m spacings); and
- Topographical Survey.

The topographical survey data took precedent over the drone survey where there is overlap between the two datasets. This is due to the higher margin of error associated with the drone survey. The extent of the DEM inputted to the hydraulic model, shown in **Figure 5-5**, covers the 1% and 0.1% AEP predicted flooding areas indicated on the OPW CFRAM maps.

An existing towpath, which runs parallel with the River Boyne approximately 100 m from its right bank, is located on an embankment. It has the potential to act as a barrier for out-of-bank-flooding from the right bank of the River Boyne. The extent of the towpath from the junction with the existing Slane Bridge upstream of the Proposed Bypass Route to approximately 1.7 km downstream was added to the DEM inputted to the hydraulic model.

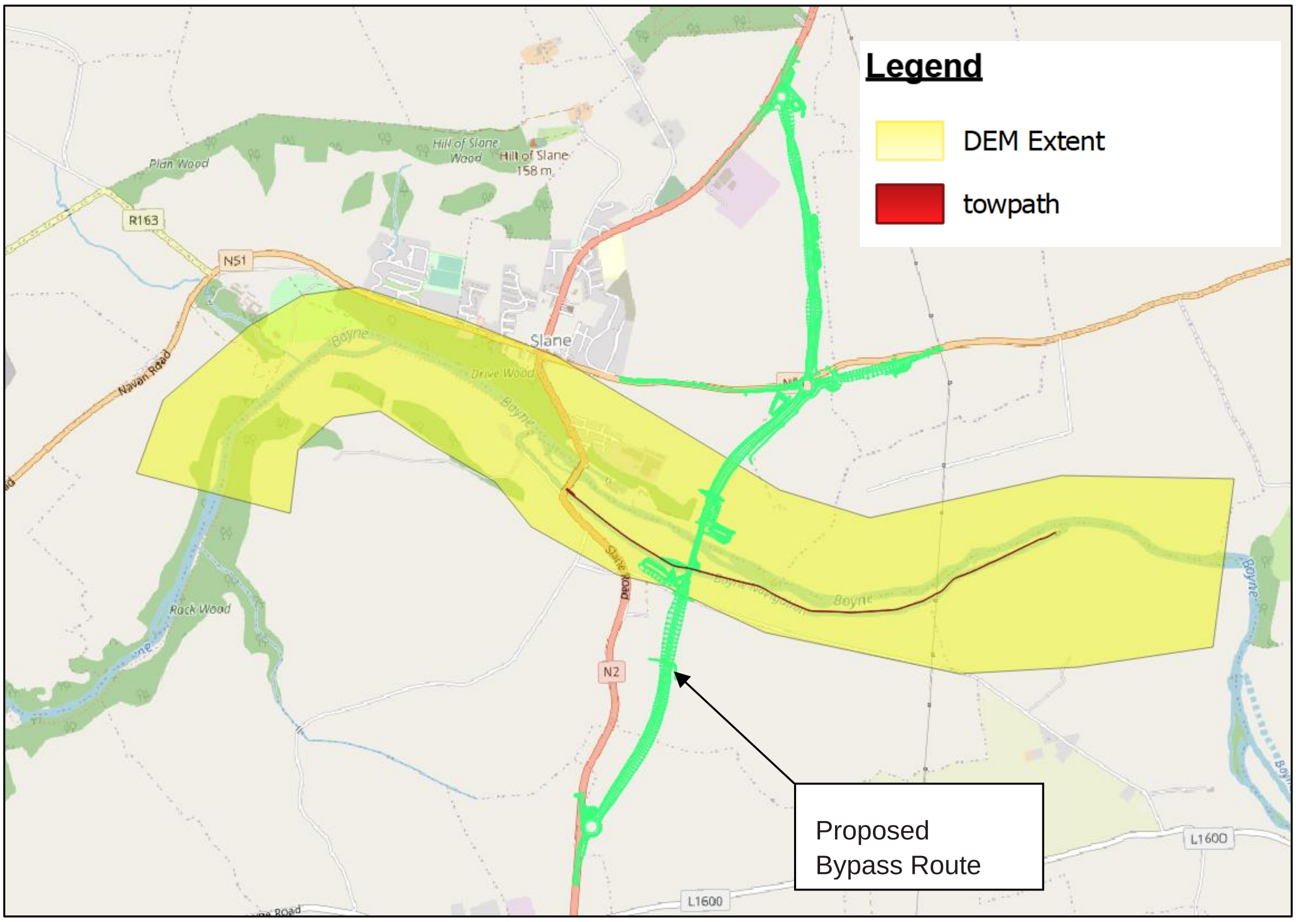


Figure 5-5 Digital Elevation Model (DEM) Extent

5.2.3 Hydraulic Model Build

A hydrodynamic one-dimension hydraulic model of the River Boyne integrated with a two-dimensional model of the surrounding terrain was constructed in InfoWorks ICM (version 10.5) utilising the following data;

- DEM constructed from Drone Survey and Topographical Survey
- CFRAM Cross Section and Hydraulic Structures Survey Information.

5.2.3.1 Model Parameters

The hydraulic model parameters (i.e. Roughness Coefficients & Downstream Water Levels) were reviewed to replicate the existing conditions during extreme flow events.

5.2.3.2 Roughness Coefficients

The Manning values ‘n’ is a measure of the roughness of the bed and side slopes of the watercourse. Evidence from the examination of photographs was used to provide a best estimate of the Manning values for the terrain for use in the hydraulic model.

Table 5-10 summarises the value of Manning’s ‘n’ used within the InfoWorks ICM analysis.

Table 5-10 Manning's Roughness Values

Feature	Units	Min	Normal	Max
Riverbed	N	0.025	0.03	0.04
Riverbank/ Grass Areas	N	0.03	0.04	0.05
Floodplain	N	0.03	0.04	0.05
Weir Discharge Coefficient	C_D	1.6	1.7	1.8
Stone Bridge	K_S	1.2	1.5	1.8

5.2.3.3 Downstream Water Levels

The downstream influence was investigated and there are no hydraulic structures immediately downstream of the Proposed Bypass Route that may cause restriction to extreme flows. The tidal influence on the downstream water levels was reviewed and it was concluded not to be significant for the Proposed Bypass Route location. Please refer to **Section 4.4** for further detail.

The hydraulic model was extended approximately 2.3 km downstream of the Proposed Bypass Route to account for the impact of downstream flooding on the predicted flood levels at the proposed River Boyne Bridge location. The downstream boundary of the model was set to “normal depth” condition.

5.2.4 Model Stability

RPS have reviewed model stability through various checks such as flow plots, water level checks, bank line flow and mass balance to ensure the model outputs are reliable and that the model is suitable for future alterations for use.

5.2.5 Model Limitations and Assumptions

5.2.5.1 Mill Canal Outfall

The Mill Canal includes 3 no. outfalls which discharges flows from the canal at the Old Mill to River Boyne 0.6 km upstream of Proposed Bypass Route as shown in **Figure 5-6** and **Figure 5-7**. The details and size of these outfall pipes are unknown.

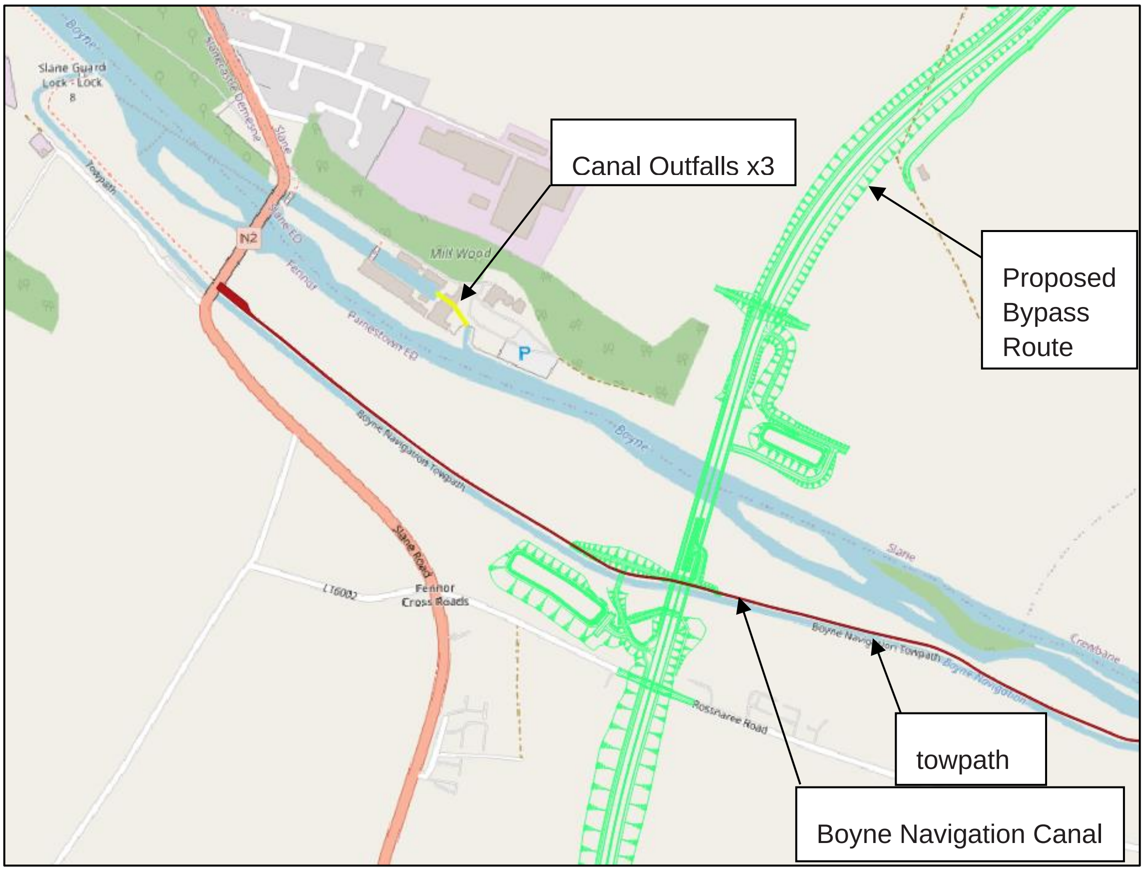


Figure 5-6 Canals in vicinity of Proposed Bypass Route

Figure 5-7 Mill Canal Outfalls from River Boyne Left Bank

An approximation of the equivalent outfall culvert sizes ranging from 900 mm to 2,000 mm diameter was made based on the topographical survey information available for the River Boyne left bank at outfall pipe discharge location. A sensitivity analysis was carried out based on the range of culvert sizes to assess whether it has significant influence on the River Boyne water levels at the vicinity of the Proposed Bypass Route. Refer to **Section 5.2.6** for further detail.

The River Boyne Navigation Canal was not taken into account in the model for reasons outlined in **Section 4.3.1**.

5.2.5.2 Mill Canal Hydraulic Structure

There is an existing hydraulic structure within the Old Mill Canal immediately downstream of the existing Slane multi-arch bridge. The hydraulic structure consists of a series of trash screens below a pedestrian bridge which spans across the width of the canal. The detail for the hydraulic structure below of the trash screens are unknown. It is assumed to include a sluice gate operated to release flow further into the Old Mill Canal. The hydraulic structure is shown in **Figure 5-8**.

Figure 5-8 Old Mill Canal Existing Hydraulic Structure (facing upstream)

For the purpose of this FRA, this hydraulic structure was not incorporated into the hydraulic model existing scenario in order to obtain representation of worst-case flooding in the vicinity of the Proposed Bypass Route.

A sensitivity analysis was carried out to assess the implications of the hydraulic structure on the predicted flooding in the model. The hydraulic structure is assumed to be closed and no inflow below the invert level of the trash screen passes through the canal. Refer to **Section 5.2.6** for further detail.

5.2.6 Sensitivity Analysis

The hydraulic model parameters (i.e. channel roughness, floodplain roughness, hydraulic structures, head losses and peak flows) were reviewed in order to establish the sensitivity of the predicted water levels and flood extents. The results of the sensitivity analysis are summarised in **Table 5-11**.

Table 5-11 Sensitivity Analysis Results Summary

Parameter	Unit	Baseline Value	Adjusted Value	Max Water Level Increase (mm)	Comment
Inlet Bridge Head Loss Coefficient	-	0.0	0.5	98	Max. increase located immediately upstream of existing Slane Bridge. No water level increase in vicinity of Proposed Bypass Route.
Floodplain Roughness	N	0.04	0.048	22	Max. increase located immediately downstream of existing Slane Bridge. The water level increase in vicinity of Proposed Bypass Route is 9 mm.
Floodplain Roughness	N	0.04	0.032	6	Max. increase located downstream of the Proposed Bypass Route. The water level increase in vicinity of Proposed Bypass Route is 1 mm.
Channel Roughness	N	0.03	0.036	215	Max. increase located downstream of the Proposed Bypass Route. The water level increase in vicinity of Proposed Bypass Route is 201 mm.
Channel Roughness	N	0.03	0.024	81	Max. increase located downstream of the Proposed Bypass Route. No water level increase in vicinity of Proposed Bypass Route.
Weir Discharge Co-efficient	C_D	1.70	1.6 – 1.8	64	Max. increase located upstream of the Proposed Bypass Route. No water level increase in vicinity of Proposed Bypass Route
Peak Flows	m^3/s	537.51	645.02	188	Max. increase located immediately upstream of existing Slane Bridge. The water level increase in vicinity of Proposed Bypass Route is 169 mm.
Mill Canal Discharge Pipes (x3) Diameter	mm	900	2000	147	Max. increase located within River Boyne adjacent to Mill Canal Outfall Pipes discharge location approximately 0.6km upstream of Proposed Bypass Route. The water level increase in vicinity of Proposed Bypass Route is 4mm.
Mill Canal Hydraulic Structure	-	-	Weir Added to Model at the hydraulic structure location with Spill Level set to canal bank level to replicate the gate closed	53	Max. increase located at weir upstream of existing Slane Bridge. The water level in vicinity of Proposed Bypass Route decreased by 6 mm.

The results of the sensitivity analysis show that the hydraulic model is sensitive to changes to the peak flows, increased channel roughness and bridge inlet head losses. The analysis also indicates that the hydraulic model in the vicinity of the Proposed Bypass Route is not significantly sensitive to changes to the following;

- Floodplain roughness;
- Weir discharge co-efficient; and
- Changes to diameter of the canal discharge pipes and also whether the Mill Canal Sluice Gates closed or not.

The outcome of changes to these parameters (i.e. predicted flood extents) are proportionate and as expected.

5.2.7 Model Calibration & Verification

5.2.7.1 Comparison with Recorded Data

The hydraulic model extent includes Slane Castle Gauging Station location for the purpose of calibrating the model against the gauging station recorded data. The sensitivity analysis indicated significant variation in water levels as a result to changes to channel roughness valves. A rating curve review was carried out based on comparison between ‘observed’ rating curve based on recorded data for Slane Castle Gauging Station and the predicted rating curve from the model for various channel roughness (ranging from 0.025 to 0.05) as shown in **Figure 5-9**.

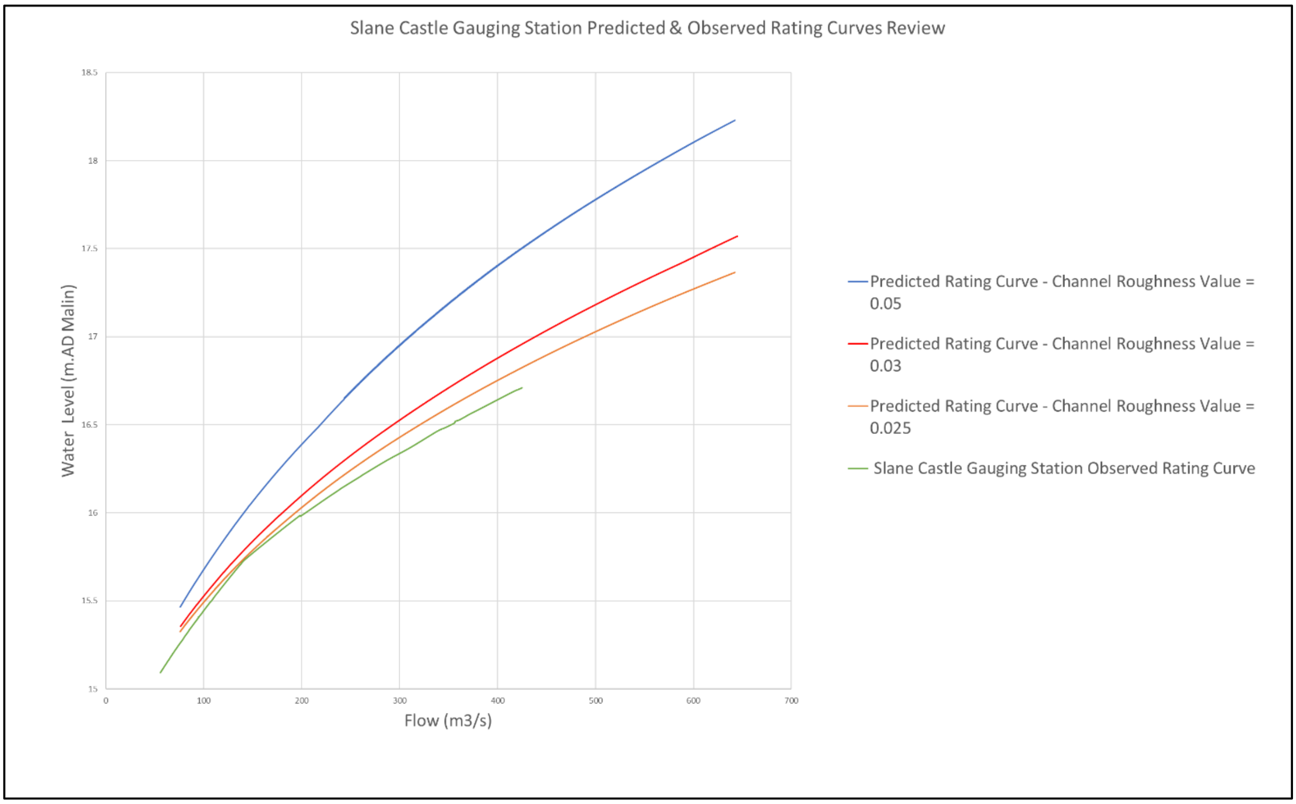


Figure 5-9 Observed and Predicted Rating Curves Comparison

The rating curve review show the three predicted rating curves for channel roughness ranging from 0.025 to 0.05 in comparison to the observed rating curve provide higher water levels for the corresponding flows. The predicted rating curve with channel roughness of 0.025 has the closest correlation to the observed rating curve at Slane Castle Gauging Station and is deemed the most accurate representation.

5.2.7.2 Eastern CFRAM Study

The Eastern CFRAM study and the hydraulic model predicted 1% AEP peak water levels was assessed for comparison. The Eastern CFRAM and hydraulic model cross sections locations are shown in **Figure 5-10**.

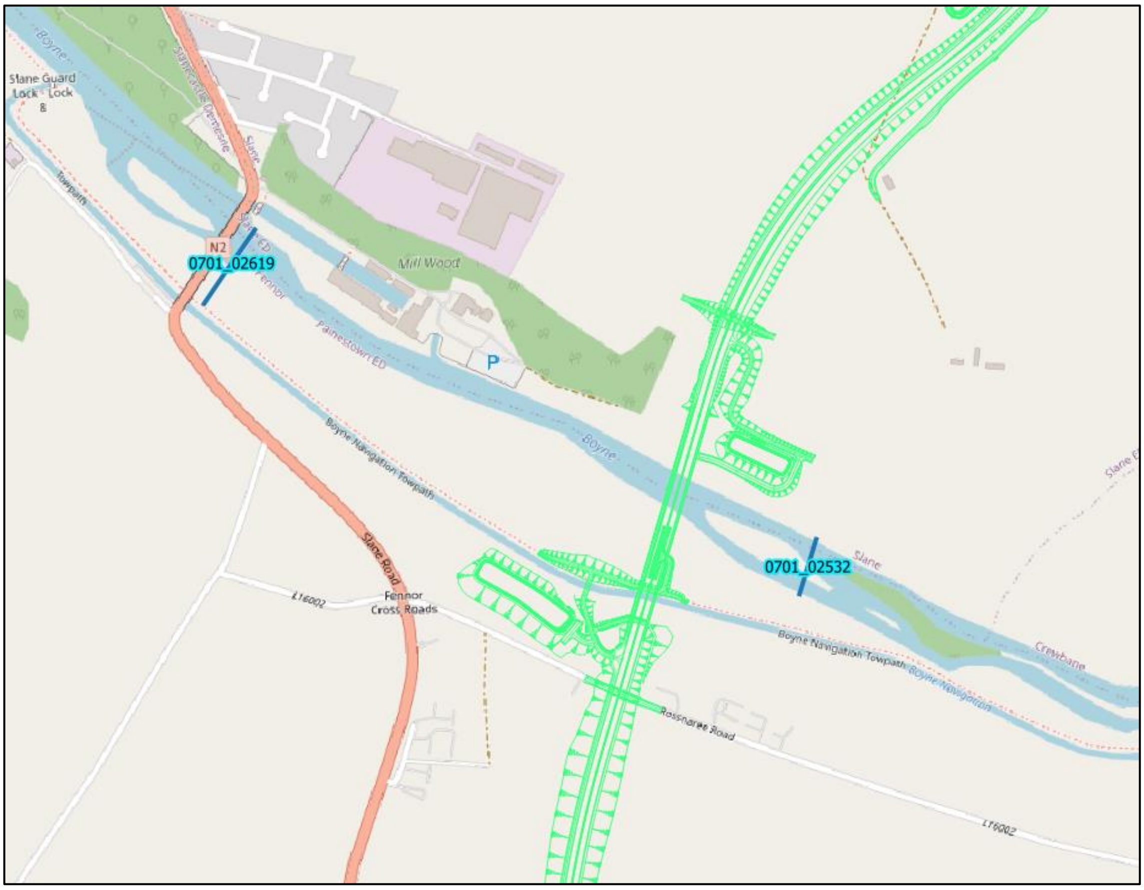


Figure 5-10 Eastern CFRAM & Hydraulic Model Cross Section Locations

The Eastern CFRAM and hydraulic model predicted 1% AEP peak water levels are listed in **Table 5-12**. The comparison shows good correlation and that the hydraulic model predicted 1% AEP peak water levels are consistently higher than the Eastern CFRAM levels in the vicinity of the Proposed Bypass Route.

Table 5-12 Eastern CFRAM & Hydraulic Model Predicted 1% AEP Levels

Cross Section Reference	CFRAM 1% AEP Flood Level (m.AD)	Model 1% AEP Flood Level (m.AD)	Difference (mm)
0701_02619	14.500	14.779	279
0701_02532	13.370	13.510	140

5.2.7.3 Historical Flooding Verification

The hydraulic model predicted flood extents were compared to anecdotal information from previous historical flooding events to verify whether the hydraulic model predicted flood extents showed good correlation. The comparison with the photos from 1990 flood event showed good correlation with the predicted flood extents from the hydraulic model.

5.2.7.4 Summary of Calibration and Verification

The hydraulic model showed good calibration with the observed rating curve for Slane Castle Gauging Station, and Eastern CFRAM Study. The historical flooding verification showed good correlation based on photos from the 1990 flood event.

5.2.8 Hydraulic Assessment of the Proposed Bypass Route

The Proposed Bypass Route was assessed in the hydraulic model for three scenarios outlined below:

- Existing Scenario.
- Proposed River Boyne Bridge and associated ancillaries.
- Temporary Works Platform for proposed River Boyne Bridge construction.

The scenarios were run based on the following assumptions:

- All bridge openings are free from debris.
- Normal values listed in **Table 5-10** are representative of the condition of the existing bridge openings, channel and terrain. The exception is the channel roughness value which is set to minimum value following rating curve review detailed in **Section 5.2.7.1**.
- Mill Canal Sluice Gates open for worst-case flooding representation.
- Downstream level set at normal depth.

5.2.8.1 Existing Scenario

The hydraulic model for the Existing Scenario was run for the 1% and 0.1% AEP events to assess the flood risk for the vicinity of the Proposed Bypass Route based on the current conditions. The extent of the predicted flooding for both events are shown in **Figure 5-11** and also Drawing MDT0806QG0002 included in **Appendix D** of this report. Four residential and leisure properties were identified upstream in the vicinity of the Proposed Bypass Route.

The dwellings within Property A and C are deemed to be outside the 1% AEP existing predicted flood extent but are located within the 0.1% AEP predicted flood extent. The dwellings at Property B and D are deemed to be outside the predicted 1% AEP and 0.1% AEP predicted flood extent.

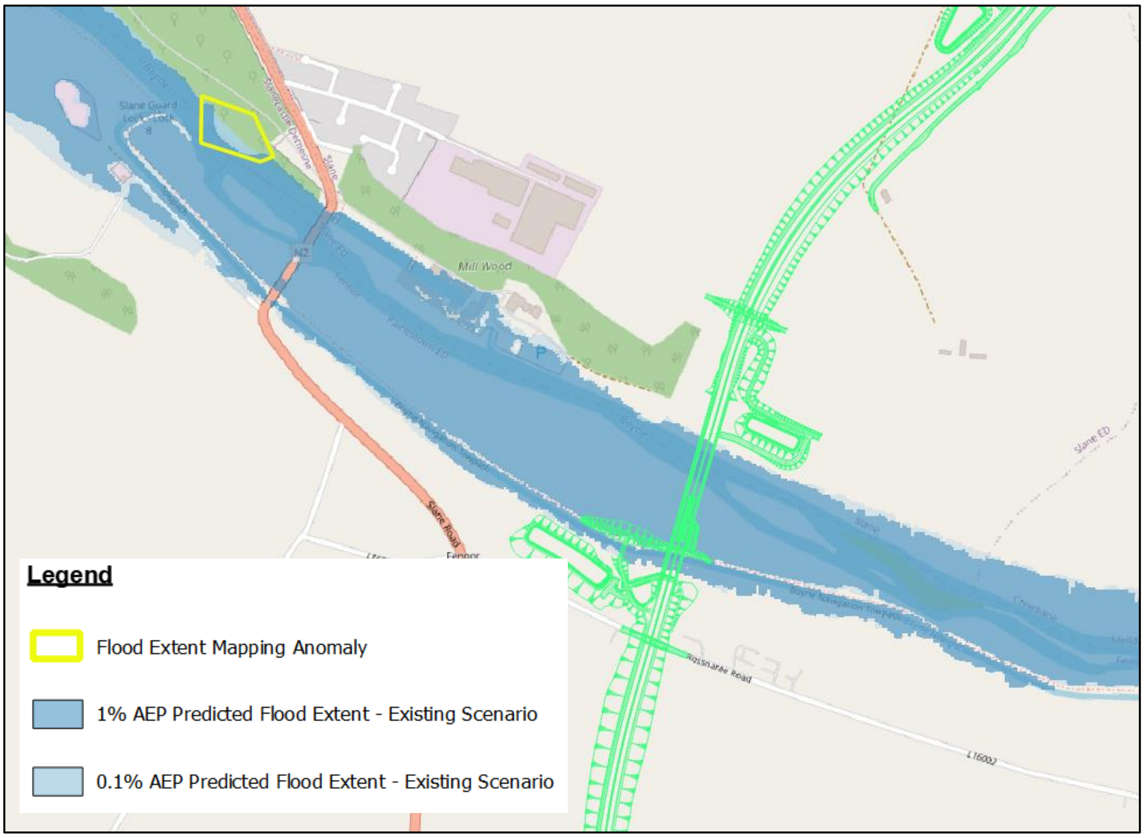


Figure 5-11 1% & 0.1% AEP Predicted Flood Extents

The predicted flood depths for the 1% AEP event in the vicinity of the Proposed Bypass Route is shown in **Figure 5-12**. The low-lying greenfield adjacent to the right bank of the River Boyne extending from existing Slane Bridge upstream to downstream of the Proposed Bypass Route are entirely within the 1% AEP predicted floodplain with flood depths ranging from 0.4 m to 1.8 m. The extent of the predicted flooding on the left bank at the location of the Proposed Bypass Route is confined to a strip along the edge of the bank due to the steep ground profile descending towards River Boyne.

