

Appendix C5.04

SECTION 1

River Finn Crossing: Structures Options Report

River Finn Crossing: Structures Options Report

TEN-T Priority Route Improvement Project, Donegal



TT_MGT0337-RPS-P3-ZZ-RP-S-BR0003
River Finn Crossing: Structures Options Report
S3 P02

March 2022

Structures Options Report - Consultation STA-1a

Category 3

SCHEME NAME

Name and location Ten-T Priority Route Improvement Project - Donegal

STRUCTURES

Name and nature of the Structure: River Finn Crossing

Structures Options Report

Reference: TT_MGT0337-RPS-P3-ZZ-RP-S-BR0003

Revision: P02

Date: 04-03-2022

SUBMITTED BY:

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Date: 13 / 03 / 2022

EXECUTIVE SUMMARY

STRUCTURE

Name:	River Finn Crossing
Structure Ref No:	N15R024
Primary Function:	To carry the N15 Mainline over the River Finn and R252 Regional Road,
Check Category:	3
Loading:	IS EN 1991-2 – LM1, LM2, LM3 (SV196)

PASSAGES

Primary:	N15
Secondary:	River Finn & R252

RECOMMENDATION

The outcome of the River Finn Structures Options Report indicates that a 7-span varying depth weathering steel multi-girder bridge (Option 2) should be considered as the preferred option. It is recommended that Option 2 is taken forward to preliminary design and planning stage as the preferred option.

ESTIMATED COST

The estimated construction cost of the bridge is approximately €34.11m excluding VAT (2022).

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1 INTRODUCTION

1.1 Consultant's Brief

In November 2016, Donegal County Council appointed joint venture RPS/Barry Transportation as design consultants for the Trans-European Network - Transportation (TEN-T) Priority Route Improvement Project, Donegal. The project is divided into three sections as illustrated in Figure 1-1.

Section 1 – N15/N13 Ballybofey / Stranorlar Urban Region

Section 2 – N56/N13 Letterkenny to Manorcunningham

Section 3 – N14 Manorcunningham to Lifford / Strabane / A5 Link.

The three sections of the TEN-T Priority Route Improvement Project, Donegal are considered as one project.

The project is being implemented in accordance with the TII Project Management Guidelines (PMGs), January 2019; superseding the NRA's 2010 Project Management Guidelines (PE-PMG-02004) and September 2017 updates which were used on the project up until the publication of the January 2019 PMGs. In the context of this Option Selection Report the 2019 PMGs have minor differences from the 2010 PMGs.

This report will focus on Section 1 and will cover a new multi-span bridge crossing the River Finn to facilitate the new route west of Ballybofey.

1.2 Background to the Scheme

Much of the TEN-T road network in Donegal does not meet the current design standards for a National Primary road in terms cross-section, horizontal and vertical alignments, junctions, overtaking opportunities, drainage, etc. Given the strategic importance of the N13, N14 and N15 routes to Donegal providing connectivity to the rest of the island, a study into the condition of the existing infrastructure was undertaken as part of the Trans-European Transport Network Corridor Needs Study, Donegal in 2015. This study reviewed the TEN-T network in Donegal, assessing the network against various technical, non-technical, economic, traffic and safety criteria. The assessment comprised a site visit, journey time surveys and a desktop study for all parts of the TEN-T network in the county, except the N15 from south of Ballybofey to the county boundary, as numerous upgrades of this section have been completed in recent times.

Six sections of the TEN-T network in Donegal were identified and ranked in order of intervention priority due to deficiencies in the existing infrastructure provision. Three sections requiring the most immediate intervention (see Figure 1-4) form part of the TEN-T Priority Route Improvement Project, Donegal:

1. The N15/N13 Ballybofey/Stranorlar Urban Region
2. The N56/N13 Letterkenny to Manorcunningham
3. The N14 Manorcunningham to Lifford/Strabane/A5 Link.

In addition to the fact these routes are strategic, nationally significant connections from Letterkenny/Donegal to the rest of the island, they also provide connectivity between key towns in County Donegal – Letterkenny, Ballybofey/Stranorlar and Lifford. Consequently, a high volume of traffic uses these routes, which has an impact on these towns. As a result, the towns suffer from issues such as congestion and a poor environment for vulnerable road users, while traffic suffers from longer journeys and poor journey time reliability.

The prioritisation of these three sections is also necessary to ensure the development of the county in line with the Donegal County Development Plan, which has long established a need for intervention at the three areas in question. Furthermore, the National Development Plan also recognises that work on these links is required. All three locations have had previous projects progressed to varying degrees and as a result, have reserved corridors for new routes in the County Development Plan.

