Appendix 8

Appendices

Appendix 8.1 Reference Tables

Appendix 8.1 Reference Tables

Appendix 8.1

8.1 Reference Tables

Construction Dust

Table A.1 Determination of Dust Raising Magnitude (IAQM)

Source	Large	Medium	Small
Demolition	Total building volume > 50,000m^3, potentially dusty construction material (e.g. concrete), on site crushing and screening, demolition activities > 20m above ground	Total building volume 20,000m^3 - 50,000m^3, potentially dusty construction material, demolition activities 10-20m above ground level	Total building volume <20,000m^3, construction material with low potential for dust release (e.g .metal cladding or timber), demolition activities <10m above ground, demolition during wetter months
Earthworks	Total site area >10,000m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry to due small particle size), >10 heavy earth moving vehicles active at any one time, formation of bunds >8m in height, total material moved >100,000 tonnes	Total site area 2,500m^2 – 10,000m^2, moderately dusty soil type (e.g. silt), 5-10 heavy earth moving vehicles active at any one time, formation of bunds 4m – 8m in height, total material moved 20,000 tonne – 100,000 tonne	Total site area <2,500m^2, soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4m in height, total material moved <10,000tonne, earthworks during wetter months
Construction	Total building volume >100,000m^3, piling, on site concrete batching; sandblasting	Total building volume 25,000m^3 – 100,000m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching	Total building volume <25,000m^3, construction material with low potential for dust release (e.g. metal cladding or timber)
Track out	>100 HDV (>3.5t) trips in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length >100m	25-100 HDV (>3.5t) trips in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50m – 100m	<25 HDV (>3.5t) trips in any one day, surface material with low potential for dust release, unpaved road length <50m

Table A.2 Receptor Sensitivity

Source	High	Medium	Low
Sensitivities of people to dust soiling effects	Users can reasonably expect an enjoyment of a high level of amenity; or The appearance, aesthetics or value of their property would be diminished by soiling; and the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Indicative examples include dwellings, museums and other culturally important collections, medium and long term car parks (**See note B**) and car showrooms.	Users would expect a to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or The appearance, aesthetics or value of their property could be diminished by soiling; or The people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Indicative examples include parks and places of work.	The enjoyment of amenity would not reasonably be expected (**See note A**); or Property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or There is transient exposure, where the people or Property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Indicative examples include playing fields, farmland (unless commercially-

Source	High	Medium	Low
			sensitive horticultural), footpaths, short term car parks (**See note B**) and roads.
Sensitivities of people to the health effects of PM_{10}	Locations where members of the public are exposed over a time period relevant to the air quality standard for PM_{10} (in the case of the 24-hour standards, a relevant location would be one where individuals may be exposed for eight hours or more in a day) Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purposes of this assessment.	Locations where the people exposed are workers (**See note C**), and exposure is over a time period relevant to the air quality standard for PM10 (in the case of the 24-hour standards, a relevant location would be one where individuals may be exposed for eight hours or more in a day). Indicative examples include office and shop workers, but will generally not include workers occupationally exposed to PM_{10}, as protection is covered by occupational health legislation.	Locations where human exposure is transient (**See note D)** Indicative examples include public footpaths, playing fields, parks and shopping streets.
Sensitivities of receptors to ecological effects (**See note E**)	Locations with an international or national designation and the designated features may be affected by dust soiling; or Locations where there is a community of a particularly dust sensitive species such as vascular species. Indicative examples include a Special Area of Conservation (SAC) designated for acid heathlands or a local site designated for lichens adjacent to the demolition of a large site containing concrete (alkali) buildings.	Locations where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown; or • Locations with a national designation where the features may be affected by dust deposition.	Locations with a local designation where the features may be affected by dust deposition.

Notes:

(A) The public's expectations will vary depending on the existing dust deposition in the area

(B) Car parks can have a range of sensitivities depending on the duration and frequency that people would be expected to park their cars there, and the level of amenity they could reasonably expect whilst doing so. Car parks associated with work place or residential parking might have a high level of sensitivity compared to car parks used less frequently and for shorter durations, such as those associated with shopping. Cases should be examined on their own merits.

(C) Notwithstanding the fact that the air quality standards and limit values do not apply to people in the workplace, such people can be affected to exposure of PM_{10}. However, they are considered to be less sensitive than the general public as a whole because those most sensitive to the effects of air pollution, such as young children are not normally workers. For this reason workers have been included in the medium sensitivity category.

(D) There are no standards that apply to short-term exposure, e.g. one or two hours, but there is still a risk of health effects, albeit less certain.

(E) A Habitat Regulation Assessment of the site may be required as part of the planning process, if the site lies close to an internationally designated site i.e. Special Conservation Areas (SACs), Special Protection Areas (SPAs) designated under the Habitats Directive (92/43/EEC) and RAMSAR sites.

Table A.3 Sensitivity of the area to dust soiling effects on people and property

Receptor Sensitivity	Number of Receptors	Distance from the source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low

Receptor Sensitivity	Number of Receptors	Distance from the source (m)			
		<20	<50	<100	<350
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

Table A.4 Sensitivity of the area to human health effects

Receptor Sensitivity	Annual Mean PM_{10} Concentration	Number of Receptors	Distance from the source (m)				
			<20	<50	<100	<200	<350
High	>32 µg/m^3	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32 µg/m^3	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28 µg/m^3	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24µg/m^3	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>32 µg/m^3	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	28-32 µg/m^3	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	24-28 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<24µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Table A.5 Sensitivity of the area to ecological effects

Receptor Sensitivity	Distance from the source (m)	
	<20	<50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Table A.6 Risk of Dust Effects - Demolition

Sensitivity of Area	Dust Emissions Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Low Risk

Table A.7 Risk of Dust Effects - Earthworks

Sensitivity of Area	Dust Emissions Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table A.8 Risk of Dust Effects - Construction

Sensitivity of Area	Dust Emissions Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table A.9 Risk of Dust Effects – Trackout

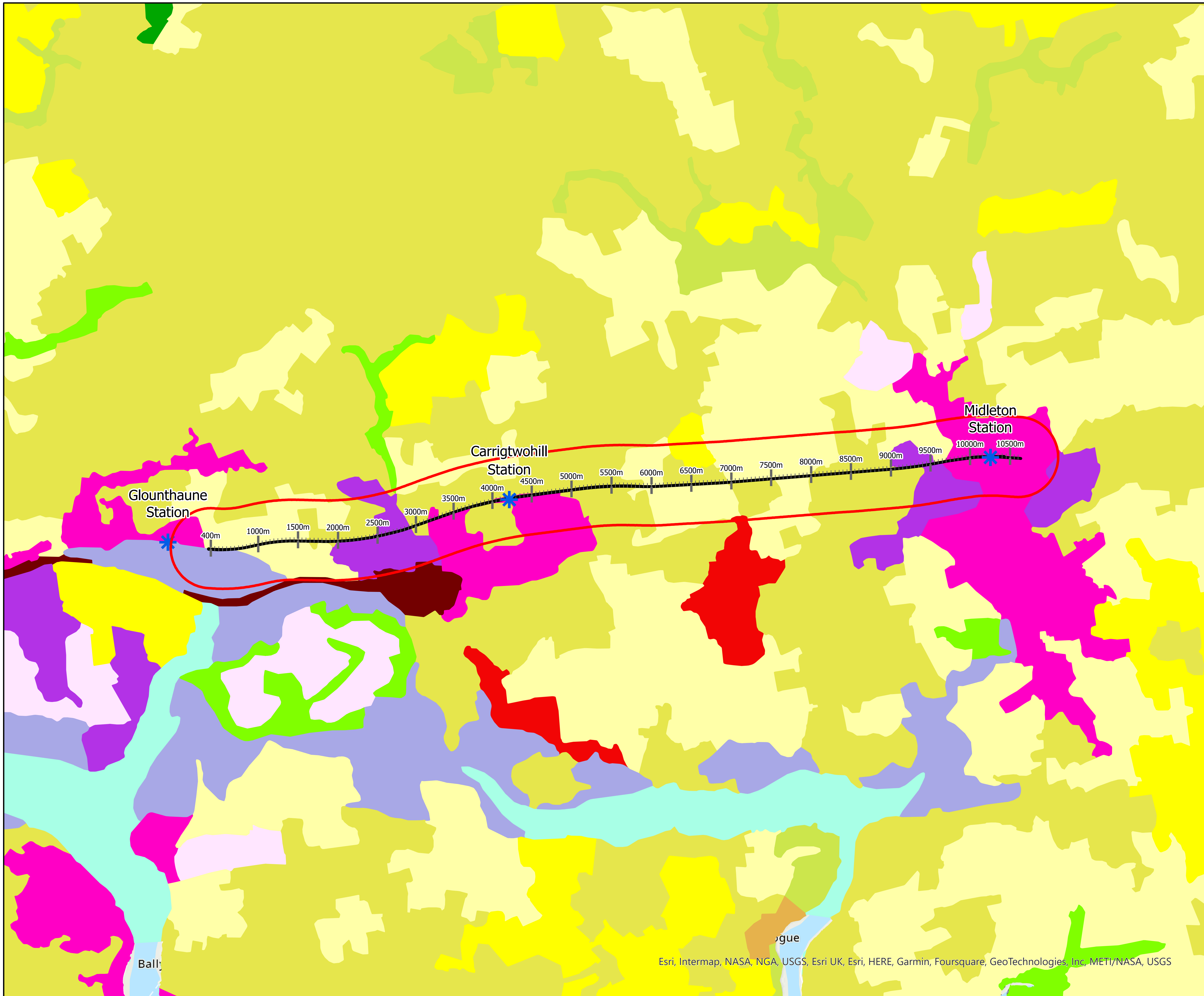
Sensitivity of Area	Dust Emissions Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

Appendix 10

Appendices

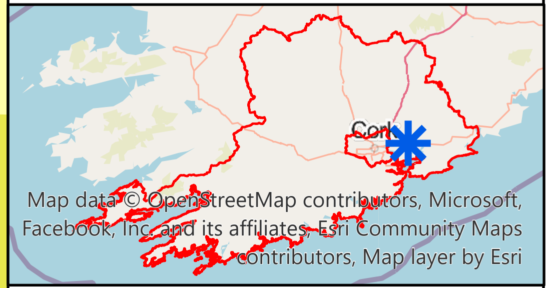
Appendix 10.1 Figures

Appendix 10.1 Figures



0 1,500 3,000 m

Location Map



Key Symbols

- Rail Station
- Rail Track
- 500m Buffer

Corine Landcover Type

- 112 Discontinuous urban fabric
- 121 Industrial or commercial units
- 122 Road and rail networks
- 131 Mineral extraction sites
- 142 Sport and leisure facilities
- 211 Non-irrigated land
- 231 Pastures
- 242 Complex cultivation patterns
- 243 Land principally occupied by agriculture with areas of natural vegetation
- 311 Broad-leaved forest
- 312 Coniferous forest
- 313 Mixed forest
- 423 Intertidal flats
- 522 Estuaries
- 523

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	31/08/2022	XW	Information	ET	LMcM

M M MOTT MACDONALD

South Block
Rockfield, Dundrum
Dublin 16
D16 R6V0
Ireland
T +353 (0)1 291 6700
W www.mottmac.ie

Client

Iarnród Éireann Irish Rail

Title

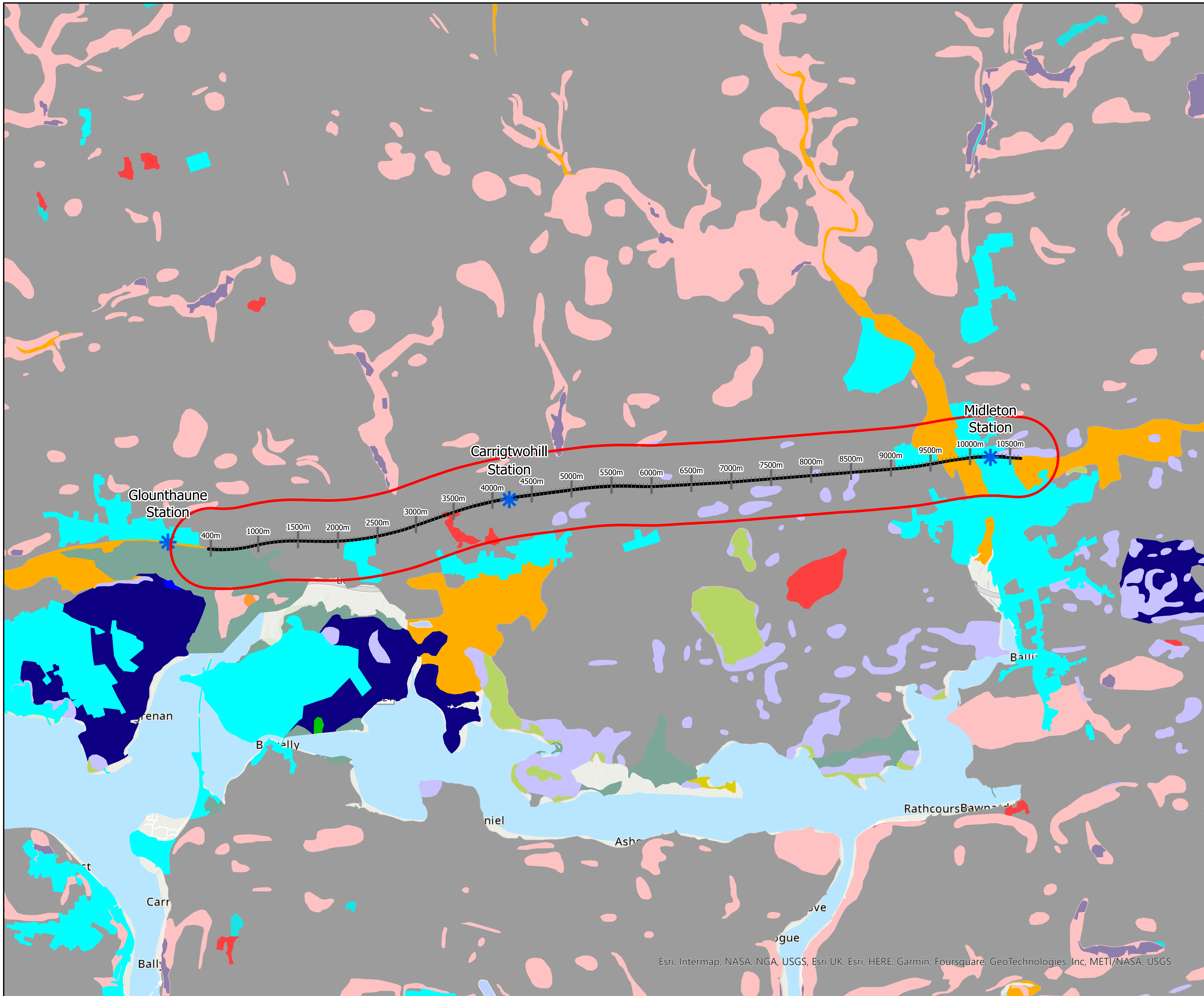
Glounthaune to Midleton Twin Track

Corine Landuse Map

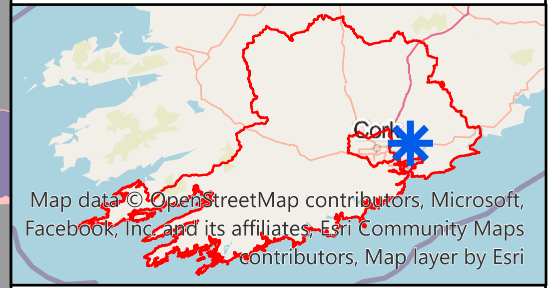
Designed	X Wan	Eng Check	L McMillan
Drawn	X Wan	Coordination	L McMillan
GIS Check	E Tiri	Approved	L McMillan

Scale at A3	Status	Rev	Security
1:40000	PRE	P1	STD

Drawing Number
229101063-MMD-00-XX-GIS-C-0001



Location Map



Key Symbols

- Rail Station
- Rail Track
- 500m Buffer

Soil Type

- AlluvMIN - Mineral alluvium
- AminDW - Acid Brown Earths / Brown Podzolics
- AminPD - Surface water Gleys / Ground water Gleys Acidic
- AminPDPT - Peaty Gleys Acidic
- AminSP - Surface water Gleys / Ground water Gleys Shallow
- AminSRPT - Podzols Peaty
- AminSW - Lithosols / Regosols
- BminDW - Grey Brown Podzolics / Brown Earths Basic
- BminPD - Surface water Gleys / Ground water Gleys Basic
- BminPDPT - Peaty Gleys Basic Parent Materials Basic
- BminSRPT - Lithosols Peats
- BminSW - Renzinas / Lithosols
- Made
- MarSands
- MarSed
- Water

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	31/08/2022	XW	Information	ET	LMcM

MOTT MACDONALD
South Block
Rockfield, Dundrum
Dublin 16
D16 R6V0
Ireland
T +353 (0)1 291 6700
W www.mottmac.ie

Client

Iarnród Éireann Irish Rail

Title

Glounthaune to Midleton Twin Track

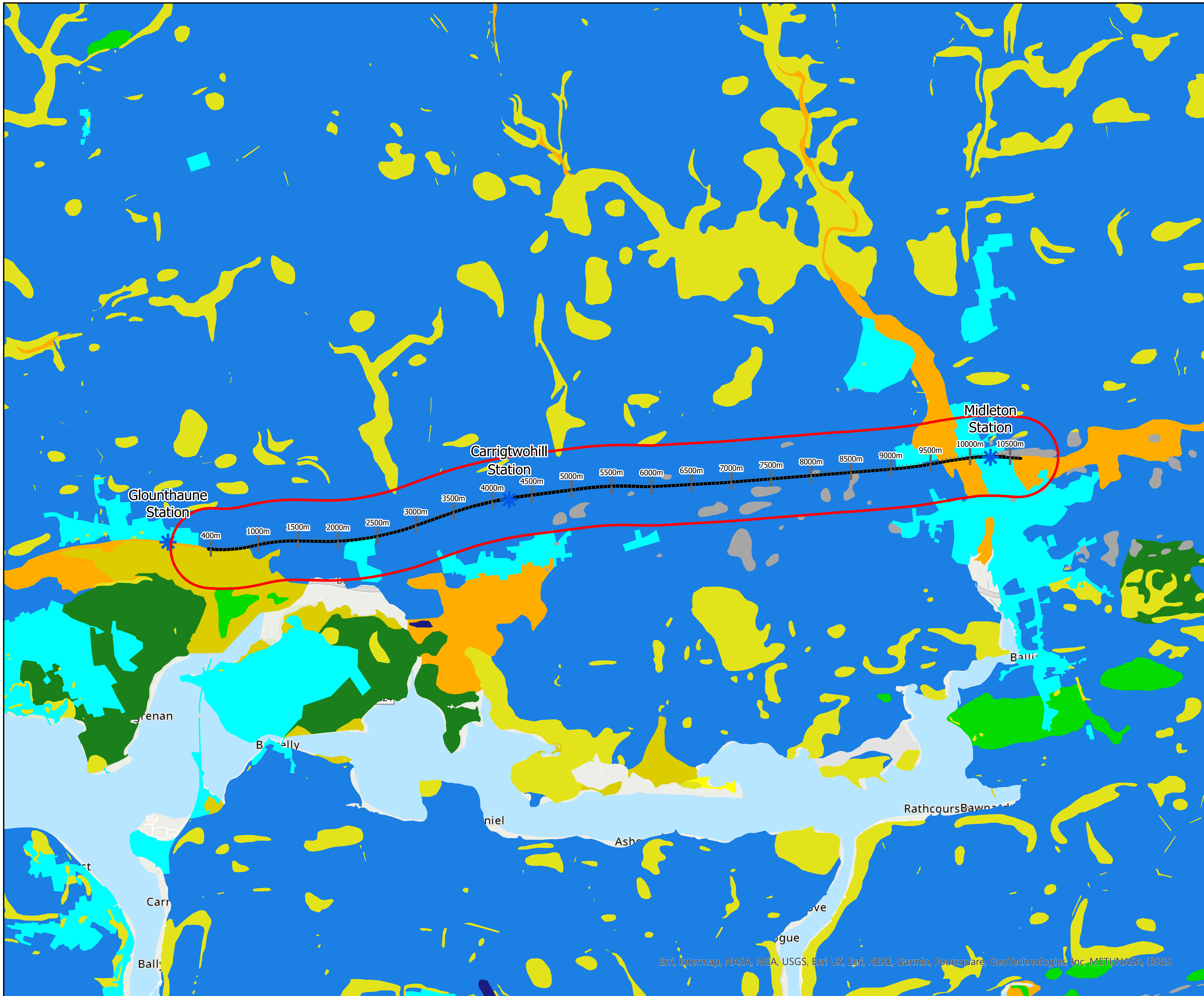
EPA Soil Map

Designed	X Wan	Eng Check	L McMillan
Drawn	X Wan	Coordination	L McMillan
GIS Check	E Tiri	Approved	L McMillan

Scale at A3	Status	Rev	Security
1:40000	PRE	P1	STD

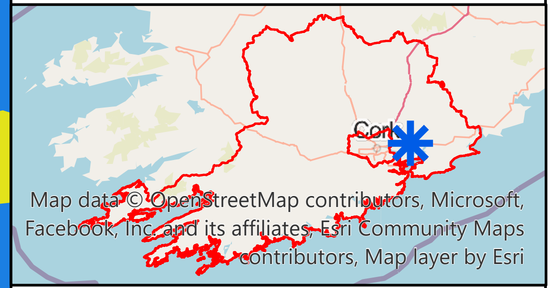
0 1,500 3,000 m

Drawing Number
229101063-MMD-00-XX-GIS-C-0002



0 1,500 3,000 m

Location Map



Key Symbols

- Rail Station
- Rail Track
- 500m Buffer

Subsoil Type

- A - Alluvium undifferentiated gravelly
- GDSs - Sandstone sands and gravels Devonian"
- KaRck - Karstified limestone bedrock at surface
- MGs - Raised beach sands and gravels
- Made ground
- Mesc - Estuarine sediments (silts/clays)
- Msi - Marine silts
- Rck - Bedrock at surface
- TDSs - Sandstone till Devonian
- TLs - Limestone till Carboniferous
- Water

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	31/08/2022	XW	Information	ET	LMcM

MOTT MACDONALD

South Block
Rockfield, Dundrum
Dublin 16
D16 R6V0
Ireland
T +353 (0)1 291 6700
W www.mottmac.ie