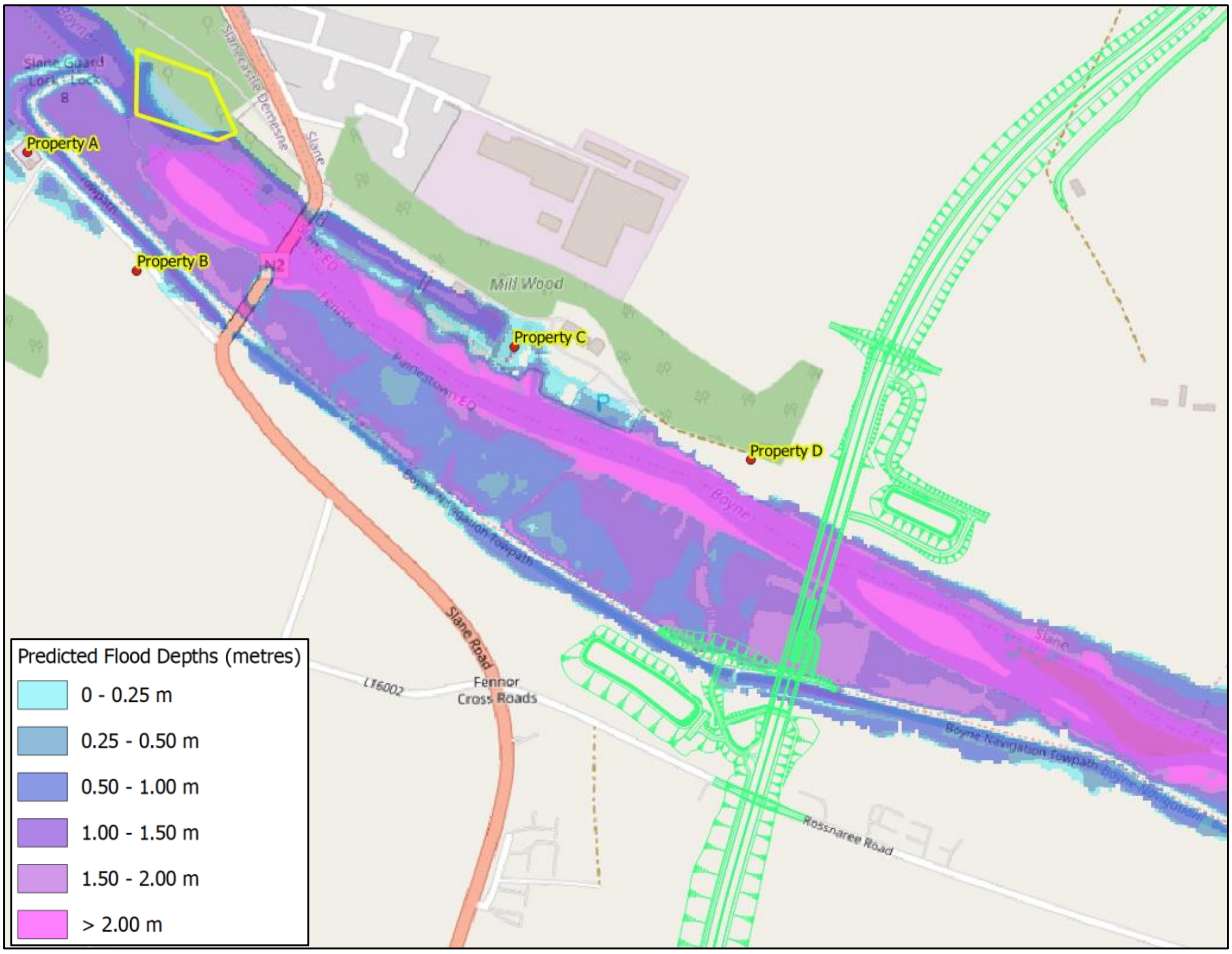


Figure 5-12 Existing Scenario 1% AEP Predicted Flood Depths

The 1% AEP predicted flooding from the River Boyne downstream of Slane between Slane Bridge and the Proposed Bypass Route are confined to the low-lying areas with the exception of Property C immediately downstream of the Old Mill Canal.

The results of the hydraulic model showed Property C to be more susceptible to flooding from the Old Mill Canal which is fed by the River Boyne immediately upstream of the Boyne Weir and existing Slane Bridge as shown in **Figure 5-13**. The predicted 1% AEP flood level from the River Boyne adjacent to the Old Mill downstream of Slane Bridge is 14.193 mAD which is estimated to be lower than the finished floor level of the Old Mill (14.26 mAD).

The results of the hydraulic model simulations show the predicted 1% AEP flooding to overtop the existing towpath extending from Slane Bridge to beyond the Proposed Bypass Route.

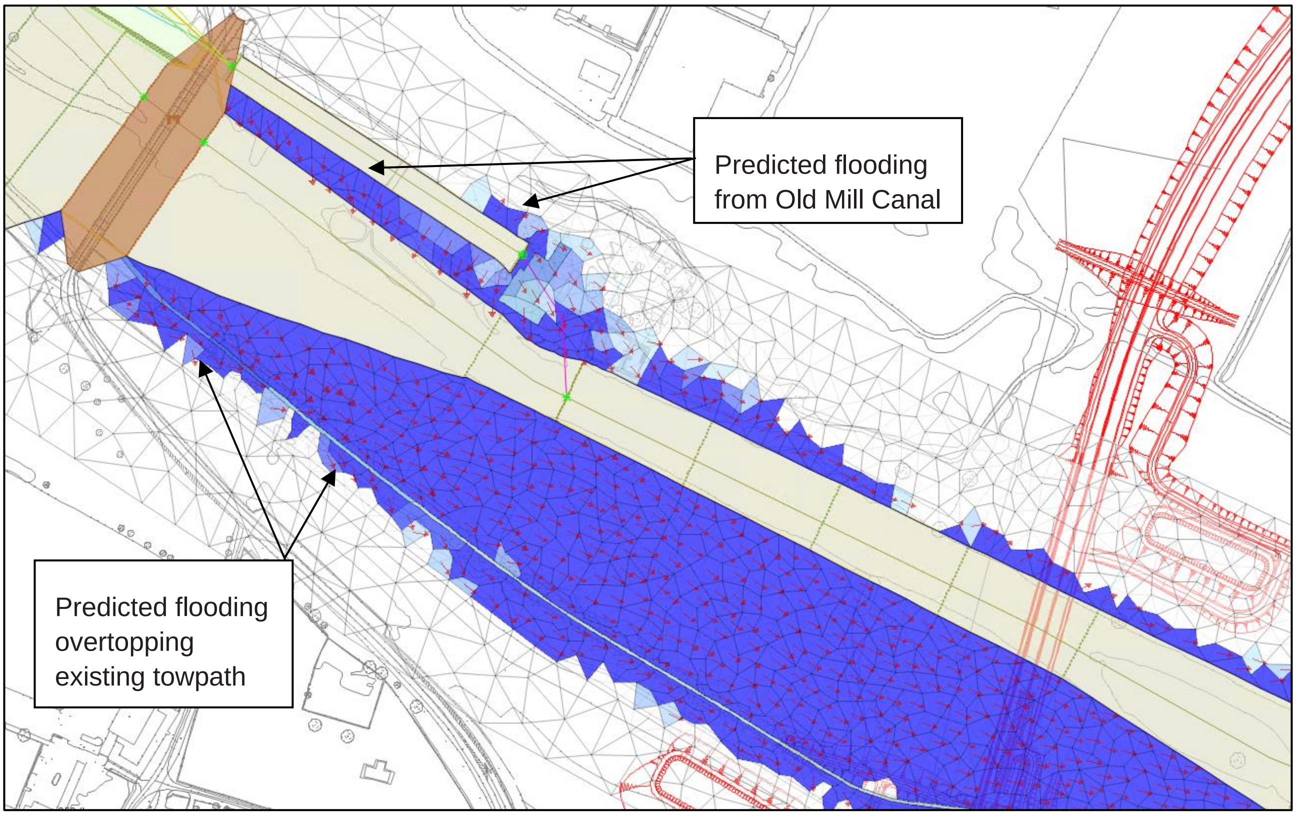


Figure 5-13 Existing Scenario Predicted 1% AEP Flooding in the vicinity of the Old Mill Canal

5.2.8.2 Proposed River Boyne Bridge & Associated Ancillaries

The proposed River Boyne Bridge and associated ancillaries was incorporated to the hydraulic model and run for the 1% and 0.1% AEP events to assess the potential impact on flood risk elsewhere. The assessment is carried out in accordance to the Office of Public Works document for "*Construction, Replacement or Alteration of Bridges and Culverts*" is a guide "to applying for *Consent under Section 50 of the Arterial Drainage Act, 1945*". The document states the following:

> "*If the land potentially affected does not include dwellings and infrastructure, a culvert must be capable of operating under the above design conditions while causing a hydraulic loss of no more than 300 mm (excluding the culvert gradient).*"

And:

> "*If the land potentially affected includes dwellings and infrastructure, it must be demonstrated that those dwellings and/or infrastructure are not adversely affected by constructing the bridge or culvert.*"

The proposed bridge piers (including foundation), abutments, towpath realignment and access track were added to the model as shown in **Figure 5-14**.

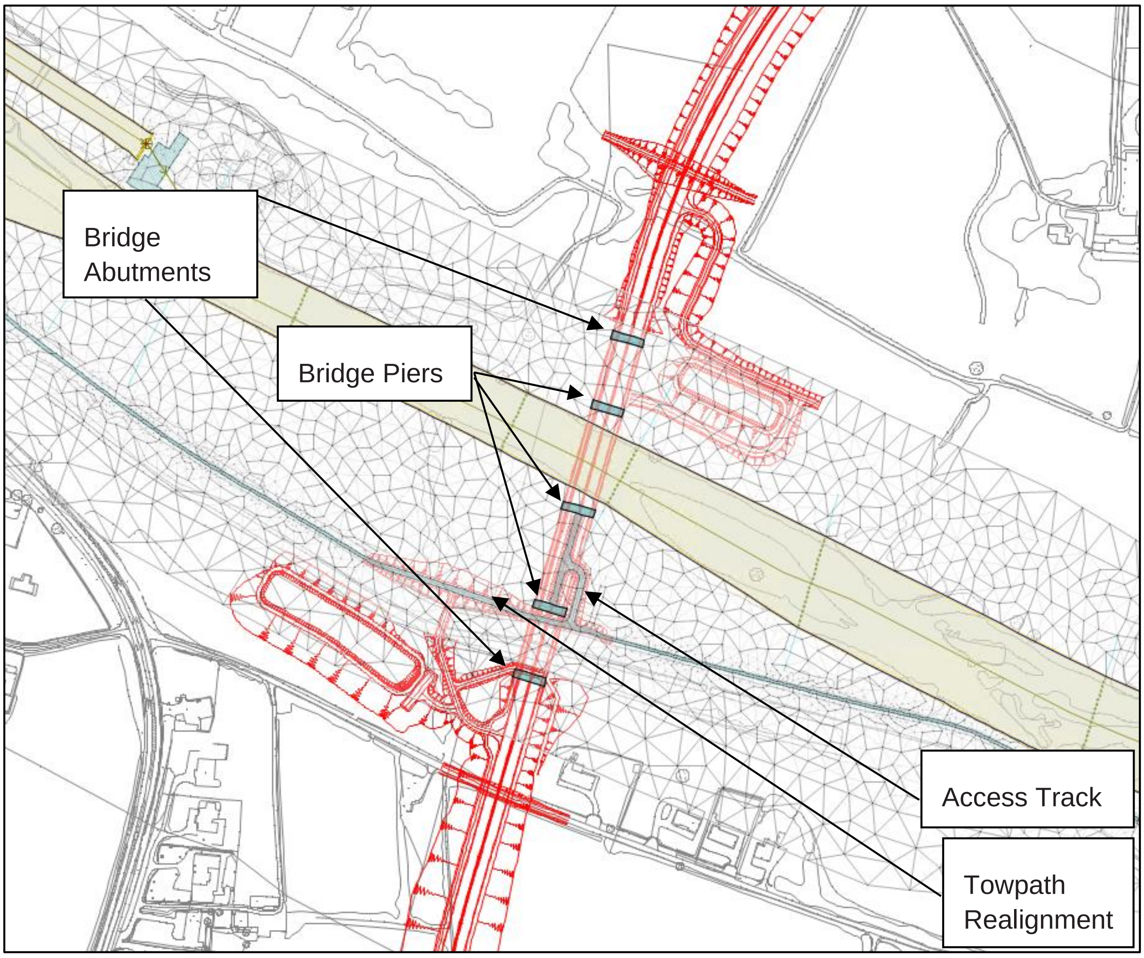


Figure 5-14 Proposed Bridge Piers & Abutments Added to Hydraulic Model

The 1% and 0.1% AEP predicted flood extents for the existing and proposed permanent works scenario are shown in MDT806QG0003 and QG0004 respectively included in **Appendix D** of this report. The comparison between the existing and proposed predicted flood extents indicates that the proposed permanent works have a negligible impact on the predicted flood extents.

The 1% and 0.1% AEP flood levels at cross section locations for the existing and proposed permanent works scenarios are provided in **Table C- 1** and **Table C- 2** respectively included in **Appendix C** of this report. The comparison between the two scenarios shows a maximum increase in peak water levels of 54mm and 52mm respectively for the 1% AEP and 0.1% AEP flow events. The location of the maximum increases in peak water levels is approximately 43 m and 140 m upstream of Property D and the Proposed Bypass Route respectively.

The extent of the increases in predicted flood depths for the permanent works scenario in the vicinity of Property A to D during the 1% AEP and 0.1% AEP events are shown in **Figure 5-15** and **Figure 5-16** respectively. The maximum increase in predicted flood depth of approximately 150mm for both 1% AEP and 0.1% AEP events are confined to the existing greenfield adjacent to the River Boyne right bank immediately upstream of the Proposed Bypass Route. The existing greenfield does not include any dwellings or sensitive infrastructure.

The finished floor levels for dwellings within Property A to D were estimated from the Drone Survey provided and compared with the predicted 1% and 0.1 AEP flood levels at each location. The finished floor levels and predicted flood levels at each Property location for the 1% AEP and 0.1% AEP events are listed in **Table 5-13** and **Table 5-14** respectively.

The finished floor levels for the dwellings within properties with the exception of Property C are deemed to be above the respective predicted 1% AEP flood levels for both the existing and permanent works scenario. The increase in predicted flood depth at Property C for the 1% AEP event is less than 10 mm.

The finished floor levels for the dwellings Property B and D are deemed to be located above the respective predicted 0.1% AEP flood levels for both the existing and permanent works scenarios. The dwellings within Property A and C are deemed to be located within the predicted 0.1% AEP flood extents. The increases in predicted flood depths at the dwellings within Property A and C are less than 10mm for the 0.1% AEP event.

The increases in predicted flood depths for the 1% and 0.1% AEP events at the properties are not deemed to be adverse, hence the impact of the permanent works scenario elsewhere is deemed to be imperceptible.

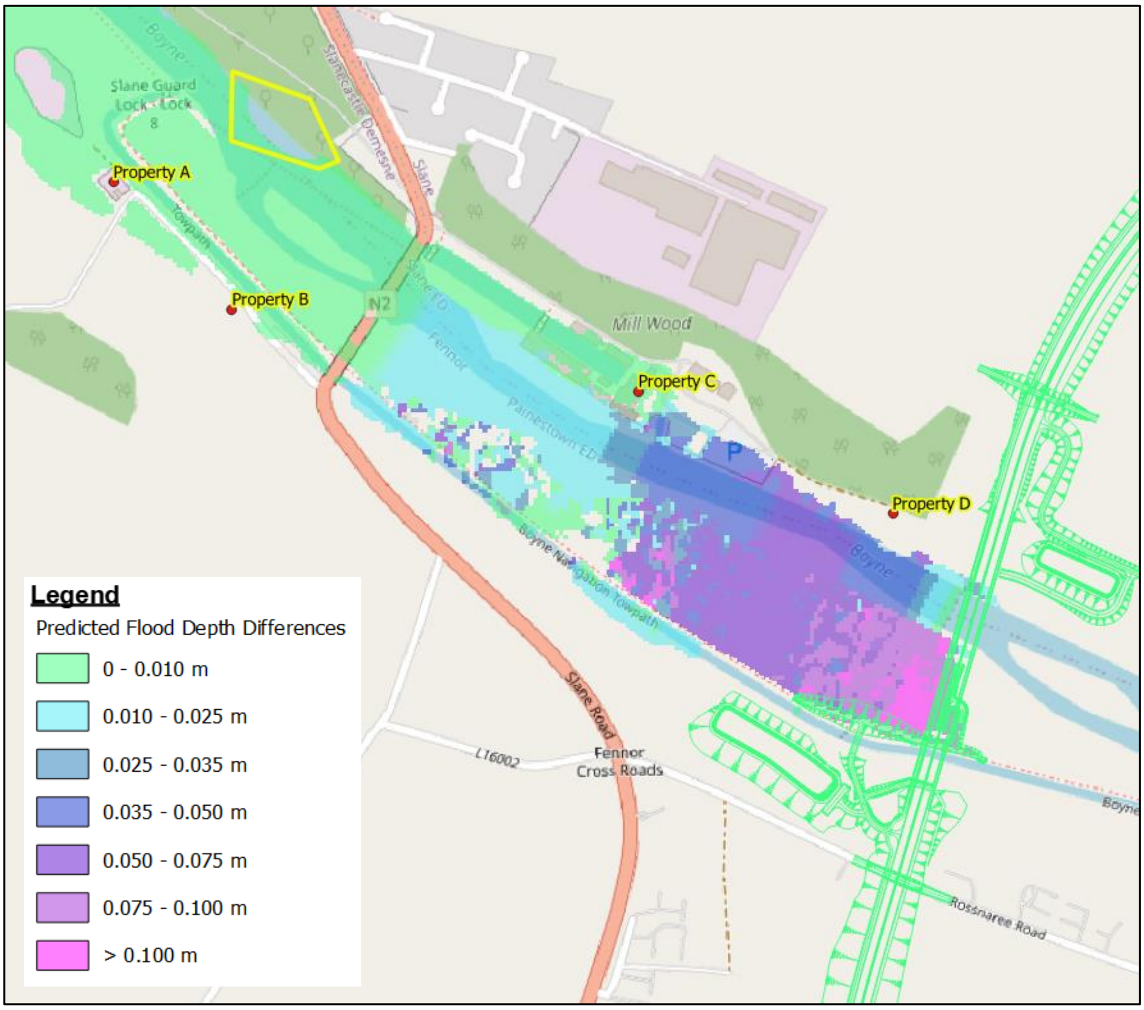


Figure 5-15 Permanent Works Scenario - 1% AEP Predicted Flood Depth Increases

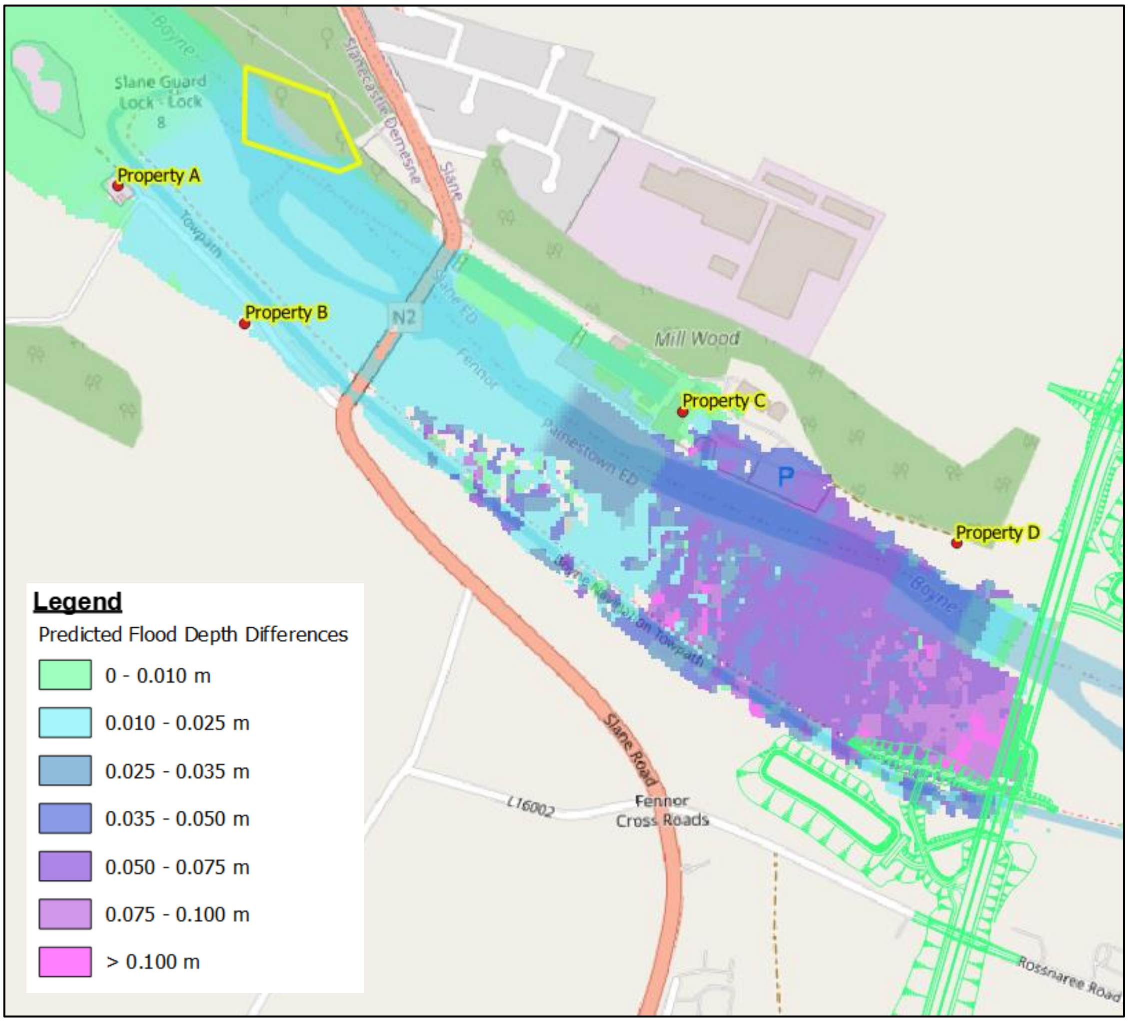


Figure 5-16 Permanent Works Scenario - 0.1% AEP Predicted Flood Depth Increases

Table 5-13 1% AEP Predicted Flood Levels at Existing Properties - Permanent Works Scenario

Feature	FFL (mAD)	Existing 1% AEP Flood Level (m.AD)	Proposed Permanent 1% AEP Flood Level (mAD)	Increase (mm)
Property A	15.60	15.261	15.266	5
Property B	15.75	15.109	15.116	7
Property C	14.26*	15.072	15.076	4
Property D	16.42	13.830	13.876	46

** Dwelling situated on sloped ground and the FFL varied across the property. The lowest FFL estimated is listed.*

Table 5-14 0.1% AEP Predicted Flood Levels at Existing Properties - Permanent Works Scenario

Feature	FFL (mAD)	Existing 0.1% AEP Flood Level (m.AD)	Proposed Permanent 0.1% AEP Flood Level (mAD)	Difference (mm)
Property A	15.60	15.779	15.790	11
Property B	15.75	15.648	15.661	13
Property C	14.26*	15.276	15.280	4
Property D	16.42	14.365	14.407	42

** Dwelling situated on sloped ground and the FFL varied across the property. The lowest FFL estimated is listed.*

The proposed permanent works scenario was re-run for the 1% AEP plus 20% for climate change event to assess freeboard requirement. The existing Slane Bridge and upstream weir were removed from the hydraulic model to discount the potential restriction on peak flow upstream of the proposed bridge for the purpose of this assessment. The results of the simulation showed a peak water level of 14.123 mAD at the bridge location. The peak water level is more than 4 m below the lowest soffit level proposed for the bridge (18.765 mAD). Hence the proposed bridge has more than adequate freeboard to cater for the 1% AEP plus 20% climate change event.

5.2.8.3 Proposed Temporary Works

The extent of the temporary works added to the hydraulic model for the proposed scenario are shown in **Figure 5-17**. The proposed temporary works consist of the following;

- Temporary Works Platform with uniform height of 1.2 m above existing ground level.
- Three Cofferdams around the proposed bridge piers.
- Access Ramp onto temporary works platform.

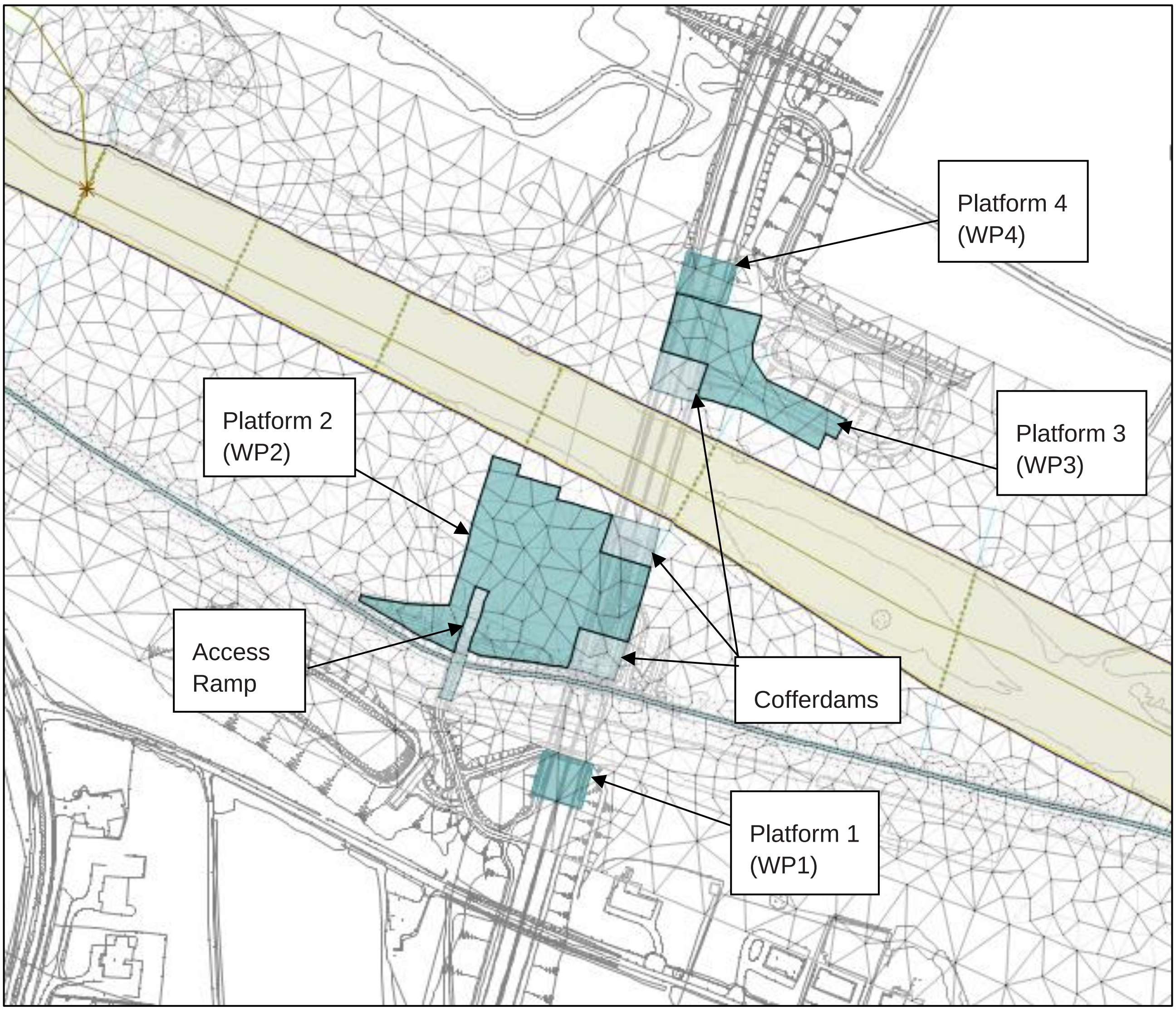


Figure 5-17 Temporary Works Platforms Extent

The top level for the cofferdams were set at above the 1% AEP flood level to ensure the floodwaters do not overtop during the construction phase.

Platform 2 consists of the largest area and is located entirely within 1% AEP predicted flood extent. Platforms 1 and 4 are located outside the predicted flood extents. Platform 3 encroaches the predicted flood extents along the southern boundary.