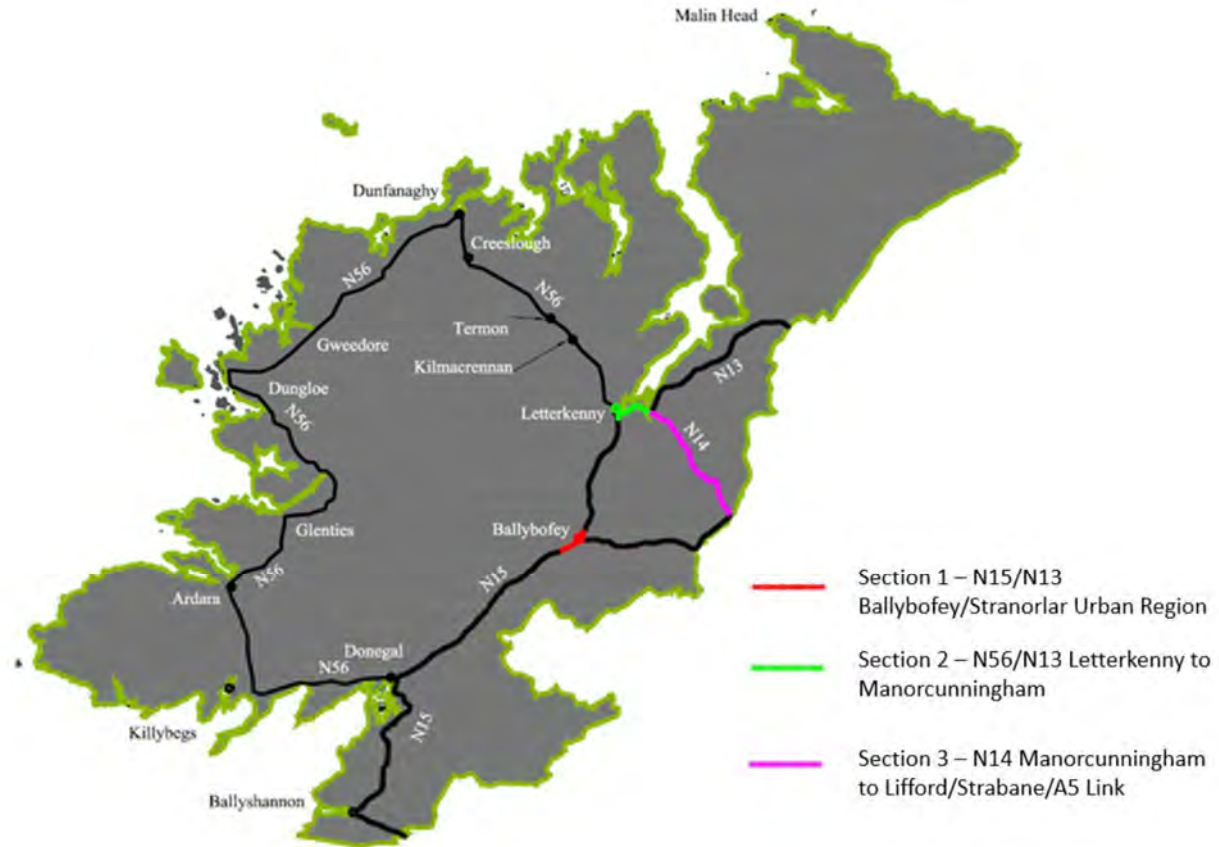


Figure 1-1: Donegal National Roads and Proposed Schemes

1.3 Previous Studies

Several reports and investigations have been previously carried out across the TEN-T network in Donegal. The fundamental reports are listed here:

- Constraints Studies – these outlined the constraints for the respective sections prior to identifying options:
 - i. N14/N13 Junction (Manorcunningham) to Lifford Constraints Study; 2000; Mott MacDonald,
 - ii. N15 Ballybofey/Stranorlar Bypass Constraints Study (2000); McCarthy Hyder.
- Route Selection Reports – conclude with proposals for route options:
 - i. N15 Ballybofey/Stranorlar Bypass Route Selection Report (2001); McCarthy Hyder,
 - ii. N14/N13 Junction (Manorcunningham) to Lifford Route Selection Report (2001); Mott MacDonald,
 - iii. N56 Letterkenny Relief Road Route Selection Report, (2010) Donegal County Council.
- Environmental Impact Statements:
 - i. Environmental Impact Statement Ballybofey/Stranorlar Bypass (2007); McCarthy Hyder
 - ii. N14/N15 to A5 Link Environmental Impact Statement (2011).
- Other reports and assessments:
 - i. N14 Four Lane Road at Letterkenny Feasibility Report Nov (2005); Michael Punch and Partners,
 - ii. Various Traffic Model Studies conducted by Jacobs,
 - iii. Traffic model reviews on the N14 conducted by RPS.

All three sections of the TEN-T Priority Route Improvement Project were previously advanced under separate projects to various stages of planning and design.