Client

Iarnród Éireann
Irish Rail

Title

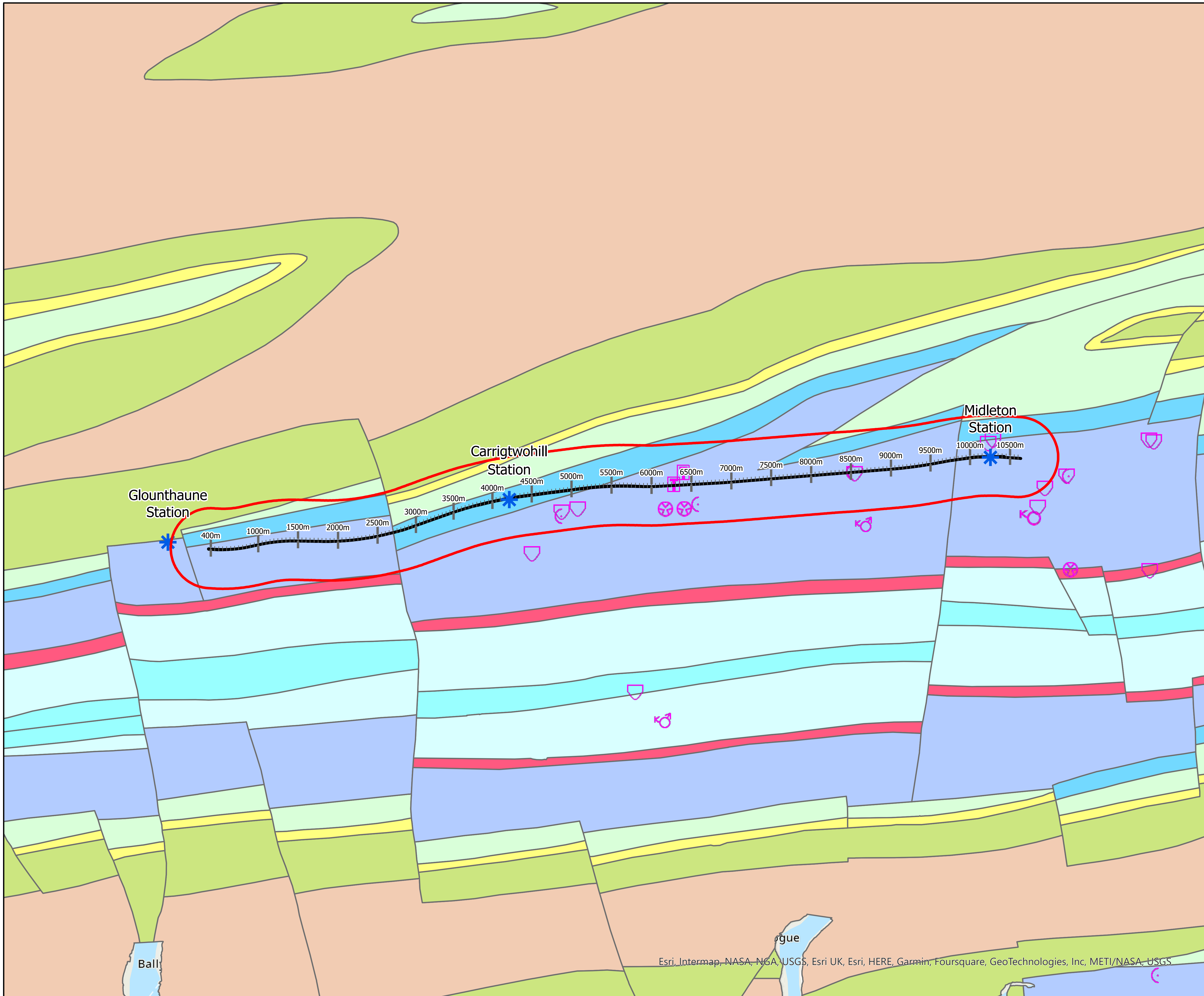
Glounthaune to Midleton Twin Track

EPA Subsoil Map

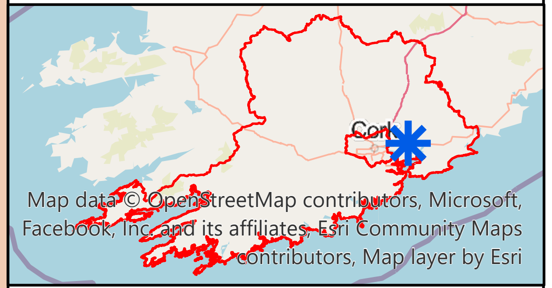
Designed	X Wan	Eng Check	L McMillan
Drawn	X Wan	Coordination	L McMillan
GIS Check	E Tiri	Approved	L McMillan

Scale at A3	Status	Rev	Security
1:40000	PRE	P1	STD

Drawing Number
229101063-MMD-00-XX-GIS-C-0003



Location Map



Key Symbols

Rail Station
Rail Track
500m Buffer

Karst Feature Types
Borehole
Cave
Enclosed Depression
Spring
Swallow Hole
Turlough

Bedrock Layers
Ballysteen Formation
Clashavodig Formation
Cork Red Marble Formation
Cuskinny Member (Kinsale Formation)
Little Island Formation
Waulsortian Limestones
Ballytrasna Formation
Gyleen Formation
Old Head Sandstone Formation

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	31/08/2022	XW	Information	ET	LMcM

MOTT MACDONALD

South Block
Rockfield, Dundrum
Dublin 16
D16 R6V0
Ireland
T +353 (0)1 291 6700
W www.mottmac.ie

Client

Iarnród Éireann
Irish Rail

Title

Glounthaune to Midleton Twin Track

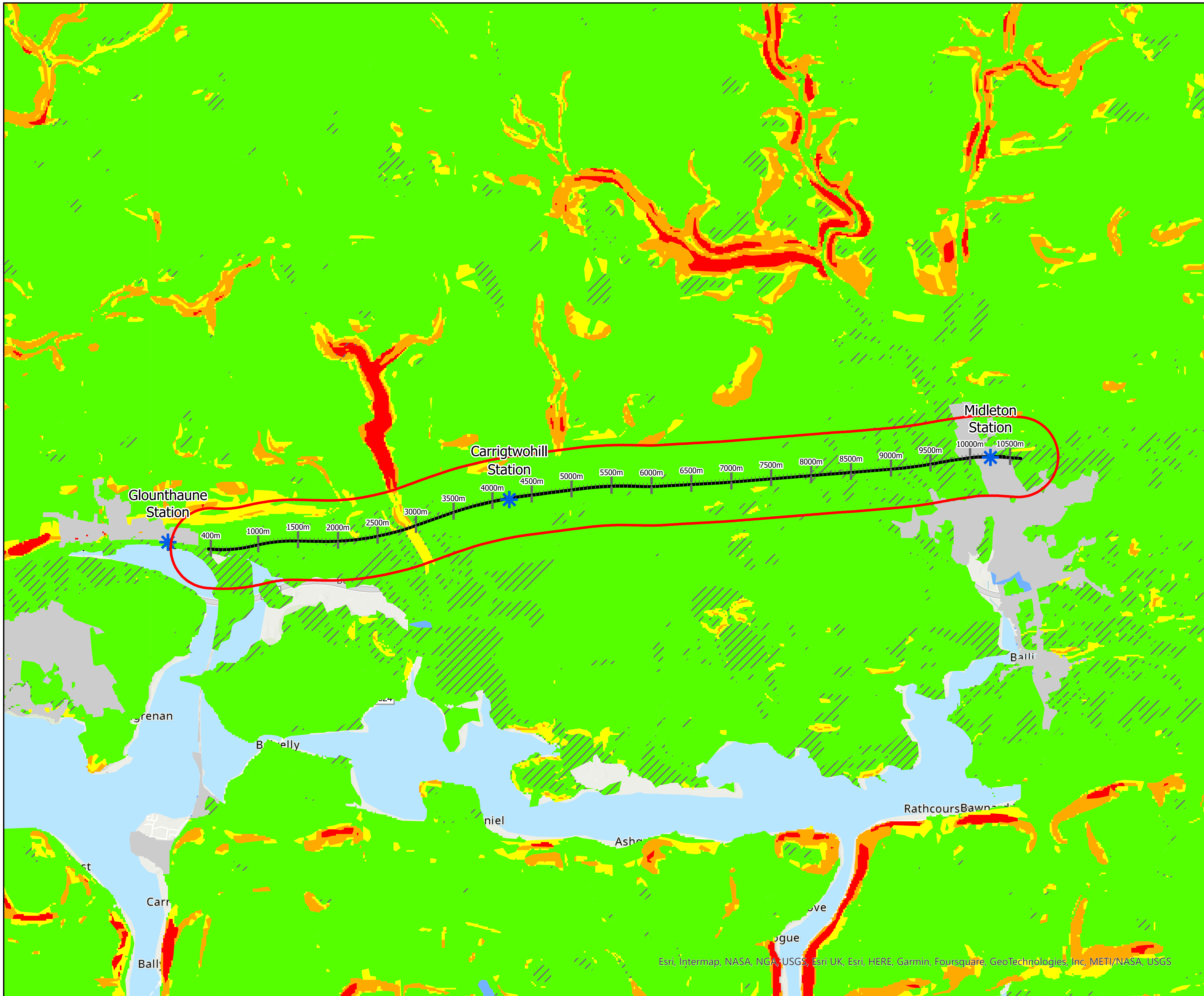
Bedrock and Karst Features

Designed	X Wan	Eng Check	L McMillan
Drawn	X Wan	Coordination	L McMillan
GIS Check	E Tiri	Approved	L McMillan

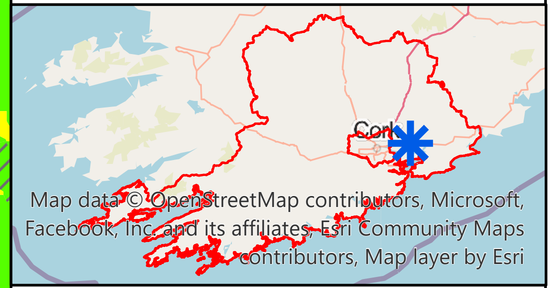
Scale at A3	Status	Rev	Security
1:40000	PRE	P1	STD

Drawing Number
229101063-MMD-00-XX-GIS-C-0004

0 1,500 3,000 m



Location Map



Key Symbols

- Rail Station
- Rail Track
- 500m Buffer

Landslide Susceptibility

- Low
- Low (inferred)
- Moderately Low
- Moderately Low (inferred)
- Moderately High
- High
- High (inferred)
- Made
- Water

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	31/08/2022	XW	Information	ET	LMcM

MOTT MACDONALD
South Block
Rockfield, Dundrum
Dublin 16
D16 R6V0
Ireland
T +353 (0)1 291 6700
W www.mottmac.ie

Client

Iarnród Éireann Irish Rail

Title

Glounthaune to Midleton Twin Track

Landslide Susceptibility

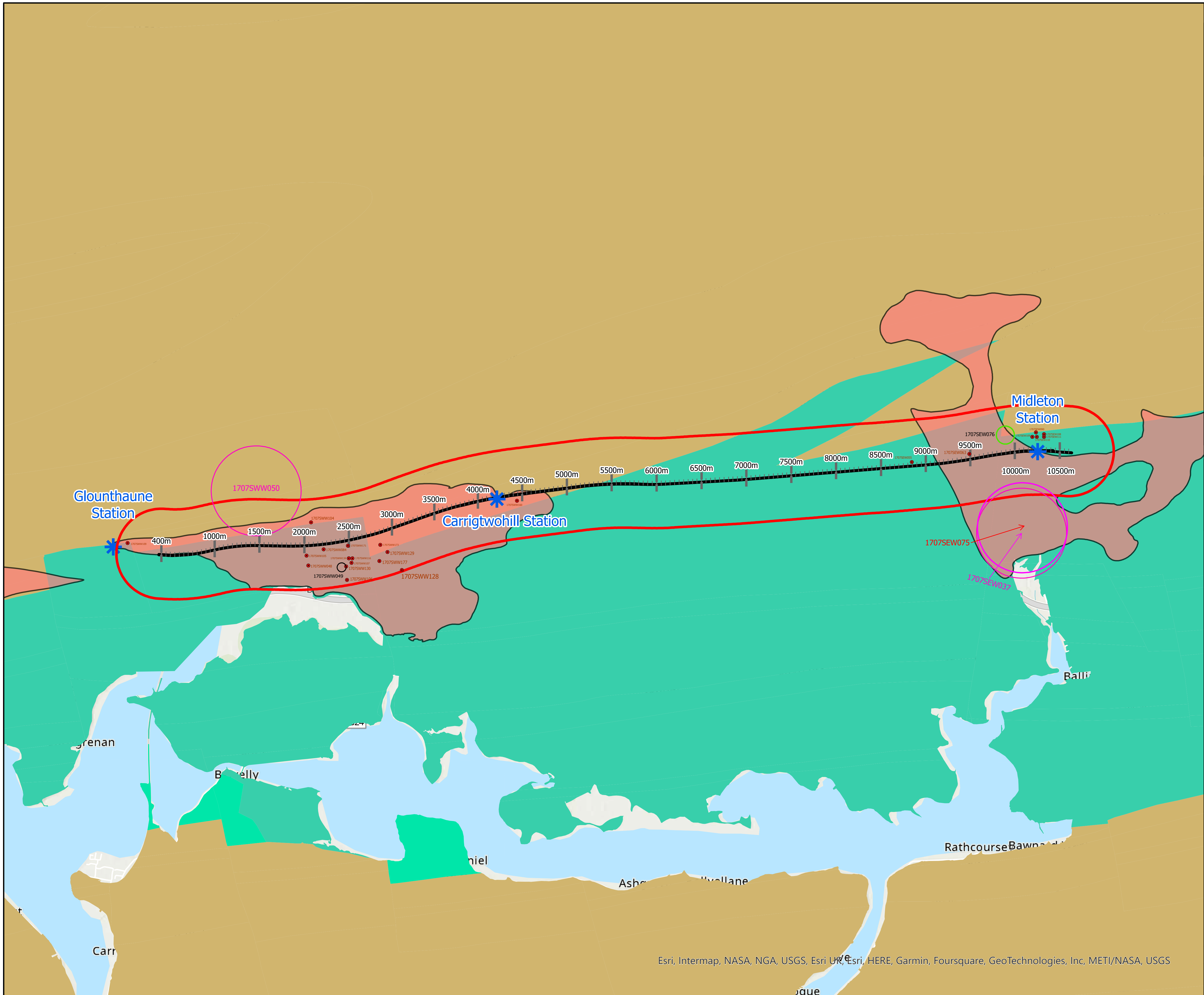
Designed	X Wan	Eng Check	L McMillan
Drawn	X Wan	Coordination	L McMillan
GIS Check	E Tiri	Approved	L McMillan

Scale at A3	Status	Rev	Security
1:40000	PRE	P1	STD

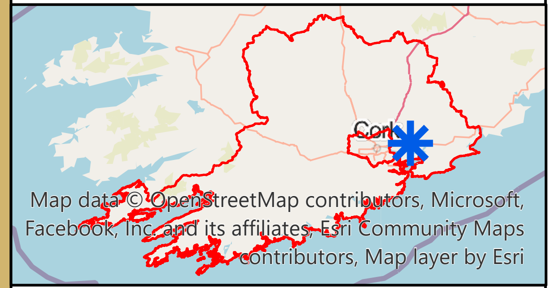
0 1,500 3,000 m

Drawing Number

229101063-MMD-00-XX-GIS-C-0005



Location Map



Key Symbols

- Rail Station
- Rail Track
- Well 10 to 50
- Wells 100 to 50B
- Wells 1km to 500B
- Wells 200 to 100B
- 500m Buffer

Groundwater Bedrock Aquifers Types

- Lk - Locally Important Aquifer - Karstified
- Ll - Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- Rkd - Regionally Important Aquifer - Karstified (diffuse)

Sand and Gravel Aquifer

- Locally important gravel aquifer

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd
01	31/08/2022	XW	Information	ET	LMcM

MOTT MACDONALD
South Block
Rockfield, Dundrum
Dublin 16
D16 R6V0
Ireland
T +353 (0)1 291 6700
W www.mottmac.ie

Client

Iarnród Éireann Irish Rail

Title

Glounthaune to Midleton Twin Track

Aquifer and Well Locations

Designed	X Wan	Eng Check	L McMillan
Drawn	X Wan	Coordination	L McMillan
GIS Check	E Tiri	Approved	L McMillan

Scale at A3	Status	Rev	Security
1:40000	PRE	P1	STD

Drawing Number

229101063-MMD-00-XX-GIS-C-0006

0 1,500 3,000 m

Appendix 11

Appendices

Appendix 11.1 Flood Maps, Culvert Modelling, River Ownenacurra Bridge
Appendix 11.2 Flood Risk Assessment Stage 1
Appendix 11.3 Flood Risk Assessment Stage 3

Appendix 11.1 Flood Maps, Culvert Modelling, River Ownenacurra Bridge

Appendix 11.1

A.	Flood Maps	2
B.	IDA and UBY2A culvert modelling	6
C.	River Owennacurra Bridge	8

A. Flood Maps

A.1 Coastal flooding

Figure A.1: 0.5% AEP Flood Risk Map (CFRAM)

Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

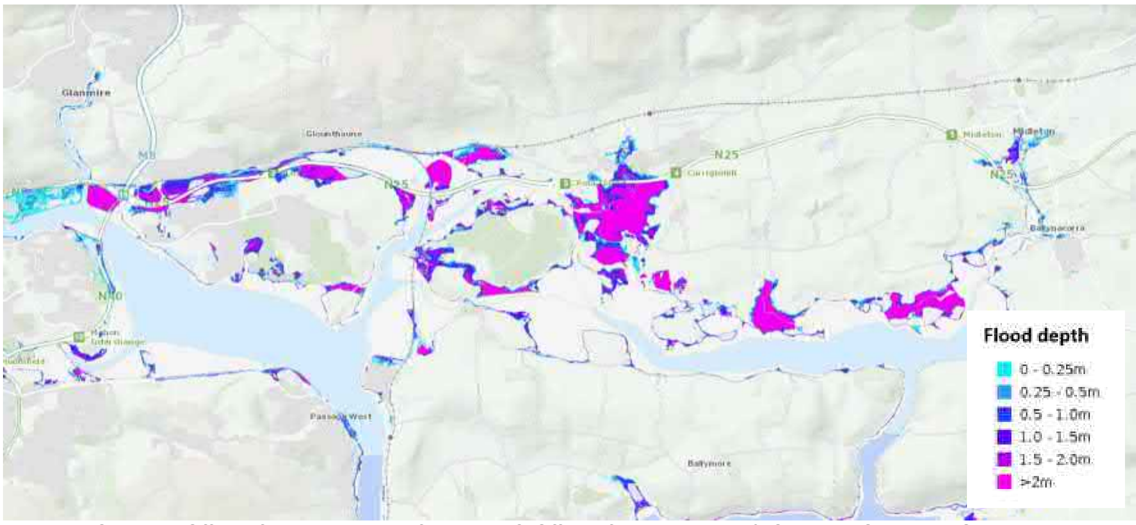
Figure A.2: 10% AEP Flood Risk Map (CFRAM)

Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

Figure A.3: Coastal flooding – flood extent (CFRAM)

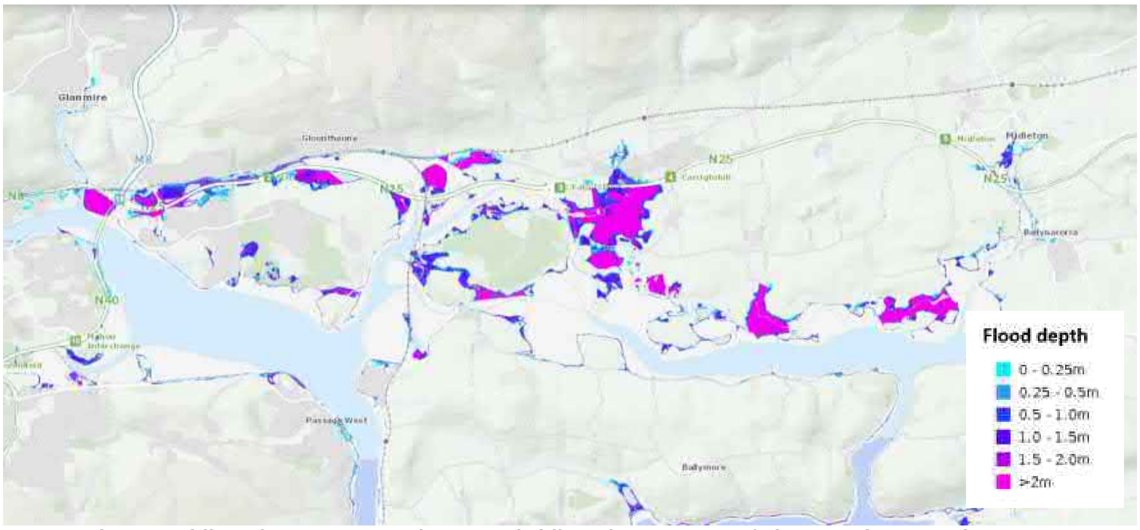
Source: CFRAM, 2012

Figure A.4: 0.5% AEP Flood Depths (Coastal Flood Hazard)