Consideration was given to the sequential approach as per the Office of Public Works "*The Planning System and Flood Risk Management*" guidelines published by the Department of Environment, Heritage and Local Government in January 2009 to manage flood risk impact particularly for the proposed temporary works.

The location of the proposed temporary works platforms, particularly Platform 2 and the two cofferdams adjacent to the right bank of the River Boyne, and extent of the 1% AEP on the floodplain within the Proposed Bypass Route indicated that it was not possible to relocate or substitute parts of the platform and cofferdams as a means of avoiding the flood risk.

The following mitigation measures were incorporated into Platforms;

- Void Ratio of 0.4 to represent the angular gravel fill for the Platforms to cater for flood storage.
- Platforms Height limited to 1.2 m required to accommodate construction loads to facilitate bridge construction.
- Platforms is to be designed to allow for overtopping during the 1% AEP event.

Additional mitigation measures were assessed in the hydraulic model and this includes for a series of 900mm diameter pipes underneath Platform 2 to improve conveyance for out-of-bank flooding flow on the right bank. The results of the model showed the additional mitigation measures to be ineffective and does not mitigate flood risk elsewhere.

The hydraulic model was run for the 1% AEP flow event to assess the impact of the proposed temporary works, including the above mitigation measures, on the peak water levels elsewhere. The 1% AEP predicted flood extents for the proposed temporary works scenario overlaid onto the existing scenario predicted flood extents are shown in MDT806QG0005 included in **Appendix D** of this report. The comparison between the existing and proposed predicted flood extents indicates that the proposed temporary works have a negligible impact on the predicted flood extents.

The 1% AEP flood levels at cross section locations for the existing and proposed temporary works scenarios are provided in **Table C- 3** included in **Appendix C** of this report. The comparison between the two scenarios shows a maximum increase in peak water levels of 90 mm for the 1% AEP event. The location of the maximum increase in peak water levels is adjacent to Property D upstream of the Proposed Bypass Route.

The extent of the increase in predicted flood depths for the temporary works scenario in the vicinity of Property A to D during the 1% AEP event are shown in **Figure 5-18**. The maximum increase in predicted flood depths of 203 mm for the 1% AEP event are confined to the existing greenfield adjacent to the River Boyne right bank immediately upstream of the Proposed Bypass Route.

The finished floor levels for Property A to D estimated from the Drone Survey provided for the area and the predicted 1% AEP flood levels at each property location are listed in **Table 5-15**.

The finished floor levels for the dwellings within properties with the exception of Property C are deemed to be above the respective predicted 1% AEP flood levels for both the existing and permanent works scenario. The increase in predicted flood depth at Property C for the 1% AEP event is 13 mm. The increase is not considered to be adverse hence the impact of the temporary works scenario on flood risk elsewhere is deemed to be imperceptible.

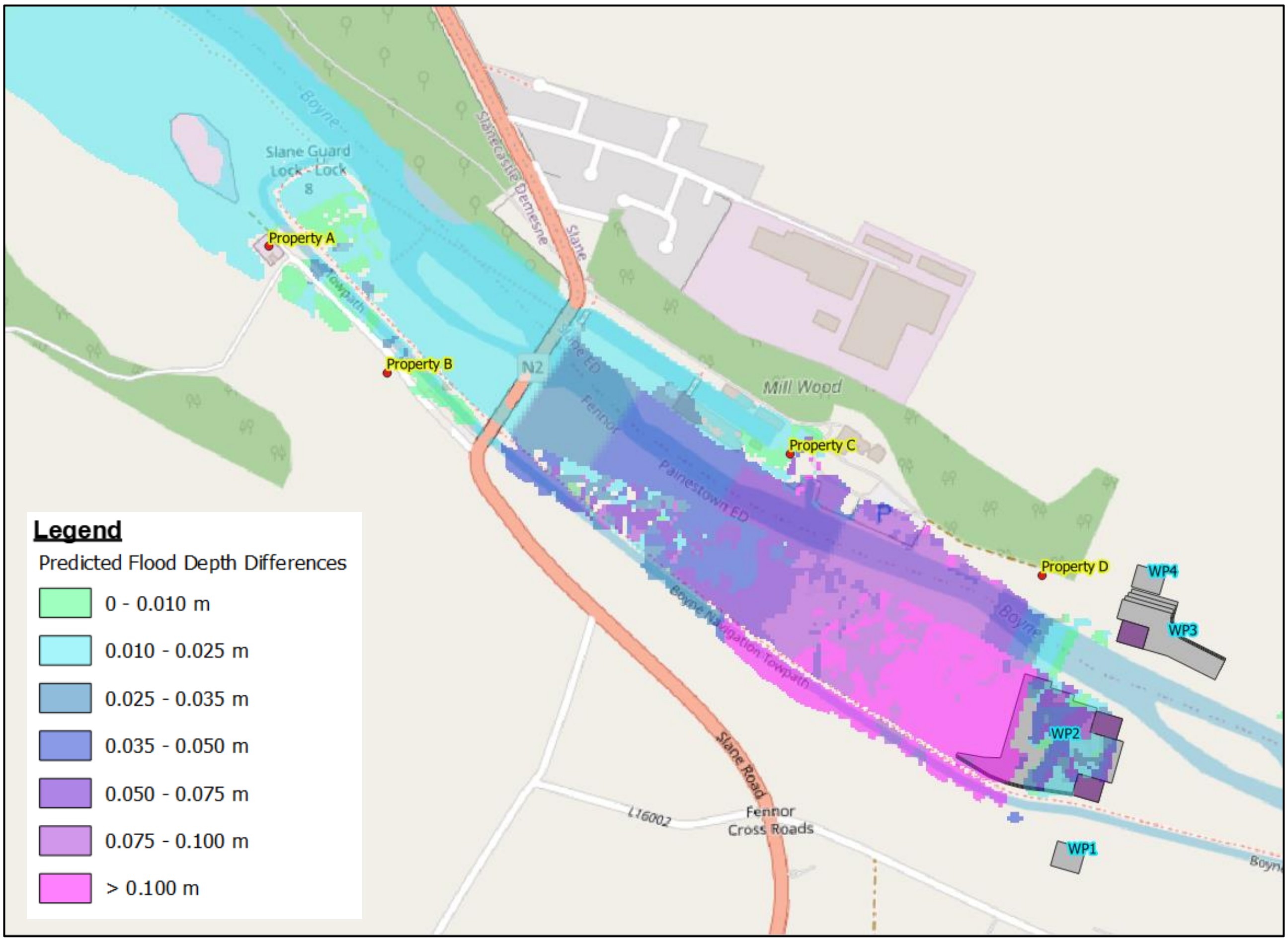


Figure 5-18 Temporary Works Scenario - 1% AEP Predicted Flood Depth Increases

Table 5-15 1% AEP Predicted Flood Levels at Existing Properties - Temporary Works Scenario

Feature	FFL (mAD)	Existing 1% AEP Flood Level (mAD)	Proposed Temporary 1% AEP Flood Level (mAD)	Increase (mm)
Property A	15.60	15.261	15.274	13
Property B	15.75	15.109	15.126	17
Property C	14.26*	15.072	15.085	13
Property D	16.42	13.830	13.880	50

** Dwelling situated on sloped ground and the FFL varied across the property. The lowest FFL estimated is listed.*

5.3 Conclusion of Stage 3 – Detailed Flood Risk Assessment

A hydraulic model was constructed to assess the impact of the permanent and temporary works proposed for the River Boyne Bridge Crossing on the flood risk elsewhere. A high level of confidence was established for the hydraulic model based on the recorded data for Slane Castle Gauging Station and verification with historical flood information and ECFRAM predicted flood extents. A sensitivity analysis was carried out to assess the implications of assumptions made in the hydraulic model. The results of the sensitivity analysis from the model showed the impact for the Old Mill Canal outfall pipe and hydraulic structure on predicted flooding to be low. A rating curve assessment was carried out to verify the channel roughness in the model and a good correlation between the observed and predicted curves was achieved. The proposed permanent and temporary works scenarios were incorporated into the hydraulic model and reviewed with the existing scenario representing current conditions. The impact of the proposed permanent and temporary works for the River Boyne Bridge crossing on flood risk for existing dwellings was assessed. The results of the assessment showed the proposed permanent and temporary works will not have an adverse impact on flood risk elsewhere and is deemed to be imperceptible.

6 JUSTIFICATION TEST

6.1 Justification Test Requirement

The requirement for a Justification Test for the Proposed Bypass Route was reviewed in accordance with the OPW guidelines "*The Planning System and Flood Risk Management – Guidelines for Planning Authorities*". The matrix shown below details the criteria used to determine whether a Justification Test was required.

Table 6-1 Justification Test Matrix

Vulnerability Level	Flood Zone A	Flood Zone B	Flood Zone C
Highly Vulnerable Development	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water-Compatible Development	Appropriate	Appropriate	Appropriate

The definitions for the flood zones are as follows:

- Flood Zone A – where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);
- Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in1000 year and 0.5% or 1 in 200 for coastal flooding); and
- Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000f or both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

The Proposed Bypass Route is a national route and is deemed a highly vulnerable development. The majority of the Proposed Bypass Route is situated within Flood Zone C. The exception are the following proposed features which require a Justification Test;

- Proposed River Boyne Bridge and associated ancillaries within Flood Zone A and B
- Proposed River Boyne Bridge Temporary Works within Flood Zone A and B
- Proposed 6A, 6B and 6C culverts on the Mattock (Mooretown) Stream Crossing within Flood Zone A and B

6.2 Justification Test

The criteria listed in **Figure 6-1** extracted from Section 5.15 of the OPW guidelines "The Planning System and Flood Risk Management – Guidelines for Planning Authorities" formed the basis for this Justification Test.

Box 5.1 Justification Test for development management (to be submitted by the applicant)

When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied:

1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:
   (i) The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;
   (ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;
   (iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and
   (iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

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

Figure 6-1 Justification Test Criteria

The Justification Test criteria contained in the above consists of Items 1 and 2 are addressed in the relevant sub-sections below.

6.2.1 ITEM 1

The proposed N2 Slane Bypass is considered an "*important infrastructural development*" necessary to facilitate "*the removal of non-local heavy goods vehicles from the N2 through Slane village, in conjunction with the TII and other relevant authorities with a view to providing an enhanced and safer environment for the village*" in the Meath County Development Plan 2021-2027. Furthermore, the proposed bypass is in line with **SLN OBJ 7** and **SLN OBJ 10** in the plan.

6.2.2 ITEM 2

The proposed River Boyne Bridge and Mattock (Mooretown) Stream culverts sites has been subject to an appropriate Flood Risk Assessment which demonstrates the following sub-items listed in **Table 6-2** and **Table 6-4** respectively.

Table 6-2 Item 2 Responses – Proposed River Boyne Bridge and Associated Ancillaries

Sub-Items	Response
(i)	A Detailed Flood Risk Assessment was carried to assess the impact of the proposed River Boyne Bridge and associated ancillaries on Flood Zone A and B. The assessment concluded that it will have an adverse impact on flood risk elsewhere.
(ii)	The proposed bridge is a multi-span bridge with the abutments located outside Flood Zone A and B. The lowest soffit level for the bridge is at least 3m above the predicted 1-in-1000-year water level. The bridge piers and the access track are proposed within Flood Zone A and B and will be designed to be water compatible. An assessment was carried to assess the impact of the proposed piers and the access track which concluded that it will not have an adverse impact on flood risk to people, property and environment.

Sub-Items	Response
(iii)	The lowest soffit level is at least 3 m above the predicted 1-in-1000-year water level hence the proposed bridge will have more than adequate flood protection for emergency services access over the bridge.
(iv)	The need for the proposed N2 Slane Bypass is strongly supported in in the Meath County Development Plan 2021-2027.

Table 6-3 Item 2 Responses – Proposed Temporary Works Platforms

Sub-Items	Response
(i)	The proposed temporary works for the River Boyne Bridge will be located within Flood Zone A and B. A detailed hydraulic modelling assessment was carried to assess the impact of the proposed temporary works on Flood Zone A and B elsewhere. The results of the assessment showed the proposed temporary works will not have an adverse impact on flood risk elsewhere.
(ii)	The proposed temporary works for the River Boyne Bridge will be located within Flood Zone A and B and will be designed to be flood compatible. The only exception is the cofferdams which the top level will be set above the 1% AEP level to provide flood protection to facilitate proposed bridge piers construction. A detailed hydraulic modelling assessment was carried to assess the impact of the proposed temporary works which concluded that it will not have an adverse impact on flood risk to people, property and environment.
(iii)	The proposed temporary works platform is designed to be flood compatible. It will not be accessible to the public and will only be in place for an interim period to facilitate construction of the bridge. The proposed temporary works includes provision for vehicular access from the public road (Fennor Road) located outside the predicted floodplain.
(iv)	The need for the proposed N2 Slane Bypass is strongly supported in in the Meath County Development Plan 2021-2027.

Table 6-4 Item 2 Responses – Proposed Mattock (Mooretown) Culverts (6A & 6B & 6C)

Sub-Items	Response
(i)	The proposed culverts (6A, 6B and 6C) are more than adequate to accommodate the 1-in-100-year fluvial flows plus 20% allowance for climate change and provision for a 300 mm freeboard as per the OPW Section 50 design criteria. The results of the Initial Flood Risk Assessment concluded that the proposed culvert will not increase flood risk to the Proposed Bypass Route and elsewhere
(ii)	The results of the Initial Flood Risk Assessment concluded that the proposed culvert will not increase flood risk elsewhere hence there is no further flood risk to people, property and environment.
(iii)	The proposed culverts (6A, 6B and 6C) are more than adequate to accommodate the 1-in-100-year fluvial flows plus 20% allowance for climate change and provision for a 300 mm freeboard as per the OPW Section 50 design criteria. Hence the Proposed Bypass Route above the Mattock (Mooretown) Stream Crossing will have adequate flood protection for emergency access.
(iv)	The need for the proposed N2 Slane Proposed Bypass Route is strongly supported in in the Meath County Development Plan 2021-2027.

7 CONCLUSION & RECOMMENDATIONS

The results of this Flood Risk Assessment concluded the flood risk to Proposed Bypass Route to be low and will not have an adverse impact on flood risk elsewhere. A Justification Test was carried out which concluded that the Proposed Bypass Route satisfied all the relevant Justification Test Criteria set out in the guideline.

In line with the above conclusion, the following recommendations are made for the design and construction of the proposed development:

- The design for the proposed surface water drainage system is to take into consideration of standards for drainage design such as the 'Greater Dublin Strategic Drainage Study Volume 2 – New Developments.' and CIRIA C753 "The SuDS Manual (c753)".
- The Construction Contractor will be required to prepare an Emergency Plan for managing flood risk during construction, which may include avoiding high flow seasons where possible and monitoring of weather conditions through consultation with Met Éireann and Meath County Council. The Contractor is to ensure measures are in place to reduce any potential inundation due to flooding during the works in the route corridor.
- The Construction Contractor shall ensure that the temporary works for construction of the bridge over the River Boyne do not impede the river flow by restricting the flow area (including works that trap large debris) within the banks of the River Boyne. Any temporary works proposed within the floodplain of the River Boyne for an extended period of time will require an appropriate flood risk assessment to quantify the impact of the temporary works on flood risk to the proposed development and elsewhere.

Appendix A
Proposed Works Drawings

NOTES

1. Typical Reno-Mattress dimensions 6.0m X 2.0m X 0.3m.
2. Each Reno-Mattress to be secured to the next with wire lacing.
3. Reno-Mattresses (max Ø50mm mesh) to be filled with clean washed rock >100mm <150mm and achieve a 40% void ratio and Φ' 40°.
4. Separation Geotextile to be placed below lowest mattress/rockfill layer.
5. 60KN biaxial Geogrid to be placed between each Reno-mattress layer.
6. A regulating course of clean/washed rock may be placed below uppermost mattress to level peaks and troughs.
7. The ground should be proof rolled after each mattress is laid.
8. Min overlay between mattresses from 1m to 5m.
9. Crane Mats/pads to be tethered to mattress or removed prior to imminent flood.
10. In-situ shear strength (S_u) of the foundation soil beneath working platforms assumed >20kpa.

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R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\DG\MDT0806-RPS-01-N2-DR-C-DG5000 Boyne Crossing Temporary Works - Plan.dwg

Client

TII Bonneagar Iompair Éireann Transport Infrastructure Ireland
An Roinn Iompair Department of Transport
comhairle chontae na mí meath county council

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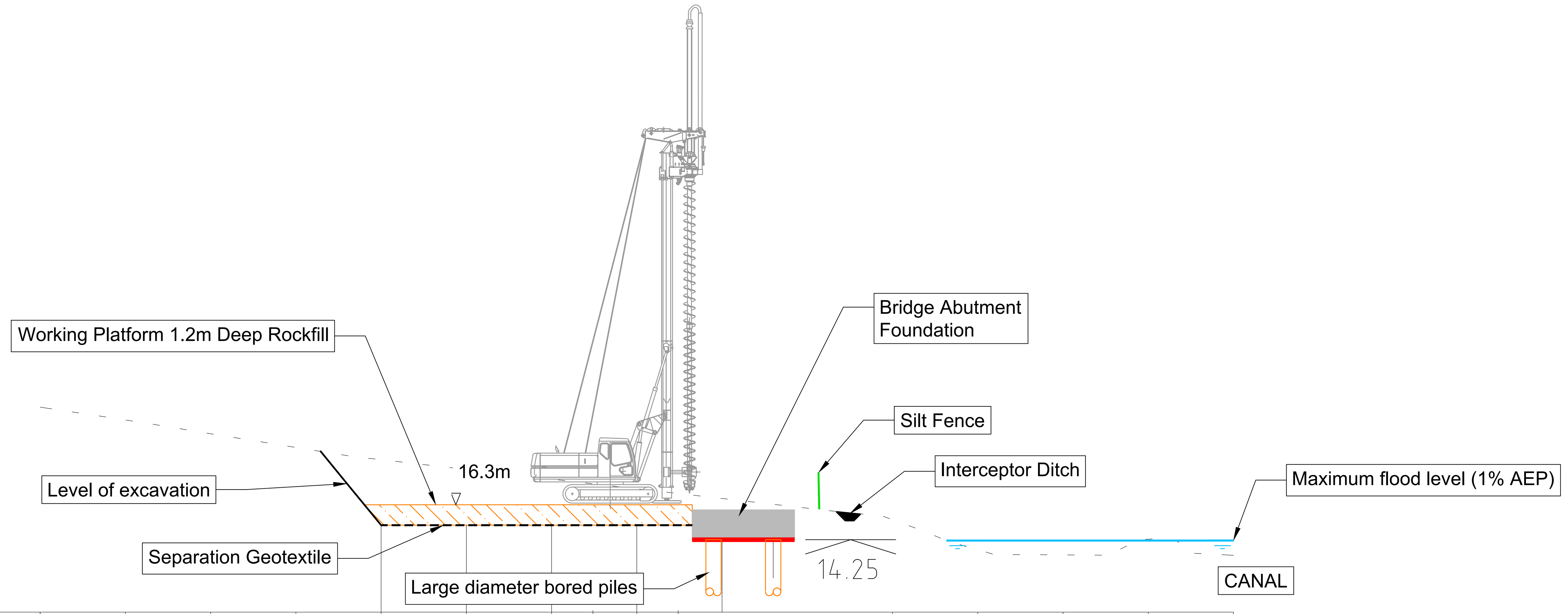
Project
N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME

Title
BOYNE CROSSING TEMPORARY WORKS
PHASE 2
TEMPORARY WORKING PLATFORMS

File Identifier MDT0806-RPS-01-N2-DR-C-DG5000
Drawing Number DG5000
Status A1
Rev C01



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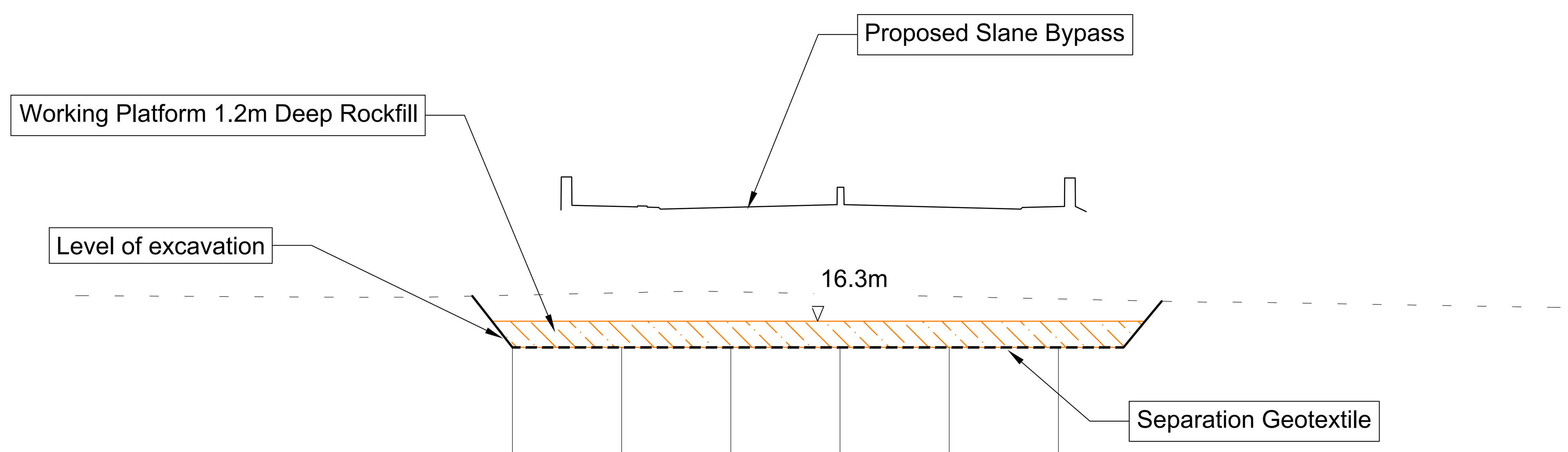
EXCAVATION LEVEL					15.100	15.100	15.100	15.100	15.100								
DISTANCE	00.000	05.000	10.000	15.000	20.000	25.000	30.000		35.000		40.000	45.000	50.000	55.000	60.000	65.000	70.000

SECTION A–A Scale Horiz. 1:200 Vert. 1:200 @ A1



EXISTING GL	17.468	17.438	17.408	17.396	17.489	17.599	17.645	17.536	17.427	17.317		17.145	17.060	16.975	16.928
EXCAVATION LEVEL					15.100	15.100	15.100	15.100	15.100	15.100					
DISTANCE	00.000	05.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	67.981

SECTION B–B Scale Horiz. 1:200 Vert. 1:200 @ A1

NOTE

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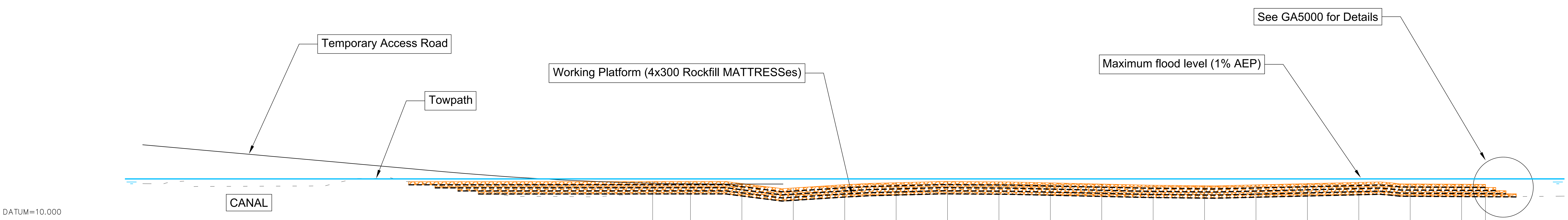
Project **N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME**

Title BOYNE CROSSING TEMPORARY WORKS BRIDGE CONSTRUCTION PLATFORMS WP1 SECTIONS

File Identifier MDT0806-RPS-01-N2-DR-C-DG5001-DG5005

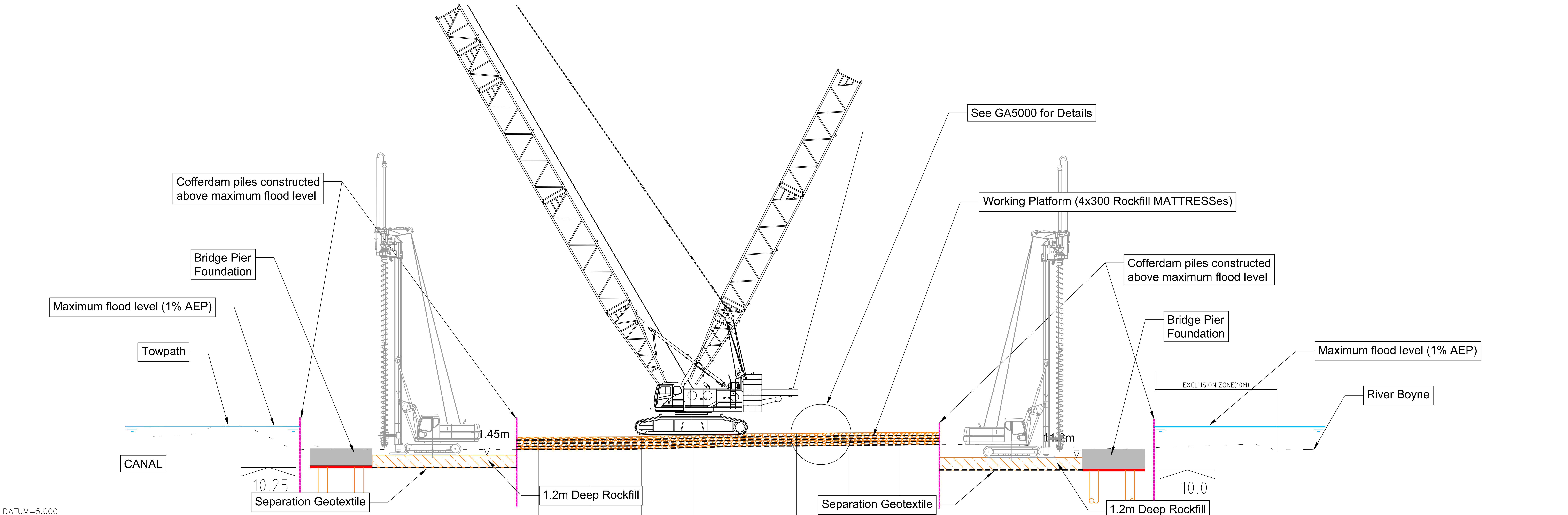
Drawing Number DG5001 | Status A1 | Rev C01

R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\MDT0806-RPS-01-N2-DR-C-DG5001-DG5005 Boyne Crossing Temporary Works - Sections.dwg



EXISTING GL		13.737	13.940	13.474	13.497	13.667	14.286	13.643	12.926	12.500	12.456	12.735	12.738	12.547	12.115	12.435	12.627	12.742	12.709	12.611	12.495	12.384	12.331	12.418	12.537	12.656	12.508	12.478	12.474	12.523
TOP OF MATTRESS													13.938	13.747	13.315	13.635	13.827	13.942	13.909	13.811	13.695	13.584	13.531	13.618	13.737	13.856	13.708	13.678		
DISTANCE	00.000		05.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000	125.000	130.000	135.000	140.000

SECTION C–C Scale Horiz. 1:200 Vert. 1:200 @ A1



EXISTING GL		13.261	13.379	14.241	12.581	12.022	11.984	11.965	11.984	12.002	12.016	12.044	12.173	12.303	12.326	12.408	12.439	12.470	12.442	12.287	12.097	12.178	12.361	12.239	11.989
TOP OF MATTRESS										13.202	13.216	13.246	13.373	13.503	13.528	13.608	13.639								
DISTANCE	00.000		05.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000

SECTION D–D Scale Horiz. 1:200 Vert. 1:200 @ A1

NOTE

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R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\DG\MDT0806-RPS-01-N2-DR-C-DG5001-DG5005 Boyne Crossing Temporary Works - Sections.dwg

Client

TII Bonneagar Iompair Éireann Transport Infrastructure Ireland

An Roinn Iompair Department of Transport

comhairle chontae na mí meath county council

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Project
N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME

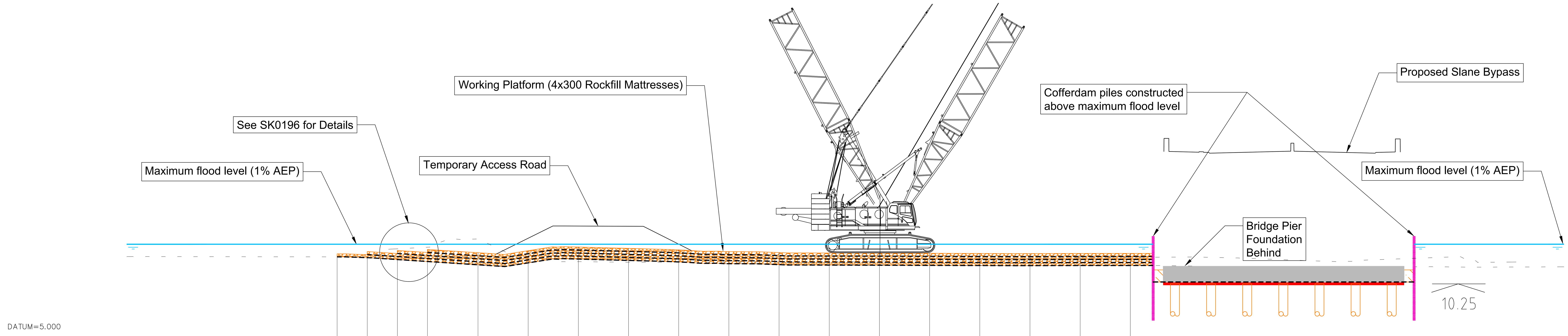
Title
BOYNE CROSSING TEMPORARY WORKS
BRIDGE CONSTRUCTION PLATFORMS
WP2 SECTIONS

File Identifier MDT0806-RPS-01-N2-DR-C-DG5001-DG5005

Drawing Number DG5002

Status A1

Rev C01



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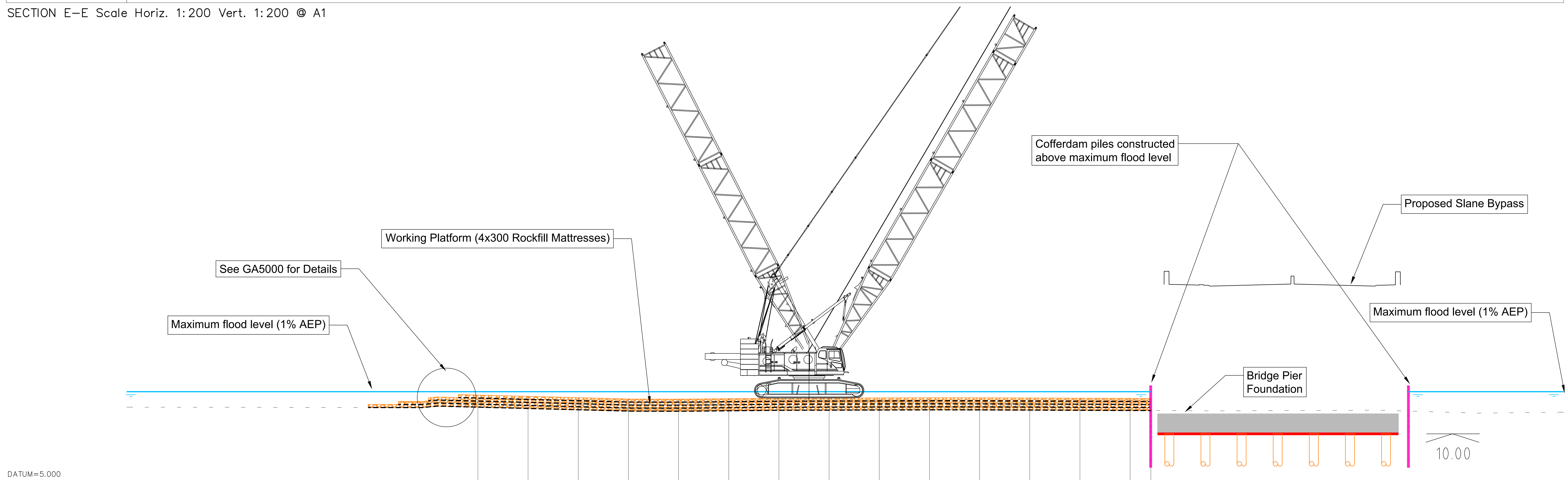
05.000	12.966	
10.000	12.958	
15.000	12.950	
20.000	12.942	
25.000	12.803	
30.000	12.478	
35.000	12.154	13.354
40.000	12.356	13.556
45.000	12.722	13.922
50.000	12.587	13.787
55.000	12.453	13.635
60.000	12.261	13.461
65.000	12.167	13.367
70.000	12.124	13.324
75.000	12.109	13.309
80.000	12.093	13.293
85.000	12.077	13.277
90.000	12.068	13.268
95.000	12.080	13.280
100.000	12.082	13.282
105.000	12.046	-999.000
110.000	11.993	-999.000
115.000	11.978	-999.000
120.000	11.958	-999.000
125.000	11.937	-999.000
130.000	11.960	-999.000
135.000	11.917	-999.000
140.000	11.935	-999.000
143.203	11.945	-999.000

SECTION E–E Scale Horiz. 1:200 Vert. 1:200 @ A1



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15.000	12.638	
20.000	12.631	
25.000	12.624	
30.000	12.672	
35.000	12.662	13.862
40.000	12.532	13.732
45.000	12.403	13.603
50.000	12.273	13.473
55.000	12.253	13.458
60.000	12.300	13.500
65.000	12.348	13.548
70.000	12.363	13.563
75.000	12.377	13.577
80.000	12.392	13.592
85.000	12.387	13.587
90.000	12.369	13.569
95.000	12.350	13.550
100.000	12.332	13.532
105.000	12.309	-999.000
110.000	12.296	-999.000
115.000	12.316	-999.000
120.000	12.335	-999.000
125.000	12.351	-999.000
130.000	12.203	-999.000
135.000	12.069	-999.000
140.000	12.122	-999.000
143.203	12.156	-999.000

SECTION F–F Scale Horiz. 1:200 Vert. 1:200 @ A1

NOTE

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R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\DG\MDT0806-RPS-01-N2-DR-C-DG5001-DG5005 Boyne Crossing Temporary Works - Sections.dwg

Client

Bonneagar Iompair Éireann Transport Infrastructure Ireland

An Roinn Iompair Department of Transport

comhairle chontae na mí meath county council

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Project: N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME

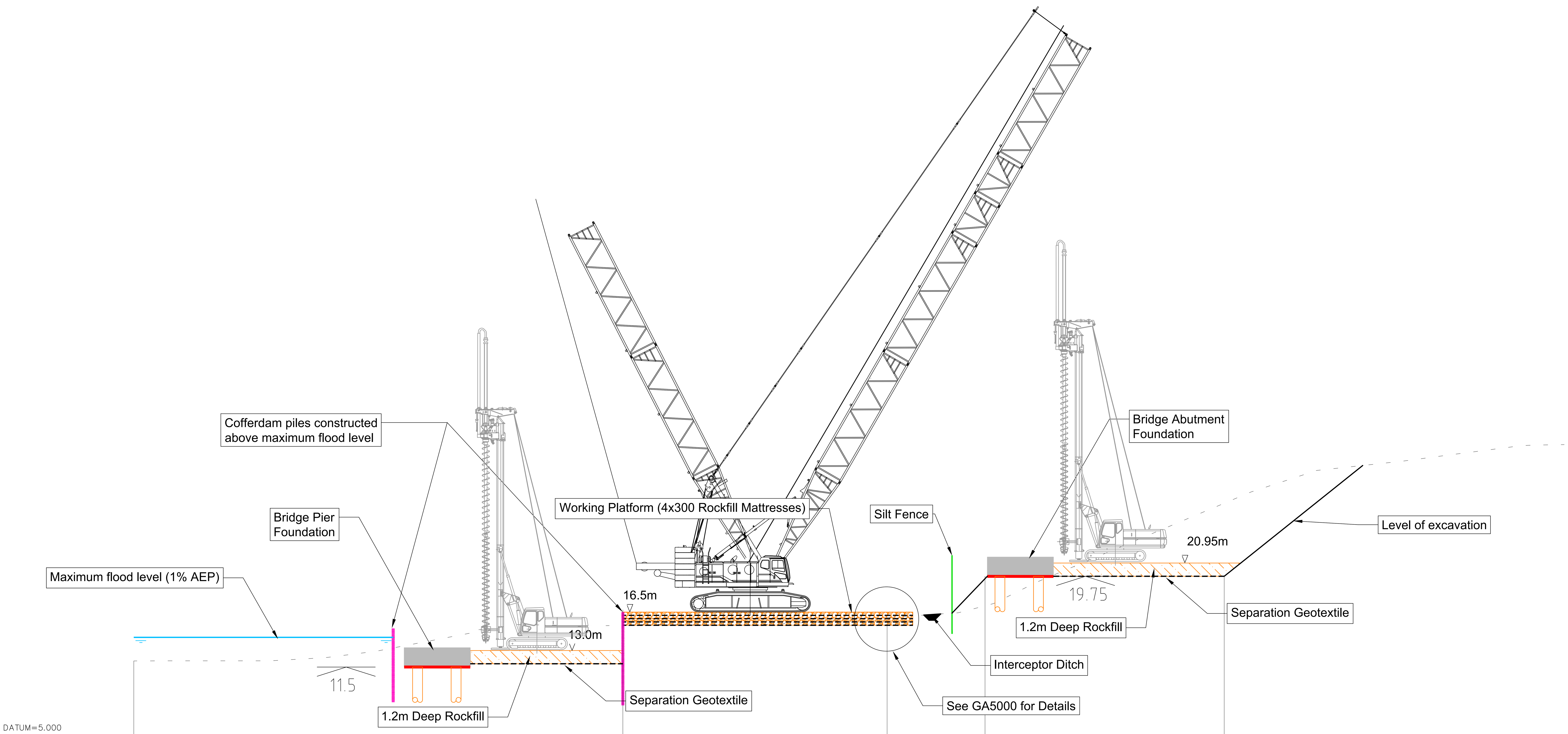
Title: BOYNE CROSSING TEMPORARY WORKS BRIDGE CONSTRUCTION PLATFORMS WP2 SECTIONS

File Identifier: MDT0806-RPS-01-N2-DR-C-DG5001-DG5005

Drawing Number: DG5003

Status: A1

Rev: C01



DISTANCE	EXISTING GL
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10.000	12.067
15.000	12.215
20.000	12.682
25.000	13.512
30.000	14.475
35.000	15.361
40.000	15.273
45.000	15.321
50.000	15.333
55.000	15.265
60.000	15.492
65.000	15.774
70.000	16.106
75.000	16.451
80.000	18.194
85.000	20.454
90.000	22.558
95.000	24.661
100.000	26.765
105.000	28.544
110.000	29.636
115.000	30.180
120.000	30.833
125.000	31.477
130.000	31.713

EXCAVATION LEVEL: 11.800, 11.800 / 15.300, 15.300, 19.750, 19.750, 16.500

SECTION G–G Scale Horiz. 1:200 Vert. 1:200 @ A1

NOTE
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File Identifier: MDT0806-RPS-01-N2-DR-C-DG5001-DG5005

Scale: 1:200 @ A1, 1:400 @ A3

Created on: 25/02/2022

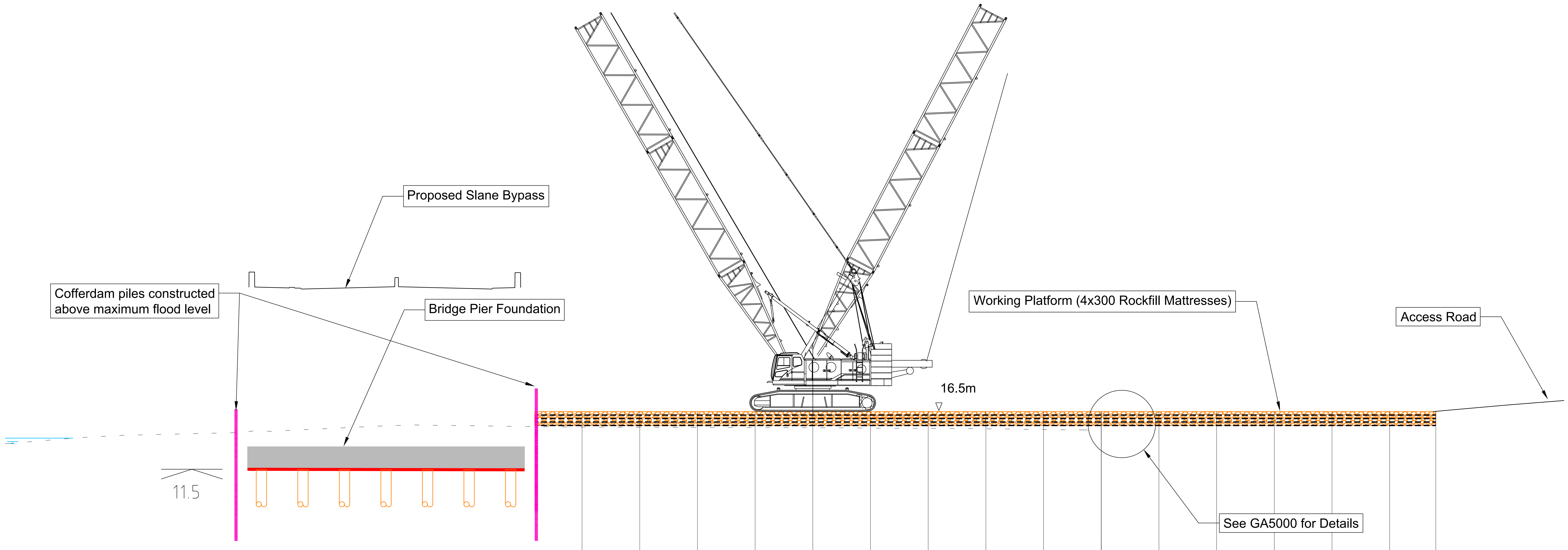
Sheets: 04 of 05

Project: **N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME**

Title: BOYNE CROSSING TEMPORARY WORKS BRIDGE CONSTRUCTION PLATFORMS WP3 & WP4 SECTIONS

Drawing Number: DG5004 | Status: A1 | Rev: C01

R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\DG\MDT0806-RPS-01-N2-DR-C-DG5001-DG5005 Boyne Crossing Temporary Works - Sections.dwg



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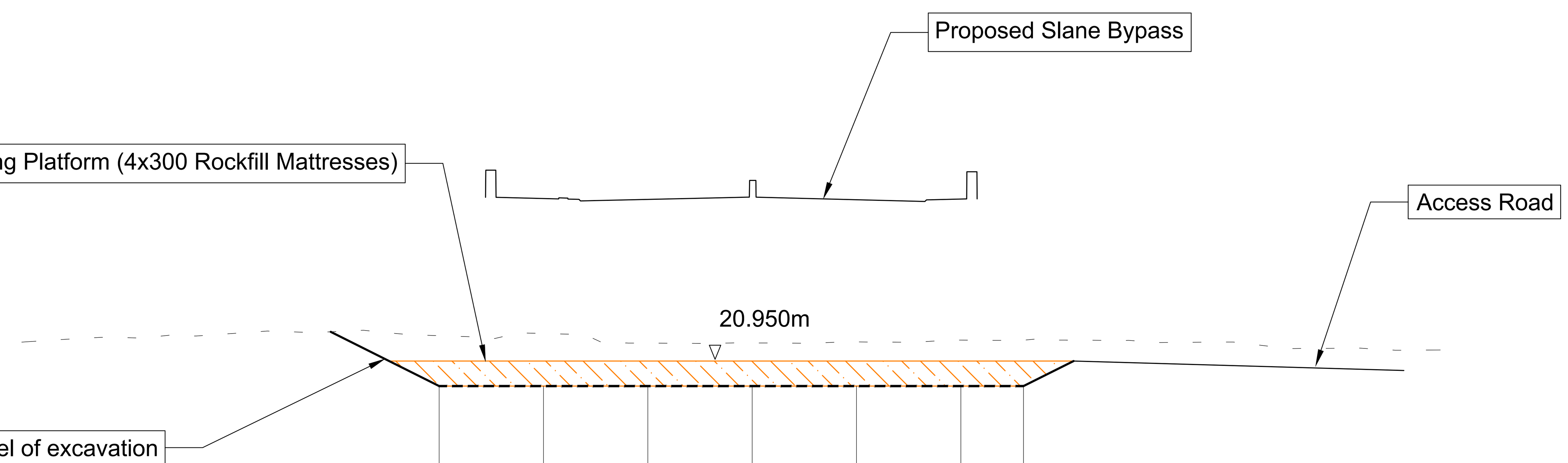
TOP OF MATTRESS											16.500	16.500	16.500	16.500	16.500
DISTANCE	00.000	05.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000	55.000	60.000	65.000	70.000

EXISTING GL	15.074	15.047	15.009	14.950										
TOP OF MATTRESS	16.500	16.500	16.500	16.500	16.500	16.500	16.500	16.500	16.500	16.500	16.500			
DISTANCE	75.000	80.000	85.000	90.000	95.000	100.000	105.000	110.000	115.000	120.000		125.000	130.000	135.000

SECTION H—H Scale Horiz. 1:200 Vert. 1:200 @ A1



DATUM=15.000

EXISTING GL	21.853	22.068	22.260	22.356	22.161	22.266	21.806	21.814	21.862	21.950		21.950	21.838	21.629	21.512	21.477
EXCAVATION LEVEL					19.750	19.750	19.750	19.750	19.750	19.750	19.750					
DISTANCE	00.000	05.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000		50.000	55.000	60.000	65.000	67.974

SECTION I—I Scale Horiz. 1:200 Vert. 1:200 @ A1

NOTE

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Client

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An Roinn Iompair Department of Transport

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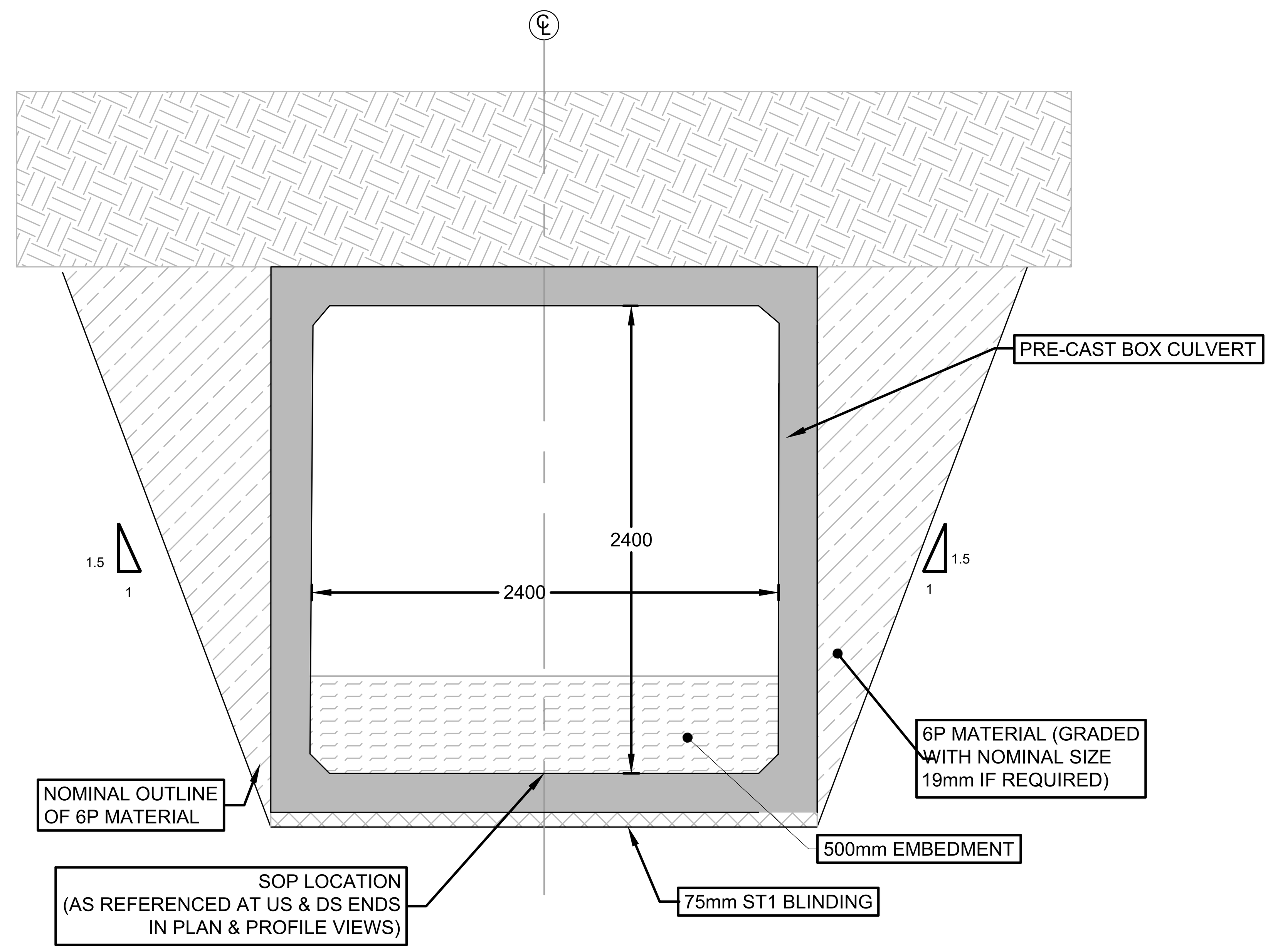
Project **N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME**

Title BOYNE CROSSING TEMPORARY WORKS BRIDGE CONSTRUCTION PLATFORMS WP3 & WP4 SECTIONS

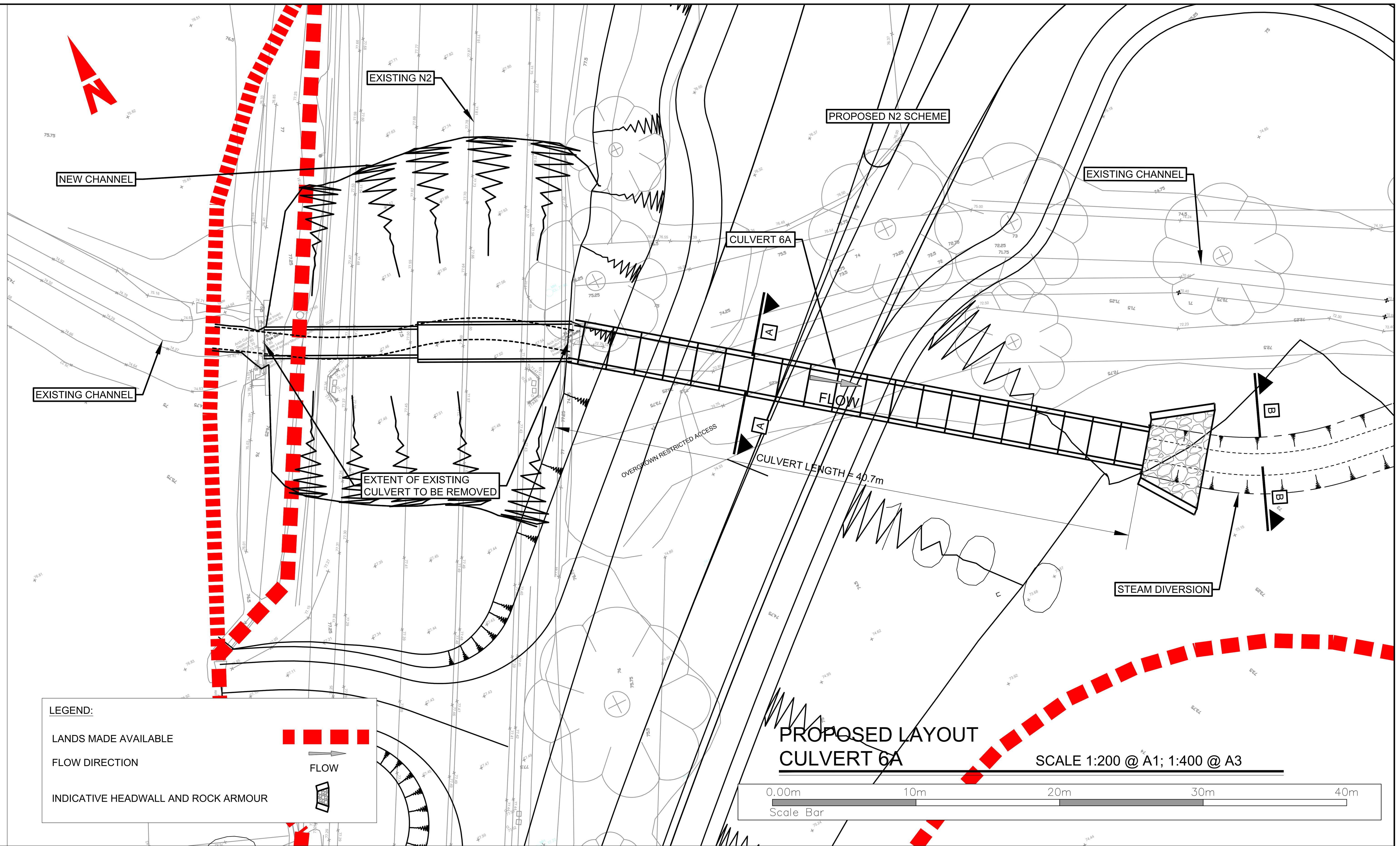
File Identifier MDT0806-RPS-01-N2-DR-C-DG5001-DG5005

Drawing Number DG5005 | Status A1 | Rev C01

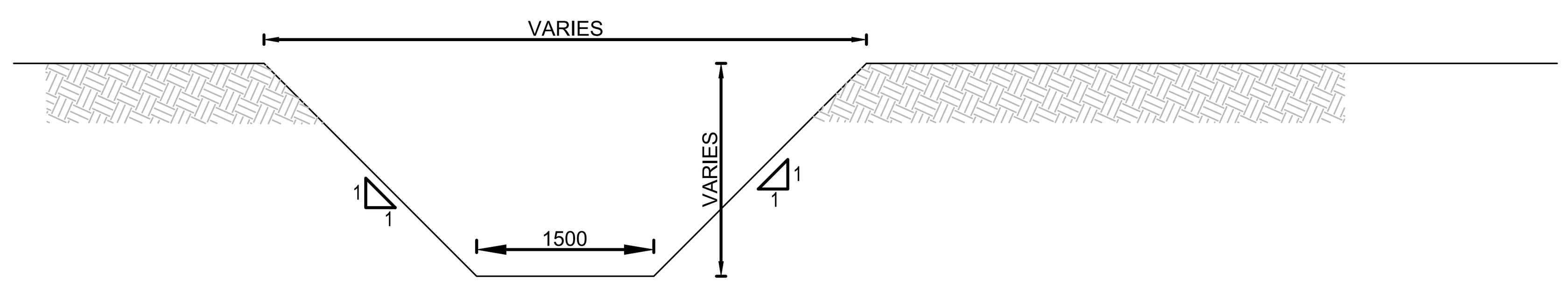
R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\MDT0806-RPS-01-N2-DR-C-DG5001-DG5005 Boyne Crossing Temporary Works - Sections.dwg



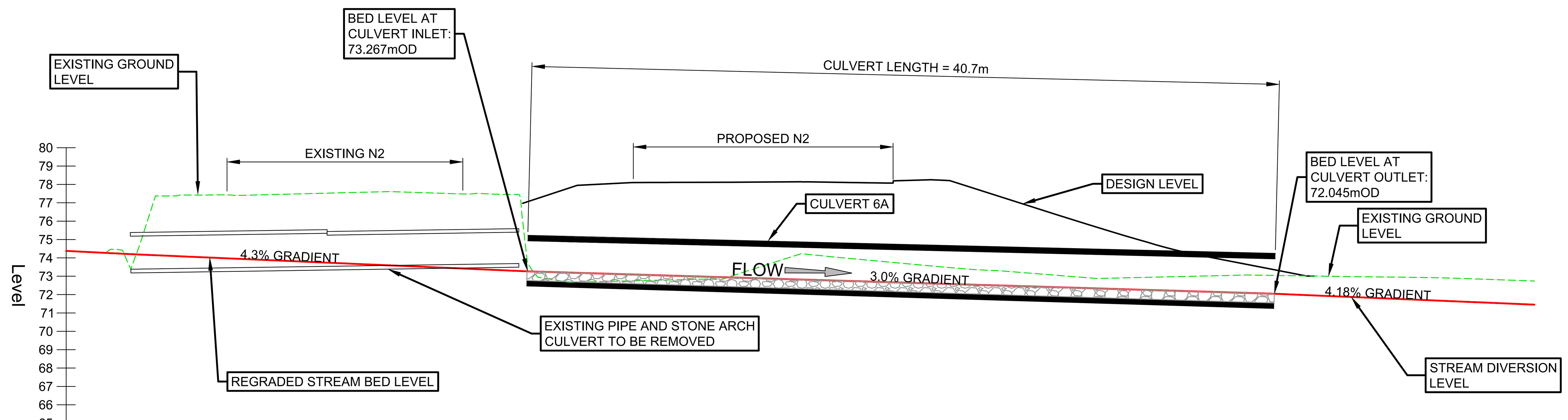
CULVERT 6A
CROSS SECTION A - A SCALE 1:20 @A1 ; 1:40 @A3