2 SITE LOCATION & CONSTRAINTS

There are a number of constraints to be considered in the study area, an overview of the constraints is presented below.

2.1 Site Location

The site of the proposed bridge is on the western side of Ballybofey town, Co. Donegal at the location where the proposed N15 Route crosses the River Finn, see Figure 2-1. A structure's location map for Section 1 of the project is attached in Appendix 1. Each structure on the project has been assigned a structure reference based on the mainline carriageway route number, structure type (O for overbridge, R for river bridge etc) and chainage location, the Finn Crossing's structure reference is therefore N15R024.



Figure 2-1: Site Location

2.2 Constraints

2.2.1 Proposed Alignment & Location

The proposed alignment and location of the new bridge is governed by the preferred option chosen at route selection stage and the location and path of the River Finn. The vertical alignment of the proposed route is over 10m higher than the existing ground level at the bridge location.

2.2.2 River Finn

The River Finn provides a significant physical constraint due to the width of the watercourse. At the proposed crossing location, the river is gently meandering with a main channel width varying from 44.5m to 50.0m and the depth from the channel bank to the riverbed level is approximately 4.75m. The river is prone to flooding with a large flood plain located on the northern bank at the proposed crossing location.



Figure 2-2: River Finn

2.2.3 R252 Regional Road

The existing R252 Regional Road runs parallel to the River Finn on its southern bank at the location of the proposed crossing. The new bridge will need to span the R252.

2.2.4 Proposed Greenway

An existing disused railway line runs parallel to the R252 at the southern end of the proposed crossing. There is potential for this railway line to be converted into a greenway so the proposed crossing will need to span the railway line with its most southern span giving satisfactory clearance and headroom.

2.2.5 Land Requirements

The land on the northern bank of the river and on the southern approach to the bridge location are privately owned and it is intended to progress the scheme by means of Compulsory Purchase Order (CPO). The land to the north is primarily agricultural. There are dwellings located along the R252 at the southern approach, with one positioned directly along the proposed alignment. A significant land take is required for the bridge and particularly the approach embankments due to the height of the vertical alignment as noted in Section 2.2.1.

2.3 Environmental Constraints

2.3.1 River Finn SAC

The primary environmental constraint at this location is the River Finn. The bridge crosses the River Finn Special Area of Conservation (SAC) (Site Code: 002301) and the River Finn flows into the River Foyle and Tributaries SAC (Site Code: UK0030320).

The River Finn flows east between Ballybofey and Stranorlar to the confluence with the River Mourne at Lifford. The SAC runs longitudinally along the River Finn and the Northern Ireland border. The River Finn SAC is designated for six qualifying features including:

- Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) [3110]
- Northern Atlantic wet heaths with *Erica tetralix* [4010]
- Blanket bogs (* if active bog) [7130]
- Transition mires and quaking bogs [7140]

- *Salmo salar* (Salmon) [1106]
- *Lutra lutra* (Otter) [1355]

The River Foyle and Tributaries SAC runs longitudinally along the River Foyle and the Northern Ireland border. Designated an SAC for the following habitats and species:

- *Water courses of plain to montane levels with the Ranunculion fluitantis and Callitriche-Batrachion vegetation.*
- *Salmo salar* (Salmon) [1106]
- *Lutra lutra* (Otter) [1355]

The River Finn and its' tributary, the Reelin River, further west of the study area are noted for being the most prolific salmon and grilse rivers in Donegal and the Foyle catchment¹. Salmon is an Annex II species and is a qualifying interest of the River Finn SAC. The River Finn is known as a spring salmon river and the grilse arrive in late June and July. The River Finn floodplain and margins support improved grassland, wet grassland, riparian woodland and broadleaved woodland.

Protected species such as kingfisher and bat species also forage and commute up and down the river corridor. Interfering with commuting corridors is likely to increase disturbance and interfere with natural flight lines/fly ways of bat and bird species, thereby creating a barrier effect.

Otter is a qualifying interest of the River Finn SAC and may be found throughout the watercourses within the study area. The extent of otter habitat, in addition to the aquatic habitat, comprises a 10m riparian buffer (both banks). Therefore, watercourses and their riparian zone connected to the River Finn within the study area are considered to provide potential habitat for otter.

The most prevalent qualifying environmental features that will impact on the scheme is from the salmonid habitats in the River Finn SAC and otter (see **Figure 2-3**). Consequently, careful consideration of the environmental impact of the scheme shall be required particularly on habitats, otter and hydrological functioning. Considering the Salmonid Habitat, instream construction works shall not be permitted and access to the riverbank for otter will also be required.