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

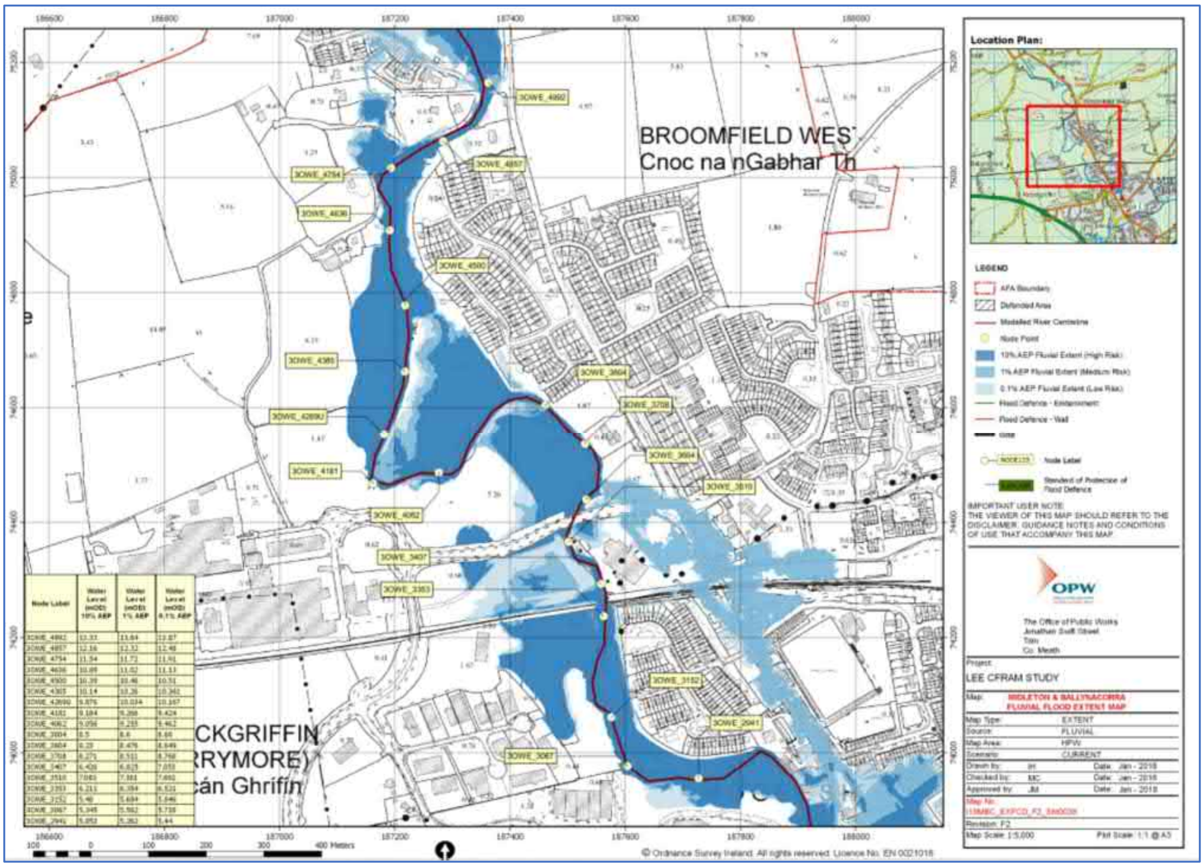
Figure A.5: 10% AEP Flood Depths (Coastal Flood Hazard)



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

A.2 Fluvial flooding

Figure A.6: CFRAM study – fluvial flood extent map – Midleton



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

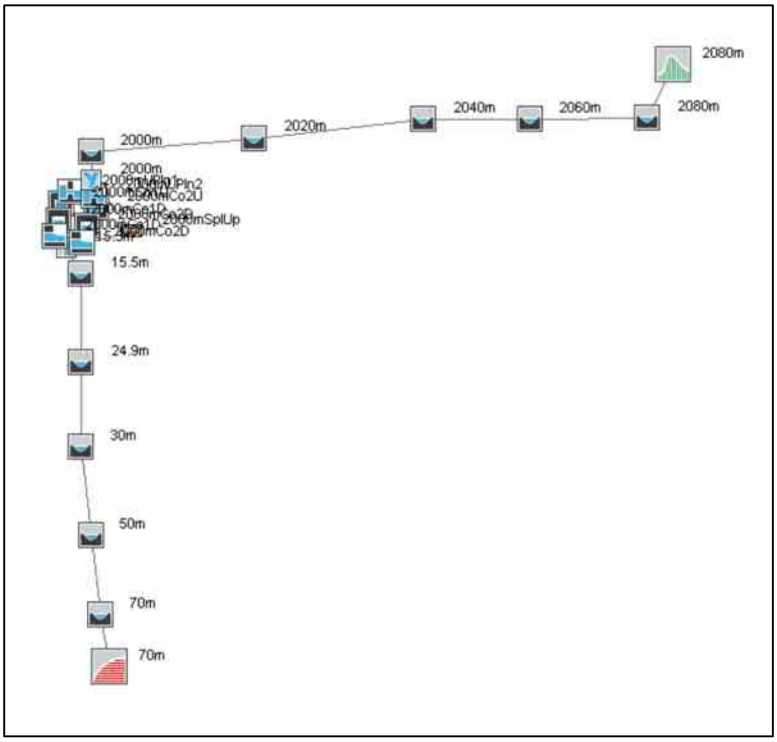
B. IDA and UBY2A culvert modelling

This appendix presents a summary of the Flood Risk Assessment (Stage 3) study presented in a separate document[1].

A 1d hydraulic model of the IDA open channel and UBY2A culvert was constructed to assess the potential impact of extension of the existing culvert by 4m in total.

The schematic of the model is shown in Figure B.7.

Figure B.7: Modelling schematic for IDA/UBY2A culverts



Source: Mott Macdonald, 2022

The flow peaks from the IOH124 method and FSU method have been determined. The hydrograph shapes have been constructed using the FSU hydrograph shape method. The model has been run for the following scenarios:

- 1% AEP (1 in 100 year return period) using IOH 124 method.
- 1% AEP (1 in 100 year return period) + climate change using IOH 124 method.
- 0.1% AEP (1 in 1000 year return period) using FSU method (sensitivity run).

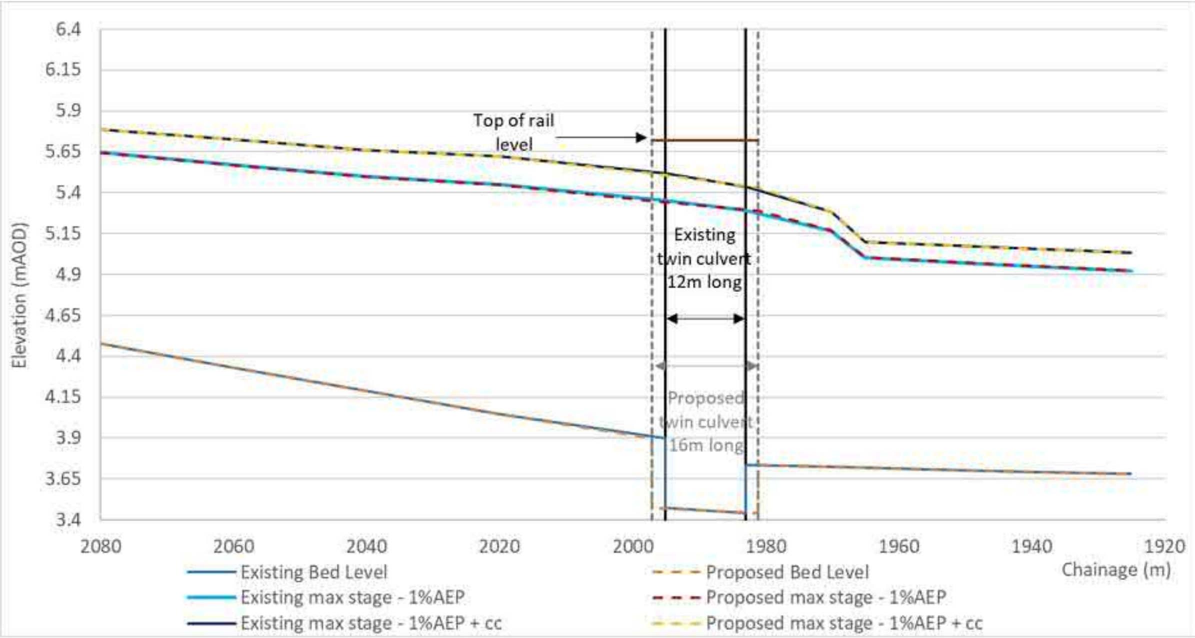
---

[1] Glounthaune and Midleton Railway Upgrade, Flood Risk Assessment Stage 3, Mott MacDonald, July 2022

Modelling results

It has been determined that the proposed lengthening of the UBY2A culvert will have a Negligible impact on flood water levels, i.e. the predicted change is less that 10mm.

Figure B.8: Maximum stage of the modelled channel.



Source: Hydraulic modelling by Mott Macdonald, 2022

C. River Owennacurra Bridge

This appendix presents a summary of the Flood Risk Assessment (Stage 3) study presented in a separate document[2].

The River Owennacurra railway bridge has been modelled during the CFRAM study in 2018. The outputs from the hydraulic model are presented in Figure A.6 (Appendix A) and tabulated for the bridge location in Table C.1.

Table C.1: CFRAM study – fluvial flood level at Owennacurra bridge (m OD)

Node	10yr RP	100yr RP	1000yr RP
3OWE_3407 (upstream)	6.426	6.825	7.053
3OWE_3353 (downstream)	6.211	6.354	6.521

As no new hydraulic modelling was carried out, the CFRAM levels were used to assess the impact of the proposed development on the flood water levels in the River Owennacurra. The impact of each element of works are presented in the following sections.

C.1 Deck extension

The bridge soffit level is at 7.119m OD based on the level of the concrete beam. Therefore, it can be concluded that the proposed deck widening will not impact the existing flood risk at the Owennacurra River up to the 0.1% AEP flood event.

C.2 Abutment widening

The proposed widening of the bridge abutment is in line with existing bridge layout and will not impact the conveyance of the water under the bridge. It is recognised that the proposed new abutment could overlap with the existing floodplain.

A high-level assessment of the potential floodplain loss has been carried out. The estimated maximum volume of displaced flood water is 14.25m^3. The volume of the upstream flood storage has been estimated at 12,500m^3 for the 0.1% AEP fluvial flood event. Therefore, the impact of the potential flood storage loss is considered negligible.

C.3 Embankment widening

It has been determined that the proposed embankment widening will take place above the predicted peak flood water level for the 0.1% AEP flood event and therefore these works will not impact existing flood risk.

[2] Glounthaune and Midleton Railway Upgrade, Flood Risk Assessment Stage 3, Mott MacDonald, July 2022

Appendix 11.2 Flood Risk Assessment (Stage 1)

MOTT MACDONALD

Glounthaune - Midelton Twin Track Project

Flood Risk Assessment Stage 1

September 2022

Mott MacDonald
5 Eastgate Avenue
Eastgate
Little Island
Co Cork T45 EE72
Ireland

T +353 (0)21 480 9800
mottmac.com

Glounthaune - Midelton Twin Track Project

Flood Risk Assessment Stage 1

September 2022

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	06/06/2022	M Nekula / R Wilson	P Ede / A Foley	L Cload	First draft
B	Sep 2022	M. Nekula	L. Cload	L. Cload	Draft for comemnt

Document reference:

Information class: Standard

Contents

1 Introduction 1

1.1 Overview 1

1.2 The Planning System and Flood Risk Management, Guidelines for Planning Authorities 1

1.3 Flood Risk Assessment Methodology 1

1.4 Decision making planning process 2

2 Background 3

2.1 Location of the development 3

2.2 Development description 3

2.3 Modification of existing bridges and culverts 4

3 Flood Risk Identification 5

3.1 Introduction 5

3.2 Potential flood sources 5

3.3 Available Flood Risk Information Sources 5

4 Existing Flood Risk 7

4.1 Coastal Flood Risk 7

4.1.1 Review of CFRAM Flood Maps 7

4.1.2 Review of Coastal Flood Hazard Mapping 8

4.1.3 Impact of the Proposed Development 9

4.2 Fluvial Flood Risk 9

4.2.1 Review of CFRAM Flood Maps 9

4.2.2 Review of National Indicative Fluvial Maps (NIFM) 11

4.2.3 Smaller watercourses and culverts 11

4.3 Pluvial Flood Risk 12

4.4 Groundwater flooding 13

4.5 Flooding from artificial drainage system and infrastructure failure 13

4.6 Historical Flooding 13

4.7 Midleton Flood Prevention Scheme 14

5 Justification Test 15

6 Conclusion 17

Appendices 19

A. Proposed development details 20

B. Flood maps 21
B.1 Coastal flooding 21
B.2 Fluvial flooding 24

C. Photographs 25

Tables

Table 1-1: Definition of Flood Zones 2
Table 2-1: Culverts and bridges along the railway line requiring modification 4
Table 3-1: Categories of Flood Risk 5
Table 3-2: South Point C3 – sea water levels (OD Malin OSGM15 in meters) 9
Table 4-2: Small watercourses features 12
Table 4-3: Past Flood Information 14

Figures

Figure 2.1: Overview of Proposed Development Site 3
Figure 4.1: 0.1% AEP Flood Risk Map (CFRAM) 7
Figure 4.2: 0.1% AEP Flood Depths (Coastal Flood Hazard) 8
Figure 4.3: 0.1% AEP CFRAM River Flood Extent Map 10
Figure 4.4: NIFM study – 0.1% AEP flooding extent at Anngrove 11
Figure 4.9: Location of Past Flood Events 14

Figures - Appendices

Figure A.1: Proposed development - chainage sections 20
Figure B.2: 0.5% AEP Flood Risk Map (CFRAM) 21
Figure B.3: 10% AEP Flood Risk Map (CFRAM) 21
Figure B.4: Coastal flooding – flood extent (CFRAM) 22
Figure B.5: 0.5% AEP Flood Depths (Coastal Flood Hazard) 22
Figure B.5: 10% AEP Flood Depths (Coastal Flood Hazard) 23
Figure B.2: CFRAM study – fluvial flood extent map – Midleton 24
Figure C.5: Glounthaune Station Viewpoint of Level Difference 25
Figure C.6: Johnstown Cl Viewpoint of Level Difference 25

1 Introduction

1.1 Overview

Mott MacDonald Ireland Limited (MMI) have been appointed by Iarnród Éireann to prepare a Flood Risk Assessment (FRA) Stage 1 (Flood risk identification) for the proposed development of a twin railway track from Glounthaune to Midleton in County Cork.

The report has been carried out to identify whether there are any flooding issues related to the proposed development which may warrant further consideration. It is a desk-based assessment, and it considers all potential sources of flood risk for the proposed twin railway track between Glounthaune and Midleton, hereafter referred to as the “Proposed Development”.

1.2 The Planning System and Flood Risk Management, Guidelines for Planning Authorities

Flooding is a natural process that can happen at any time in a variety of locations, and which affects people indiscriminately. Flooding from rivers and sea is probably the best-known source of flooding, however flooding can also occur from prolonged, intense, and localised rainfall leading to flooding from sewers, overland flow and groundwater flooding.

The frequency, pattern and severity of flooding are expected to increase as a result of climate change. Development can also exacerbate the problems of flooding by removing floodplain storage, altering watercourses, and accelerating and increasing surface water runoff.

In November 2009 The Office of Public Works (OPW) published “The Planning System and Flood Risk Management, Guidelines for Planning Authorities”[1] (The Planning Guidelines). The guidelines aim to integrate flood risk management into the planning process to assist the delivery of sustainable development. It aims to encourage a transparent and consistent consideration of flood risk in the planning process.

The objectives of the guidelines are given as (Paragraph 1.6):

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water runoff;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and

Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

1.3 Flood Risk Assessment Methodology

The recommended stages of flood risk assessment within the guidelines are:

- Stage 1 Flood risk identification – A desk-based study to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation.

[1] 2009-Planning-System-Flood-Risk-Mgmt-1.pdf (opr.ie).

- Stage 2 Initial flood risk assessment – A qualitative or semi-quantitative study to confirm the sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information, to provide a qualitative appraisal of the risk of flooding to development, including the scope of possible mitigation measures, and the potential impact of development on flooding elsewhere, and to determine the need for further detailed assessment.
- Stage 3 Detailed flood risk assessment – A methodology to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of flood hazard to a proposed or existing development, of its potential impact on flood elsewhere and of the effectiveness of any proposed measures.

1.4 Decision making planning process

Management of flood hazard and potential risks in the planning system should be based on an interpretation of issues of both planning and flood risk set out within the guidelines and primarily, but not solely, based around the use of:

Sequential Approach through the use of identified flood zones (see Table 1-1: Definition of Flood Zones

1. for definition of Flood Zones);
2. **Justification Test** for development that needs to be in flood risk areas for reasons of proper planning and sustainable development.

The Planning Guidelines categorise the likelihood of flooding in the form of three flood zones. These flood zones each relate to geographical areas at high, moderate or low risk of flooding, depending on if they are Zone A, B or C respectively. Table 1-1: Definition of Flood Zones

below provides a definition of each flood zone.

The likelihood of flooding is defined as a percentage risk of occurring in any year. For example, a flood event may be described as having an Annual Exceedance Probability (AEP) of 1%. A flood event of 1% AEP is therefore commonly referred to as a 1 in 100-year flood event.

Table 1-1: Definition of Flood Zones

Flood Zone	Description
A	The AEP of flooding from rivers and seas is highest (greater than 1% or 1 in 100 years for river flooding, or 0.5% or 1 in 200 years for coastal flooding)
B	The AEP of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 years and 1% or 1 in 100 years for river flooding, and between 0.1% or 1 in 1000 years and 0.5% or 1 in 200 years for coastal flooding)
C	The probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 years for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in Zone A or B

Source: The Office of Public Works, *The Planning System and Flood Risk Management, Guidelines for Planning Authorities* (November 2009).

It is important to note that the flood zones shown in Table 1-1 are indicative of fluvial (river) and coastal flooding only, and do not include other information on the risk of flooding from sources such as pluvial, groundwater or artificial drainage systems.

The determination of the extent of the flood zones should be based on current extreme water levels without any allowance for climate change. The effects of climate change, such as more severe rainfall events and raising sea levels, will increase these risks and put other areas at risk. Therefore, the Planning Guidelines recommend that any site-specific flood risk assessment will also need to take account of the impacts of climate change.

2 Background

2.1 Location of the development

The Proposed Development is located in County Cork, Ireland and incorporates the existing railway system from Glounthaune (177830,073230) to Midleton (188130,074320). The proposed development includes twin-tracking of the existing railway track between these places. The railway line is ca. 10km in length. The extent of the development is shown in **Error! Reference source not found.**.

Figure 2.1: Overview of Proposed Development Site

Source: OSM Standard (© OpenStreetMap contributors)

2.2 Development description

It is proposed to construct an adjacent railway track between Glounthaune and Midleton to facilitate the passage of two trains along the railway line. The railway line is 10km in length. The project entails:

- Twin tracking of the single track sections between Glounthaune and Midleton;
- Reconfiguration of the operational track layouts, as required;
- Modification/replacement of existing bridges/culverts and level crossings to facilitate the twin tracking and future electrification;
- Provision of sidings/turn back facility at Midleton, as required;
- Provision of new cable containment routes from Glounthaune to Midleton to facilitate the signalling upgrades and alterations;
- Associated signalling upgrades and alterations;
- Passive provision for future electrification of the Glounthaune – Midleton line;

- All associated works (drainage, retaining walls, boundary treatments, etc.).

2.3 Modification of existing bridges and culverts

There are several structures along the Glounthaune to Midleton railway track, some of them will require modification during the twin-tracking which may impact the existing flood risk, see Table 2-1.

Table 2-1: Culverts and bridges along the railway line requiring modification

Structure		Chainage	Function	Works required
Name	Denotation			
Culvert	UBY2A or CV3	1+985m	Carries the rail line over a local water course	Culvert to be extended
Culvert	IDA Culvert	1+985	Carries local watercourse adjacent to the track.	Section of the culvert to be realigned.
Owenacurra River	UBY11	9+870m	Carries the rail line over the Owenacurra River	Extend the deck of the bridge onto the existing piers

Comments: Refer to Appendix A for chainage sections for site area.

3 Flood Risk Identification

3.1 Introduction

The following section consists of a desk-based study using various available flood risk information sources to assess existing or future flood risk.

3.2 Potential flood sources

In general, potential sources of flood risk to a development are as identified in Table 3-1.

Table 3-1: Categories of Flood Risk

Category	Mechanism
Fluvial flooding	Exceedance of the flow capacity of the channel of a river, stream or other natural watercourse (which may be culverted). Fluvial flooding is typically associated with heavy rainfall events, and excess water spills onto the river floodplain.
Coastal and tidal flooding	Caused by high astronomical tide, storm surge, wave action, and local bathymetric effects, often in combination. In estuaries and watercourses affected by tidelocking, flooding can occur as a result of high tidal levels and high fluvial flows in combination
Pluvial flooding (overland flow)	Water flowing over the ground surface that has not reached a natural or artificial drainage channel. This can occur when intense rainfall exceeds the infiltration capacity of the ground, or when the ground is so highly saturated that it cannot accept any more water.
Groundwater flooding	Raised groundwater levels, typically following prolonged rain (that may be slow to recede). High groundwater levels may result in increased overland flow flooding. Normally associated with catchments where porous substrate and/or aquifers exist.
Flooding from artificial drainage systems	Blockage or overloading of pipes, sewers, canals, and drainage channels or failure of pumping systems. Typically occurs following heavy rainfall or as a result of high water levels in a receiving watercourse
Flooding from infrastructure failure	Structural, hydraulic or geotechnical failure of infrastructure that retains, transmits, or controls the flow of water. Examples include hydro-power dams, water supply reservoirs, canals, flood defence structures, underground conduits (e.g. sewers), and water treatment tanks.

Source: CIRIA (2004) Development and Flood Risk, C624, Box 2.3

3.3 Available Flood Risk Information Sources

The Proposed Development site has been screened for all potential sources of flooding. To undertake this study the following data and information were collated and analysed:

- Floodinfo.ie – CFRAM Flood Maps[2]
- Floodinfo.ie – Coastal Maps[3]
- Ordnance Survey Maps[4]
- Geological Survey Ireland Spatial Resources[5]
- Google Maps[6]

[2] Flood Maps - Floodinfo.ie
[3] Coastal Map - Floodinfo.ie
[4] Ordnance Survey | See A Better Place
[5] Geological Survey Ireland Spatial Resources (arcgis.com)
[6] Google Maps

- FSU Web Portal[7]
- Historic flooding data[8]
- Geohive Map Viewer[9]

The key source of information to determine the existing and future flood risk were the flood maps on the OPW flood information portal, namely Floodinfor.ie. The online flood maps come from different studies as follows:

- The Flood Maps provide information based on the National Catchment-based Flood Risk assessment and Management (CFRAM) study from 2012. The flood maps present the river and coastal flood extents for the present-day scenario.
- The Coastal Maps provide information from the National Coastal Flood Hazard Mapping in 2021. These maps produced updated national scale coastal flood extents and depths maps for a wider range of return periods for the present day and future scenarios.
- The National Indicative Fluvial Mapping (NIFM) provide second generation of indicative fluvial spatial data of a higher quality and accuracy.

[7] FSU Web Portal - Home (hydronet.com)
[8] Home - Floodinfo.ie
[9] GeoHive Map Viewer

4 Existing Flood Risk

4.1 Coastal Flood Risk

4.1.1 Review of CFRAM Flood Maps

A review of the Flood Maps[10] from CFRAM study has been carried out. The CFRAM Coastal flood extents are available for the following present day scenarios:

- Low Probability flood events have an indicative 1-in-a-1000 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 0.1%.
- Medium Probability flood events have approximately a 1-in-a-200 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 0.5%.
- High Probability flood events have approximately a 1-in-a-10 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 10%.