PROPOSED LAYOUT
CULVERT 6A SCALE 1:200 @ A1; 1:400 @ A3



STREAM DIVERSION
CROSS SECTION B - B SCALE 1:50 @A1 ; 1:100 @A3



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EXISTING LEVELS	74.379	77.416	77.531	72.730	74.213	73.335	72.966	72.978	72.739

LONGITUDINAL SECTION
CULVERT 6A SCALE 1:200 @A1 ; 1:400 @A3

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R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\DR\MDT0806-RPS-01-N2-DR-C-DR2001-DR2004 - Culverts 6A, 6B & 6C.dwg

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Rev	Date	Drn Chk	Amendment / Issue	App
C01	14/06/23	MR PM	FINAL ISSUE	BL

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Scale: AS SHOWN @ A1; AS SHOWN @ A3

Created on: 13/05/2022

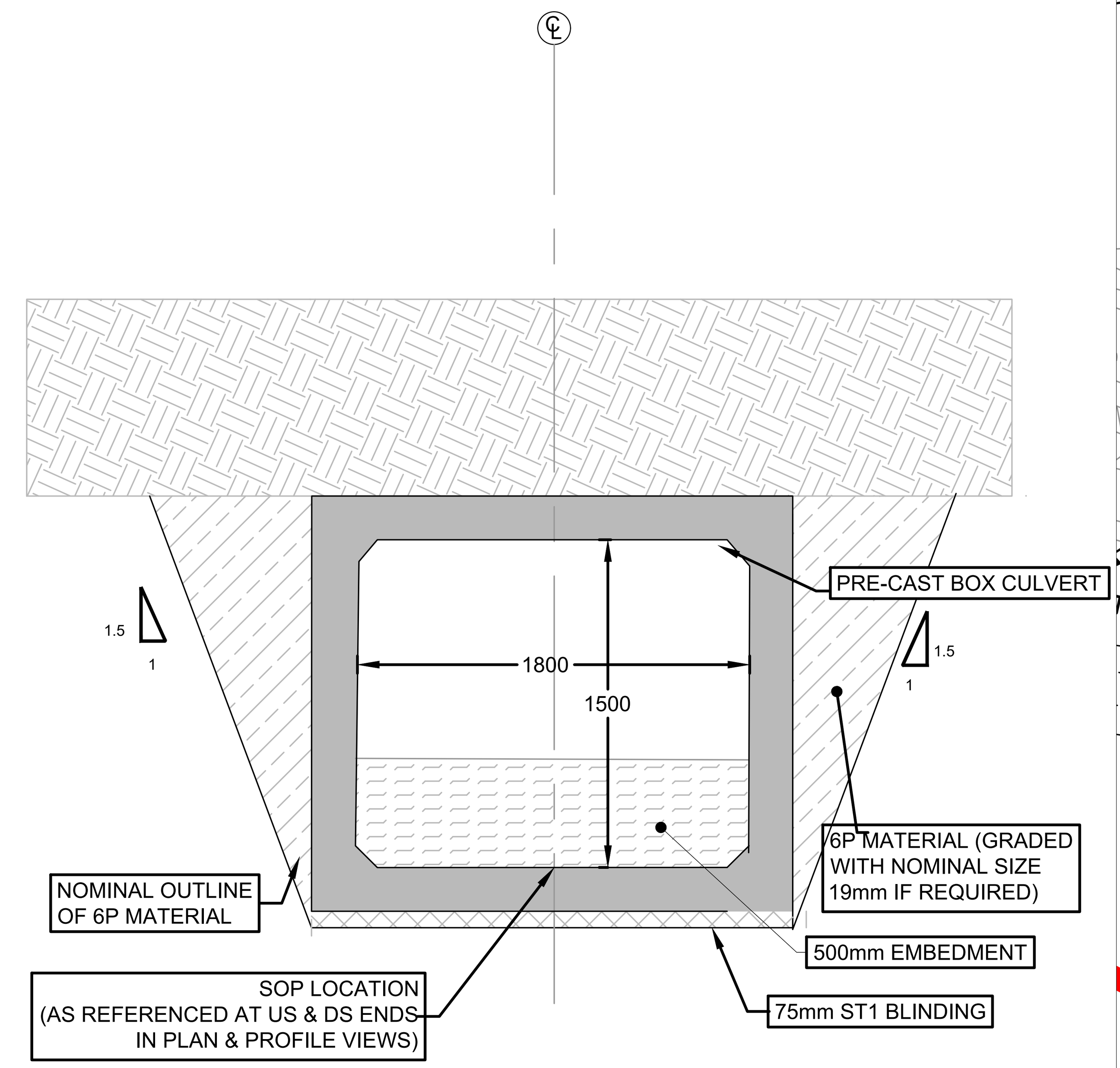
Sheets: 01 of 03

Project: N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME

Title: CULVERTS 6A, 6B AND 6C LAYOUT PLAN

File Identifier: MDT0806-RPS-01-N2-DR-C-DR2001-DR2004

Drawing Number	Status	Rev
DR2001	A1	C01



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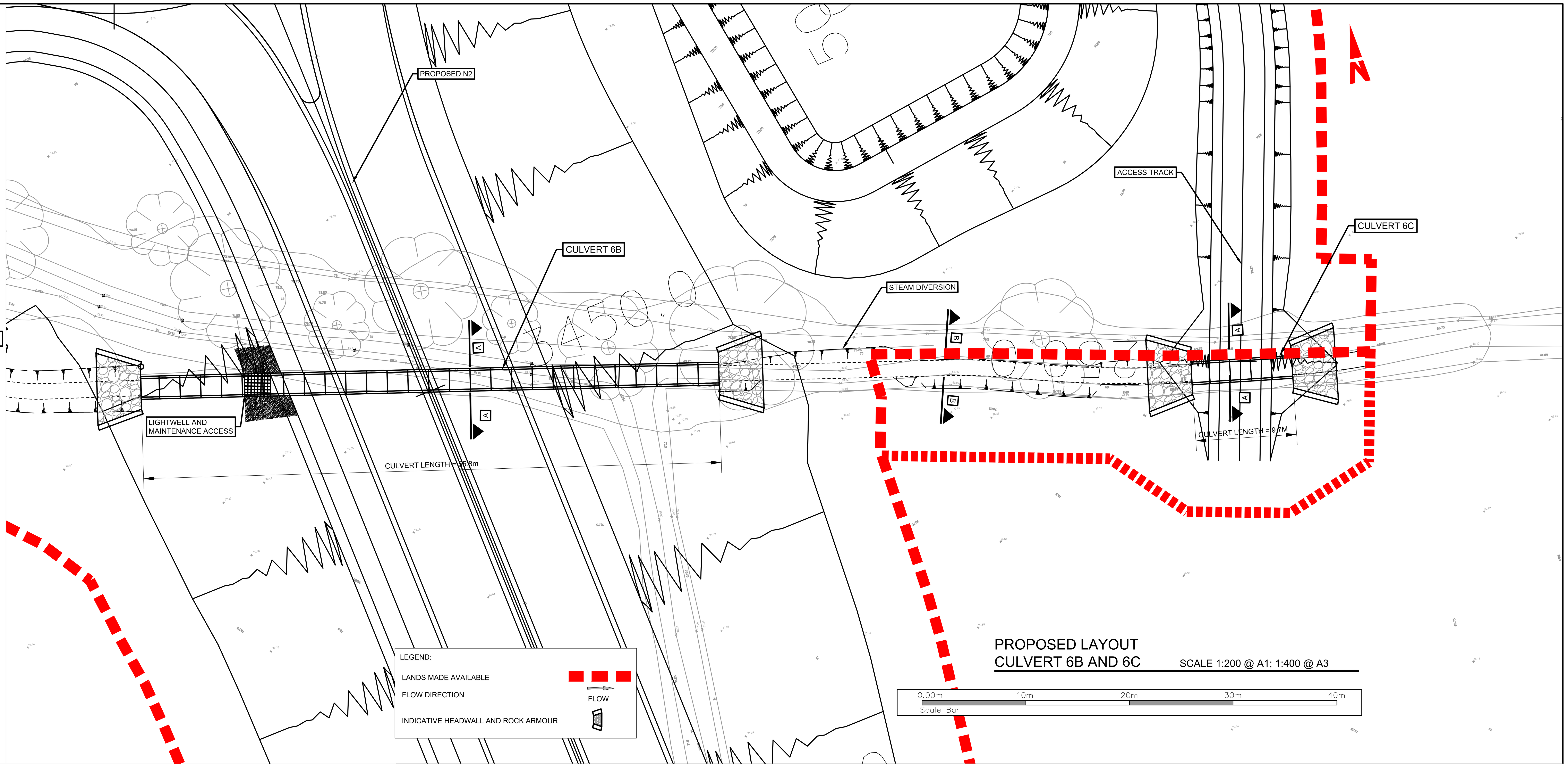
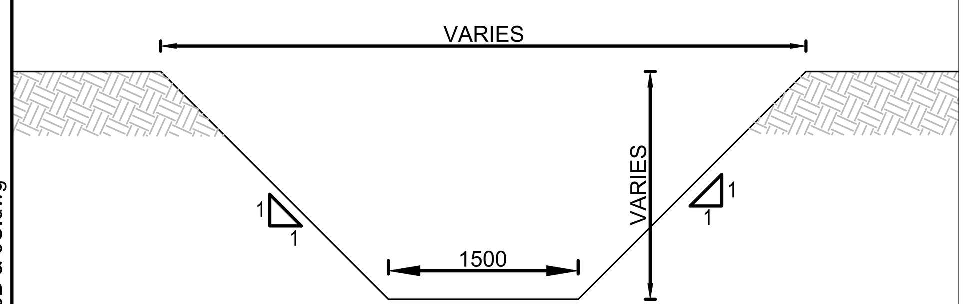


PROPOSED LAYOUT
CULVERT 6B AND 6C SCALE 1:200 @ A1; 1:400 @ A3



STREAM DIVERSION
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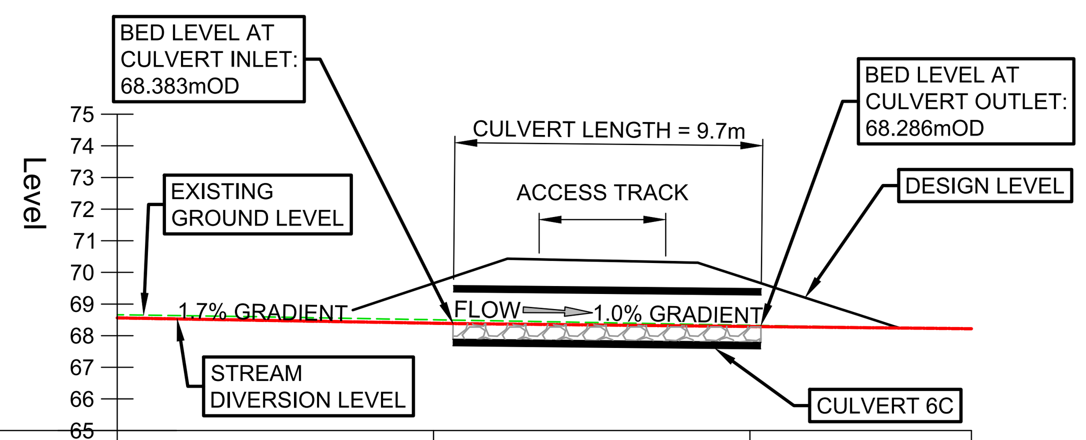

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PROPOSED LEVELS	68.561	68.393	68.289	68.219
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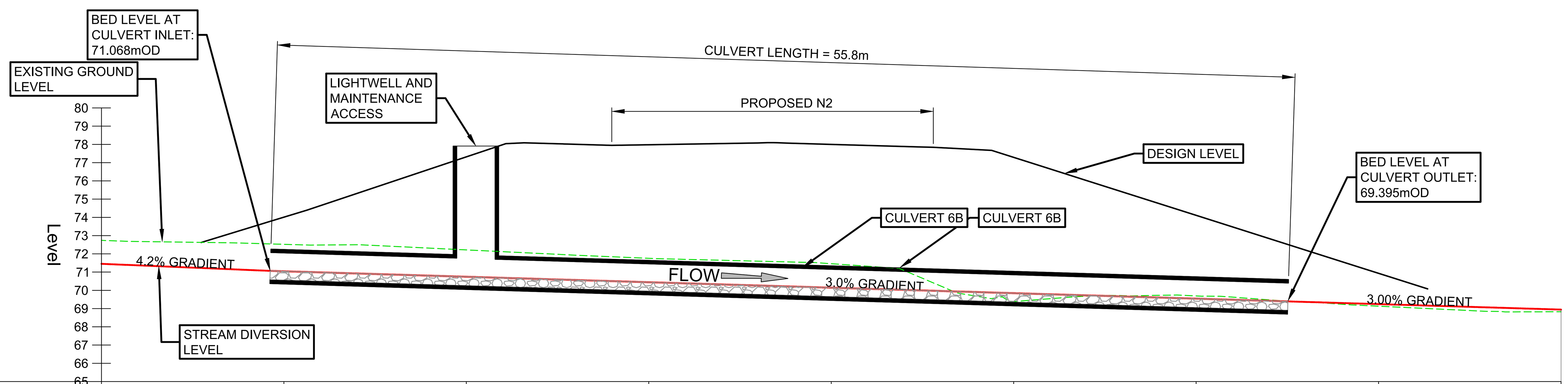
LONGITUDINAL SECTION
CULVERT 6C SCALE 1:200 @A1 ; 1:400 @A3



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PROPOSED LEVELS	71.454	71.045	70.745	70.445	70.145	69.845	69.544	69.245	68.945
EXISTING LEVELS	72.739	72.523	72.217	71.755	71.460	69.384	69.693	69.131	68.826

LONGITUDINAL SECTION
CULVERT 6B SCALE 1:200 @A1 ; 1:400 @A3

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R:\MDT0806_N2 Slane Bypass\8.0 Drawings\DG\DR\MDT0806-RPS-01-N2-DR-C-DR2001-DR2004 - Culverts 6A, 6B & 6C.dwg

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C01	14/06/23	MR	PM	FINAL ISSUE	BL

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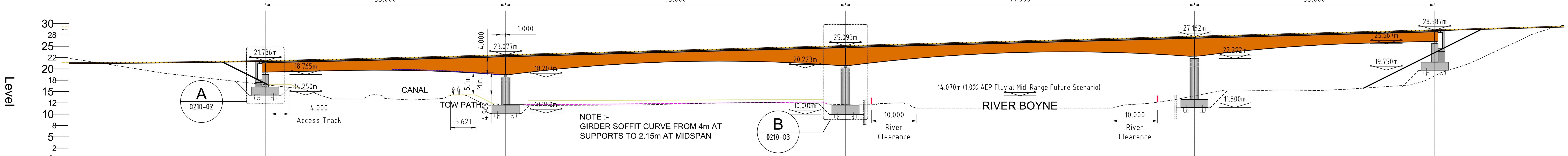
Created on: 04/06/2020
Sheets: 02 of 03

Project: N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME
Title: CULVERTS 6A, 6B AND 6C LAYOUT PLAN

File Identifier: MDT0806-RPS-01-N2-DR-C-DR2001-DR2004
Drawing Number: DR2002
Status: A1
Rev: C01

PLAN LAYOUT
(Scale 1 : 500)



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1150.000	21.378	21.333
1155.000	20.585	21.370
1160.000	19.780	21.414
1165.000	19.028	21.466
1170.000	18.429	21.526
1175.000	17.853	21.594
1180.000	17.272	21.669
1185.000	16.716	21.751
1190.000	16.158	21.842
1195.000	15.586	21.940
1200.000	13.877	22.045
1205.000	13.419	22.158
1210.000	14.178	22.279
1215.000	13.384	22.407
1220.000	13.250	22.541
1225.000	13.426	22.676
1230.000	14.250	22.810
1235.000	12.340	22.944
1240.000	12.052	23.079
1245.000	11.978	23.213
1250.000	11.956	23.348
1255.000	11.974	23.482
1260.000	11.988	23.616
1265.000	12.012	23.751
1270.000	12.088	23.885
1275.000	12.190	24.020
1280.000	12.311	24.154
1285.000	12.410	24.288
1290.000	12.501	24.423
1295.000	12.561	24.557
1300.000	12.514	24.692
1305.000	12.410	24.826
1310.000	12.265	24.960
1315.000	12.250	25.095
1320.000	12.250	25.229
1325.000	12.388	25.363
1330.000	11.524	25.498
1335.000		25.632
1340.000		25.767
1345.000		25.901
1350.000		26.035
1355.000		26.170
1360.000		26.304
1365.000		26.439
1370.000		26.573
1375.000	11.678	26.707
1380.000	12.282	26.842
1385.000	12.859	26.976
1390.000	13.673	27.111
1395.000	14.623	27.245
1400.000	15.287	27.379
1405.000	15.250	27.514
1410.000	15.250	27.648
1415.000	15.250	27.783
1420.000	15.266	27.917
1425.000	15.496	28.051
1430.000	15.810	28.186
1435.000	16.143	28.320
1440.000	16.609	28.455
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1455.000	22.839	28.858
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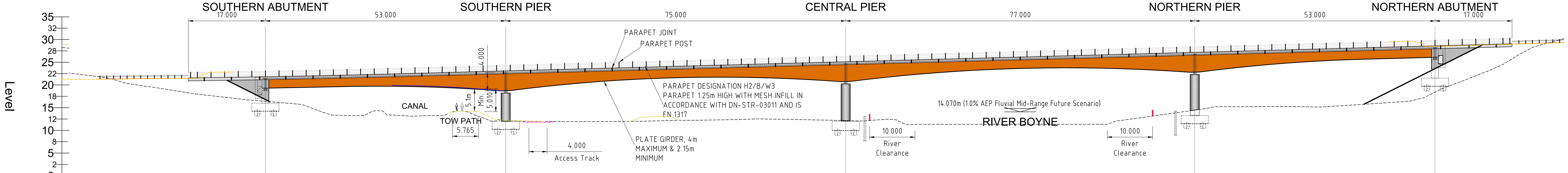
1470.000	28.796	29.284
1473.383	29.602	29.385

CENTERLINE LONG SECTION
(Scale 1 : 500)



Chainage	Existing Levels	Proposed Levels
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1160.000	19.788	21.414
1165.000	19.029	21.466
1170.000	18.257	21.526
1175.000	17.630	21.594
1180.000	17.062	21.669
1185.000	16.557	21.751
1190.000	16.125	21.842
1195.000	15.606	21.940
1200.000	13.863	22.045
1205.000	13.362	22.158
1210.000	13.936	22.279
1215.000	13.392	22.407
1220.000	13.250	22.541
1225.000	13.265	22.676
1230.000	14.000	22.810
1235.000	12.718	22.944
1240.000	12.000	23.079
1245.000	11.987	23.213
1250.000	11.982	23.348
1255.000	11.987	23.482
1260.000	11.992	23.616
1265.000	11.997	23.751
1270.000	12.012	23.885
1275.000	12.129	24.020
1280.000	12.211	24.154
1285.000	12.278	24.288
1290.000	12.384	24.423
1295.000	12.479	24.557
1300.000	12.448	24.692
1305.000	12.356	24.826
1310.000	12.264	24.960
1315.000	12.152	25.095
1320.000	12.159	25.229
1325.000	12.379	25.363
1330.000	11.309	25.498
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1340.000		25.767
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1360.000		26.304
1365.000		26.439
1370.000		26.573
1375.000	12.102	26.707
1380.000	12.686	26.842
1385.000	13.467	26.976
1390.000	14.213	27.111
1395.000	14.956	27.245
1400.000	15.217	27.379
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1415.000	15.250	27.783
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1430.000	15.794	28.186
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1440.000	16.587	28.455
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1455.000	23.049	28.858
1460.000	25.320	28.996
1465.000	27.598	29.138
1470.000	29.252	29.284
1473.383	30.172	29.385

WESTERN ELEVATION
(Scale 1 : 500)

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A1 C01	Jun '23	DC JM	Final Issue	MN

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File Identifier
MDT0806-RPS-ST01-N2-DR-D-BR0000

Scale: As Shown @ A1, Half @ A3
Created on: May'21
Sheets: 1 of 3

Project: N2 SLANE BYPASS AND PUBLIC REALM ENHANCEMENT SCHEME

Title: BOYNE CROSSING - ST01 GENERAL ARRANGEMENT (Sheet 1 of 3)

Drawing Number: MDT0806-RPS-ST01-N2-DR-D-BR0210-01
Status: A1
Rev: C01

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Appendix B
Mattock (Mooretown) Stream Culverts Section 50 Report

TECHNICAL REPORT FOR OPW SECTION 50 APPLICATION

Culverts 6A, 6B and 6C

N2 SLANE BYPASS & PUBLIC REALM ENHANCEMENT
Technical Report for OPW Section 50 Application
Culverts 6A, 6B and 6C
MDT0806-RPS-00-SW-RP-D-DR001 S4 P01
16 July 2021

Contents

Tables

Figures

Appendices

1 INTRODUCTION

1.1 N2 Slane Bypass and Public Realm Enhancement Scheme Proposed Development

RPS have been appointed by Meath County council as designer for phase 3 of the N2 Slane Bypass and Public Realm Enhancement Scheme. This project involves the design of a national primary road bypass of Slane village including approximately 3.5 km of Type 2 dual carriageway, 3 no. roundabout junctions and a bridge crossing over the River Boyne. The project also includes the design of route improvements for the existing N51 between Slane village and the proposed bypass, and the design of traffic management measures within the village.

The route crosses the Boyne River and a number of smaller water courses including field drains and small streams. Where these streams will be crossed by the proposed road and require the consent of the OPW in accordance with Section 50 of the Arterial Drainage Act, 1945 a Section 50 application will be submitted to the OPW for approval. All crossings shall have a separate section 50 application.

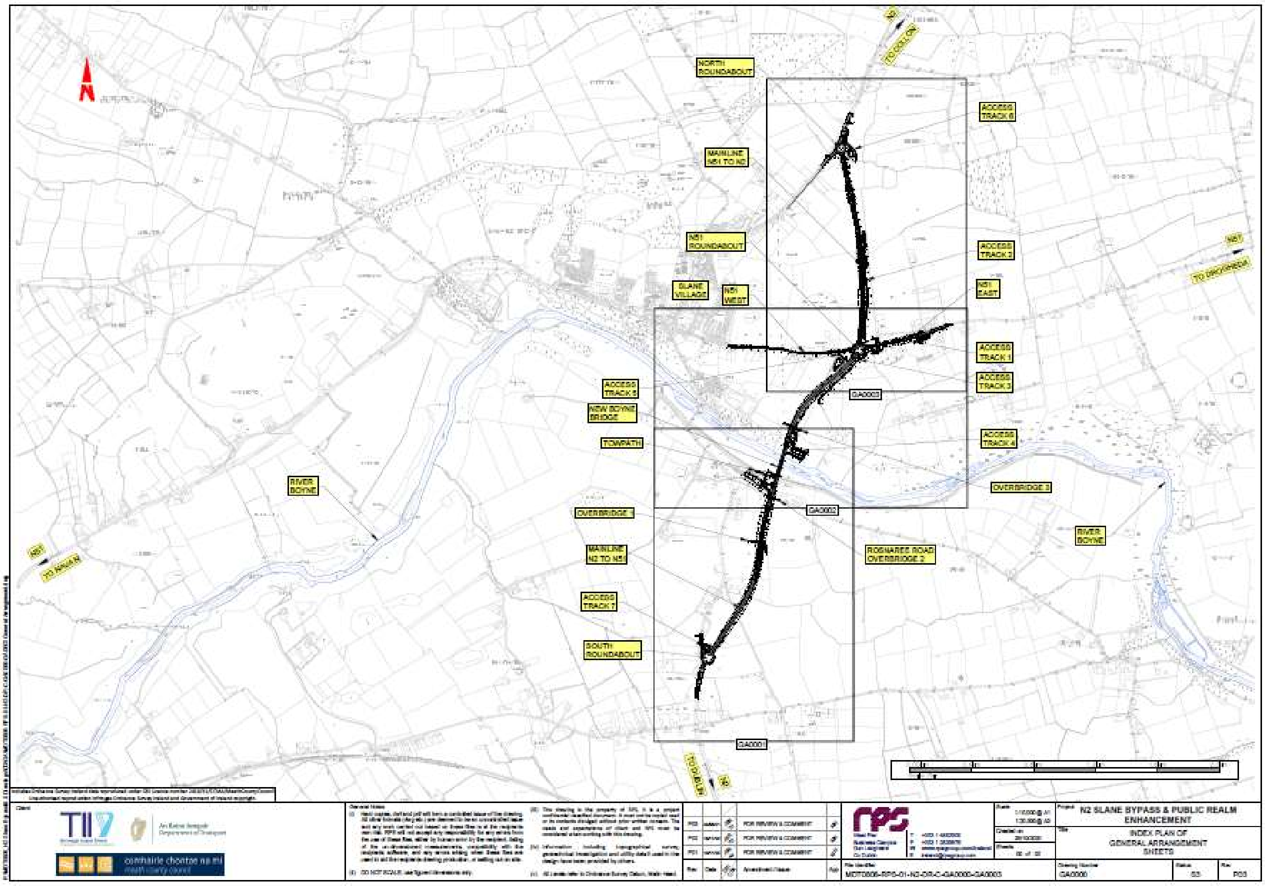

Figure 1.1 N2 Slane Bypass and Public Realm Enhancement Scheme Location Plan

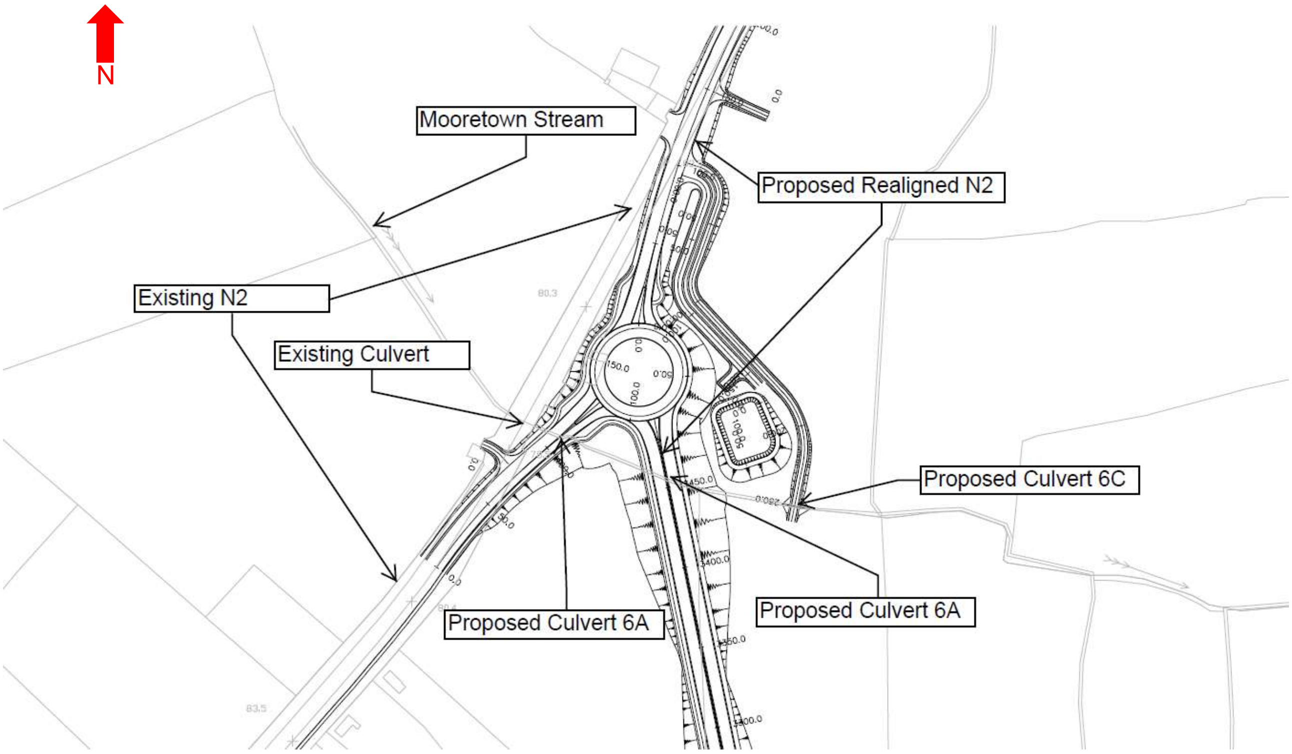

Figure 1.2 Culvert Locations

1.2 Existing Drainage Regime

The proposed scheme crosses the Mooretown stream in three location near the north roundabout. The stream originates from three separate smaller stream in Commons approximately 1.2km to the north west of the proposed culverts and runs through an agricultural area from north west to south east. The stream joins the Mattock River approximately 4km downstream of the culvert locations. The stream passes under the existing N2 and it is proposed that culvert 6A will connect to the existing culvert. The stream consists primarily of open channel but is culverted at the existing N2. The estimated size of the channel is 1.2m to 2m wide, with an average depth of approx. 1.5m. The catchment size for this river upstream of the culvert is 1.424km^2. The stream is not part of the OPW drainage scheme.