Figure 2-3: River Finn SAC north of Ballybofey / Stranorlar

¹ <http://www.fishinginireland.info/salmon/loughs/finn.htm>

Given the high ecological sensitivity of this location, a precautionary strategy has been applied to the design approach to bridge the River Finn SAC. By proposing a continuous bridge structure solution across the flood plain (defined by the CFRAM 100-year event flood mapping) it minimises potential ecological impact to the SAC.

If a shorter bridge and extended embankments with flood culverts was proposed, the following environmental difficulties would arise from construction of the embankment in the flood plain:

1. A single span structure with an embankment adjacent to the riverbank would block access more than multi-span. This could impact otter movement and possible salmon spawning.
2. Working within a flood plain of an SAC would require very detailed construction methodology to be considered in the NIS (far more detail than is currently needed). The designers would need to clearly demonstrate how construction of embankments and such within the flood plain will be managed during the construction phase, with significant detail required. This would be highly prescriptive and would impede the flexibility for a Contractor to deploy a construction methodology more suited to his own working. In the event that flooding does occur during construction this will lead to excessive silt and sediment release to the River Finn which may adversely impact on the integrity of the SAC, which significantly increases exposure to Donegal County Council as the Client for the works.
3. DCC would need to show that there would be “No adverse effects on integrity” due to the direct connection of the flood plain to the SAC. This includes impacts to water quality, flow regimes and potential wash through of the working zone. This is very hard to prove, particularly in the case of worst-case levels of flooding with the need to be certain. If impacts on the SAC cannot be ruled out and integrity is affected, then the NIS will probably recommend Article 6(4) of the Habitats Directive, i.e. IROPI. This would introduce significant risk to the project’s success at the Planning Stage.
4. The multi-span bridge across the entire flood plain was chosen during Stage 2 Option Selection Stage with consideration for environmental reasons and found to be the best option, and for hydrology reasons explained below. Changing it would require doing a full environmental assessment again, which would significantly delay the project.

2.4 Archaeological and Cultural Heritage

A number of areas of high archaeological potential were identified following a review of the local topography, recorded archaeological records and locational data, historic cartographic sources and aerial mapping which was supplemented by observations in the field. These areas of high archaeological potential have been identified at 6 no. locations and have been abbreviated as Section 1 Area of Archaeological Potential_01 to 06 (S1AAP_01 to S1AAP_06). S1-AAP02 incorporates the River Finn and its flood plains located to the north and south.

The S1-AAP-2 area is located along the southwest and north-eastern banks of the River Finn, demarcated by the R252 to the south-west and the local road network skirting along the lower slopes of Trooper’s Hill and incorporating Drumboe Lower. The eastern portion of this Area of Archaeological Potential at Drumboe Lower also forms part of the north-western area of Garden Demesne lands associated with Drumboe Castle (NIAH Garden ID DG0047), although the demesne grounds are now largely fragmented by modern housing development. Within this area is also Holy Well Woods – an amenity woodland with a cultural holy well site that is well maintained, regularly visited and in use. It is possible that this site may have original associations with the adjacent site of Drumboe Abbey (site of), c. 300m to the south, see Figure 2-4.

The River Finn itself is an important natural resource and would have been vital to early settlers in terms of transport, socioeconomics and politics/territorial boundaries. Trooper’s Hill overlooks the river valley floor at the north and has 3 no. recorded archaeological sites: DG077-009--- (ringfort); DG077-010--- (ringfort) and DG077-011--- (enclosure). Further to the west is the recorded remains of Drumboe Abbey (no surface trace, but with significant potential for sub-surface remains, including burials) near a bend in the River Finn, at its northern banks (DG078-005---).

Rivers were regarded as sacred places, particularly during the Bronze Age, when ritual deposition of important artefacts (often elaborate metalwork) took place. It is possible that there may be underwater archaeological potential to discover prehistoric finds/features at this crossing location. Furthermore, the valley floor would have been an attractive location from earliest times, and as such, there is high potential to uncover site types ranging from the prehistoric era to medieval times.