The initial approximate 2000m of the proposed development is at risk of coastal flooding from Lough Mahon, which is a sea lough in the north-western part of Cork Harbour. The sea lough flows under the N25 Road Bridge and fills the coastal area north of the road. The proposed development run along the coastline and is predicted to be at risk of coastal flood in its lower sections, especially at the chainage 0 – 1500m, i.e. from Glounthaune to the L3004 Road bridge crossing.

The 0.1% AEP (or 1 in 1000yr) flood extent is presented in Figure 4.1. The remaining return periods are presented in Appendix B.

Figure 4.1: 0.1% AEP Flood Risk Map (CFRAM)

Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

[10] Home - Floodinfo.ie

4.1.2 Review of Coastal Flood Hazard Mapping

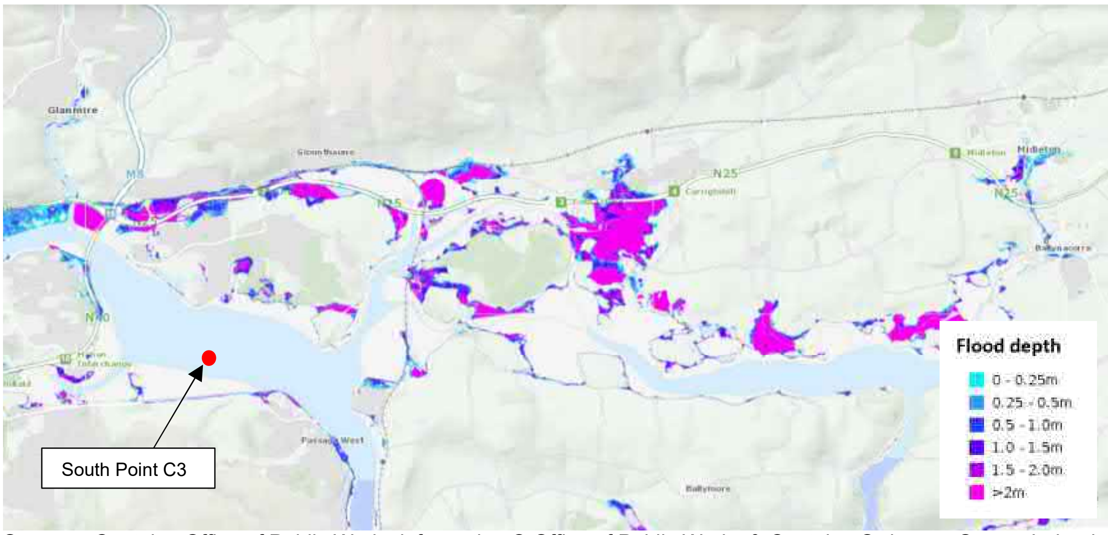
The 2021 National Coastal Flood Hazard Mapping provides more detailed picture of the coastal flooding in Ireland. The study provides not only the flood extents but also flood depths and the flood level information for key locations along the coastline for a wider range of return periods.

4.1.2.1 Flood extent/depth

The new coastal flooding maps are very similar to the CFRAM study flood maps and indicate that the Proposed Development is at risk of coastal flooding on its initial sections at Glounthaune, i.e. approximately the first 1800m when it runs between the coast line and L3004 Road. The remaining section of the track are not at risk of coastal flooding.

Figure 4.2 shows the extents and flood depths for the 0.1%AEP (or 1 in 1000yr) flood event. The remaining key flood return periods are in Appendix B.

Figure 4.2: 0.1% AEP Flood Depths (Coastal Flood Hazard)



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

4.1.2.2 Flood water level

The National Coastal Extreme Water Levels Estimation Points[11] has been examined. The estimation point 'South Point C3' provide extreme sea levels location inside Lough Mahon. The summary of these levels is provided in Table 4-3. The location of the 'South Point C3' point is in Figure 4.2 above.

[11] Dataset providing estimate of extreme water levels around the coast of Ireland (Coastal Map - Floodinfo.ie)

Table 4-1: South Point C3 – sea water levels (OD Malin OSGM15 in meters)

AEP	Present Day	MRFS*	HEFS**	H+EFS***	H++EFS****
50%	2.55	3.05	3.55	4.05	4.55
20%	2.67	3.17	3.67	4.17	4.67
10%	2.76	3.26	3.76	4.26	4.76
5%	2.84	3.34	3.84	4.34	4.84
2%	2.95	3.45	3.95	4.45	4.95
1%	3.03	3.53	4.03	4.53	5.03
0.5%	3.12	3.62	4.12	4.62	5.12
0.1%	3.31	3.81	4.31	4.81	5.31

* - MRFS – Mid-Range Future Scenario (mean sea level rise by 500mm by 2100)
** - HEFS – High End Future Scenario (mean sea level rise by 1000mm by 2100)
*** - H+EFS – High+ End Future Scenario (mean sea level rise by 1500mm by 2100)
*** - H++EFS – High++ End Future Scenario (mean sea level rise by 2000mm by 2100)

The review of partially available information on the railway track levels suggests that the existing track is as low as 3m AOD at its initial sections at Chainage 1300m. This would suggest that the track is at risk of 1% AEP (or 1 in 100yr) coastal flood event in the present-day scenario. However, this will reduce to approximately 50% AEP (or 1 in 2yr) coastal flood event considering the Mid-Range Future Scenario (MRFS) sea level rise by 2100.

4.1.3 Impact of the Proposed Development

The new railway track will be built along the existing track, i.e. at the same level with the same exposure to the coastal flooding as the existing track. As the new track is at the same level, it will not create new flood paths for coastal flooding.

The twin-tracking work will include widening of the existing track area. The widening works may include infilling of the existing coastal floodplain. However, a loss of the coastal flood storage will not increase flood risk elsewhere.

4.2 Fluvial Flood Risk

4.2.1 Review of CFRAM Flood Maps

A review of the Flood Maps[12] from CFRAM study has been carried out. The CFRAM Coastal flood extents are available for the following scenarios:

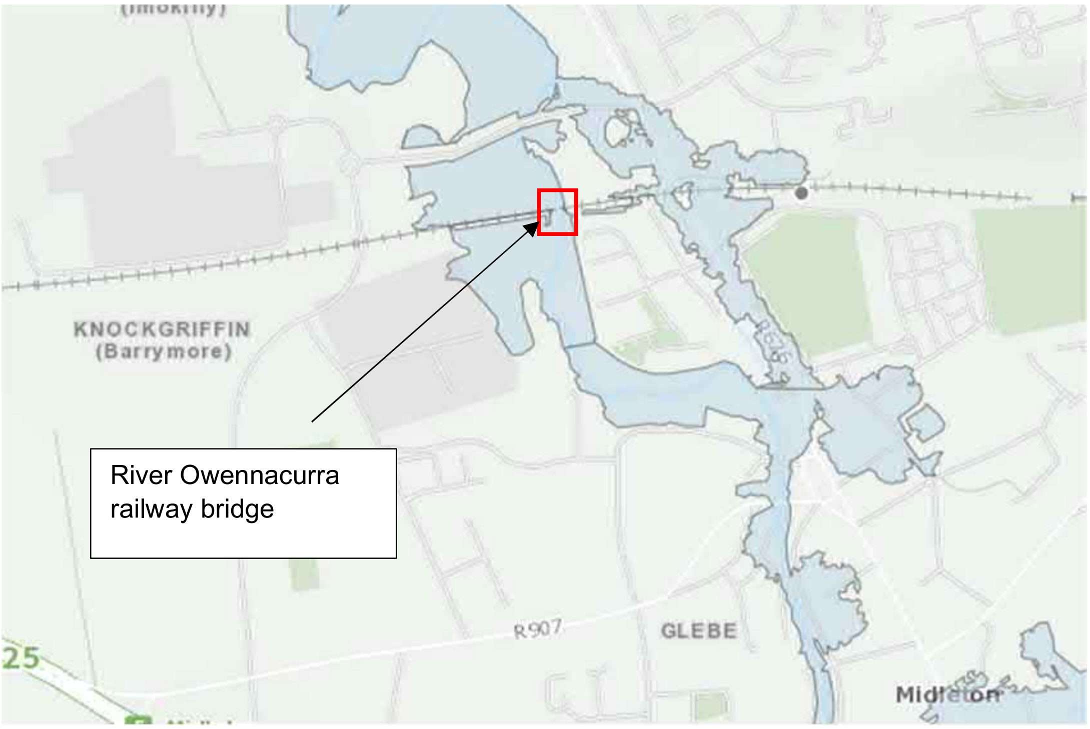
- Low Probability flood events have an indicative 1-in-a-1000 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 0.1%.
- Medium Probability flood events have approximately a 1-in-a-100 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 1%.
- High Probability flood events have approximately a 1-in-a-10 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 10%.

[10] Home - Floodinfo.ie

The CFRAM river flood extent maps predict that the proposed development is within the 0.1% AEP fluvial extent from the River Owennacurra in the Midleton area. The flood water for the 0.1% AEP is predicted to spill out of the channel upstream of the railway track and flood low laying areas along the R626 Road and railway track. The River Owennacurra railway bridge is also predicted to be of insufficient capacity and the railway track is predicted to be overtopped by the flood water.

Figure 4.3 shows the predicted flood extents from the 0.1% AEP (or 1 in 1000yr) river flood extents from the CFRAM study for the present day scenario. Further maps are provided in Appendix B.

Figure 4.3: 0.1% AEP CFRAM River Flood Extent Map



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

Proposed modifications at the River Owennacurra bridge

As part of the twin-tracking process, the bridge deck over the River Owennacurra is proposed to be widened. The works will use the existing concrete piers and the existing deck will be widened in the upstream direction to allow the addition of the second track.

The widening of the deck could impact the hydraulic behaviour of the flood flow and therefore it is recommended to quantify the impact inside the hydraulic model.

4.2.2 Review of National Indicative Fluvial Maps (NIFM)

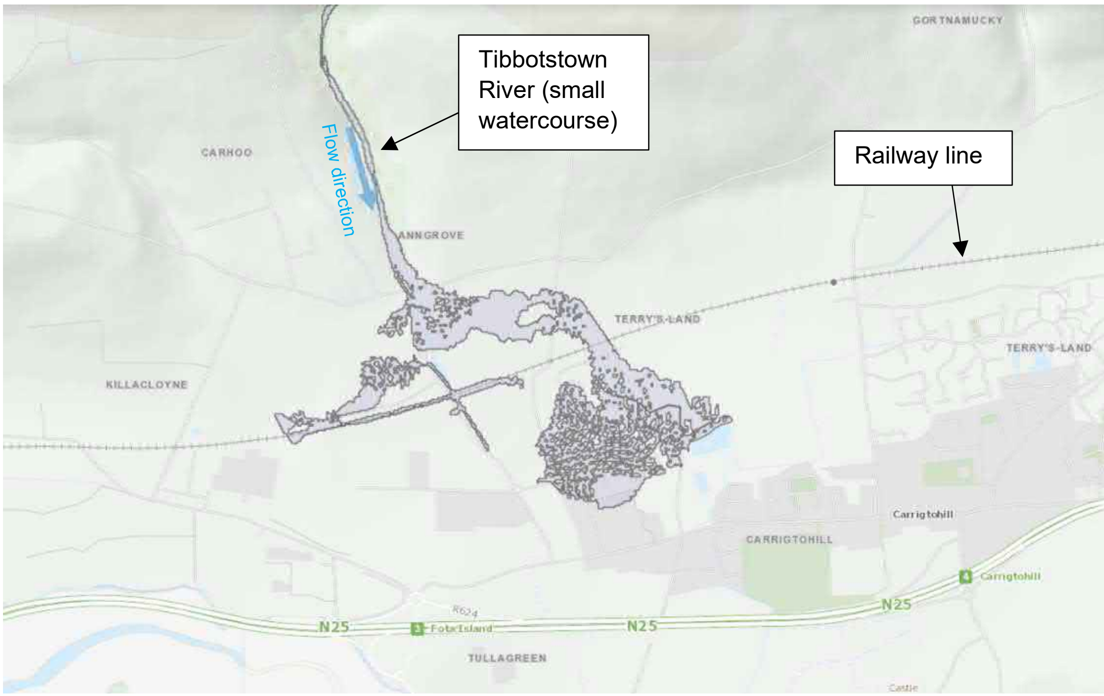
A review of the Flood Maps[13] from NIFM study has been carried out. The NIFM River flood extents are available for the following present day scenarios:

- Low Probability flood events have an indicative 1-in-a-1000 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 0.1%.
- Medium Probability flood events have approximately a 1-in-a-100 chance of occurring or being exceeded in any given year. This is also referred to as an Annual Exceedance Probability (AEP) of 1%.

In addition to the Midleton area, the NIFM study predicts fluvial flood risk at the Anngrove crossing. The small local watercourse is predicted to spill out of the bank and flood low laying sections of the railway track. The indicative fluvial flooding occurs from chainage 2300m to 3500m

Figure 4.4 shows the predicted flood extent of the 0.1% AEP fluvial flood event from the NIFM study.

Figure 4.4: NIFM study – 0.1% AEP flooding extent at Anngrove



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

4.2.3 Smaller watercourses and culverts

The OS Maps and available information on the railway structures have been reviewed to determine whether there are other potential sources of fluvial flooding from smaller

[10] Home - Floodinfo.ie

watercourses that have been too small to be included in the two national studies (i.e. the CFRAM and NIFM study).

The review identified several minor water features with culvert crossings under the existing railway line. These are summarised in Table 4-2.

Table 4-2: Small watercourses features

NGR (Easting/Northing)	Chainage (m)	Description	Proposed works during twin-tracking
179153 073241	1350	UBY1B Culvert – precast concrete box, currently single-track section, span length 1.5m	No works proposed
179506 073239	1700	UBY1C Culvert Killacloyne – precast concrete box at the start of the IDA side channel, currently single-track section, span length 2.1m	No works proposed
179792 073240	1985	UBY2A Culvert – precast concrete box, currently single-track section, span length 4.8m	**Section of the culvert to be realigned.**
	1700 to 2900	IDA drainage channel along the north side of the track. The channel drains the Anngrove area, which is an identified source of fluvial flooding in Section 4.2.2	**Open channel section to be re-positioned**
181686 073722	3950	UBY5E Carrigtohill – concrete precast pipe, currently twin-track section, span length 0.60m	No works proposed
181763 073738	4020	UBY5C Culvert Carrigtohill – concrete pre-cast box, currently twin-track section, span length 1.8m	No works proposed
183042 073916	5300	UBY6B Culvert – concrete pre-cast box, currently twin-track section, span length 1.5m.	No works proposed
183185 073925	5460	UBY6C Culvert – concrete pre-cast box, currently twin-track section, span length 2.1m	No works proposed
186248 074100	8520	Water Rock watercourse – no culvert identified	No works proposed

Comments: Refer to Appendix A for chainage sections for site area.

Two locations in Table 4-2 have proposed works as part of the track twin-tracking, namely UBY2A Culvert and IDA drainage channel. The proposed modifications are in the area where the fluvial flood risk is identified by the NIFM study. Therefore, these modifications could increase fluvial flood risk and further hydraulic assessment is recommended to quantify the potential impacts.

The other structures along the Proposed Development are not proposed to be modified and therefore there will be no further change in the fluvial flood risk.

4.3 Pluvial Flood Risk

No pluvial flood maps are available for the Glounthaune / Midleton area at Floodinfo.ie. However, the existing track runs along hill sides and intercepts rainfall runoff. The existing track is at risk of pluvial flooding if the track drainage is not sufficient, especially on lower lying areas and cuttings. The proposed track is of a similar level to the existing and so could be at pluvial flood risk.

As part of the twin-tracking works, drainage provision for the track (particularly the ballast) will be provided by a combination of transverse and linear filter and / or sealed drains which in turn will discharge to ditches or carrier pipes conveying the runoff to the nearest outfall point, either a culvert or natural watercourse. However, it is not proposed to change the existing pluvial flood risk from runoff, so flood risk elsewhere will not be increased.

4.4 Groundwater flooding

Groundwater flooding occurs when the water stored within the ground rises above the land surface. This is normally related to prolonged rainfall causing water table rise in the limestone lowland areas in the west of the country.

An online Groundwater Flooding Data Viewer[14] has been reviewed and there is no area of High, Medium or Low Probability of groundwater flooding along the proposed development.

However, the Geological Survey of Ireland Spatial Resources[15] indicates that the primary bedrock geology makeup, along the railway, comprises largely of limestone, in many places covered by variable thickness of glacial till, consisting predominantly of clay but with significant presence of silts, sands and gravels. There are several known cave systems in the area and many features associated with subterranean drainage including sinking streams, ephemeral springs, sinkholes/ground collapses and turloughs. This is why some of the surface water courses in the area appear to disappear: they entirely sink to ground, rising down-hydraulic gradient as springs, or as seepage/discharge in river beds or the coastal zone.

Therefore, the proposed development is deemed to be at moderate to high risk of groundwater flooding. To further quantify the groundwater flooding a detailed assessment would be required.

The Proposed Development is expected to have a minimum impact in the existing ground water conditions, however, this should be confirmed once the extent of the existing ground water flood risk is established.

4.5 Flooding from artificial drainage system and infrastructure failure

The proposed twin-tracking of the railway track will follow the route of the existing railway. The review of the OS map did not identify any water holding or water conveying infrastructure that could potentially cause further flood risk to the new track.

Therefore, the proposed development is deemed not to be at risk of flooding from the artificial drainage system or infrastructure failure. As the new track is proposed to run adjacent to the old track, the Proposed Development will not increase flood risk elsewhere.

4.6 Historical Flooding

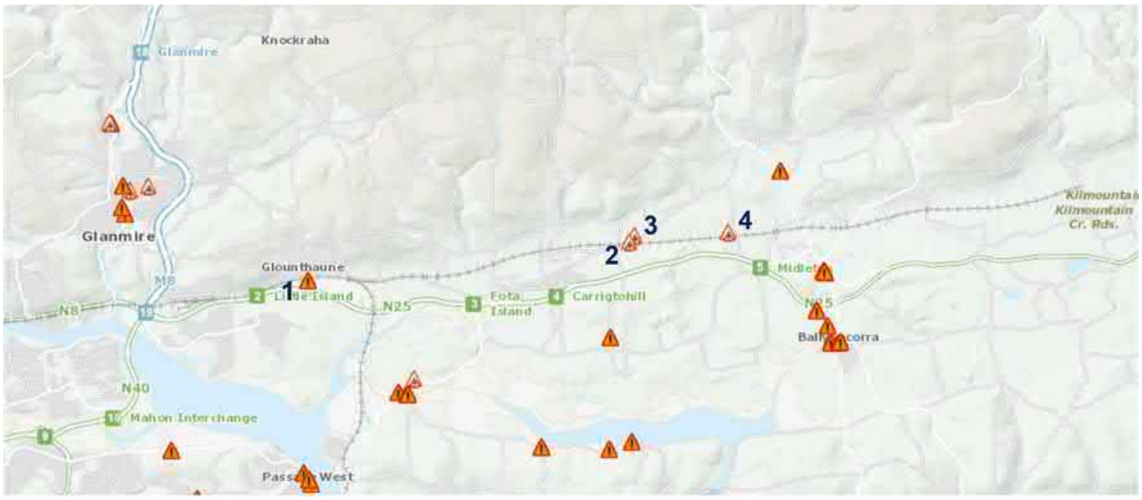
The past flood events information on Floodinfo.ie have been reviewed and summarised in Figure 4.5 and Table 4-3.

Reports detailing the past floods do not state that the railway was affected during any of these recorded flood events, however due to the proximity of the events to the railway, they are relevant to this study.

[14] Groundwater Flooding Data Viewer (arcgis.com)

[15] Geological Survey Ireland Spatial Resources (arcgis.com)

Figure 4.5: Location of Past Flood Events



Source: OPW, Floodinfo.ie

Table 4-3: Past Flood Information

	Location	Date	Source of Flood
1	Glounthaune	26th October 2004	Coastal/Estuarine Waters
2	Turlough - Ballyadam, Carrigane, Cork	Reoccurring	Turlough
3	Turlough - Ballyadam, Carrigane, Cork	Reoccurring	Turlough
4	Water Rock Midleton, Cork	Reoccurring	Other

Source: OPW, Floodinfo.ie

4.7 Midleton Flood Prevention Scheme

A new flood relief scheme is proposed for the Midleton Area. The scheme will include measures to alleviate flooding at 400 homes and 180 businesses and cover Midleton, Water Rock and Ballinacurra. It will involve dealing with tidal, fluvial, pluvial and groundwater flooding. It is expected that the work on the scheme will start in 2023.

It is understood that the proposed scheme will also reduce future flood risk to the existing and proposed railway track, as the out-of-bank flood flow over the Midleton area will be largely mitigated (see Figure B.2 for existing flood risk in Midleton area)

5 Justification Test

The Proposed Development is located inside the moderate or high flood risk zone (see Table 1-1) of coastal and fluvial flooding. The Proposed Development is a primary infrastructure and is classed as 'Essential infrastructure' (i.e. Highly vulnerable development), that cannot be located elsewhere.

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of particular developments that, for the reasons outlined above, are being considered in areas of moderate or high flood risk.

This section summarises the Justification Test for the Glounthaune Midleton twin track reflecting the latest findings and information as follows:

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[16].*

The National Transport Authority (NTA), in collaboration with Transport Infrastructure Ireland (TII), Cork City Council and Cork County Council prepared the Cork Metropolitan Area Transport Strategy (CMATS) 2040 to provide a land use and transport strategy for the managed delivery of an efficient transport network.

The CMATS provides a coherent transport planning policy framework and implementation plan around which other agencies involved in land use planning, environmental protection, and delivery of other infrastructure such as housing and water can align their investment priorities.

The proposed development of the current rail corridor is consistent with the Cork County Development Plan 2014 (as varied) and Draft Cork County Development Plan 2022-2028 and its policy framework to support the intensification of residential and commercial activity of settlements along the Glounthaune-Midleton line, namely, Midleton, Carrigtwohill and Water Rock.

It is proposed to construct the new track alongside the existing single track sections so that the line between Glounthaune to Midleton will have full twin tracks to facilitate a future increase in train trip frequency. No alternative route for the twin track is deemed to be more favourable based on technical, environmental and planning considerations.

2. *The proposal has been subject to an appropriate flood risk assessment that demonstrates:*
   a. *The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;*

The Proposed Development has been subjected the Flood Risk Assessment Stage 1 (Flood Risk Identification), which is presented in this report. The flood risk assessment identified the key flood sources and the need for further actions, such as hydraulic modelling of the fluvial flooding at the specific structures and more detailed groundwater assessment.