Directly upstream of the proposed culvert 6A an existing culvert is proposed to remain in use. Culvert 6a will connect to the existing culvert with maintenance access as shown on Drawing No. MDT0806-RPS-01-N2-DR-C-DR0002. The existing culvert has been constructed in two phases as there are two different cross sections evident. It is assumed that the eastern side of the culvert was construction originally and consists of a stone arch culvert 1.7m high and 2.4m wide. The western side of the culvert was constructed at a later date and consists of a 1.8mØ precast pipe. There is a vertical drop at the upstream entrance to the culvert and the upstream end of the culvert is at a lower elevation to the downstream end by approximately 300mm. It is evident that some unknown constraints at the time of construction necessitated these features.

Picture 1 Existing Condition at Outlet of Existing Culvert

Picture 2 Existing Culvert looking towards inlet

1.3 Proposed Culvert installation

The details of the proposed new culverts are outlined in Table 1.1. The proposed culverts layout is shown on Drawing No. MDT0806-RPS-01-N2-DR-C-DR0002 included in Appendix B. The proposed culvert 6A has been sized to aid construction and maintenance by matching the existing stone arch culvert cross section with the closest available box sections.

As the stream has been considered fisheries sensitive light wells have been provided in culverts 6A and 6B due to their lengths, box sections have been selected over pipe culverts and all new culverts will be embedded 500mm below the stream level.

.

Table 1.1: Proposed Culvert Information

Culvert Ref.	Location	Type	Length	Size (m)	Embedment (m)	Inlet Coordinates (ITM)	Outlet Coordinates (ITM)
6A	North Roundabout Exit to Slane	Box	32.6	2.4mx2.4m	0.5	X: 697193.998 Y:775321.4934	X:697219.9584 Y:75301.7257
6B	N51 to N2 Mainline	Box	55.73	1.5mx1.5m	0.5	X: 697248.278 Y:775291.0313	X: 97303.1145 Y: 75280.9923
6C	Access Track 6	Box	9.66	1.5mx1.5m	0.5	X: 697348.0289 Y:775273.0622	X: 697357.6001 Y: 775271.5128

1.4 Flood History

The OPW maintained database www.floodinfo.ie was consulted to identify areas prone to flooding. The database shows that there are a number of recurring flood events within 2.5km of the site. It was determined that the proposed culvert would not have any impact on the recorded flooding as the flooding events were not related to the stream in question but to the Boyne river and areas of low lying land. An extract from www.floodinfo.ie with culvert location is outlined in Figure 1.3.

The PFRA fluvial mapping was produced to identify areas of potentially significant risk to be further assessed under the CFRAM studies. Figure 1.3 shows extracts from the indicative flood maps produced under the OPW CFRAM study. The CFRAM maps shows no probable flooding in the event of 1in100year event adjacent to the proposed culverts. Some probable fluvial flooding is present 3.7km to the south of these culverts however it was determined that theses culverts would not cause further flooding in the area as it is not part of the catchment area in the area of flooding.

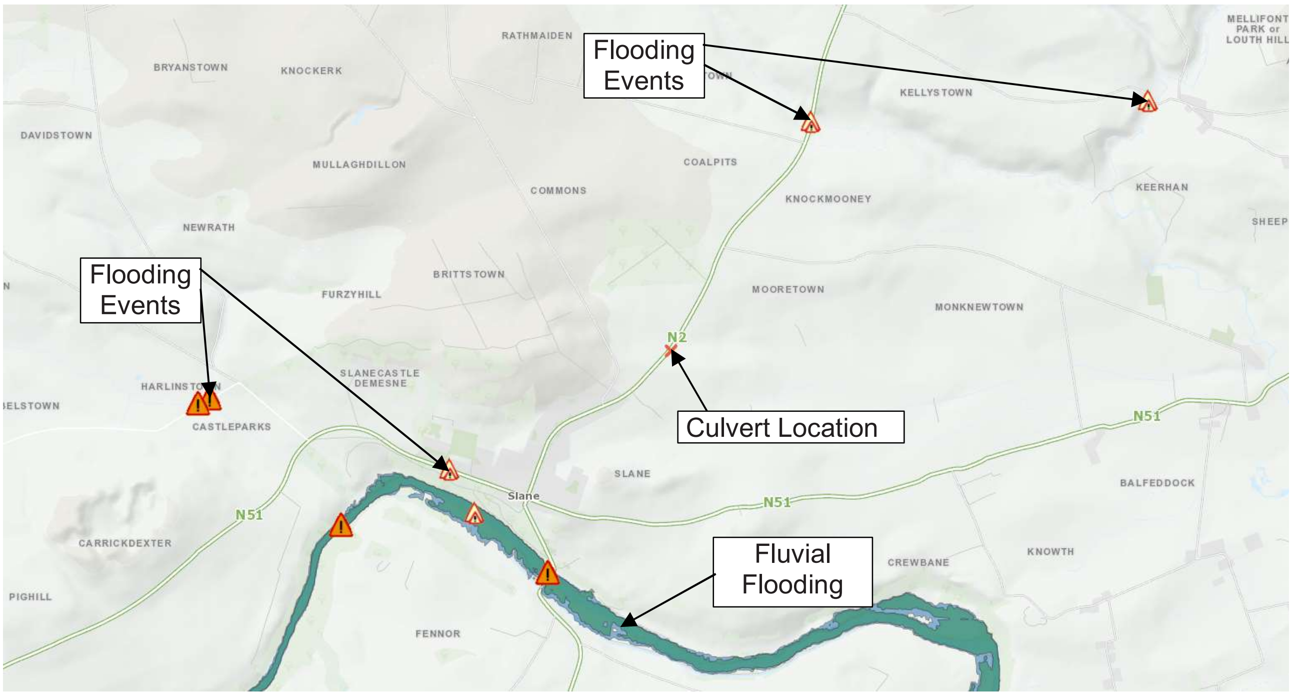

Figure 1.3 CFRAM study flood mapping (www.Floodinfo.ie)

2 CULVERT DESIGN HYDROLOGY

Overland flows contribute to the flow in this stream and benefiting lands that contribute to flow in the stream can be seen in Figure 2.1.

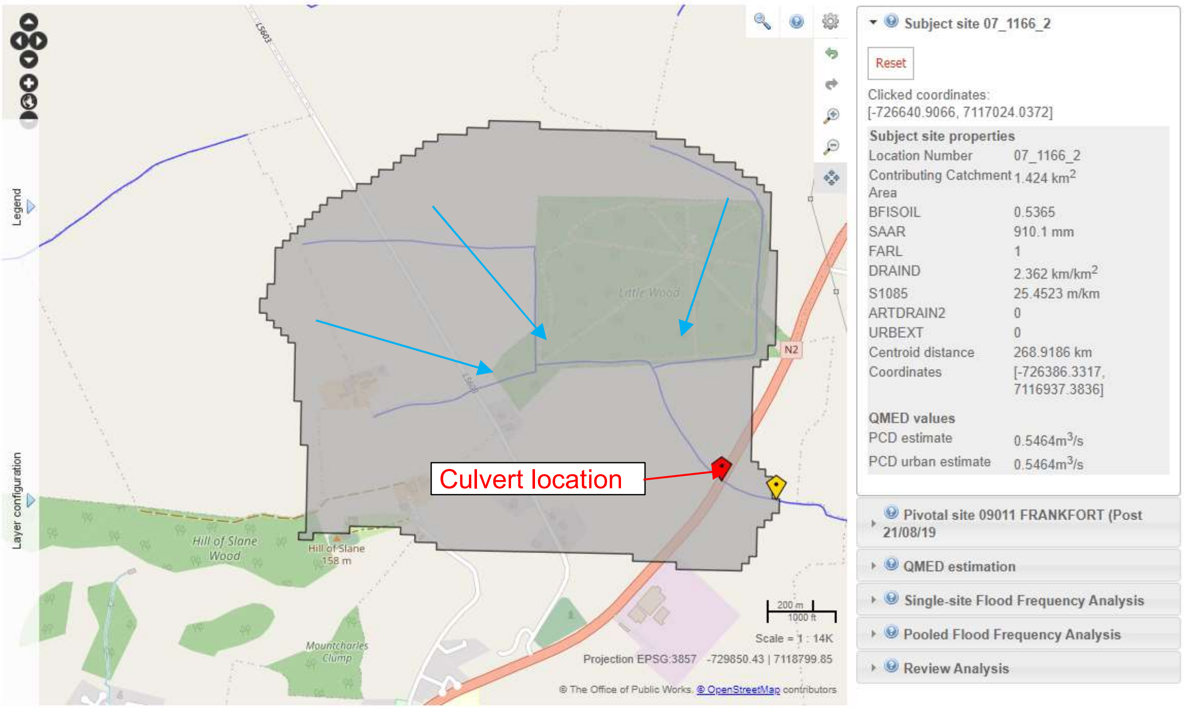

Figure 2.1 Catchment Area

2.1 Flood Hydrology

The stream is ungauged and so the design flows have been estimated using a number of methods. The UK Institute of Hydrology Methodology (IH 124), 3-variable revision of the original Flood Studies Report six variable equation, Agricultural Development and Advisory Service (ADAS) method and flood frequencies module of the Flood Studies Update (FSU) online portal are used to estimate flow. All flow estimates are subject to a 20% climate change allowance. A factorial standard error (FSE) of 1.651 is applied to the IH 124 method and a factor of 1.58 is applied to the FSSR 3- variable method. Irish growth curve figure of 1.96 is applied to IH124 and FSSR 3 variable and a growth factor of 3.06 is applied to the FSU method to account for the 100-year flood flows. A factor of 1.05 is applied to ADAS to convert 75 year to 100-year flood event.

After reviewing the results from each method with relevant factors applied, the estimated flow from the FSU method is used in the culvert sizing calculations as it gave the most conservative (i.e. the highest) estimated flow.

The river has a catchment area of 1.424km². This has been estimated using the Flood Studies Update (FSU) online portal and referencing Ordnance Survey 1:50,000 scale Discovery Series Maps and other scheme mapping.

Table 2.1 below illustrates the catchment characteristics for the subject catchment. Standard Average Annual Rainfall (SAAR) was obtained from the Flood Studies Update (FSU website). The SOIL index value was calculated as 0.3 from the winter rain acceptance potential (WRAP) map.

Table 2.1 Catchment characteristics

Culvert Location	Watercourse name	Catchment Area (km^2)	SAAR (mm)
N2 Slane Bypass	Mooretown Stream	1.424	910.1

Table 2.2 below presents the estimated 100-year return period flood flow for the subject river at the culvert crossing. Inclusive of the 20% climate change allowance, the estimated design flow for the subject culvert is 1.908m^3/sec (calculated using the FSU method).

Table 2.2 Design flow estimation

Culvert Location	Method	Area (km^2)	SAAR (mm)	QMED (m^3/s)	Growth Factor	Q100 (m^3/s)	+CC (20%)
N2 Slane Bypass	FSU	1.424	910.1	0.519	3.09	1.59	1.908

3 HYDRAULIC DESIGN

The hydraulic design of this culvert was carried out by developing a HEC-RAS hydraulic model of the associated river channel and in accordance with the guidelines set out in the UK CIRIA Report No. 689 "Culvert Design and Operation Guide" (2010). The subject culvert is designed to flow in unsubmerged condition. The tail water level was determined by the 'Normal Depth' method. Manning's roughness value of between 0.035 was used for the mainstream channel and the culvert embedment, 0.013 for the culvert concrete surfaces and 0.04 for the flood plains.

A culvert diameter, height and width must not be less than 900 mm to facilitate maintenance access and reduce the likelihood of debris blockage. The new culverts are designed to mimic as far as reasonably possible the existing bed levels within the river, there is no major change in bed slope envisaged from its installation.

The proposed culvert detail is shown on Drawing No. MDT0806-RPS-01-N2-DR-C-DR0002 included in Appendix B, the hydraulic summary of the proposed arrangement is given below. Under the proposed culverts conditions, outlet control governs, due to the gradual culvert slope and downstream channel conditions.

Table 3.1 Proposed Culvert- HECRAS Hydraulic Summary

Summary of hydraulic Calculation – Proposed Culverts			
Culvert Reference	6A	6B	6C
Culvert Width	2.4m	1.8m	1.8m
Culvert Height	2.4m	1.5m	1.5m
Effective conveyance area (Area minus 500mm embedded depth)	4.56m^2	1.8 m^2	1.8 m^2
Culvert inlet invert level ILI	73.1mOD	71.46 mOD	67.84 mOD
Culvert outlet invert level ILo	71.93mOD	69.12 mOD	67.5 mOD
Culvert soffit (upstream end)	75.5mOD	72.96 mOD	66.34 mOD
Culvert soffit (downstream end)	74.33mOD	70.62 mOD	69.00 mOD
Culvert Slope	0.0358 (1 in 27.93)	0.0419(1 in 23.87)	0.0351(1 in 28.49)
Headwater elevation at inlet	74.00 mOD	72.45 mOD	68.83 mOD
Freeboard above Q100+CC	1.5m	0.51m	0.51m
Hydraulic Loss	10mm	290mm	130mm
Velocities along the culvert	1.31-1.98m/s	2.18-2.86m/s	1.68-2.18m/s

From the table above the freeboard and hydraulic loss estimated from the model are within OPW requirements. As expected with stream gradient, the model output velocities along the culverts are between 1.31 and 2.86m/s. It is proposed to install energy dissipators upstream and downstream of the proposed culverts to reduce potential for bank and riverbed erosion. This will be designed at the detailed design stage for the Works. The proposed culverts are therefore adequate to convey the 100-year return period flood. The proposed culverts will not pose any flooding risk in its upstream or downstream vicinity.

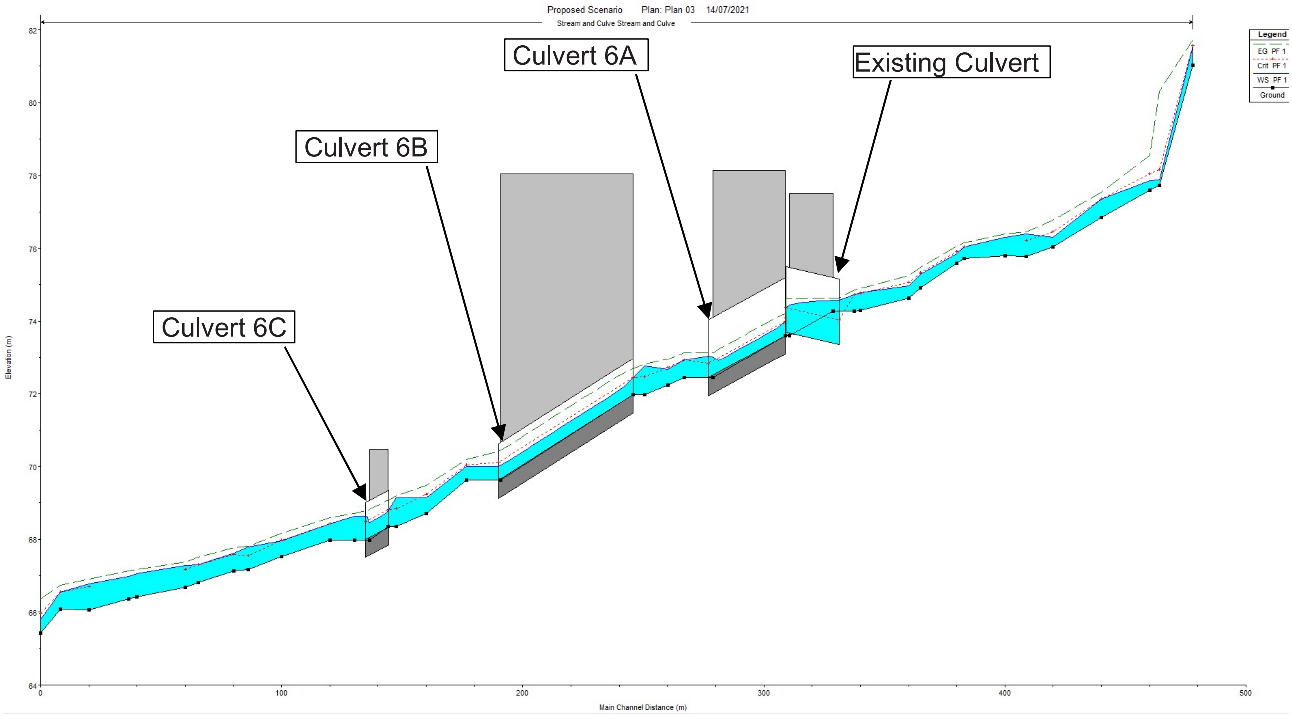

Figure 3-1 100 year flood profile plot output from HEC RAS

4 CONCLUSION

The main findings of the Section 50 are as follows:

- The route intersects a number of water courses along its route.
- New culverts will be installed at these locations in order to maintain the flow within the watercourses, while facilitating proposed N2 works.
- Installation of these culverts requires the consent of the OPW in accordance with Section 50 of the Arterial Drainage Act, 1945.
- The stream in question consist primarily of open channel.
- In order to facilitate the works, it is proposed to construct 3no culverts as described above at the proposed locations.
- Floodmaps.ie indicate areas of historical flooding nearby the subject site, it has been determined that the proposed culverts would not cause further flooding of the area.
- CFRAM maps indicate some probable flooding in the region of the culvert, it has been determined that the proposed culverts would not cause further flooding of the area.
- The new culvert was designed to mimic as far as reasonably possible the existing bed levels within the river.
- The proposed culvert satisfies the minimum requirements of the Section 50 process and provide an increase in capacity to the current arrangement upstream.

Appendix A
OPW Section 50 Application Forms

AF50 Rev1113

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**N5 Westport to Turlough**	Structure Ref No.	**Culvert 6A**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name: Meath County Council	
Postal Address:	
Contact Person:	
Phone:	Fax:
E-mail:	

Agent (Correspondence will issue to agent)		
Company or Organisation Name: RPS Consulting Engineers		
Postal Address:	Lyrr Building, IDA Business and Technology Park, Mervue, Galway	
Contact Person:	Brendan Lyons	
Phone:	+353 91 400 200	Fax:
E-mail:	brendan.lyons@rpsgroup.com	

Location and Parameters of crossing			
Watercourse: Mooretown Stream		Catchment: Boyne	
Address (Townland – County):	Mooretown, Slane, Meath		
Grid Reference	X: 697193.998	Y: 775321.4934 (ITM)	
Hydrometric Station(s) utilized (including reference number):	N/A		
Area of Contributing Catchment:	1.424 Km^2	Road Reference: N2	
Design Flood Flow: 1.908 m^3/s	Annual Exceedance Probability (AEP):		1.0 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Brendan Lyons
Company/Organisation:	RPS
Signature:	Brendan Lyons
Date:	**16.07.21**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☐
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	*OPW Register No:*	
	Consent Issued	☐

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied		
Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics	☐	
3 – Variable Catchment Characteristics	☒	0.529
IH 124	☒	0.519
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	1.04
Other	☐	
FSR ☐	FSU ☒ 0.519 m^3/sec	Other ☐

Comments SAAR 910mm/yr; Soil Factor=0.3;

Factors Applied	
Type of Factor	Value Used
Climate Change	1.2
Irish Growth Curve (IH 124 & 3 - Variable Catchment Characteristics)	1.96
Irish Growth Curve (ADAS)	1.05
Factor for Standard Error (IH 124)	1.65
Factor for Standard Error (3 - Variable Catchment Characteristics)	1.58
FSU Growth Factor F	3.06

Tidal ☐

Comments
Irish Growth Curve (ADAS) used to convert 75yr to 100yr in ADAS.

Hydraulic/Structure Details

Description of Structure*3 Box structure with reinforced concrete headwalls and wingwalls. The internal dimensions of the box will be 2.4m x 2.4m (WxH). The culvert will have500mm embedment.
Upstream and downstream invert levels below refer to the structural invert levels of the culverts.

Effective Conveyance Area *4 0.96m^2

Upstream Invert Level **73.1** mOD	Downstream Invert Level **71.93** mOD
Upstream Soffit Level **75.5** mOD	Downstream Soffit Level **74.33** mOD
Upstream Design Flood Level **74.0** mOD	Downstream Design Flood Level **73.04** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

3. The following details are to be included: the channel bed level, invert and soffit levels of the structure along with the width, length and total conveyance area. Any environmental considerations such as bed depression, baffles, mammal walkways etc. should be described.
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

AF50 Rev1113

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**N5 Westport to Turlough**	Structure Ref No.	**Culvert 6B**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name: Meath County Council	
Postal Address:	
Contact Person:	
Phone:	Fax:
E-mail:	

Agent (Correspondence will issue to agent)		
Company or Organisation Name: RPS Consulting Engineers		
Postal Address:	Lyrr Building, IDA Business and Technology Park, Mervue, Galway	
Contact Person:	Brendan Lyons	
Phone:	+353 91 400 200	Fax:
E-mail:	brendan.lyons@rpsgroup.com	

Location and Parameters of crossing			
Watercourse:	Mooretown Stream	Catchment:	Boyne
Address (Townland – County):	Mooretown, Slane, Meath		
Grid Reference	X: 697248.280	Y: 775291.0313 (ITM)	
Hydrometric Station(s) utilized (including reference number):	N/A		
Area of Contributing Catchment:	1.424 Km^2	Road Reference: N2	
Design Flood Flow:	1.908 m^3/s	Annual Exceedance Probability (AEP):	1.0 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Brendan Lyons
Company/Organisation:	RPS
Signature:	Brendan Lyons
Date:	**16/07/21**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☐
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	*OPW Register No:*	
	Consent Issued	☐

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow [*2] (m^3/sec)
6 – Variable Catchment characteristics	☐	
3 – Variable Catchment Characteristics	☒	0.529
IH 124	☒	0.519
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	1.04
Other	☐	

FSR ☐ FSU ☒ 0.519 m^3/sec Other ☐

Comments SAAR 910mm/yr; Soil Factor=0.3;

Factors Applied

Type of Factor	Value Used
Climate Change	1.2
Irish Growth Curve (IH 124 & 3 - Variable Catchment Characteristics)	1.96
Irish Growth Curve (ADAS)	1.05
Factor for Standard Error (IH 124)	1.65
Factor for Standard Error (3 - Variable Catchment Characteristics)	1.58
FSU Growth Factor F	3.06

Tidal ☐

Comments
Irish Growth Curve (ADAS) used to convert 75yr to 100yr in ADAS.

Hydraulic/Structure Details

Description of Structure[*3] Box structure with reinforced concrete headwalls and wingwalls. The internal dimensions of the box will be 1.8m x 1.5m (WxH). The culvert will have 500mm embedment.
Upstream and downstream invert levels below refer to the structural invert levels of the culverts.

Effective Conveyance Area [*4]	$0.882m^2$
Upstream Invert Level **71.46** mOD	Downstream Invert Level **69.12** mOD
Upstream Soffit Level **72.96** mOD	Downstream Soffit Level **70.62** mOD
Upstream Design Flood Level **72.45** mOD	Downstream Design Flood Level **69.99** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
2. Flow is the estimated flow from the catchment, without any factors applied.

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4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

AF50 Rev1113

Construction, Replacement or Alteration of Bridges and Culverts
Application for Consent under Section 50 of the Arterial Drainage Act, 1945 & EU (Assessment and Management of Flood Risks) Regulations SI 122 of 2010

Project Name	**N5 Westport to Turlough**	Structure Ref No.	**Culvert 6C**

Applicant (Correspondence will issue to agent)	
Company or Organisation Name: Meath County Council	
Postal Address:	
Contact Person:	
Phone:	Fax:
E-mail:	

Agent (Correspondence will issue to agent)		
Company or Organisation Name: RPS Consulting Engineers		
Postal Address:	Lyrr Building, IDA Business and Technology Park, Mervue, Galway	
Contact Person:	Brendan Lyons	
Phone:	+353 91 400 200	Fax:
E-mail:	brendan.lyons@rpsgroup.com	

Location and Parameters of crossing				
Watercourse:	Mooretown Stream		Catchment:	Boyne
Address (Townland – County):	Mooretown, Slane, Meath			
Grid Reference	X:	697348.0289	Y:	775273.0622 (ITM)
Hydrometric Station(s) utilized (including reference number):	N/A			
Area of Contributing Catchment:	1.424	Km^2	Road Reference:	N2
Design Flood Flow:	1.908 m^3/s	Annual Exceedance Probability (AEP):		1.0 %

Statement of Authenticity	
I hereby certify that the information contained in this application form, along with all appended supporting information, has been checked by me and that all statements are true and accurate.	
Name:	Brendan Lyons
Company/Organisation:	RPS
Signature:	
Date:	**16/07/21**

Application Check List	☐
COMPLETED APPLICATION FORM	☒
SUPPORTING HYDROLOGICAL AND HYDRAULIC INFORMATION	☒
PHOTOGRAPHS COVERING SITE OF ALL PROPOSED WORKS	☒
SCALED PLAN OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED CROSS SECTION OF BRIDGE/CULVERT/APPROACH EARTHWORKS	☒
SCALED LONG SECTION OF CHANNEL THROUGH BRIDGE/CULVERT	☒
DETAILS OF RELEVANT EXISTING STRUCTURES	☒
COMPLETED STATEMENT OF AUTHENTICITY	☐
PLAN OF CATCHMENT AREA	☒
COPY OF NOTICE OF GRANT OF PLANNING PERMISSION WITH CONDITIONS *1	☐

For OPW use only	*Date of Receipt*							
OPW Drainage Maintenance Region	*East*	☐	*South East*	☐	*South West*	☐	*West*	☐

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Correspondence Number	*OPW Register No:*	
	Consent Issued	☐

ADDITIONAL INFORMATION

Hydrological Analysis

Methodology Applied

Method Used	Tick box if used or state other	Flow *2 (m^3/sec)
6 – Variable Catchment characteristics	☐	
3 – Variable Catchment Characteristics	☒	0.529
IH 124	☒	0.519
Gauged Flow	☐	
Unit Hydrograph	☐	
ADAS	☒	1.04
Other	☐	

FSR ☐ FSU ☒ 0.519 m^3/sec Other ☐

Comments SAAR 910mm/yr; Soil Factor=0.3;

Factors Applied

Type of Factor	Value Used
Climate Change	1.2
Irish Growth Curve (IH 124 & 3 - Variable Catchment Characteristics)	1.96
Irish Growth Curve (ADAS)	1.05
Factor for Standard Error (IH 124)	1.65
Factor for Standard Error (3 - Variable Catchment Characteristics)	1.58
FSU Growth Factor F	3.06

Tidal ☐

Comments
Irish Growth Curve (ADAS) used to convert 75yr to 100yr in ADAS.