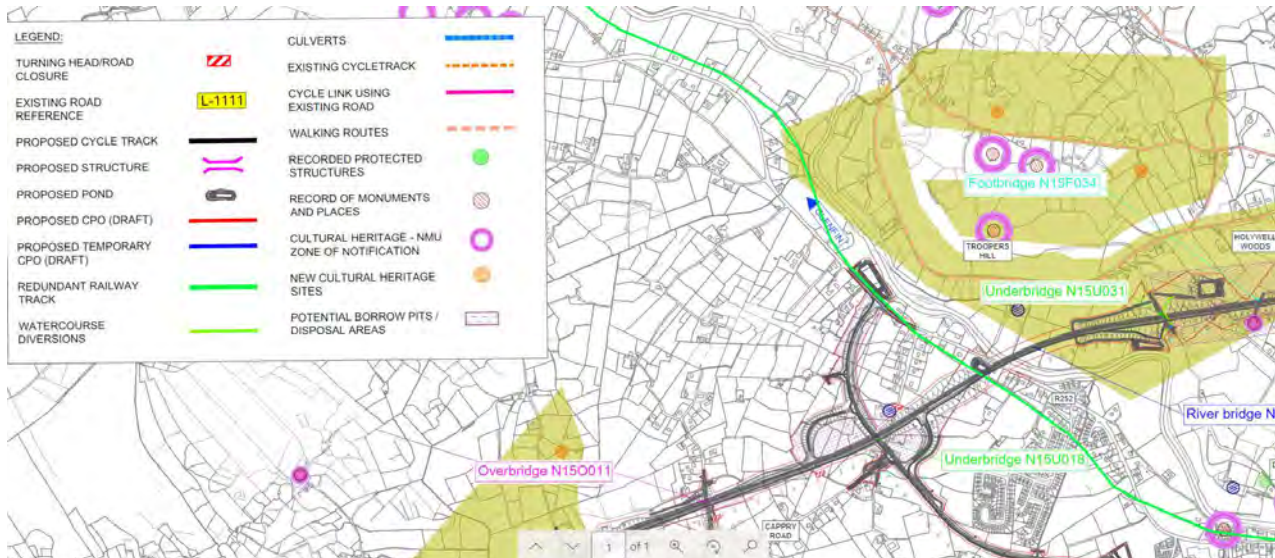


Figure 2-4: Cultural Heritage Features near the crossing of the River Finn

2.5 Landscape and Visual Effects

The landscape of the study area is dominated by the relatively wide valley associated with the River Finn. The River Finn traverses the study area in a generally east-west orientation, with elevated land to the north and west of Ballybofey/ Stranorlar providing a sense of enclosure to the flat, valley landscape. Land cover associated with the study area is varied though generally comprised of a fertile agricultural plain adjacent to the River Finn, set within a wider, gently undulating mixed arable and pastoral agricultural landscape with large tracts of mixed species woodland and coniferous forestry on more elevated, poorer quality land.

The construction of new bridge crossing across the River Finn and associated modifications to local road network, R252 which will involve the remodelling of the existing topography to form new cuttings and embankments resulting in the loss of established roadside vegetation and woodland adjacent to the River Finn. Mitigation of these adverse impacts will need to be considered through naturalising the contours of the earthworks and with introduction of woodland landscaping to disguise these features and development of suitable bridge aesthetics. The height of the proposed bridge crossing should have minimal visual impact in the wider landscape, and the preferred bridge profile should be simple and understated.

2.6 External Constraints & Design Parameters

2.6.1 Design Parameters – Geometric

The bridge will carry a Type 2 dual carriageway with a shared pedestrian/cycle facility in the verge over the River Finn.

2.6.2 Design Parameters – Structural

The proposed structure shall be designed in accordance with Eurocodes and the TII Design Manual for Roads and Bridges (DMRB), which specify a design life of 120 years and for the normal loading specified in IS EN 1991-2, load models LM1 and LM3 (SV196). A structures Preliminary Design Report (PDR) will be prepared in accordance with TII DN-STR-03001 where all the relevant design parameters will be listed.

As the proposed structure will form a pedestrian link, the parapet height shall be a minimum of 1.25m high in accordance with TII DMRB requirements.

2.6.3 Construction Phase

During the period of construction, it is anticipated that there will be disruption to the existing R252 due to the construction of the proposed bridge.

2.6.4 Stakeholders

There are a number of stakeholders to consider as part of the scheme. Stakeholders to the project include:

- Transport Infrastructure Ireland as the funding body and the agency responsible for future maintenance of the structure.
- Donegal County Council as the asset owner and one of the bodies responsible for delivering the bridge.
- Office of Public Works – responsible for the hydraulic impact of the structure.
- Inland Fisheries Ireland and the National Parks and Wildlife Service for protection of the aquatic and terrestrial environments.
- Service providers with utilities in the vicinity (see section 2.5.5)
- Owner of the lands on each bank that require access under the bridge, even during times of flood.

2.6.5 Utilities

The exact nature and location of buried services will be confirmed during site investigation works. There are several known utilities in the vicinity of the bridge:

- 110kv ESB overhead transmission line crossing the river
- Buried Eir Services.
- Buried watermain.
- Overhead electrical lines along the R252 feeding the lighting columns east and west of the crossing location.

2.6.6 Hydraulic Constraints

The new structure will clear span the river channel. The piers located on the approach spans to the river channel will be located within an area prone to flooding so will introduce a new hydraulic constraint in the area prone to flooding. The existing channel is well contained with a width of approximately 50m. The area prone to flooding is however wide with the bridge crossing approximately 200m of area within the 1:100-year flood level (1% AEP) of 21.45mOD on the upstream face of the proposed bridge crossing and 20.84mOD at the downstream face. This represents a flood level ranging approximately from 0.5m to 1.0m above the existing riverbank levels.