The new track will run along the existing railway track and because of this proximity the new track will be at the same elevation as the existing or thereby. Reprofiling of existing embankments will be required. In areas of cut, embankment slopes will be reprofiled to allow for

[16] 2009-Planning-System-Flood-Risk-Mgmt-1.pdf (opr.ie).

the twin track gauge and may incorporate toe retention to reduce the quantity of spoil generated. In areas where space is restricted, retaining structures will be installed.

The proposed works will have a minimal impact on the existing flood mechanisms regarding pluvial, fluvial and coastal flooding. The impact of the fluvial and groundwater flood mechanism should be further assessed in a more detailed flood risk assessment.

> b. *The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;*

The Proposed Development will consider the existing and future flood risk. Flood mitigations will be developed and included in the detailed design. The potential flood mitigations may include new track drainage, upgraded local culverts and Owennaccura river bridge and new provisions for the coastal flood protection.

> c. *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;*

The residual flood risk (Pluvial, fluvial and coastal flood risk) should be considered in the operational plan of the railway. It is understood that the with no mitigations in place the existing track is at risk of the 1% AEP (or 1 in 100yr), but could be more frequent. Considering future impact of climate change and the rise in sea levels, the coastal flooding is likely to become more frequent. It is understood that the existing flood risk to the track is manageable and acceptable. With the proposed track to be built adjacent to the existing, it is considered not viable to raise the track higher than the existing track level or thereby, so the existing risk will remain.

> d. *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 Proposed Development has been developed in accordance with the sustainable development objectives of the Cork County Development Plan 2014 (as varied) and Draft Cork County Development Plan 2022-2028 and in accordance with The Planning System and Flood Risk Management Guidelines

6 Conclusion

A Flood Risk Assessment Level 1 for the Proposed Development of Glounthaune to Midleton has been carried out. This included a desk-based screening of the available data for potential sources of flooding in the subject area. All potential flood sources have been assessed, with the following findings:

Coastal flooding

The initial section of the Proposed Development, i.e. Chainage 0 – 1500m, is at risk from coastal flooding. The review of the track levels suggest that track elevation is as low as 3m OD at Chainage 1300 and this section is at risk of coastal flooding from the 1% AEP (or 1 in 100 year) coastal flood event considering the present day flood water levels.

The remaining sections after Chainage 1500 are higher and outwit the coastal flood risk.

It is recommended that the low elevations of the track at its initial section at Glounthaune are considered when developing the detailed design. Possible mitigation measures could be proposed to protect the low sections of the track from coastal flooding. The proposed mitigations would need further hydraulic assessment.

Fluvial flooding

The Proposed Development is at risk from fluvial flooding from a small watercourse at the Anngrove area and from the River Owenacurra in Midleton.

It is proposed to extend the railway culvert and re-position open channel at Anngrove and also widen the railway bridge over the river Owenacurra. The proposed changes of the existing structures and open channel will need to be further assessed inside the hydraulic model to find out the potential impact on flood risk.

Pluvial flooding

No pluvial flood maps are available for the track area. However, it is considered that the existing track intercepts the rainfall runoff and the low lying areas of the track and cuttings might be at risk of pluvial flooding if the track drainage is not sufficient.

A new railway track drainage will be design during the twin-tracking upgrade. The new drainage system will consider the pluvial flood risk along the railway and will be designed in line with the latest standards. However, it is not proposed to change the existing pluvial flood risk from runoff, so flood risk elsewhere will not be increased.

Groundwater flooding

The Proposed Development includes areas with potential for groundwater flooding. It is proposed to further investigate the impact of the Proposed Development on the groundwater flooding.

Flooding from artificial drainage system and artificial infrastructure

There are no water holding or water conveying infrastructure that could potentially cause further flood risk to the new track.

Therefore, the Proposed Development is deemed not to be at risk flooding from the artificial drainage system of infrastructure failure. As the new track is proposed along the same route as the old track, the new development will not increase flood risk elsewhere.

Past flood events

The existing records of flooding in the Glounthaune to Midleton area have been reviewed. Past food events have occurred in the area but there is no information to suggest that the railway was affected.

Justification test

As the Proposed Development is located in the flood zones, the planning process requires to undertake the Justification Test. The Justification Test has been carried out and is presented in Section 5 supporting the development within flood risk areas principally due to the fact that there is an existing railway line at the same line and level as the new track. This should be reviewed once the more detailed flood risk studies are available.

Appendices

A. Proposed development details 20
B. Flood maps 21
C. Photographs 25

A. Proposed development details

Figure A.1: Proposed development - chainage sections

Source: OSM Standard (© OpenStreetMap contributors)

B. Flood maps

B.1 Coastal flooding

Figure B.2: 0.5% AEP Flood Risk Map (CFRAM)

Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

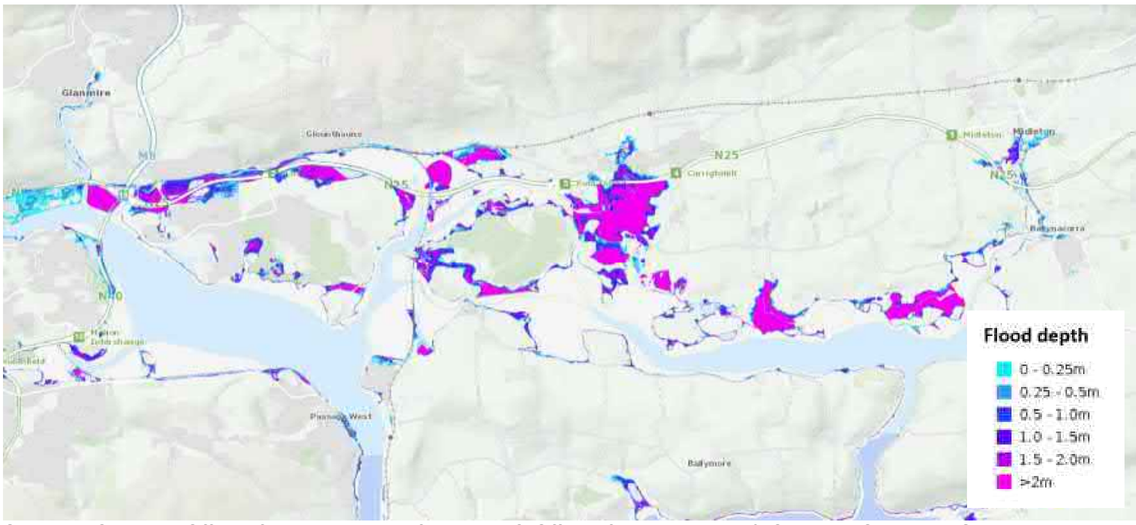
Figure B.3: 10% AEP Flood Risk Map (CFRAM)

Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

Figure B.4: Coastal flooding – flood extent (CFRAM)

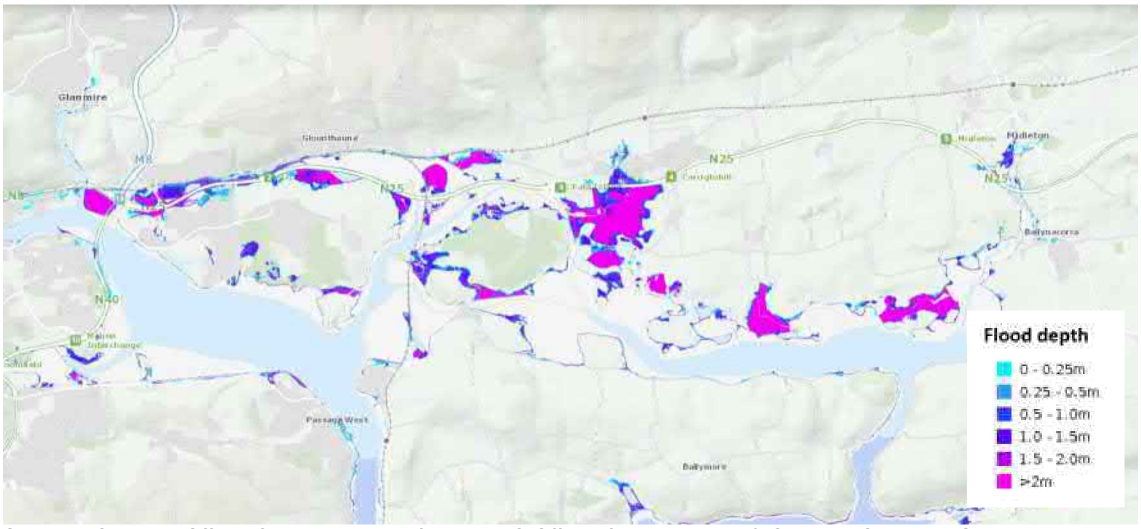
Source: CFRAM, 2012

Figure B.5: 0.5% AEP Flood Depths (Coastal Flood Hazard)



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

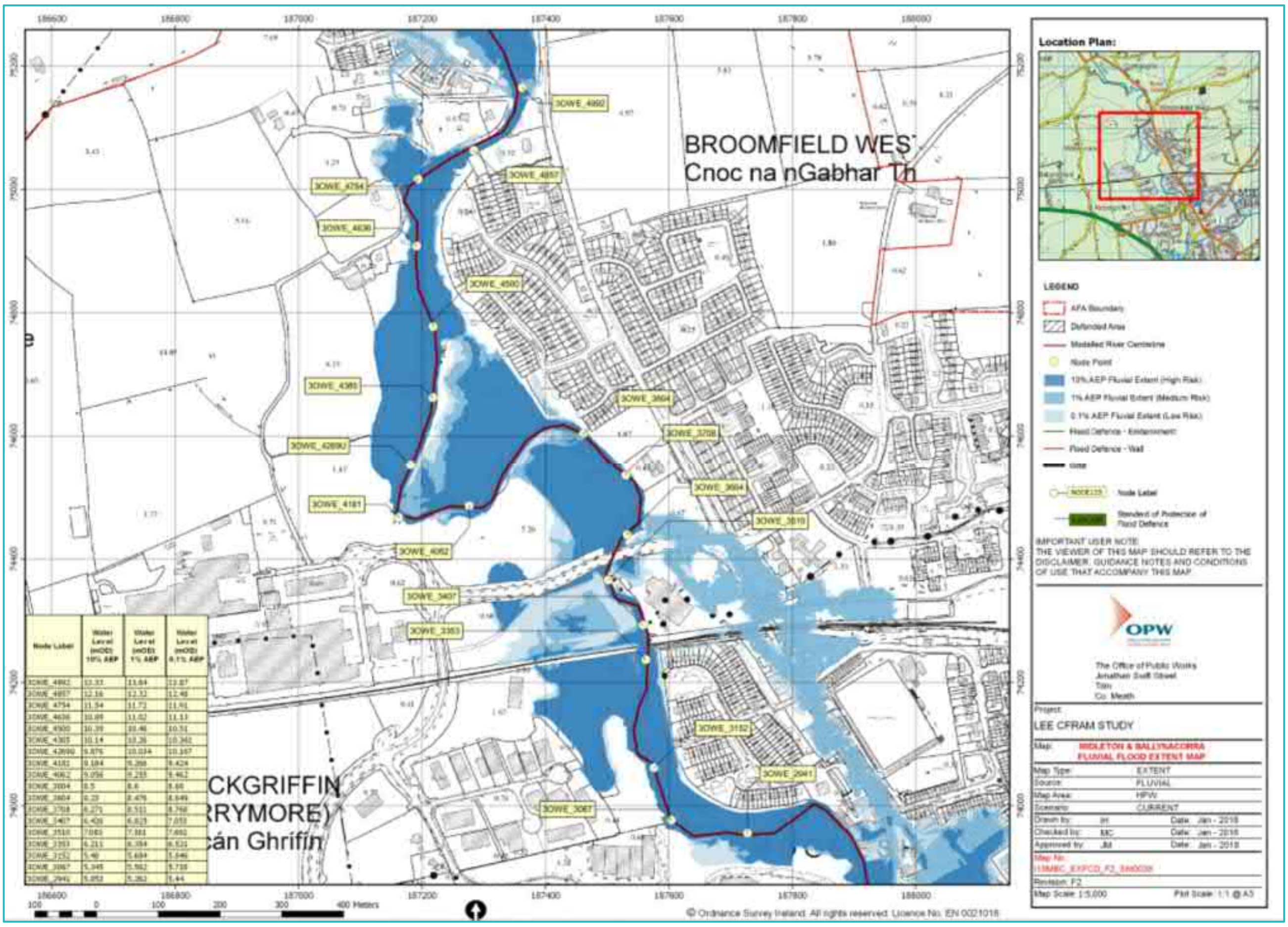
Figure B.6: 10% AEP Flood Depths (Coastal Flood Hazard)



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

B.2 Fluvial flooding

Figure B.7: CFRAM study – fluvial flood extent map – Midleton



Source: Contains Office of Public Works information © Office of Public Works & Contains Ordnance Survey Ireland information © Ordnance Survey Ireland

C. Photographs

Figure C.8: Glounthaune Station Viewpoint of Level Difference

Source: Glounthaune railway station, County Cork, cc-by-sa/2.0 - © Nigel Thompson - geograph.org.uk/p/5939097

Figure C.9: Johnstown Cl Viewpoint of Level Difference

Source: Google,"Streetview" digital images, Google Maps (https://www.google.com/maps), photograph of Johnstown Close, County Cork,Glounthaune, Ireland, taken September 2021

mottmac.com

Appendix 11.3 Flood Risk Assessment (Stage 3)

MOTT MACDONALD

Glounthaune - Midleton Twin Track Project

Flood Risk Assessment Stage 3

September 2022

This page left intentionally blank for pagination.

Mott MacDonald
5 Eastgate Avenue
Eastgate
Little Island
Co Cork T45 EE72
Ireland

T +353 (0)21 480 9800
mottmac.com

Glounthaune - Midleton Twin Track Project

Flood Risk Assessment Stage 3

September 2022

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	25/07/2022	R Wilson / M Nekula	P Ede	L Cload	First Issue

Document reference: 229101063 | | |

Information class: Standard

Contents

1 Introduction 1

1.1 Scope and purpose of study 1
1.2 Development description 2
1.2.1 IDA Open Culvert 2
1.2.2 UBY2A Culvert 2
1.2.3 Owennacurra River Bridge 2
1.3 Data sources 3

2 The Planning System and Flood Risk Management Guidelines 4

2.1 The Planning System and Flood Risk Management, Guidelines for Planning Authorities 4
2.2 Flood risk assessment methodology 4
2.3 Decision making planning process 5

3 IDA Open Culvert and UBY2A Culvert Assessment 6

3.1 UBY2A Culvert Hydrological analysis 6
3.1.1 FSU Web Portal analysis 6
3.1.2 IOH 124 Method 7
3.1.3 Climate Change 8
3.2 Hydraulic modelling 8
3.2.1 Modelling schematic 8
3.2.2 1D boundaries 10
3.2.3 Roughness 10
3.2.4 1D Structures 10
3.2.5 Model inflows 11
3.2.6 Modelled flood events 11
3.2.7 Modelling assumptions 12
3.3 Result assessment 12
3.3.1 Comparison of existing culvert and proposed culvert 12
3.4 Sensitivity analysis 14
3.4.1 Reduced conveyance due to sedimentation 14
3.4.2 Increase of flows to 0.1% AEP (or 1 in 1000yr) flood event 14

4 River Owennacurra Bridge 15

4.1 Estimation of flood level 15
4.2 Bridge deck widening 15
4.3 Abutment widening 15
4.4 Embankment widening 16

5 Conclusion 17

5.1 IDA Open Culvert and UBY2A Culvert 17
5.2 River Owennacurra Bridge 17

Appendices 18

A. Hydrology Analysis Details 19

A.1 FSU Web Portal hydrological analysis – Catchment A (19_1554_6) 19
A.2 FSU Web Portal hydrological analysis – Catchment B (19_1733_5) 22

B. IDA Open Culvert and UBY2A Culvert drawings 25

C. River Owennacurra 26

C.1 River Owennacurra CFRAM Flood Maps 26
C.2 River Owennacurra drawings 27

Tables

Table 2.1: Definition of Flood Zones 5
Table 3.1: Subject catchment properties 7
Table 3.2: FSU estimated peak flow (m^3/s) 7
Table 3.3: Input parameters for IOH124 method 8
Table 3.4: IOH 124 estimated peak flow (m^3/s) 8
Table 3.5: Existing and proposed UBY2A culvert properties 11
Table 3.6: Peak flows through the UBY2A Culvert 12
Table 3.7: Peak water level along the model section 13
Table 4.1: CFRAM Study flood map water level (mOD) 15
Table 4.2: Flood storage loss at new abutments 16

Figures

Figure 1.1: Overview of Proposed Development Site with IDA/UBY2A Culvert and Owennacurra River Bridge 1
Figure 3.1: Catchment A (West) 6
Figure 3.2: Catchment B (East) 6
Figure 3.3: Modelling schematic for IDA Open Culvert and UBY2A Culvert 9
Figure 3.4: Enlargement of modelling schematic at UBY2A Culvert 10
Figure 3.5: Derived flood hydrographs 11
Figure 3.6: Maximum stage of the modelled channel 14

Figures - Appendices

Figure A.1: Catchment A boundary 19
Figure A.2: QMED value and properties for Pivotal Site 22009 White Bridge 20
Figure A.3: Catchment A – Pooled analysis 20
Figure A.4: Catchment A – Final Growth Curve 21
Figure A.5: Catchment A – Final Hydrographs Flows 21
Figure A.6: Catchment B boundary 22
Figure A.7: QMED value and properties for Pivotal Site 22009 White Bridge 23
Figure A.8: Catchment B – Pooled analysis 23
Figure A.9: Catchment B – Final Growth Curve 24
Figure A.10: Catchment B – Final Hydrograph Flows 24
Figure B.11: Existing culvert drawings 25
Figure B.12: Proposed changes at IDA Open Culvert and UBY2A Culvert drawings 25
Figure C.13: CFRAM flood map - River Owennacurra 26
Figure C.14: River Owennacurra Bridge – proposed deck and abutment widening 27
Figure C.15: River Owennacurra Bridge – Proposed embankment widening 28
Figure C.16: Cross section of the proposed infill areas 29

1 Introduction

1.1 Scope and purpose of study

Mott MacDonald Ireland Limited (MMI) have been appointed by Iarnród Éireann to prepare a Flood Risk Assessment (FRA) Stage 3 to assess the impact of the proposed twin-tracking of the existing railway track from Glounthaune to Midleton in County Cork as seen in Figure 1.1. This follows on from a FRA Stage 1 which determined that hydraulic modelling was required in some areas of the proposed development.

Overall, the proposed works follows the line and level of the existing railway and in most places the existing railway corridor is wide enough to accommodate the new track. However, in some places, the railway corridor is to be widened requiring modification to some existing watercourse crossings. Three watercourse structures have been identified where the proposed works may potentially impact flood risk. These proposed works include repositioning of the IDA Open Culvert and extension of the connected UBY2A Culvert, plus the proposed widening of the railway bridge deck over the River Owennacurra (Railway Underbridge UBY11), as located in Figure 1.1.

The impact on flood risk on the permanent works has been assessed through hydraulic modelling and through comparison of the available flood levels from the local CFRAM study against the proposed development levels.

The proposed development is located in County Cork, Ireland and incorporates the existing railway system from Gounthaune (177830,073230) to Midleton (188130,074320). The IDA Open Culvert and UBY2A Culvert are located at Grid Reference 179798,073261 and River Owennacurra at 187562,074260.

Figure 1.1: Overview of Proposed Development Site with IDA/UBY2A Culvert and Owennacurra River Bridge

Source: OSM Standard (© OpenStreetMap contributors)

1.2 Development description

1.2.1 IDA Open Culvert

The IDA Open Culvert carries a stream that runs parallel to the north of the existing track and it ties into the existing UBY2A Culvert at its west end which carries the stream under the existing single track.

The existing open culvert is approximately 900m in length. The culvert consists of a U-shaped cross-section with an inclined wall on the north side and a vertical wall on the south side. The wall heights vary throughout the culvert length between 1.4m and 2.56m. The channel width of the culvert is 1.45m.

A portion of the existing open culvert is to be repositioned to accommodate the proposed second track.

It is proposed to re-use the existing culvert units which are fitted with lifting eyes and have a spigot and socket joint detail. An in-situ connection will be required at the interface where the repositioning begins and at the interface with the existing IDA attenuation outfall. The re-aligned culvert will tie into the UBY2A Culvert which is also being lengthened with the construction of new wing walls. A sheet pile wall is to be installed just north of the works area to retain the existing embankment during construction. Existing bed material, including stone insets, will need to be removed from the culvert bed as part of the re-alignment. The bed material will be re-instated in line with IFI requirements.

1.2.2 UBY2A Culvert

The existing UBY2A Culvert carries a single track over a stream which flows in a north to south direction. The bridge is to be widened to accommodate the proposed second track. The bridge site is rural with a mixture of agricultural and industrial land. There is a school located directly to the southeast of the culvert. Overbridge OBY2 is located directly to the west of the culvert and the IDA Open Culvert ties into UBY2A Culvert at the north inlet.

The existing culvert is a 12m long twin cell structure. The spans from west to east are 2.4m and 2.1m and the culvert internal height is 1.2m. Reinforced concrete wingwalls are provided at both the inlet and outlet.

The culvert is to be lengthened by 2m to the north and 2m to the south. The cross-section dimensions of the lengthened sections will match the existing cross section. The existing north and south wingwalls are to be demolished and rebuilt to accommodate the lengthened structure.

1.2.3 Owennacurra River Bridge

The existing Owennacurra River Bridge (Railway Underbridge UBY11) carries a single track over the Owennacurra River in the town of Midleton. The bridge is to be widened to accommodate the proposed second track. The bridge is to be supported on piers that already exist in the river.

The proposed bridge is a three-span continuous deck with integral abutments, spanning between existing piers at a 00 degree skew. The span lengths from west to east are 10.85m, 7.16m and 10.85m. The proposed structure span arrangement, structural form and articulation will match the existing bridge. The widening deck consists of precast prestressed concrete beams with an in-situ infill concrete deck which is to be stitched to the existing deck. The bankseat widenings are supported on continuous flight auger piles. The existing pier capping beams are to be widened to accommodate the proposed deck. The existing north walkway is to be removed, reinstated on the widened deck and increased to 1.5m width. The existing reinforced concrete northern wingwalls are to be demolished and rebuilt to accommodate the widened deck.