Hydraulic/Structure Details

Description of Structure*3 Box structure with reinforced concrete headwalls and wingwalls. The internal dimensions of the box will be 1.8m x 1.5m (WxH). The culvert will have 500mm embedment.
Upstream and downstream invert levels below refer to the structural invert levels of the culverts.

Effective Conveyance Area *4 $0.882m^2$

Upstream Invert Level **67.84** mOD	Downstream Invert Level **67.5** mOD
Upstream Soffit Level **66.34** mOD	Downstream Soffit Level **69** mOD
Upstream Design Flood Level 68.83 mOD	Downstream Design Flood Level **68.63** mOD

NOTES :

1. In line with OPW policy, section 50 approvals should be sought for bridges and culverts that are necessary for access or deemed acceptable by the planning authority. A copy of the notice of grant of planning permission with all conditions should be enclosed with all applications, that are not exempt development under the Planning and Development Act, 2000, as evidence that these factors have been considered.
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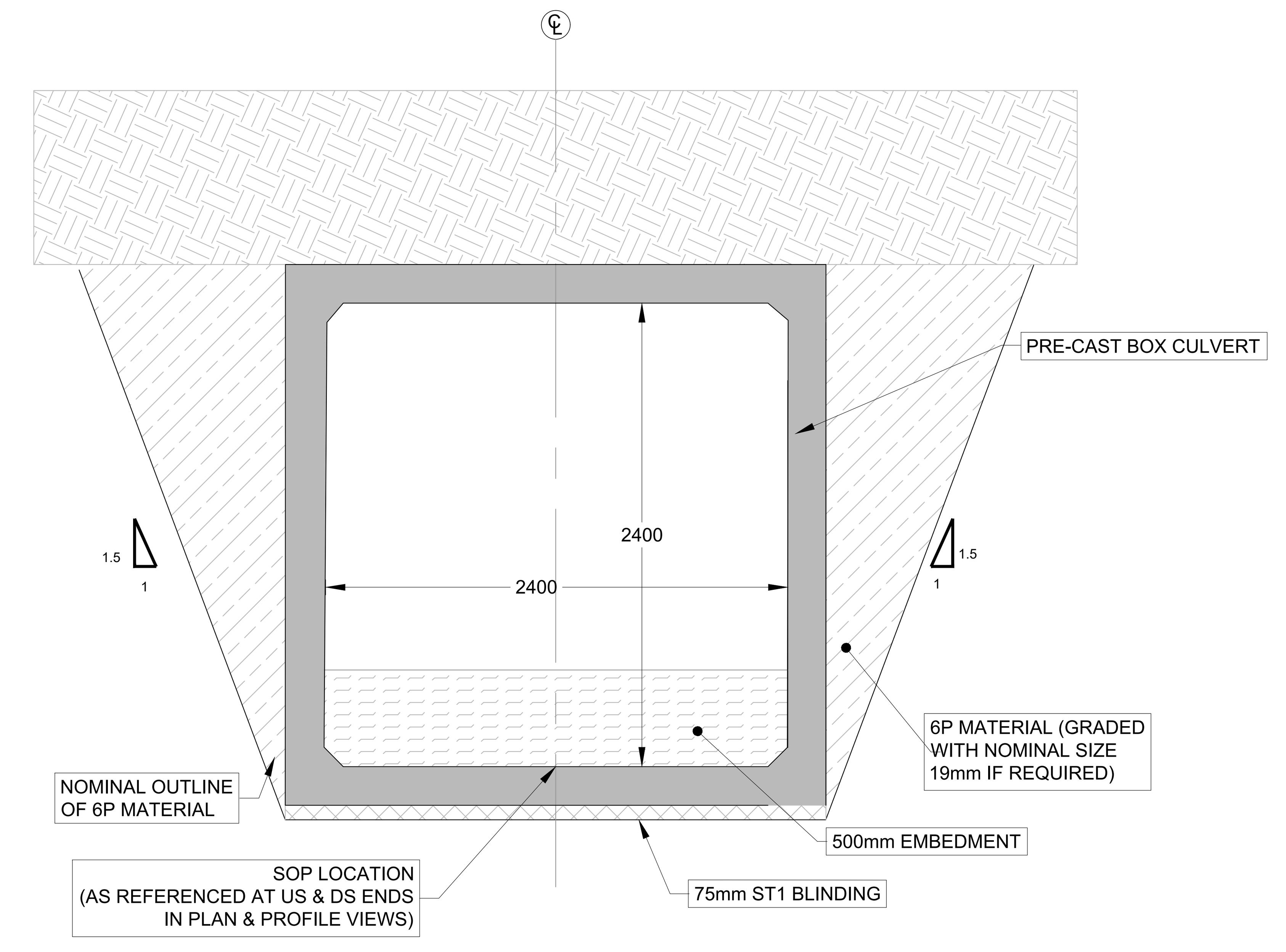
4. Effective conveyance area is from channel bed level to design flood level.
5. All levels must be given to Ordnance Datum, Malin Head.

If the application form is not completed correctly, and in its entirety, the application may be deemed invalid and returned for correction.

Appendix B
Culvert Plan and Section Detail



CULVERT 6A
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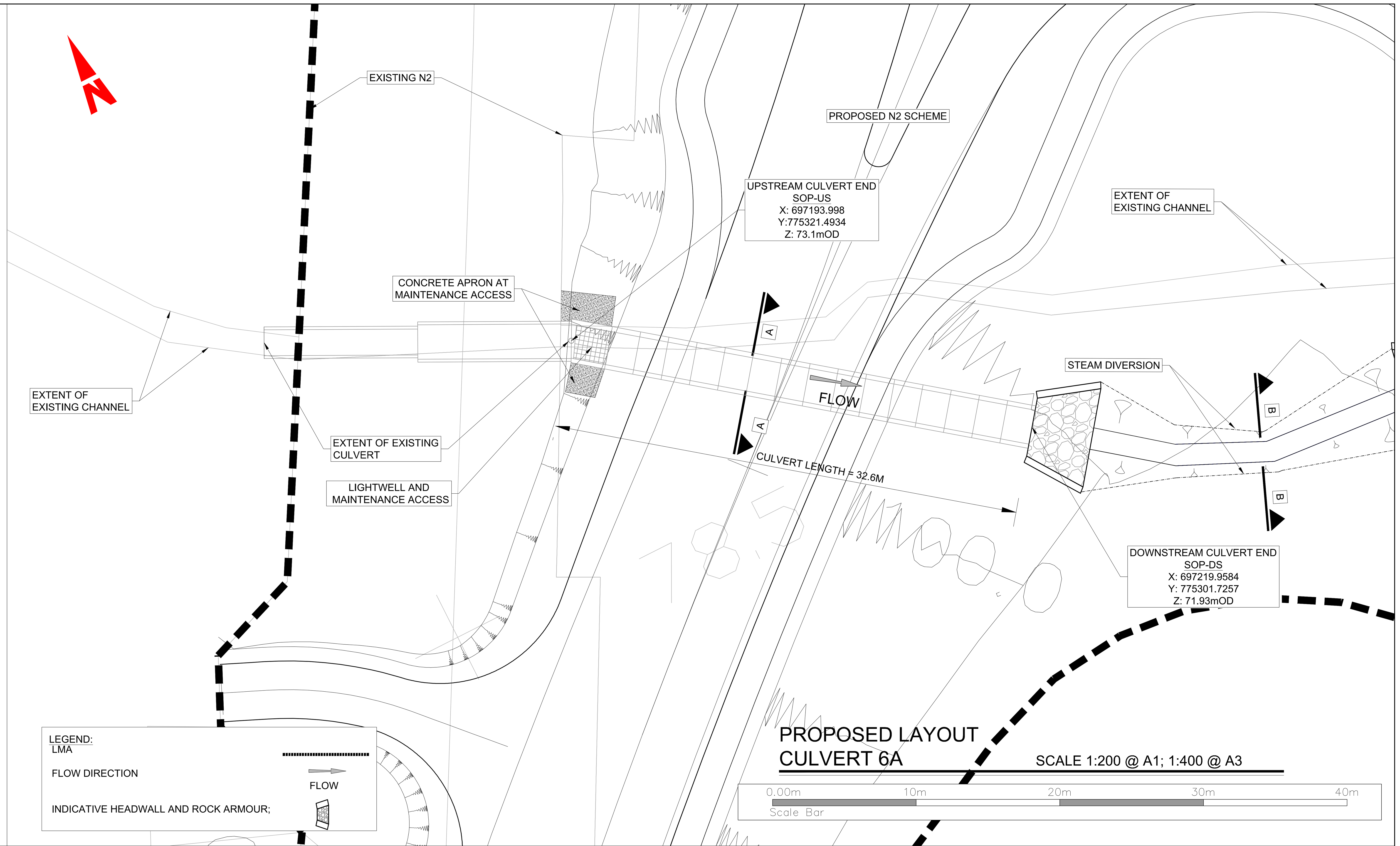
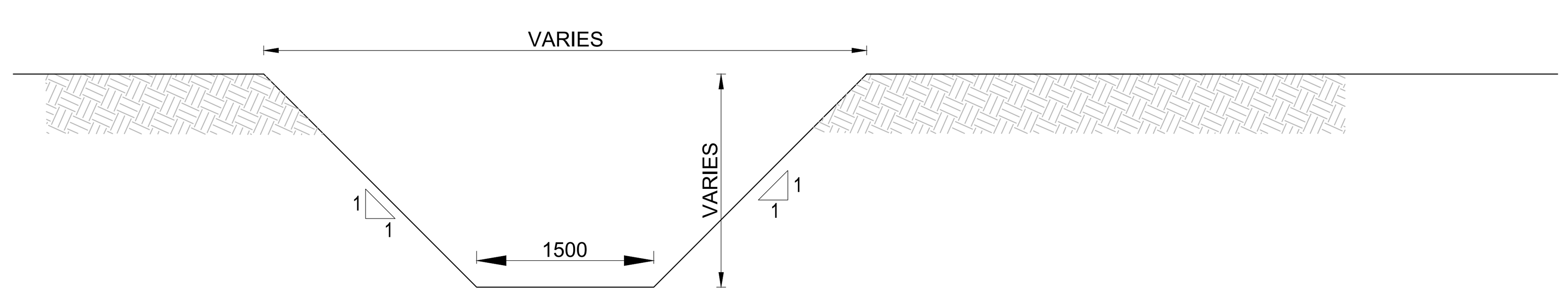


PROPOSED LAYOUT
CULVERT 6A SCALE 1:200 @ A1; 1:400 @ A3



STREAM DIVERSION
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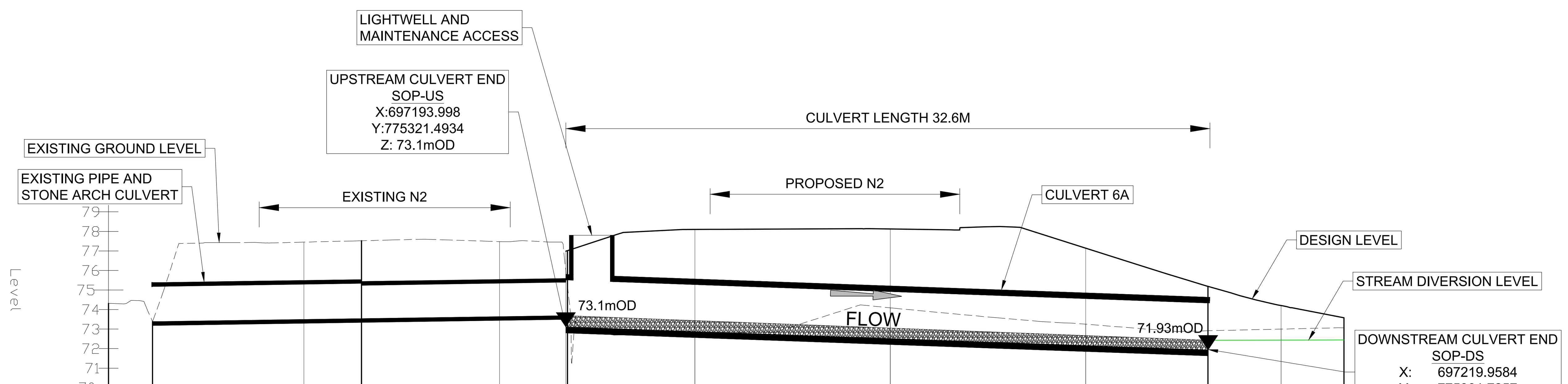

CHAINAGE	00.000	10.000	20.000	30.000	40.000	50.000	60.000	63.213
EXISTING LEVELS	74.317	77.452	77.478	72.764	74.085	73.250	73.000	73.062
PROPOSED LEVELS				78.103	78.122	77.138	74.206	73.582

LONGITUDINAL SECTION
CULVERT 6A SCALE 1:200 @A1 ; 1:400 @A3

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Client
TII Bonneagar Iompair Éireann Transport Infrastructure Ireland
An Roinn Iompair Department of Transport
comhairle chontae na mí meath county council

General Notes
(i) Hard copies, dwf and pdf will form a controlled issue of the drawing. All other formats (dwg etc.) are deemed to be an uncontrolled issue and any work carried out based on these files is at the recipients own risk. RPS will not accept any responsibility for any errors from the use of these files, either by human error by the recipient, listing of the un-dimensioned measurements, compatibility with the recipients software, and any errors arising when these files are used to aid the recipients drawing production, or setting out on site.
(ii) DO NOT SCALE, use figured dimensions only.
(iii) This drawing is the property of RPS, it is a project confidential classified document. It must not be copied used or its contents divulged without prior written consent. The needs and expectations of client and RPS must be considered when working with this drawing.
(iv) Information including topographical survey, geotechnical investigation and utility detail used in the design have been provided by others.
(v) All Levels refer to Ordnance Survey Datum, Malin Head.

Rev	Date	Drn Chk	Amendment / Issue	App
P01	15.07.21	MR PM	FOR APPROVAL	BL

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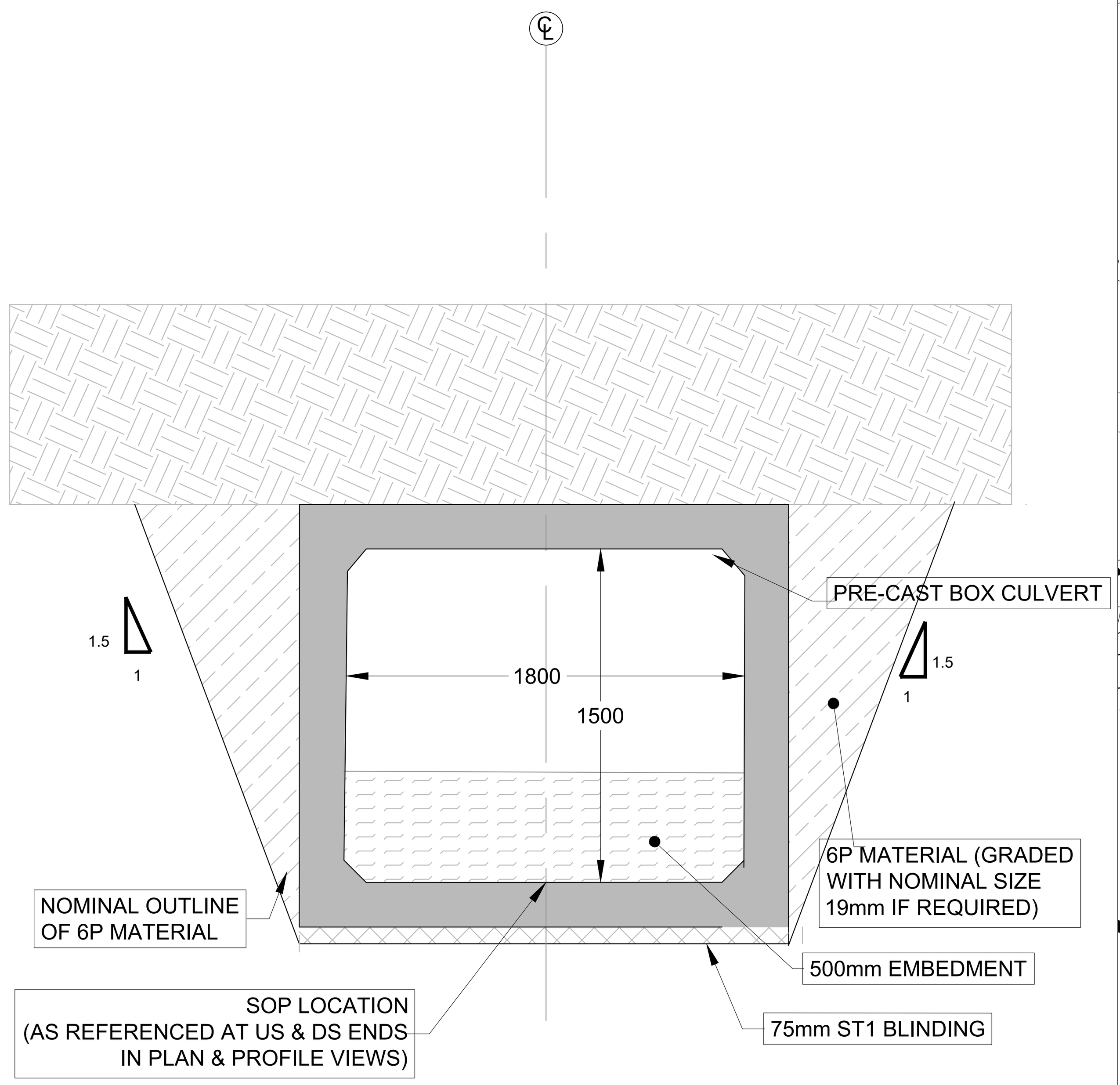
W www.rpsgroup.com/ireland
E ireland@rpsgroup.com

Scale AS SHOWN @ A1 AS SHOWN @ A3
Created on 04/06/2020
Sheets 1 of 2
Project **N2 SLANE BYPASS & PUBLIC REALM ENHANCEMENT**
Title CULVERTS 6A, 6B AND 6C LAYOUT PLAN
File Identifier MDT0806-RPS-01-N2-DR-C-DR0002.
Drawing Number DR0002-01
Status S3
Rev P01

C:\Users\michael.ruane\Desktop\Slane\MDT0806-RPS-01-N2-DR-C-DR0002.dwg



CULVERT 6B AND 6C
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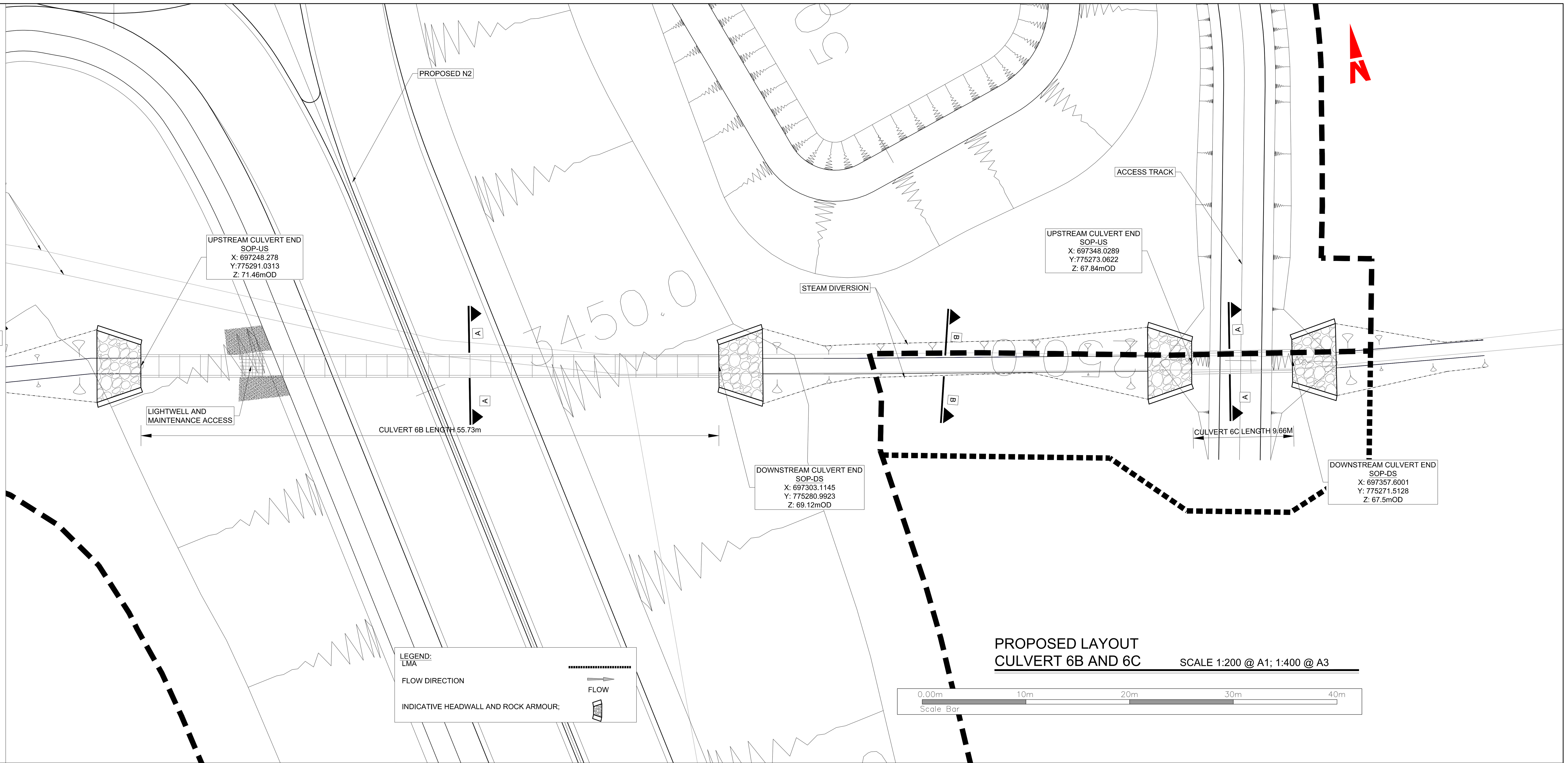
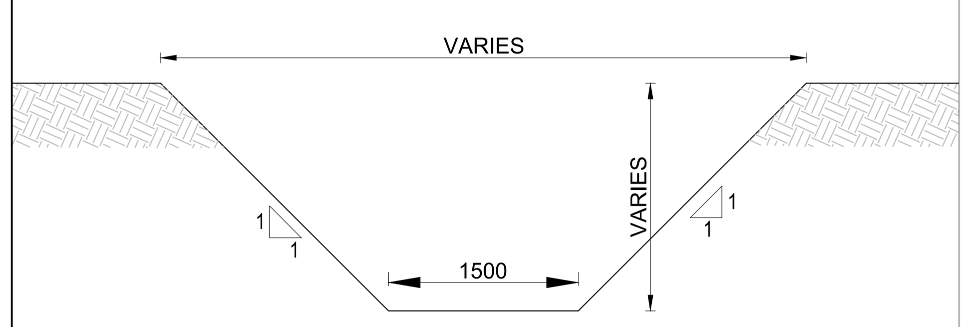
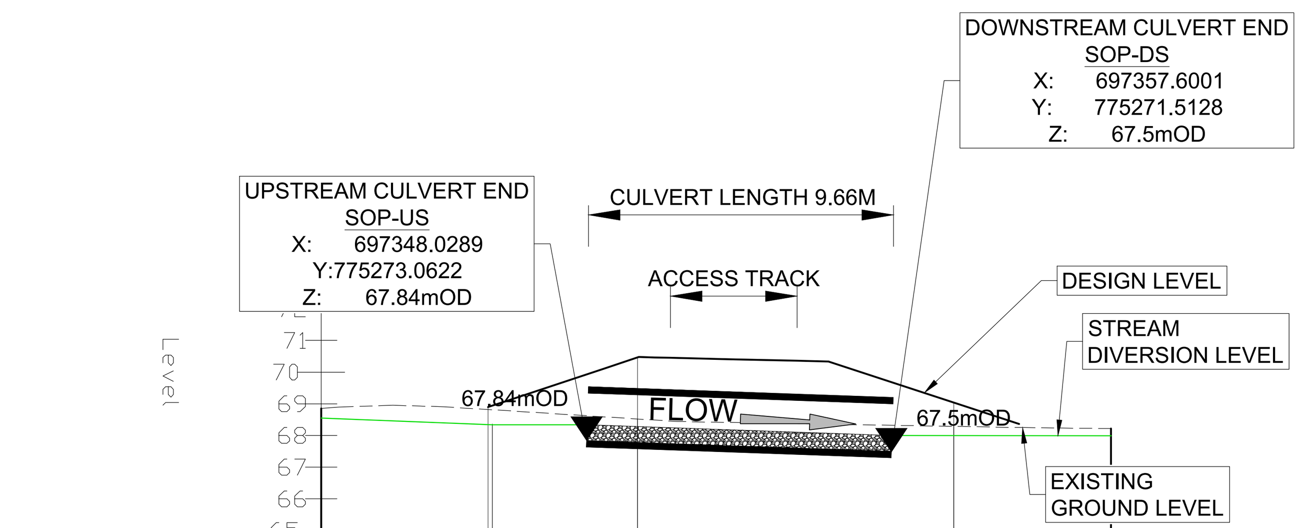


PROPOSED LAYOUT
CULVERT 6B AND 6C SCALE 1:200 @ A1; 1:400 @ A3

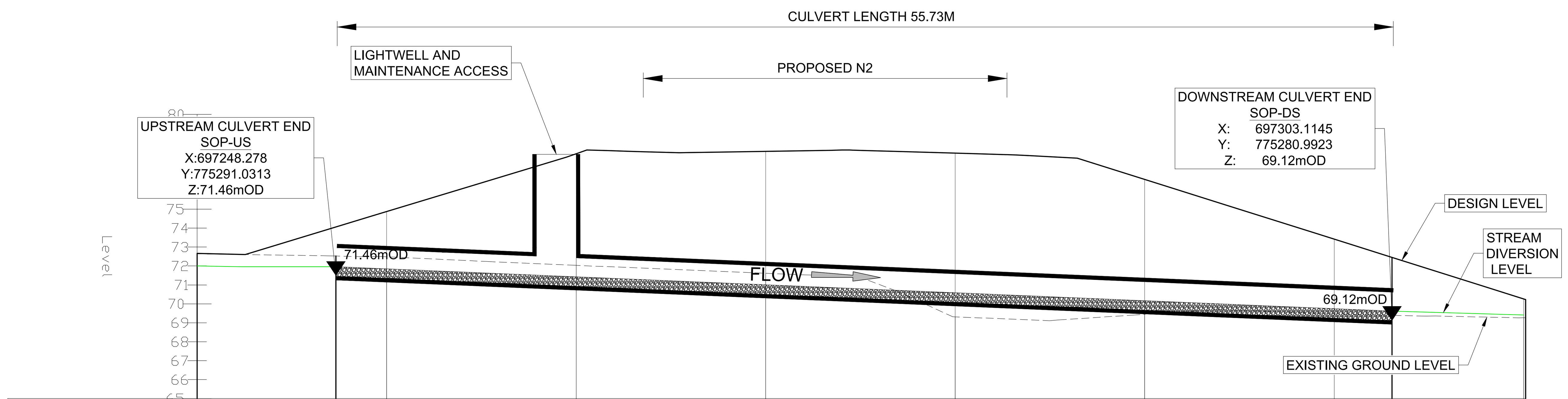


STREAM DIVERSION
CROSS SECTION B - B SCALE 1:50 @A1 ; 1:100 @A3



CHAINAGE	00.000	10.000	20.000	24.964
EXISTING LEVELS	68.855	68.521	68.287	68.216
PROPOSED LEVELS		70.463	69.038	

LONGITUDINAL SECTION
CULVERT 6C SCALE 1:200 @A1 ; 1:400 @A3



CHAINAGE	00.000	10.000	20.000	30.000	40.000	50.000	60.000	70.099 / 70.000
EXISTING LEVELS	72.639	72.485	72.033	71.617	69.315	69.453	69.478	69.266 / 69.269
PROPOSED LEVELS	72.667	74.875	77.924	78.051	77.955	76.569	73.416	70.230 / 70.261

LONGITUDINAL SECTION
CULVERT 6B SCALE 1:200 @A1 ; 1:400 @A3

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Client
TII Bonneagar Iompair Éireann Transport Infrastructure Ireland
An Roinn Iompair Department of Transport
comhairle chontae na mí meath county council

General Notes
(i) Hard copies, dwf and pdf will form a controlled issue of the drawing. All other formats (dwg etc.) are deemed to be an uncontrolled issue and any work carried out based on these files is at the recipients own risk. RPS will not accept any responsibility for any errors from the use of these files, either by human error by the recipient, listing of the un-dimensioned measurements, compatibility with the recipients software, and any errors arising when these files are used to aid the recipients drawing production, or setting out on site.
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(iv) Information including topographical survey, geotechnical investigation and utility detail used in the design have been provided by others.
(v) All Levels refer to Ordnance Survey Datum, Malin Head.