Anecdotal evidence and photographs illustrate historical flooding upstream and downstream of the proposed Finn Crossing. The flooding illustrated in Figure 2-5 is reported to have occurred on 05 December 2015. The winter of 2015/2016 saw exceptional and widespread flooding due to prolonged intense rainfall in Ireland. The floods recorded across the country during the winter of 2015/2016 are believed to be the worst on record. This holds true for the River Finn catchment where the catchment experienced the highest flow ever recorded at Ballybofey hydrometric station 01043 on 15 November 2015 and the second highest flow ever recorded at the station on 05 December 2015. The annual maximum flow recorded in 2015 is an outlier when compared to other annual maxima data. The return period for the two floods recorded in November (568.75 m³/s) and December 2015 (555.42 m³/s) have proven to be in excess of the predicted 100-year flood.

OPW recommends a minimum 300mm freeboard above the 100-year (1% AEP) level to the soffit of any new structure. All flood levels used in the hydraulic analysis at the proposed crossing include an allowance for climate change as per OPW guidelines.

Furthermore, given the demonstrable increase in severity of flooding events during recent years at this location (see below), and the uncertainty over the long-term impact of climate change on alluvial flooding, a precautionary strategy has been applied to the design approach to bridge the entire flood plain (defined by the CFRAM 100-year event flood mapping). By taking such an approach, the risk of the proposed bridge contributing to additional flooding in future years, through a reduction of flow capacity within the flood plain, is negligible. This has been demonstrated by sensitivity testing undertaken within the Flood Impact Assessment for this project.

The introduction of a large embankment within the flood plain would result in greater land take and the loss of flood storage capacity within the flood plain. This loss of capacity would need to be compensated through the provision of flood compensation areas, that themselves would require further land take, and whose construction would significantly increase the risk of sediment pollution to the SAC (see earlier chapter on environmental considerations).

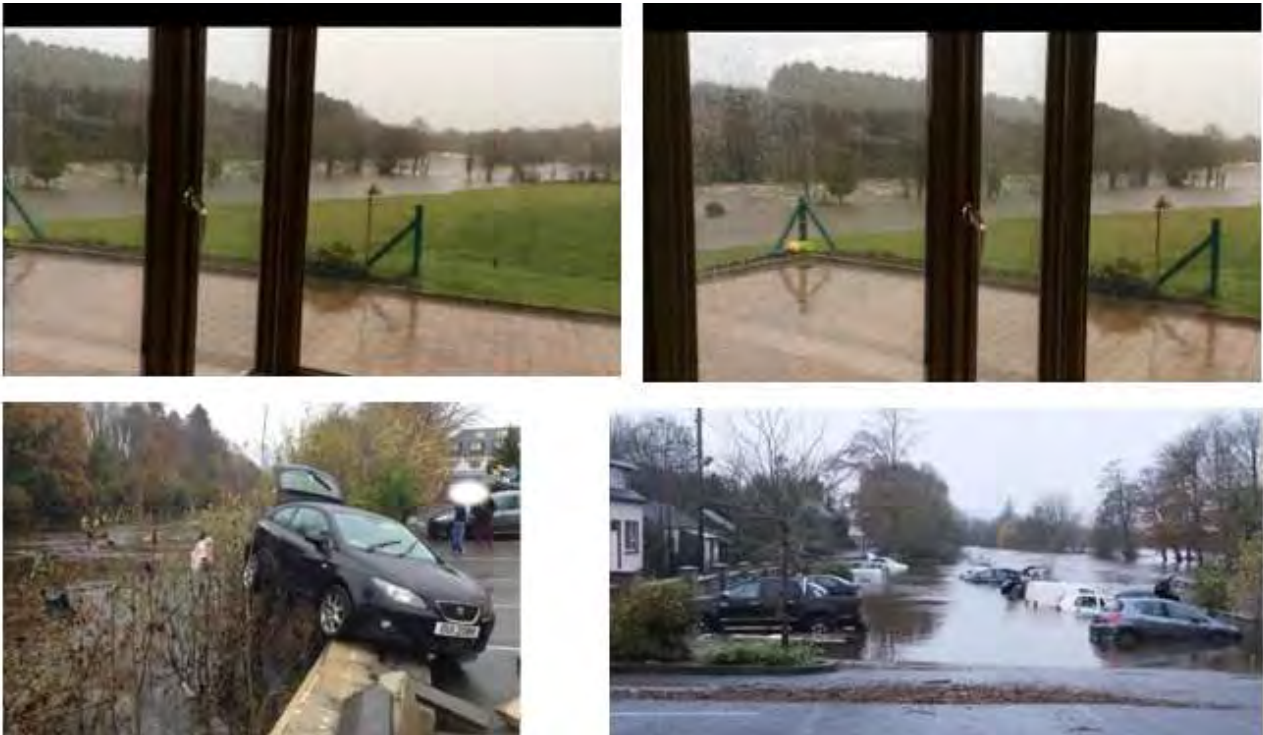


Figure 2-5: Image 1 & 2 Flooding at Cappry, Ballybofey upstream of proposed crossing, Image 3 & 4 Flooding at Jackson's Hotel, Ballybofey downstream of proposed crossing

3 OPTIONS FOR PROPOSED CROSSING

Options for the crossing were developed by RPS Consulting Engineers considering the various constraints outlined in detail in Section 2 of this report.