1.3 Data sources

To undertake this study the following data and information were collated and analysed:

- FSU Web portal (FSU Web Portal - Home (hydronet.com));
- Floodinfo.ie (Home - Floodinfo.ie);
- Ordnance Survey Maps;
- Engineering Hydrology – Rainfall and Soil Characteristics of the British Isles;
- Civil3D design model:
  - C745-WP3 03-XX-XX-XX-M3-MMD-CE-0003, Mott MacDonald, 2022
  - C745-WP3 03-XX-XX-XX-M3-MMD-CE-0004, Mott MacDonald, 2022
- Drawings:
  - 011274_49_DR_0545_1, PM Group, 2007
  - 011274_49_DR_0546_1, PM Group, 2007
  - 011274_49_DR_0547_1, PM Group, 2007
  - 011274_49_DR_0548_1, PM Group, 2007
  - 011274_49_DR_0549_1, PM Group, 2007
  - C745-WP3_03-XX-XX-XXX-DR_MMD_SE-0240, Mott MacDonald, June 2022
  - C745-WP3_03-XX-XX-XXX-DR_MMD_SE-0230-P01, Mott MacDonald, June 2022

2 The Planning System and Flood Risk Management Guidelines

2.1 The Planning System and Flood Risk Management, Guidelines for Planning Authorities

Flooding is a natural process that can happen at any time in a variety of locations, and which affects people indiscriminately. Flooding from rivers and sea is probably the best-known source of flooding, however flooding can also occur from prolonged, intense, and localised rainfall leading to flooding from sewers, overland flow and groundwater flooding.

The frequency, pattern and severity of flooding are expected to increase as a result of climate change. Development can also exacerbate the problems of flooding by removing floodplain storage, altering watercourses, and accelerating and increasing surface water runoff.

In November 2009 The Office of Public Works (OPW) published “The Planning System and Flood Risk Management, Guidelines for Planning Authorities”[1] (The Planning Guidelines). The guidelines aim to integrate flood risk management into the planning process to assist the delivery of sustainable development. It aims to encourage a transparent and consistent consideration of flood risk in the planning process.

The objectives of the guidelines are given as (Paragraph 1.6):

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water runoff;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

2.2 Flood risk assessment methodology

The recommended stages of flood risk assessment within the guidelines are:

- Stage 1 Flood risk identification ‑ A desk-based study to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation.
- Stage 2 Initial flood risk assessment ‑ A qualitative or semi-quantitative study to confirm the sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information, to provide a qualitative appraisal of the risk of flooding to development, including the scope of possible mitigation measures, and the potential impact of development on flooding elsewhere, and to determine the need for further detailed assessment.
- Stage 3 Detailed flood risk assessment – A methodology to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of flood hazard to a proposed or

[1] 2009-Planning-System-Flood-Risk-Mgmt-1.pdf (opr.ie).

existing development, of its potential impact on flood elsewhere and of the effectiveness of any proposed measures.

2.3 Decision making planning process

Management of flood hazard and potential risks in the planning system should be based on an interpretation of issues of both planning and flood risk set out within the guidelines and primarily, but not solely, based around the use of:

- **Sequential Approach** through the use of identified flood zones (see Table 2.1 for definition of Flood Zones);
- **Justification Test** for development that needs to be in flood risk areas for reasons of proper planning and sustainable development. The Justification Test was undertaken in Stage 1 of the FRA.

The Planning Guidelines categorise the likelihood of flooding in the form of three flood zones. These flood zones each relate to geographical areas at high, moderate or low risk of flooding, depending on if they are Zone A, B or C respectively. Table 2.1 below provides a definition of each flood zone.

The likelihood of flooding is defined as a percentage risk of occurring in any year. For example, a flood event may be described as having an Annual Exceedance Probability (AEP) of 1%. A flood event of 1% AEP is therefore commonly referred to as a 1 in 100-year flood event.

Table 2.1: Definition of Flood Zones

Flood Zone	Description
A	The AEP of flooding from rivers and seas is highest (greater than 1% or 1 in 100 years for river flooding, or 0.5% or 1 in 200 years for coastal flooding)
B	The AEP of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 years and 1% or 1 in 100 years for river flooding, and between 0.1% or 1 in 1000 years and 0.5% or 1 in 200 years for coastal flooding)
C	The probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 years for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in Zone A or B

Source: The Office of Public Works, The Planning System and Flood Risk Management, Guidelines for Planning Authorities (November 2009).

It is important to note that the flood zones shown in Table 2.1 are indicative of fluvial (river) and coastal flooding only, and do not include other information on the risk of flooding from sources such as pluvial, groundwater or artificial drainage systems.

The determination of the extent of the flood zones should be based on current extreme water levels without any allowance for climate change. The effects of climate change, such as more severe rainfall events and raising sea levels, will increase these risks and put other areas at risk. Therefore, the Planning Guidelines recommend that any site-specific flood risk assessment will also need to take account of the impacts of climate change.

3 IDA Open Culvert and UBY2A Culvert Assessment

A detailed hydraulic assessment has been carried out to determine potential changes in flood risk due to the proposed upgrade works to the IDA Open Culvert along the northern embankment and connected downstream UBY2A Culvert under the existing railway. The assessment included the hydrological analysis of the upstream catchment (i.e. the entire catchment up to the UBY2A Culvert) and 1d hydraulic modelling of the existing and proposed culvert system (i.e. both IDA Open Culvert and UBY2A Culvert).

3.1 UBY2A Culvert Hydrological analysis

The hydrological analysis for the UBY2A Culvert crossing has been carried out using two independent hydrological methods, namely the FSU Web Portal and IOH124 method. It is noted that the IDA Open Culvert is connected to the inlet of the UBY2A Culvert, therefore the hydrology analysis cover contributing catchment area of both subject culverts.

3.1.1 FSU Web Portal analysis

Design flows have been calculated for two catchments, namely Catchment A and Catchment B which form the inflow to the UBY2A Culvert at Grid Reference 179798,073261. Catchment A drains the area north of the UBY2A Culvert, Catchment B drains the area north of the IDA open culvert which subsequently discharges towards the UBY2A Culvert.

It is recognised that Catchment A might partially also be drained by the UBY1C Culvert, therefore adding an entire discharge towards UBY2A Culvert provide a conservative approach in the culvert capacity assessment.

The two catchments are shown in Figure 3.1 and Figure 3.2. Further details on each catchment are presented in Table 3.1.

Figure 3.1: Catchment A (West)

Source: FSU Web Portal, 2022

Figure 3.2: Catchment B (East)

Source: FSU Web Portal, 2022

Table 3.1: Subject catchment properties

	Catchment A (west)	Catchment B (east)
Location number	19_1554_6	19_1733_5
Catchment area (km^2)	2.978	6.107
BFISOIL	0.6608	0.6816
SAAR (mm)	1076	1088
URBEXT	0.0238	0

Source: FSU Web Portal, 2022

The final peak flows estimated by the FSU Web Portal are presented in Table 3.2. The hydrological analysis details are presented in Appendix A.

It is recognised that the FSU web portal hydrological analyses are best suited for catchments above 25km^2, therefore, the presented values from this method should be used with caution as the subject catchments are well below the recommended threshold.

Table 3.2: FSU estimated peak flow (m^3/s)

	Catchment A (west)	Catchment B (east)	Total (A+B)
10% AEP (1 in 10 year)	1.77	2.77	4.54
2% AEP (1 in 50 year)	2.34	3.65	5.99
1% AEP (1 in 100 year)	2.59	4.01	6.60
1% AEP (1 in 100 year) + climate change	3.11	4.81	7.95
0.5% AEP (1 in 200 year)	2.83	4.38	7.21
0.1% AEP (1 in 1000 year)	3.39	5.23	8.62

Source: FSU Web Portal, 2022

3.1.2 IOH 124 Method

The Institute of Hydrology Report No. 124 provided a method for estimation of flood flows in small rural catchments up to 25km^2.

The IOH 124 method has been used as an additional hydrological method to estimate the flood flows for the UBY2A Culvert crossing. The IOH124 method uses a general model to estimate the Index Flood (QBAR) and general growth factors, which is applied to all catchment across Ireland.

The input parameters for the IOH124 are presented in Table 3.3. The final estimates are presented in Table 3.4.

The results from the IOH 124 method have been chosen for the model inputs as this method is best suited for the rural catchment of size between 0.5 to 25km^2, which both catchments fall within.

It is noted that the IOH124 method does not provide flow estimates for the 0.1%AEP flood event.

Table 3.3: Input parameters for IOH124 method

Parameter	Catchment A (west)	Catchment B (east)
Catchment area (km2)	2.978	6.107
SAAR4170 (mm)	1076	1088
SOIL	0.300	0.300
WRAP class	Class 2	Class 2
URBAN	0.04879	0

Source: FSU Web Portal, 2022

Table 3.4: IOH 124 estimated peak flow (m^3/s)

	Catchment A (west)	Catchment B (east)	Total (A+B)
10% AEP (1 in 10 year)	1.01	1.91	2.92
2% AEP (1 in 50 year)	1.31	2.48	3.79
1% AEP (1 in 100 year)	1.44	2.73	4.17
1% AEP (1 in 100 year) + climate change	1.73	3.28	5.00
0.5% AEP (1 in 200 year)	1.58	2.99	4.57

Source: FSU Web Portal, 2022

3.1.3 Climate Change

Based on the latest guidance[2] an additional allowance of 20% should be applied to the peak flood flows to allow for future climate change in line with the Mid-Range Future Scenario (MRFS).

3.2 Hydraulic modelling

A 1D Flood Modeller hydraulic model of the IDA Open Culvert and UBY2A Culvert has been developed to understand the potential change in flood risk after the proposed culvert extension.

Two scenarios were modelled to compare the impact on flood risk

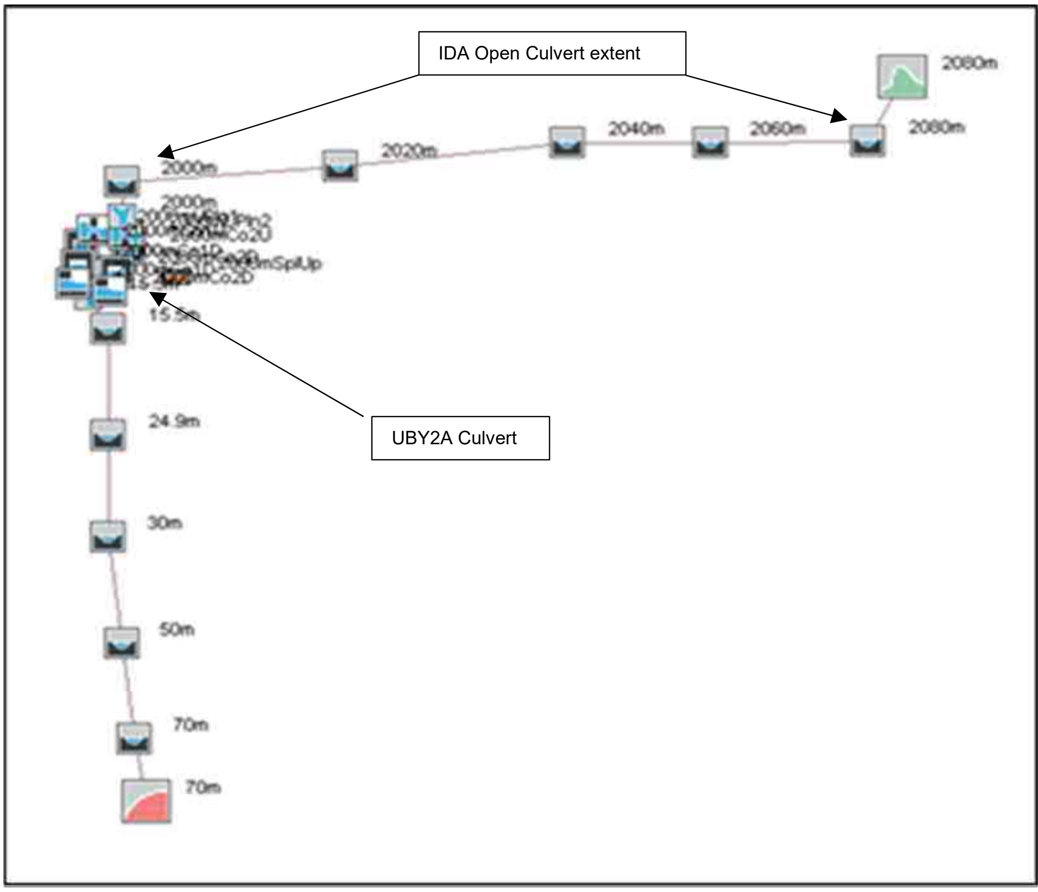
- Existing culvert (12m in length)
- 4m extension of the existing culvert (16m in length in total)

3.2.1 Modelling schematic

The IDA Open Culvert leading to a rectangular double-barrel UBY2A Culvert with a spill node to represent the railway was constructed. The model schematic is presented in Figure 3.3, with more details on the UBY2A Culvert area in Figure 3.4.

[2] Flood Risk Management, Climate Change Sectoral Adaption Plan, Office of Public Works, Sep 2019

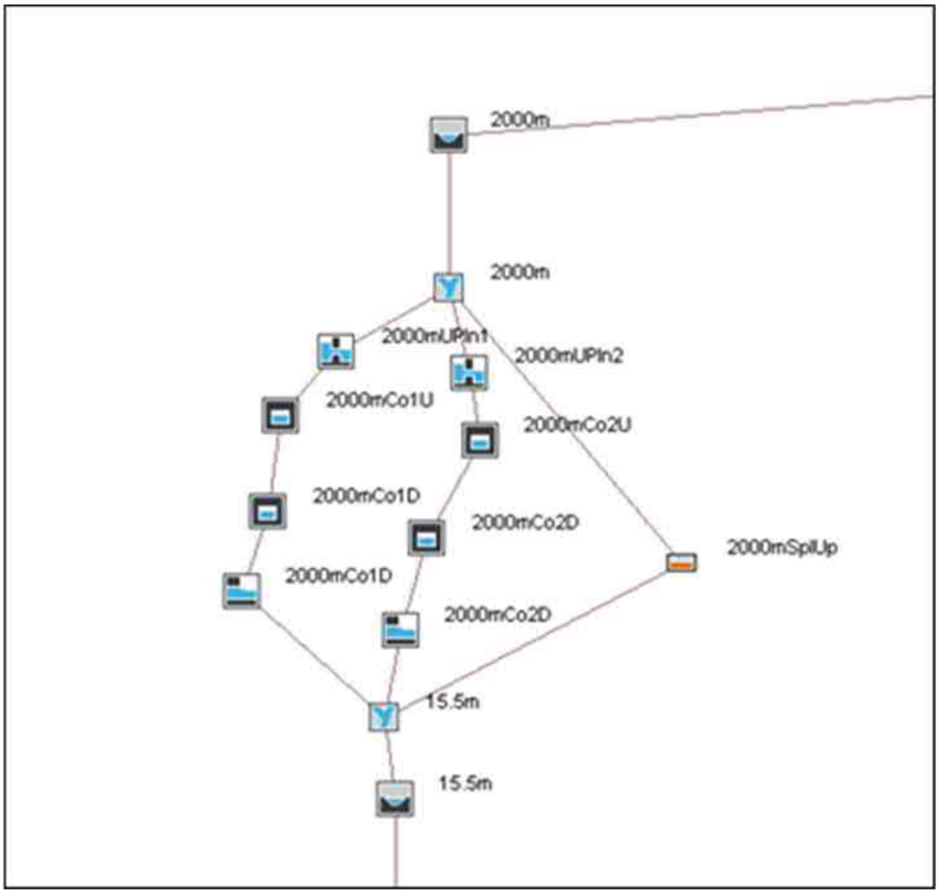
Figure 3.3: Modelling schematic for IDA Open Culvert and UBY2A Culvert



Source

Source: Mott MacDonald 2022

Figure 3.4: Enlargement of modelling schematic at UBY2A Culvert



Source: Mott MacDonald 2022

3.2.2 1D boundaries

1D boundaries include the upstream Flow-Time Boundary in which a hydrograph is an input. The outputs from the hydrological analysis in Section 0 have been used as inflow hydrographs.

A normal depth boundary is applied as the downstream boundary of the model.

3.2.3 Roughness

Channel roughness was modelled using the Manning's roughness coefficient 'n'. The roughness coefficients were determined from the standard tabular values based on the channel type in the model.

Natural bed material is proposed to be placed in the base of the new structures. For modelling purpose a roughness of 0.035 was considered appropriate for the bed of the IDA Open Culvert and 0.06 for the banks.

A roughness of 0.020 was used inside the UBY2A culvert to represent concrete invert, walls and soffit. A sensitivity analysis with an increased roughness in the culvert was also carried out.

3.2.4 1D Structures

The culverts were modelled as two barrels to represent the drawing of existing culvert 011274-49-DR-0545 January 2008 (Appendix B). The details of the culvert geometry are in Table 3.5.

Table 3.5: Existing and proposed UBY2A culvert properties

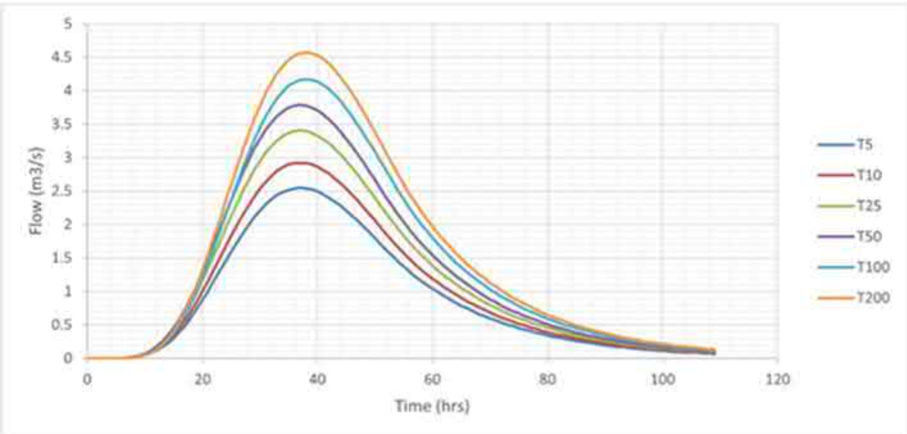
	Existing Culvert (barrel 1)	Existing Culvert (barrel 2)	Proposed Culvert (barrel 1)	Proposed Culvert (barrel 2)
Culvert Type	Rectangular	Rectangular	Rectangular	Rectangular
Length (m)	12	12	16	16
Width (m)	2.4	2.1	2.4	2.1
Height (m)	1.2	1.2	1.2	1.2
Upstream Invert (mAOD)	3.475	3.475	3.475	3.475
Downstream Invert (mAOD)	3.440	3.440	3.440	3.440
Roughness Coefficient (invert)	0.020	0.020	0.020	0.020
Roughness Coefficient (walls, soffit)	0.020	0.020	0.020	0.020

3.2.5 Model inflows

The flow peaks from the IOH124 method have been selected as the best estimates, due to the size of the subject catchments. The hydrograph shapes from the FSU method were scaled to match these flows. These are presented in Figure 3.5.

A simulation run with the 0.1% AEP flood flow was carried out as part of the sensitivity analysis. As the IOH124 method does not provide an estimate for the 0.1%AEP flood flow, this flow was taken from the FSU method. The estimated flood peaks in the FSU method are approximately 50% larger than the flood peaks from the IOH124 method, therefore, using the FSU 0.1% AEP flood event provides a conservative estimate.

Figure 3.5: Derived flood hydrographs



Source: Mott MacDonald, 2022

3.2.6 Modelled flood events

The hydraulic model was run for the following fluvial flood events:

- 1% AEP (1 in 100 year return period) using IOH 124 method.
- 1% AEP (1 in 100 year return period) + climate change using IOH 124 method.
- 0.1% AEP (1 in 1000 year return period) using FSU method (sensitivity run).

3.2.7 Modelling assumptions

- The available drawing from PM group (Figure B.11) shows that the UBY2A culvert invert level is by approximately 300mm lower than the open channel river bed. The UBY2A invert is made of concrete and there is no additional sediment or river bed material. The culvert internal height is 1.2m. This has been modelled as an existing scenario. A sensitivity run with sedimentation in the culvert was included in the sensitivity analysis.
- Orifice unit was used to model the energy losses at UBY2A culvert inlet to reduce risk of model instability.
- At chainage 15.5m shown in drawing 011274-49-DR-0547 by PM Group, no bed channel width is provided and therefore it was assumed to be 10.5m by approximation from the culvert plan.
- Downstream cross-sections in drawings 011274-49-DR-0547 by PM Group, shown in Appendix B, provide no offset (x value) which is required for modelling inputs and therefore was estimated for each design level (y value).
- A downstream slope of 0.003 for the normal depth node was estimated based on surveyed sections.

3.3 Result assessment

3.3.1 Comparison of existing culvert and proposed culvert

The performance of the existing culvert and proposed culvert was compared for two flood events, the 1% AEP and 1%AEP + CC event, the later including an allowance for climate change.

Table 3.6 shows the peak flow through each UBY2A Culvert under different scenarios. Both barrels of the UBY2A Culvert are entirely submerged during the peak flow of both modelled flood events. The peak flows at the UBY2A Culvert remains the same between existing and proposed scenarios. Due to the difference in culvert barrel widths, the peak flow in barrel 1 is approximately 15% higher than the peak flow in barrel 2.

Table 3.6: Peak flows through the UBY2A Culvert

Event	Structure	Existing scenario (m^3/s)	Proposed scenario (m^3/s)
1% AEP	Culvert (barrel 1)	2.23	2.23
	Culvert (barrel 2)	1.94	1.94
1%AEP + CC	Culvert (barrel 1)	2.68	2.68
	Culvert (barrel 2)	2.33	2.33

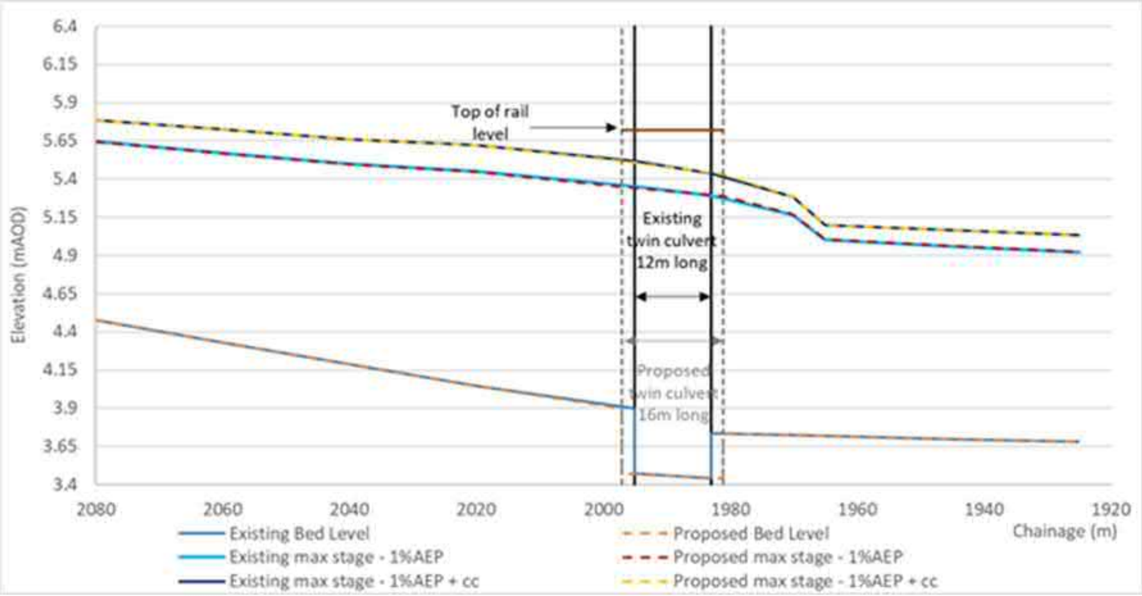
Table 3.7 shows the maximum water level along the modelled channel during both 1%AEP and 1%AEP + CC fluvial flood event. The model indicates that there is an insignificant change in the predicted peak flood levels. The predicted changes up to 0.005m are within modelling accuracy and are likely to be due to temporary numerical oscillations in the hydraulic model.