Rev	Date	Drn	Chk	Amendment / Issue	App
P01	15.07.21	MR	PM	FOR APPROVAL	BL

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W www.rpsgroup.com/ireland
E ireland@rpsgroup.com

Scale AS SHOWN @ A1 AS SHOWN @ A3
Created on 04/06/2020
Sheets 2 of 2

Project N2 SLANE BYPASS & PUBLIC REALM ENHANCEMENT
Title CULVERTS 6A, 6B AND 6C LAYOUT PLAN

File Identifier MDT0806-RPS-01-N2-DR-C-DR0002.
Drawing Number DR0002 -02
Status S3
Rev P01

C:\Users\michael.ruane\Desktop\Slane\MDT0806-RPS-01-N2-DR-C-DR0002.dwg

Appendix C
Hydraulic Model Results

Table C- 1 Proposed Permanent Works Scenario - 1% AEP w/out cc Predicted Peak Water Levels

River Section	Existing Scenario Section level (m AD)	Proposed Scenario Section level (m AD)	Difference +/- (mm)
0701_02754	16.639	16.639	0
0701_02753X	16.046	16.048	2
0701_02752	16.174	16.175	1
0701_02741	16.07	16.072	2
0701_02710	15.756	15.758	2
0701_02681	15.594	15.598	4
0701_02651	15.387	15.392	5
0701_02637	15.261	15.266	5
0701_02636X	15.177	15.182	5
0701_02636X-0701_02621	15.109	15.116	7
0701_02636X-0701_02621-0701_02621	15.051	15.058	7
0701_02621_3	14.978	14.986	8
0701_02619	14.779	14.789	10
0701_02596_5	14.198	14.22	22
0701_02591_3	14.086	14.125	39
0701_02591_3	14.086	14.125	39
0701_02591_3-0-0701_02552_3	13.951	14.001	50
0701_02591_3-1-0701_02552_3	13.884	13.938	54
0701_02591_3-2-0701_02552_3	13.775	13.817	42
0701_02552_3	13.727	13.688	-39
0701_02532	13.51	13.494	-16
0701_02517	13.084	13.084	0
0701_02502	12.924	12.923	-1
0701_02452_3	12.187	12.186	-1
0701_02428	11.852	11.852	0
0701_02405_3	11.3	11.3	0
0701_02374	11.175	11.175	0
0701_02345_3	10.463	10.463	0
0701_02315_5	9.448	9.448	0

Table C- 2 Proposed Permanent Works Scenario – 0.1% AEP w/out cc Predicted Peak Water Levels

River Section	Existing Scenario Section level (m AD)	Proposed Scenario Section level (m AD)	Difference +/- (mm)
0701_02754	16.979	16.979	0
0701_02753X	16.519	16.522	3
0701_02752	16.640	16.644	4
0701_02741	16.539	16.543	4
0701_02710	16.246	16.252	6
0701_02681	16.143	16.150	7
0701_02651	15.967	15.976	9

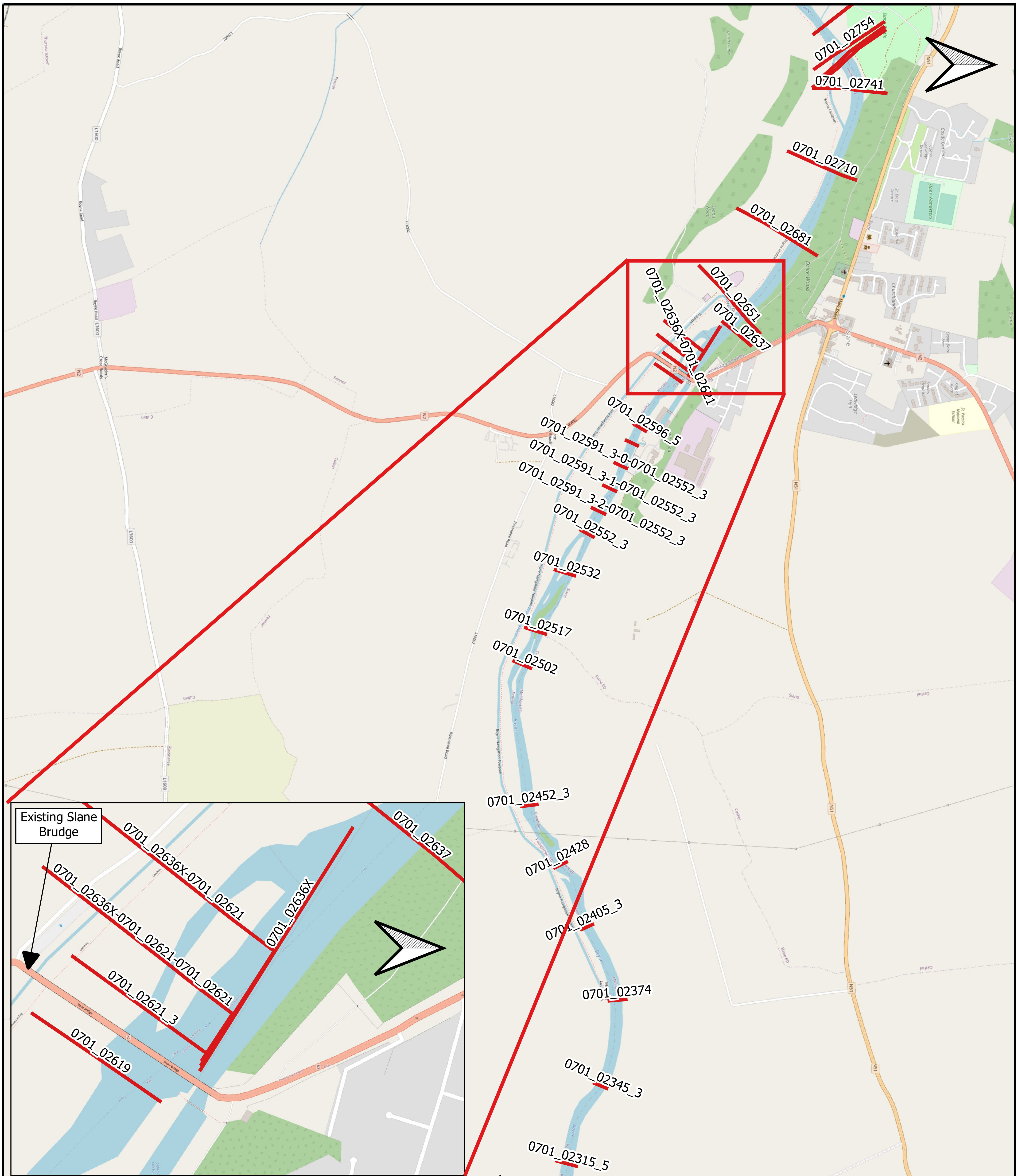
River Section	Existing Scenario Section level (m AD)	Proposed Scenario Section level (m AD)	Difference +/- (mm)
0701_02637	15.779	15.790	11
0701_02636X	15.707	15.718	11
0701_02636X-0701_02621	15.648	15.661	13
0701_02636X-0701_02621-0701_02621	15.595	15.608	13
0701_02621_3	15.519	15.533	14
0701_02619	15.262	15.278	16
0701_02596_5	14.690	14.721	31
0701_02591_3	14.589	14.634	45
0701_02591_3	14.589	14.634	45
0701_02591_3-0-0701_02552_3	14.480	14.530	50
0701_02591_3-1-0701_02552_3	14.416	14.468	52
0701_02591_3-2-0701_02552_3	14.313	14.345	32
0701_02552_3	14.260	14.219	-41
0701_02532	14.035	14.011	-24
0701_02517	13.600	13.601	1
0701_02502	13.449	13.451	2
0701_02452_3	12.738	12.735	-3
0701_02428	12.325	12.325	0
0701_02405_3	11.768	11.768	0
0701_02374	11.579	11.579	0
0701_02345_3	10.912	10.912	0
0701_02315_5	9.832	9.832	0

Table C- 3 Proposed Temporary Works Scenario - 1% AEP w/out cc Predicted Peak Water Levels

River Section	Existing Scenario Section level (m AD)	Proposed Scenario Section level (m AD)	Difference +/- (mm)
0701_02754	16.639	16.639	0
0701_02753X	16.046	16.05	4
0701_02752	16.174	16.178	4
0701_02741	16.07	16.074	4
0701_02710	15.756	15.763	7
0701_02681	15.594	15.605	11
0701_02651	15.387	15.402	15
0701_02637	15.261	15.274	13
0701_02636X	15.177	15.191	14
0701_02636X-0701_02621	15.109	15.126	17
0701_02636X-0701_02621-0701_02621	15.051	15.069	18
0701_02621_3	14.978	14.999	21
0701_02619	14.779	14.805	26
0701_02596_5	14.198	14.251	53

River Section	Existing Scenario Section level (m AD)	Proposed Scenario Section level (m AD)	Difference +/- (mm)
0701_02591_3	14.086	14.156	70
0701_02591_3	14.086	14.156	70
0701_02591_3-0-0701_02552_3	13.951	14.036	85
0701_02591_3-1-0701_02552_3	13.884	13.974	90
0701_02591_3-2-0701_02552_3	13.775	13.786	11
0701_02552_3	13.727	13.653	-74
0701_02532	13.51	13.49	-20
0701_02517	13.084	13.081	-3
0701_02502	12.924	12.921	-3
0701_02452_3	12.187	12.195	8
0701_02428	11.852	11.853	1
0701_02405_3	11.3	11.3	0
0701_02374	11.175	11.175	0
0701_02345_3	10.463	10.463	0
0701_02315_5	9.448	9.448	0

Appendix D
Predicted Flood Maps



Legend

Modelled Cross Section Locations

Project	N2 Slane Bypass
Title	Cross Section Locations

Issue Details

Drawn: VMcA		**Project:**	MDT0806
Checked: UM		**File Ref:**	MDT0806G0001
Approved: UM			
Scale: 1:5000	@ A4	**Projection:**	Irish Grid / IG
Date: 03/06/2022			

Client

Meath County Council

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Legend

- Flood Extent Mapping Anomaly
- 1% AEP Predicted Flood Extent - Existing Scenario
- 0.1% AEP Predicted Flood Extent - Existing Scenario

Project	N2 Slane Bypass
Title	1% & 0.1% AEP Predicted Flood Extents - Existing Scenario

Issue Details

Drawn:	VMcA	**Project:**	MDT0806
Checked:	UM	**File Ref:**	
Approved:	UM		MDT0806G0002
Scale:	**1:5000** @ A4	**Projection:**	
Date:	03/06/2022		Irish Grid / IG

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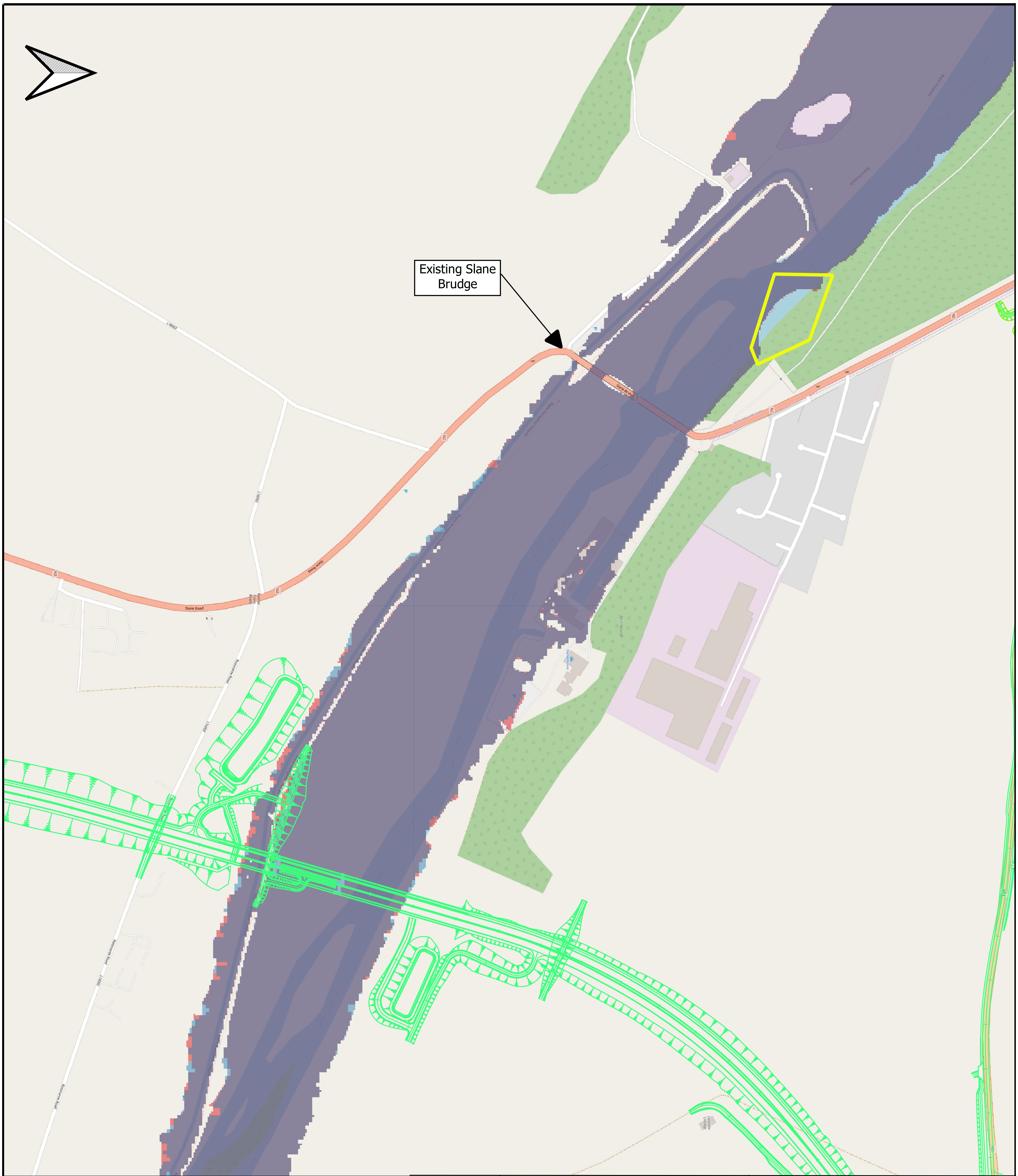

Legend

- Flood Extent Mapping Anomaly
- Permanent Works Extents
- 1% AEP Predicted Flood Extent - Existing Scenario
- 1% AEP Predicted Flood Extent - Permanent Scenario

Project	N2 Slane Bypass
Title	1% AEP Predicted Flood Extents - Permanent Works

Issue Details

Drawn:	VMcA	Project:	MDT0806
Checked:	UM	File Ref:	MDT0806G0003
Approved:	UM		
Scale:	1:5000 @ A4	Projection:	Irish Grid / IG
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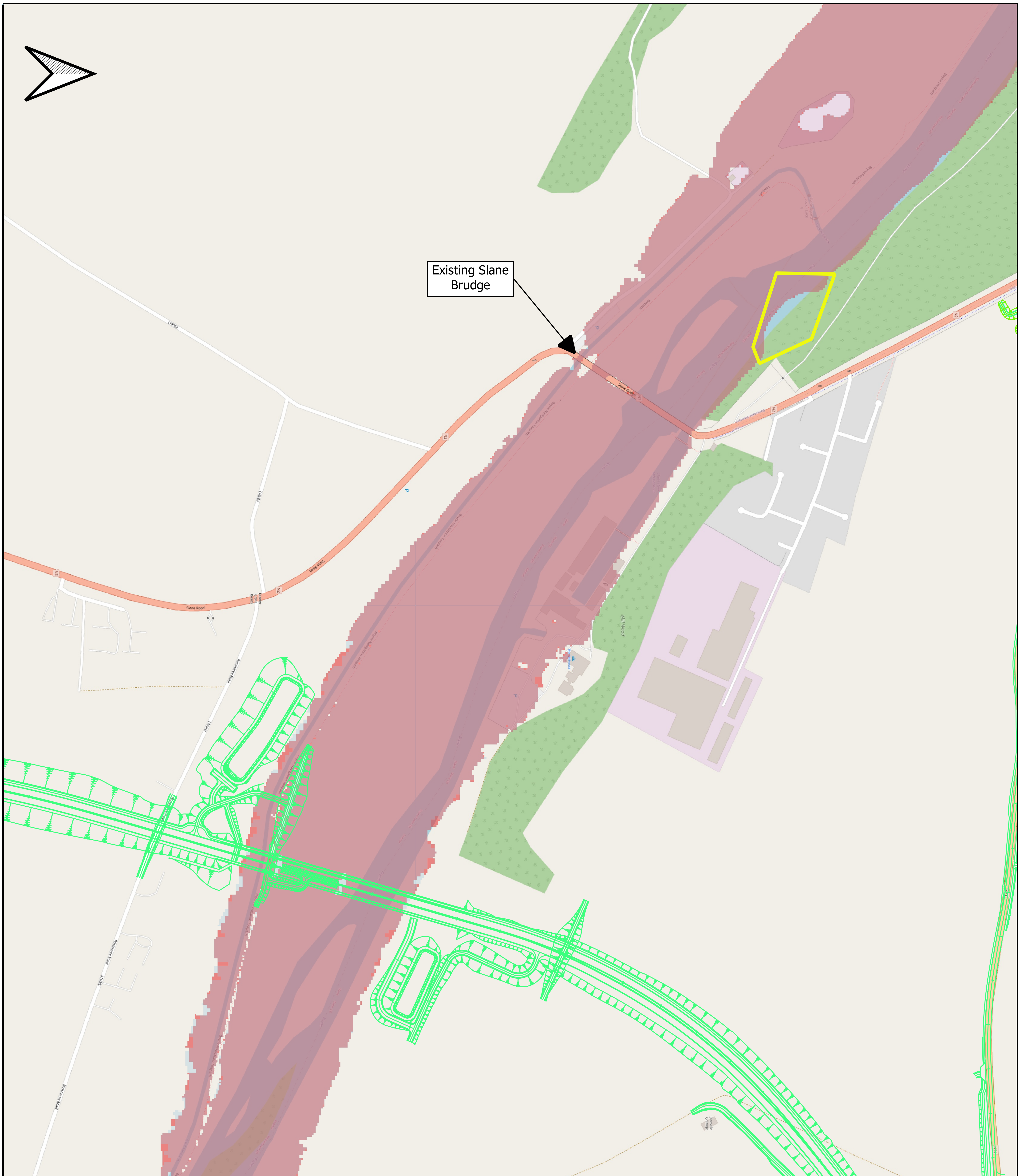

Legend

- Flood Extent Mapping Anomaly
- Permanent Works Extents
- 0.1% AEP Predicted Flood Extent - Existing Scenario
- 0.1% AEP Predicted Flood Extent - Permanent Scenario

Project	N2 Slane Bypass		
Title	0.1% AEP Predicted Flood Extents - Permanent Works		
Issue Details			
Drawn:	VMcA	**Project:**	MDT0806
Checked:	UM	**File Ref:**	
Approved:	UM		MDT0806G0004
Scale:	1:5000 @ A4	**Projection:**	
Date:	07/12/2022		Irish Grid / IG

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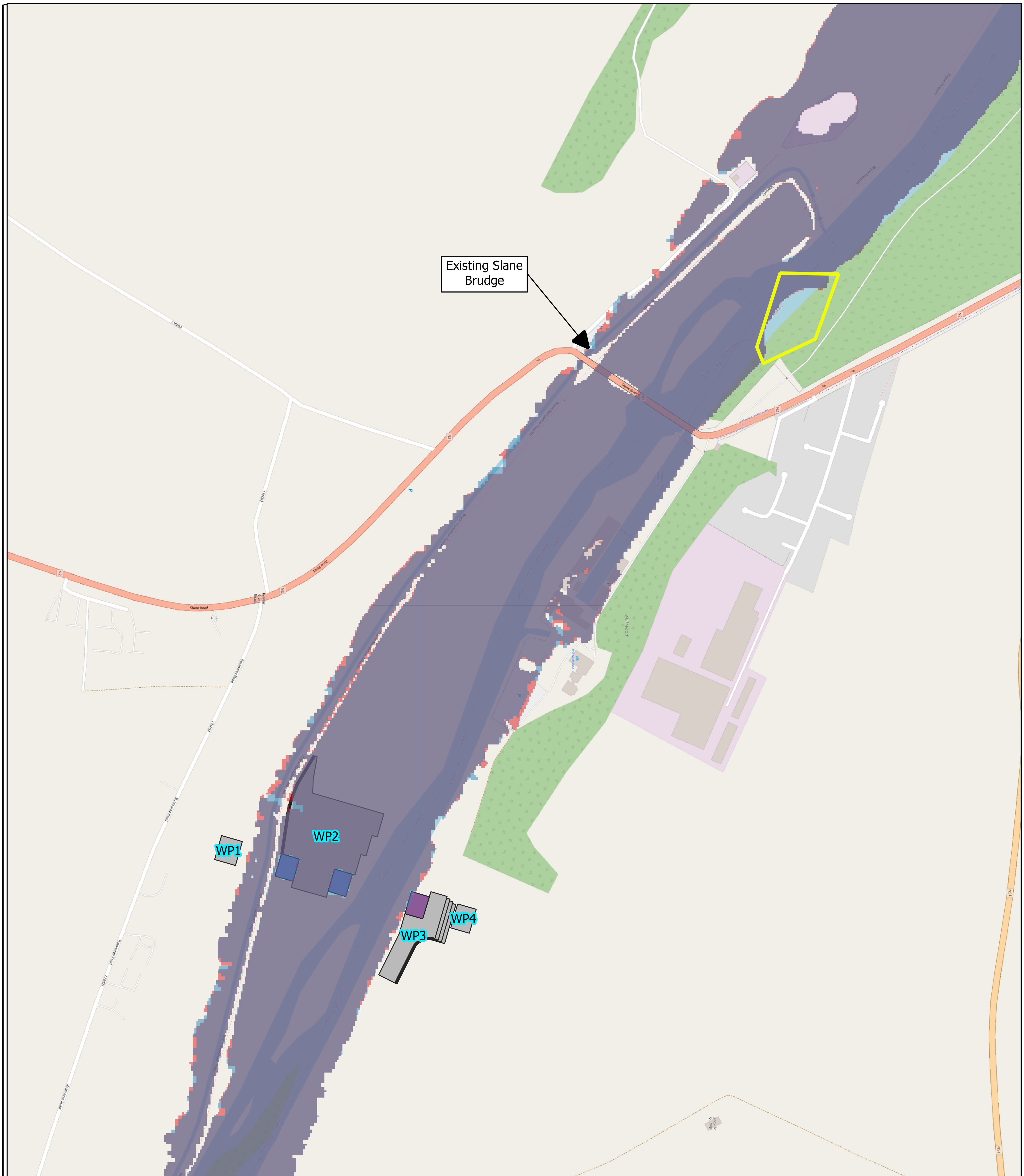

Legend

- Flood Extent Mapping Anomaly
- Temporary Works Platforms
- Cofferdams
- 1% AEP Predicted Flood Extent - Existing Scenario
- 1% AEP Predicted Flood Extent - Temporary Scenario

Project	N2 Slane Bypass
Title	1% AEP Predicted Flood Extents - Temporary Works

Issue Details

Drawn:	VMcA	Project:	MDT0806
Checked:	UM	File Ref:	MDT0806G0005
Approved:	UM		
Scale:	1:5000 @ A4	Projection:	Irish Grid / IG
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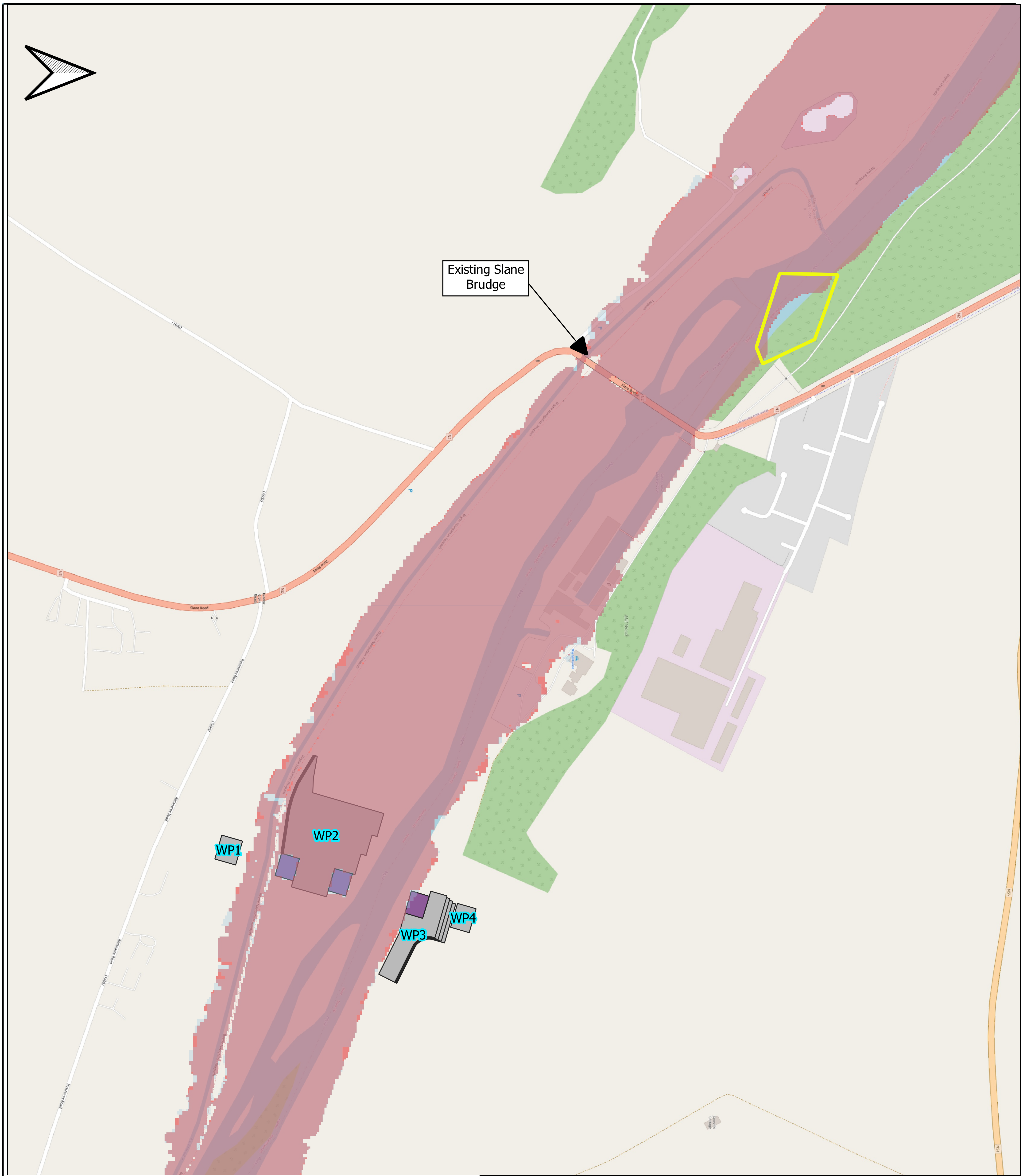

Legend

- Flood Extent Mapping Anomaly
- Temporary Works Platforms
- Cofferdams
- 0.1% AEP Predicted Flood Extent - Existing Scenario
- 0.1% AEP Predicted Flood Extent - Temporary Scenario

Project: **N2 Slane Bypass**

Title: 0.1% AEP Predicted Flood Extents - Temporary Works

Issue Details

Drawn:	VMcA	**Project:**	MDT0806
Checked:	UM	**File Ref:**	MDT0806G0006
Approved:	UM		
Scale: 1:5000	@ A4	**Projection:**	Irish Grid / IG
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