3.1 Structural Forms Considered

In developing the recommended option for the Finn Crossing, a wide variety of structural forms were considered in an initial scoping exercise with several being discounted for a number of reasons:

- A multi-span steel twin ladder deck with the main span launched from the north of the river to the south. The structural depth for this option would have been in excess of the options considered viable and so would have necessitated a large increase in the vertical alignment to facilitate the launching operation and to achieve the desired clearance to the R252.

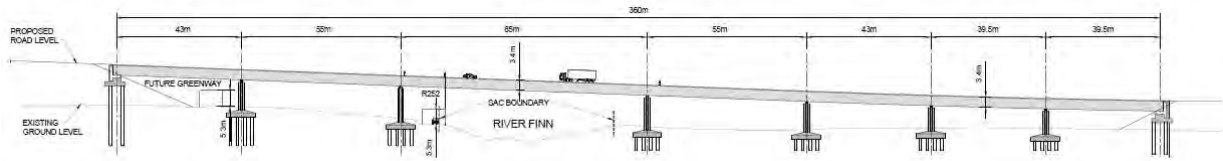


Figure 3-1: Twin ladder deck option

- A multi-span varying depth steel box arrangement which would be lifted into position by crane. While this option would have aesthetic merits, the weight of the boxes required would have made the lifting operation by crane impractical and therefore the plate girder arrangement was preferred (Option 2).

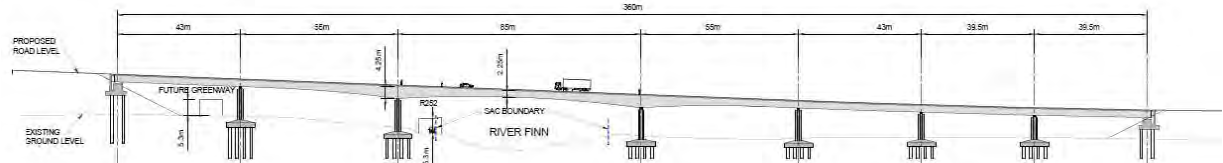


Figure 3-2: Varying depth steel box option

- A three-span bridge with approach embankments. This option considered a much shorter bridge with 3-spans (several deck options possible) with the approaches formed by fill embankments. This option would cause significant environmental issues as outlined in Section 2.3.1. As noted in Section 3.2 and Section 8, shorter bridge options also raised significant potential flooding issues, flood relief culverts would be required though the approach embankments where there would a risk of frequent blockages. The poor ground conditions may require the fill embankment to be piled, further complicating the construction of this option. Flood culverts piled embankments and an additional structure to span the proposed greenway would reduce the potential cost savings initially expected with this option.

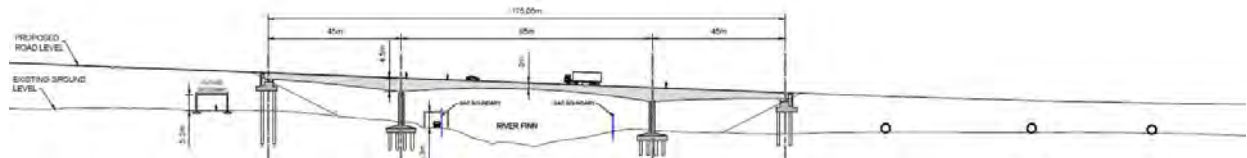


Figure 3-3: Three-span option

- A single span bridge with a main span of varying depth multi cell post-tensioned concrete box. At either end of this main span is an extended sub structure which includes both pier and abutment. This substructure acts as a short end span with two foundations, a primary piled foundation under the pier and a shallow foundation with rock anchors under the abutment. Similar to the three-span this option also raises significant environment issues as well as potential flooding, piled embankments, additional flood culverts and an additional structure to span the proposed greenway. These issues are all compounded

by the longer approach embankments required for the shorter bridge, this option was therefore not considered further as a viable option.