Figure 3.6 also shows that the maximum water levels for modelled scenarios. It is noted that the predicted peak levels for the 1% AEP fluvial flood event including an allowance for climate change do not overtop the railway track level.

Table 3.7: Peak water level along the model section

Event	Structure	Existing scenario (m OD)	Proposed scenario (m OD)	Impact (m)
1% AEP	IDA Open culvert (Node 2080m)	5.645	5.644	-0.001
	IDA Open culvert (Node 2060)	5.570	5.570	0.000
	IDA Open culvert (Node 2040m)	5.498	5.497	-0.001
	IDA Open culvert (Node 2020m)	5.450	5.450	0.000
	UBY2A culvert (barrel 1) - inlet	5.305	5.304	-0.001
	UBY2A culvert (barrel 1) - outlet	5.295	5.291	-0.004
	UBY2A culvert (barrel 2) – inlet	5.305	5.304	-0.001
	UBY2A culvert (barrel 2) - outlet	5.295	5.291	-0.004
	Downstream open channel (Node 24.9m)	5.167	5.167	0.000
	Downstream open channel (Node 30m)	5.005	5.005	0.000
	Downstream open channel (Node 50m)	4.962	4.962	0.000
	Open channel (Node 70m)	4.924	4.924	0.000
1%AEP + CC	IDA Open culvert (Node 2080m)	5.787	5.787	0.000
	IDA Open culvert (Node 2060)	5.519	5.519	0.000
	IDA Open culvert (Node 2040m)	5.519	5.519	0.000
	IDA Open culvert (Node 2020m)	5.436	5.431	-0.005
	UBY2A culvert (barrel 1) - inlet	5.519	5.519	0.000
	UBY2A culvert (barrel 1) - outlet	5.450	5.450	0.000
	UBY2A culvert (barrel 2) – inlet	5.436	5.431	-0.005
	UBY2A culvert (barrel 2) - outlet	5.436	5.431	-0.005
	Downstream open channel (Node 24.9m)	5.519	5.519	0.000
	Downstream open channel (Node 30m)	5.451	5.451	0.000
	Downstream open channel (Node 50m)	5.436	5.431	-0.005
	Open channel (Node 70m)	5.436	5.431	-0.005

Figure 3.6: Maximum stage of the modelled channel



Source: Hydraulic model result, Mott MacDonald 2022

3.4 Sensitivity analysis

3.4.1 Reduced conveyance due to sedimentation

A sensitivity test with an increased silt level within the UBY2A Culvert was carried out to study impacts on flood risk.

The sediment has been represented by an increase in the invert level at both barrels of the UBY2A Culvert from 3.475m OD to 3.780m OD at the inlet and from 3.440m OD to 3.735m OD at the outlet. The roughness value of the culvert inlet has been increased from 0.020 to 0.035 to represent a typical river bed.

The sedimentation in the UBY2A Culvert increased the 1% AEP fluvial peak flood levels upstream of the culvert by 0.112m in the existing scenario and by 0.125m in the proposed scenario. There is no predicted change in peak flood water levels downstream of the culvert.

The predicted increase in the peak flood water levels upstream of the inlet will stay within the IDA Open Culvert and will not spill out to affect any receptors.

3.4.2 Increase of flows to 0.1% AEP (or 1 in 1000yr) flood event

The 0.1% AEP fluvial flood flow from the FSU method has been used to determine the impact of this flood magnitude on the UBY2A Culvert flood mechanism.

The model predicts that neither the existing or the proposed culvert have enough capacity to convey the 0.1%AEP event flood flow and the surcharging flood water will spill over the railway track.

The peak flow over the railway track has been estimated at 1.28m^3/s with a flow velocity of 0.52m/s. This is about 15% of the peak catchment runoff. This is the same as the existing situation.

4 River Owennacurra Bridge

4.1 Estimation of flood level

Hydraulic modelling of the River Owennacurra was carried out as part of the CFRAM study in 2018[3]. The study used 1d-2d FMP-TUFLOW hydraulic model. The results from the study have been extracted and used to assess flood risk at the Owennacurra River Bridge location (Node 3OWE_3407 and 3OWE_3353).

The peak levels extracted from the CFRAM study are presented in Table 4.1 and the full flood extents are presented in Figure C.13 in Appendix C.

Table 4.1: CFRAM Study flood map water level (mOD)

%AEP	Node 3OWE_3407 – upstream node	Node 3OWE_3353 – downstream node
10% (1 in 10 years)	6.426	6.211
1% (1 in 100 years)	6.825	6.354
0.1% (1 in 1000 years)	7.053	6.521

Source: LEE CFRAM Study, 2018

4.2 Bridge deck widening

The bridge deck is supported on existing river piers, so the only potential new impact on flood risk would be related to the bridge soffit level. The bridge soffit level is at 7.119m OD based on the level of the concrete beam in the drawing (see Figure D.14), which is above the predicted flood levels. Therefore, it can be concluded that the proposed deck widening will not impact the existing flood risk at the Owennacurra River up to the 0.1% AEP flood event.

It is noted that the estimated freeboard between the soffit level and the 1% AEP and 0.1% flood event is 0.29m and 0.07m respectively.

4.3 Abutment widening

The proposed widening of the bridge abutment is in line with the existing bridge layout and will not impact the conveyance of the water under the bridge. However, it is recognised that the proposed new abutment will encroach into the existing floodplain and consequently could reduce the existing flood storage above the existing ground levels which are approximately at 6.4m AOD.

A high-level assessment of the potential loss of the floodplain storage has been carried out as follows:

The estimated size of the proposed new abutment is 3.3m x 3.80m giving a surface area of 12.54m^2. The existing ground levels at this location are approximately 6.4m AOD. Therefore, the maximum potential loss of flood storage has been calculated up to the peak flood level for each return period, as presented in Table 4.2.

[3] LEE CFRAM Study, 2018

Table 4.2: Flood storage loss at new abutments

%AEP	Flood level (m OD)	Maximum loss of storage (m^3)
10% (1 in 10 years)	6.426	0.65
1% (1 in 100 years)	6.825	10.66
0.1% (1 in 1000 years)	7.053	16.38

The area of flood storage upstream of the railway track (up to the Northern Relief Road) is estimated to be over 25,000m^2 for the 0.1%AEP fluvial flood event (based on the CFRAM flood map in Figure C.13). Assuming an average depth of 0.5m (based on the 0.1% AEP flood level and a ground level of 6.4mAOD), this results in a flood storage of approximately 12,500m^3. Therefore, the max displaced volume of flood water by the new abutments is approximately 0.13% of the total volume of the immediate upstream floodplain. Therefore, the impact is considered negligible and is not expected to result in a flood risk increase elsewhere.

It is noted that the estimated volumes in Table 4.2 are conservative and the area where the new abutments will be placed is already largely infilled with soil. If further assessment is required, the flood storage loss figures should be further reviewed.

4.4 Embankment widening

Available design drawings were interrogated and the proposed embankment infill changes compared against the available flood levels from the CFRAM study. This was carried out for each location of the infill as shown in Figure D.15.

It has been determined that the proposed embankment widening will take place above the predicted peak flood water level for the 0.1% AEP flood event and therefore these proposed works are considered not to impact existing flood risk.

Further details of the cross sectional analysis of the embankment infill are presented in Figure D.16.

5 Conclusion

5.1 Summary

This FRA Stage 3 assesses the impact of the proposed twin-tracking of the existing railway track from Glounthaune to Midleton in County Cork. This follows on from a FRA Stage 1 which determined that hydraulic modelling was required in some areas of the proposed development.

A Justification Test was undertaken in FRA Stage 1, which supported the development of the railway within flood risk areas, due to the need to adopt the adjacent existing track level or thereby for the new track.

This FRA Stage 3 assesses the flood risk impact on repositioning of the IDA Open Culvert and extension of the connected UBY2A Culvert, plus the proposed widening of the railway bridge deck over the River Owennacurra (Railway Underbridge UBY11), in more detail.

5.2 IDA Open Culvert and UBY2A Culvert

A 1D hydraulic model of the IDA Open Culvert and UBY2A Culvert, in the existing and proposed scenario, has been developed to assess the potential impact of the proposed works on flood risk.

The hydraulic model predicts that there will be insignificant changes in peak flood levels between the existing and proposed scenarios for the 1% AEP (or 1 in 100 year) fluvial flood event including an allowance for future climate change. The changes are between 0 and -0.005m predicting an insignificant reduction in flood water levels.

5.3 River Owennacurra Bridge

Flood water levels predicted by the local CFRAM flood study for the 0.1% AEP (or 1 in 1000 year) fluvial flood event do not reach the soffit of the proposed bridge. As the bridge is proposed to use the existing piers, it is considered that there is no significant impact on flood levels upstream from the proposed bridge.

The proposed abutment widening will potentially encroach into the existing flood plain upstream, however, the predicted impact is considered negligible due to the insignificant volume lost by the widening (0.13%).

The proposed embankment widening will take place above the predicted flood extent and therefore it is considered not to impact flood storage in the area.

It can therefore be concluded that the proposed widened bridge, constructed utilising the existing piers, will not impact the existing flood risk.

Appendices

A.	Hydrology Analysis Details	19
B.	IDA/UBY2A culvert drawings	25
C.	River Owenacurra	26

A. Hydrology Analysis Details

The hydrological analysis for the IDA Culvert has been carried out using the FSU Web Portal. The IOH 124 method has been used as an additional hydrological method due to the small size of the subject catchments. The IOH 124 results have been used for modelling inputs, as the method is deemed to be more suitable for the subject catchments.

Two catchments contributing towards the UBY2A culvert were analysed, namely Catchment A (19_1554_6) and a neighbouring Catchment B (19_1733_5).

A.1 FSU Web Portal hydrological analysis – Catchment A (19_1554_6)

A.1.1 Subject catchment

The extent of the subject catchment, as defined inside the FSU Web Portal, together with the Physical Catchment Descriptors (PCD) are displayed in Figure A.1.

Figure A.1: Catchment A boundary

Source: FSU Web Portal, 2022

A.1.2 QMED

To estimate the QMED at the ungauged subject site, the 22009 White Bridge pivotal site has been selected, which is geographically the closest. The pivotal site properties and QMED values as returned by the FSU Web Portal are shown Figure A.2.

Figure A.2: QMED value and properties for Pivotal Site 22009 White Bridge

Pivotal site candidate properties	
Station Number	22009
Contributing Catchment Area	35.397 km^2
BFISOIL	0.6011
SAAR	1172.49 mm
FARL	0.995
DRAIND	1.083 km/km^2
S1085	10.5456 m/km
ARTDRAIN2	0
URBEXT	0.0575
Centroid distance	132.8999 km
Hydrological similarity	1.5645
$QMED_{rural}$ values and confidence	
Pivotal gauged	11.465m^3/s
Pivotal PCD rural	8.9551m^3/s
Pivotal PCD urban	9.7287m^3/s
Subject PCD estimate	1.511m^3/s
68% upper bound	2.0701m^3/s
68% lower bound	1.103m^3/s
95% upper bound	2.8361m^3/s
95% lower bound	0.8051m^3/s
Status	

QMED values	
Sub. $QMED_{rural}$	0.9124m^3/s
Sub. QMED	0.9448m^3/s
Piv. QMED gauged	11.465m^3/s
Piv. adjfac QMED	1.1785
Sub. QMED adjusted	**1.1134m^3/s**

Source: FSU Web Portal 2022

A.1.3 Growth curve

The growth curve at the subject site has been derived using a pooling group analysis inside the FSU Web Portal. The Euclidean scheme and EV1 distribution have been applied, as per FSU guidance. The pooling group has been set up for the 1000yr flood return period, using 1000 year of pooled data. No further changes to the default selection of donors has been deemed necessary. The generated pooling group and growth curve are presented in Figure A.3 and Figure A.4.

The estimated final peak flows are provided in Table 3.2 in Section 3.

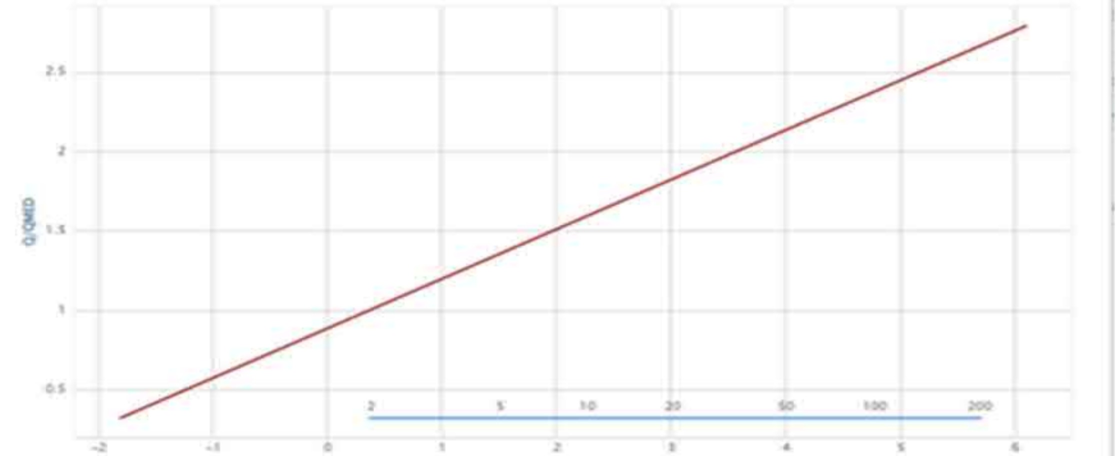
Figure A.3: Catchment A – Pooled analysis

Station	Euclidean DIST(ij)	# years in FSU database	Cumulative # station-years
25034	1.342	26	26
30020	1.674	16	42
25040	1.842	19	61
10022	1.99	17	78
22009	2.066	24	102
06030	2.084	27	129
09011	2.101	16	145
16051	2.204	13	158
24022	2.418	20	178
06031	2.444	18	196
13002	2.465	19	215
19046	2.505	9	224
26058	2.546	24	248
10021	2.555	24	272
19020	2.595	28	300
16006	2.625	33	333
26022	2.642	33	366

Legend: Pooled Auxiliary Selected

Source: FSU Web Portal, 2022

Figure A.4: Catchment A – Final Growth Curve



Distribution: EV1

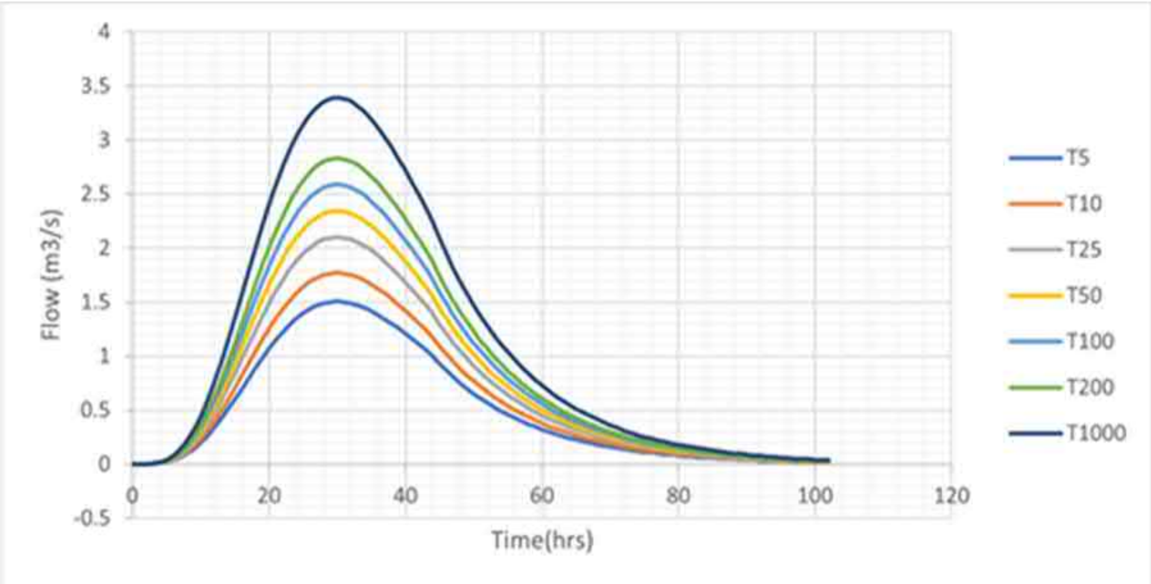
	T=1.3	T=2	T=5	T=10	T=20	T=30	T=50	T=100	T=200	T=500	T=1000
Growth Factors	0.77	1	1.25	1.59	1.81	1.94	2.11	2.32	2.54	2.83	3.05
Design Peak Flows (m^3/s)	0.85	1.11	1.51	1.77	2.02	2.16	2.34	2.59	2.83	3.15	3.39

Source: FSU Web Portal, 2022

A.1.4 Hydrograph Width

For the hydrograph width the 16013 Fourmilewater pivotal site has been selected, which is hydrologically the closest.

Figure A.5: Catchment A – Final Hydrographs Flows



Source: FSU Web Portal, 2022

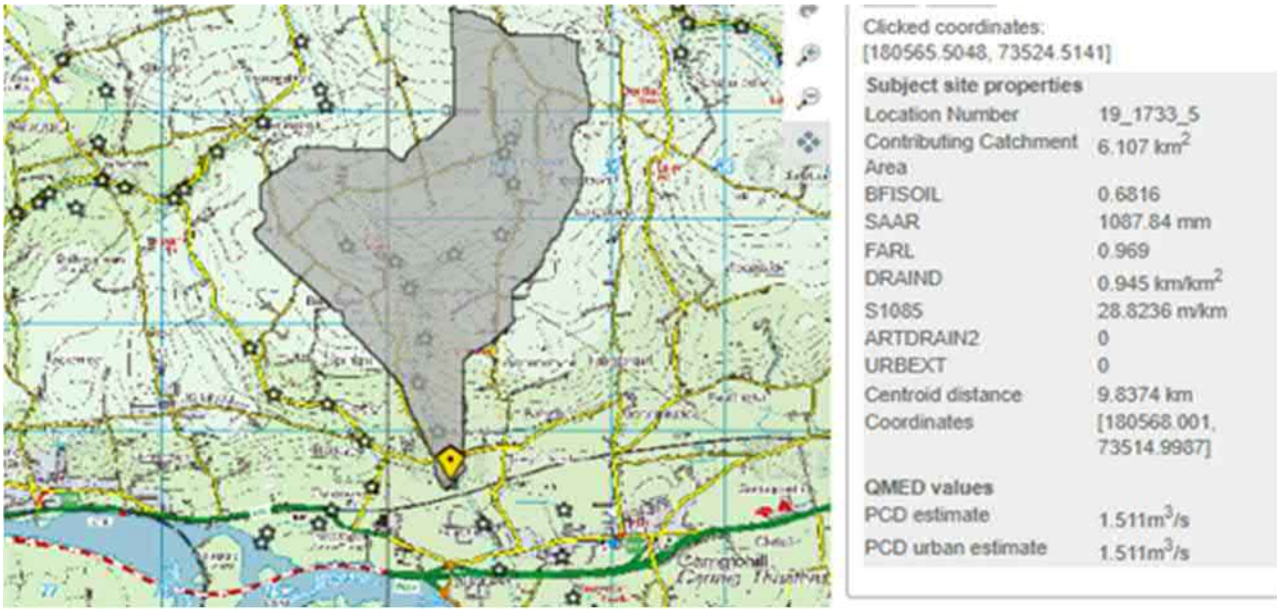
A.2 FSU Web Portal hydrological analysis – Catchment B (19_1733_5)

A.2.1 Subject catchment

The design flood flows have been calculated for the area of Catchment B (19_1733_5). This catchment also contributes to the flow at UBY2A Culvert.

The extent of Catchment B, as defined inside the FSU Web Portal, together with the Physical Catchment Descriptors (PCD) are displayed in Figure A.6.

Figure A.6: Catchment B boundary



Source: FSU Web Portal, 2022

A.2.2 QMED

To estimate the QMED at the ungauged subject site, the 22009 White Bridge pivotal site has been selected, which is geographically the closest. The pivotal site properties and QMED values as returned by the FSU Web Portal are shown Figure A.7.

Figure A.7: QMED value and properties for Pivotal Site 22009 White Bridge

Pivotal site candidate properties	
Station Number	22009
Contributing Catchment Area	35.397 km^2
BFISOIL	0.6011
SAAR	1172.49 mm
FARL	0.995
DRAIND	1.083 km/km^2
S1085	10.5456 m/km
ARTDRAIN2	0
URBEXT	0.0575
Centroid distance	132.8999 km
Hydrological similarity	1.5645
QMED$_{rural}$ values and confidence	
Pivotal gauged	11.465m^3/s
Pivotal PCD rural	8.9551m^3/s
Pivotal PCD urban	9.7287m^3/s
Subject PCD estimate	1.511m^3/s
68% upper bound	2.0701m^3/s
68% lower bound	1.103m^3/s
95% upper bound	2.8361m^3/s
95% lower bound	0.8051m^3/s
Status	

QMED values	
Sub. QMED$_{rural}$	1.511m^3/s
Sub. QMED	1.511m^3/s
Piv. QMED gauged	11.465m^3/s
Piv. adjfac QMED	1.1785
Sub. QMED adjusted	1.7807m^3/s

Source: FSU Web Portal, 2022

A.2.3 Growth curve

The growth curve at the subject site has been derived using a pooling group analysis inside the FSU Web Portal. The Euclidean scheme and EV1 distribution have been applied, as per FSU guidance. The pooling group has been set up for the 1000yr flood return period, using 1000 year of pooled data. No further changes to the default selection of donors has been deemed necessary. The generated pooling group and growth curve are presented in Figure A.8 and Figure A.9.

The estimated final peak flows are provided in Table 3.2 in Section 3.

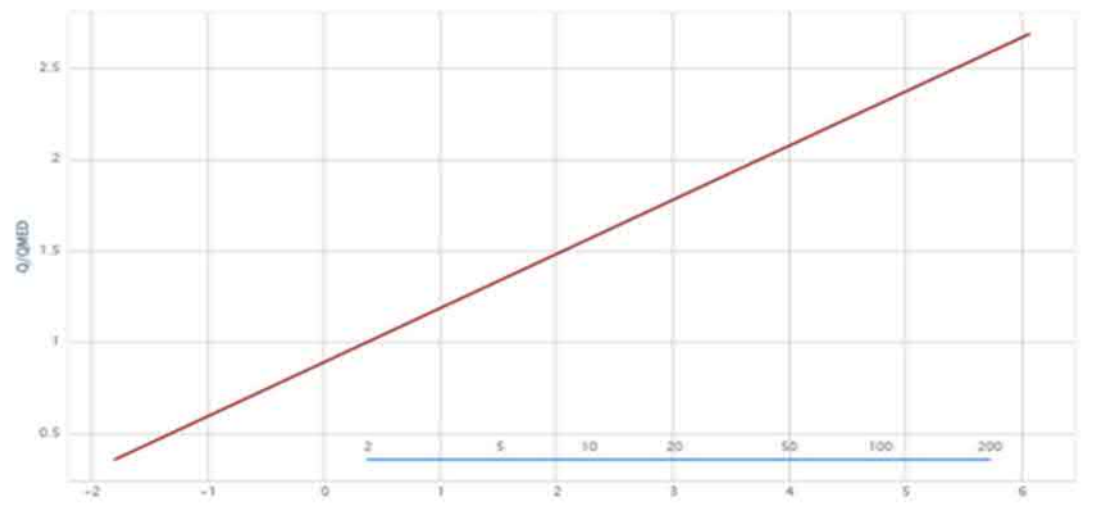
Figure A.8: Catchment B – Pooled analysis

Station	Euclidean DIST(ij)	# years in FSU database	Cumulative # station-years	
25034	0.945	26	26	✗
30020	1.121	16	42	✗
25040	1.352	19	61	✗
22009	1.564	24	85	✗
16051	1.768	13	98	✗
10022	1.821	17	115	✗
13002	1.889	19	134	✗
19046	1.931	9	143	✗
26058	2.001	24	167	✗
06030	2.004	27	194	✗
19020	2.03	28	222	✗
06031	2.046	18	240	✗
24022	2.052	20	260	✗
16006	2.111	33	293	✗
09011	2.162	16	309	✗
26022	2.213	33	342	✗

Legend: Pooled Auxiliary Selected

Source: FSU Web Portal, 2022

Figure A.9: Catchment B – Final Growth Curve



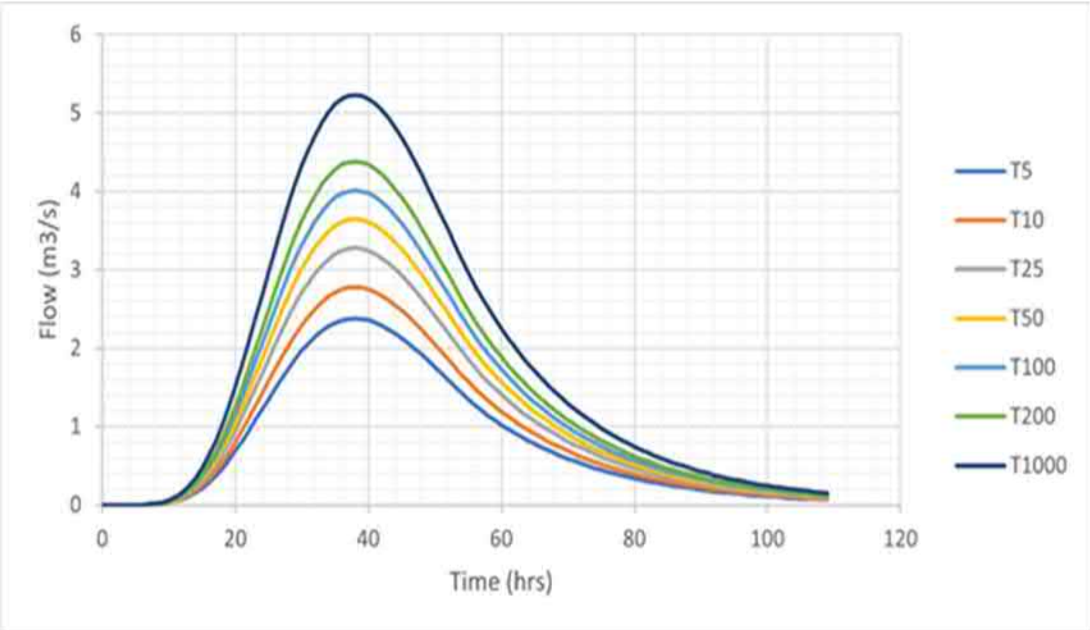
Distribution	EV1										
	t=1.3	t=2	t=5	t=10	t=20	t=30	t=50	t=100	t=200	t=500	t=1000
Growth Factors	0.78	1	1.34	1.56	1.77	1.89	2.05	2.25	2.46	2.73	2.94
Design Peak Flows (m^3/s)	1.39	1.78	2.38	2.77	3.15	3.37	3.65	4.01	4.38	4.87	5.23

Source: FSU Web Portal, 2022

A.2.4 Hydrograph Width

For the hydrograph width the 19020 Ballyedmond pivotal site has been selected as a most suitable hydrograph pivotal site. The final hydrographs are presented in Figure A.10.

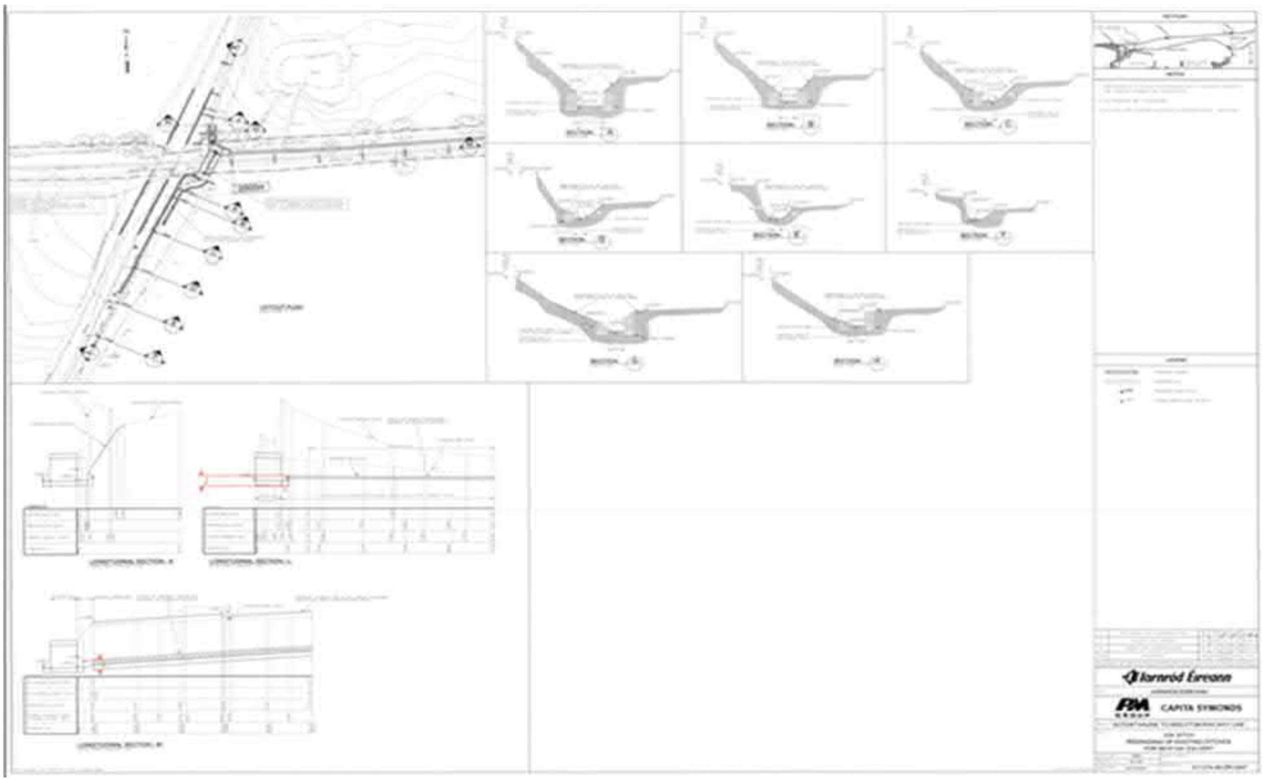
Figure A.10: Catchment B – Final Hydrograph Flows



Source: FSU Web Portal, 2022

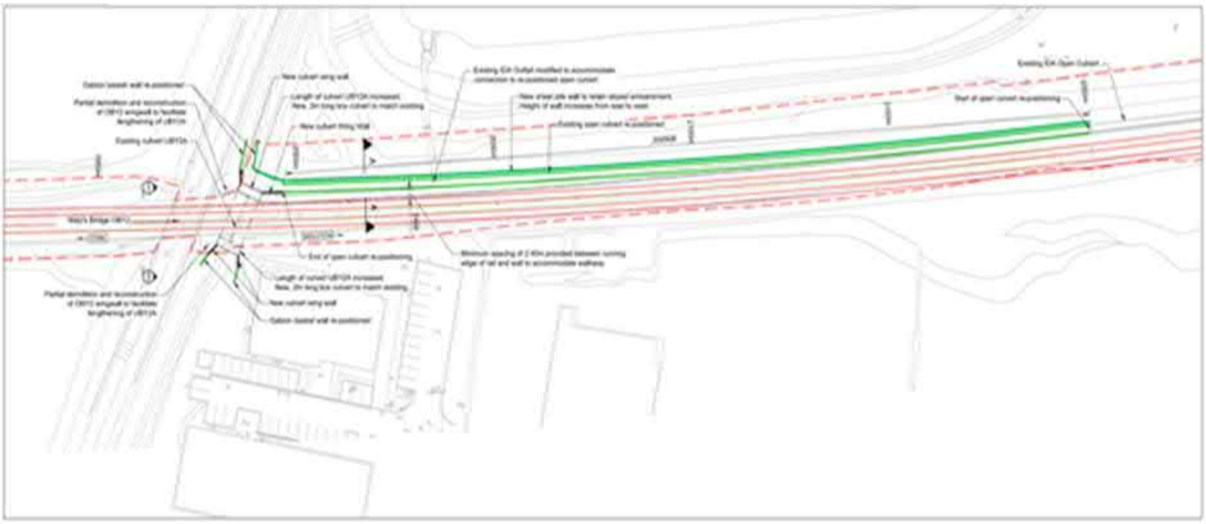
B. IDA Open Culvert and UBY2A Culvert drawings

Figure B.11: Existing culvert drawings



Source: PM Group, 2007

Figure B.12: Proposed changes at IDA Open Culvert and UBY2A Culvert drawings

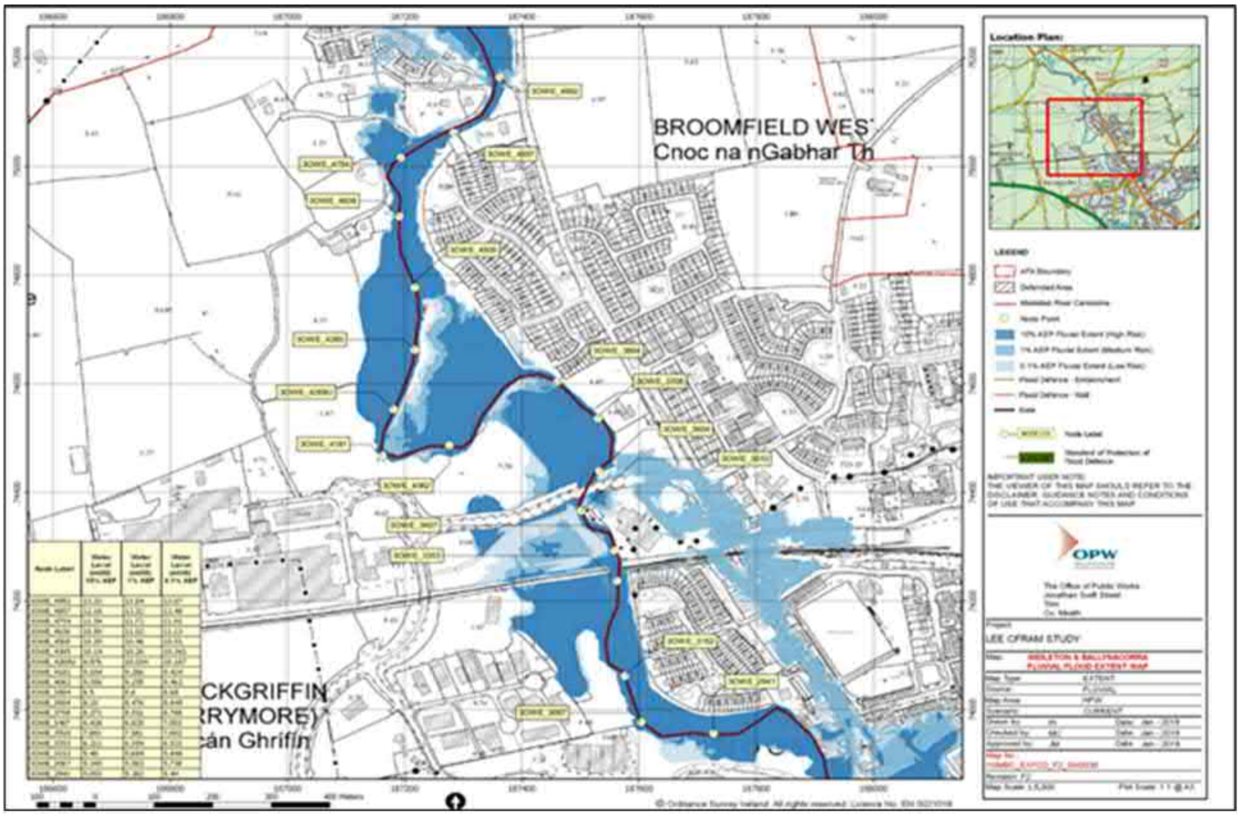


Source: Mott MacDonald,2022

C. River Owennacurra

C.1 River Owennacurra CFRAM Flood Maps

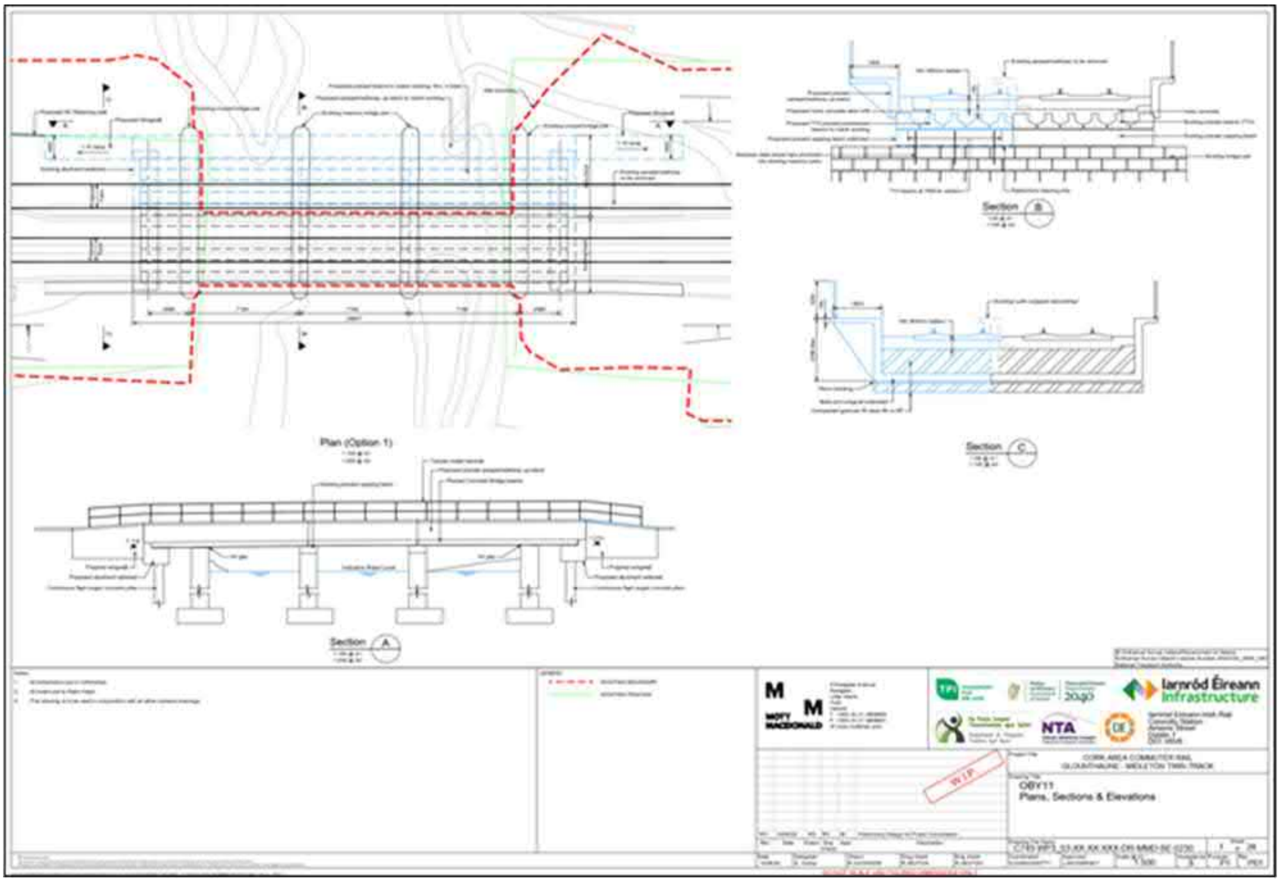
Figure C.13: CFRAM flood map - River Owennacurra



Source: LEE CFRAM Study, 2018

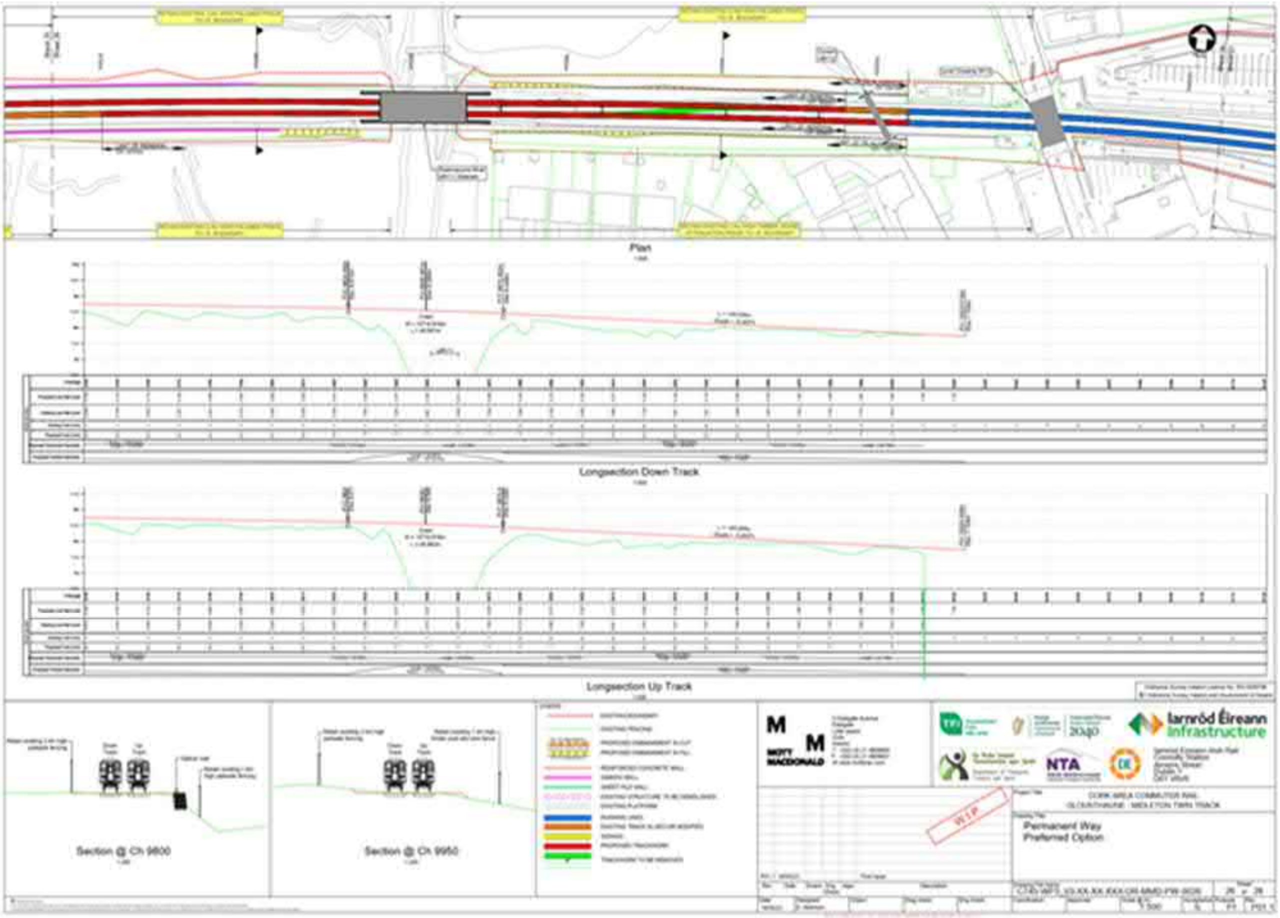
C.2 River Owennacurra drawings

Figure C.14: River Owennacurra Bridge – proposed deck and abutment widening



Source: Mott MacDonald,2022

Figure C.15: River Owennacurra Bridge – Proposed embankment widening



Source: Mott MacDonald,2022

Figure C.16: Cross section of the proposed infill areas