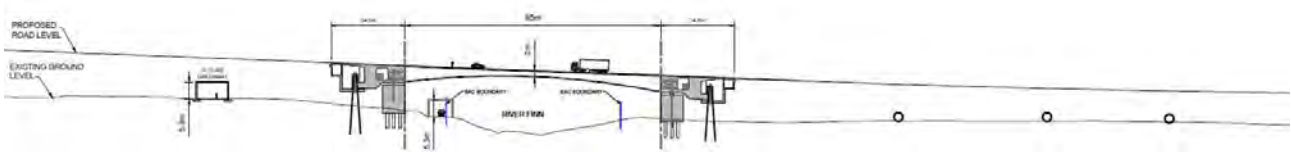


Figure 3-4: Single-span option

3.2 Viable Options

Following the initial scoping exercise, the following five options are proposed for further consideration:

- Option 1: 7-span constant depth steel box girders,
- Option 2: 7-span varying depth steel plate girders,
- Option 3: 7-span varying depth post-tensioned concrete box girder,
- Option 4: 4-span varying depth post-tensioned concrete box girder,
- Option 5: 5-span cable stayed steel plate girder.

All options considered are multi-span and have a total length of 360m, a shorter bridge structure with embankments and flood culverts constructed within the flood plain would result in increased risk to flooding and potential impact on the River Finn SAC and would require a significant increase in land take. General arrangement drawings of each option are included in Appendix 1

3.2.1 Option 1 - 7-span constant depth steel box girders

Option 1 is a 7-span steel box girder bridge with three constant depth boxes made composite with a reinforced concrete deck slab. The span arrangement is 43m, 55m, 85m, 55m, 43m, 39.5m, 39.5m giving a total length of 360m. The composite boxes have a constant overall depth of 3.4m. This represents a feasible option with an uncomplicated structure. This option could be incrementally launched across the valley from the north to the pier intermediate pier on the southern side of the river, southern sections would be lifted into position by crane. The substructure consists of cast in-situ reinforced concrete piers and abutments supported by bored pile foundations

3.2.2 Option 2 - 7-span varying depth steel plate girders

Option 2 has the same span arrangement, length and substructure as Option 1. The superstructure comprises steel plate girders made composite with a reinforced concrete deck slab. The girder depth varies from 4.25m at the intermediate supports to 2.25m away from the supports thus achieving good clearance and aesthetics. The varying depth multi-girder deck would be erected by crane from outside of the SAC. Access for a very large crane on both sides of the river would be required.

3.2.3 Option 3 - 7-span varying depth post-tensioned concrete box girder

Option 3 is a 7-span concrete box girder option with 3 spans of varying depths and 4 approach spans of constant depth. The girder depth varies from 4.5m at the intermediate supports to 2m away from the supports. This option achieves good aesthetics, an open aspect and it would be similar in appearance to the Harry Blaney Bridge spanning Mulroy Bay in Co. Donegal. The span arrangement is again 43m, 55m, 85m, 55m, 43m, 39.5m, 39.5m giving a total length of 360m. The bridge consists of an in-situ, post tensioned concrete box girder structure, constructed via balanced cantilever method. The substructure consists of cast in-situ reinforced concrete piers and abutments supported by bored pile foundations. A significant construction site will be required to cater for the specialist balanced cantilever construction methodology of the varying depth spans and the traditional construction of the approach spans.

3.2.4 Option 4 - 4-span varying depth post-tensioned concrete box girder

Option 4 is a similar structure to Option 3. There are 4-spans of varying depth in-situ, post tensioned concrete box girder structure, constructed via balanced cantilever method. The span arrangement is again 75m, 105m, 105m, 75m giving a total length of 360m. The girder depth varies from 5.3m at the intermediate supports to 2.3m away from the supports. This option achieves good symmetry and an open aspect. The increase in cross-section depth would give this option a heavier appearance. This option would significantly increase the scale of the balanced cantilever construction compared to Option 3.

3.2.5 Option 5 - 5-span cable stayed steel plate girder

This option comprises a single pylon cable stayed structure. The main span is 145m long and the overall length is 360m. The deck comprises two 2.5m longitudinal steel plate girders with intermediate transverse girders supporting an insitu reinforced concrete slab. This option is based on the current vertical alignment being considered for the overall scheme with one pylon positioned to the south of the River Finn. This option would require the vertical alignment on the approach to be amended to move the sag transition curve off the bridge. The pylon foundation would require a significant piled foundation. This option would be highly visual and visible with a pylon which stands over 80m high above the adjacent landscape. Landmark structures of this scale are not commonplace in Ireland.

4 TECHNICAL EVALUATION

4.1 Option 1 – 7-span constant depth steel box girders

4.1.1 Option 1 – Advantages

This option provides a technical solution to satisfy the constraints outlined in Section 2 and all the requirements of the brief.

The span arrangement provides reasonably good overall symmetry and a structurally efficient ratio of secondary span to main span of 0.65 is achieved.

The box girders would be fabricated from weathering steel which means the maintenance requirements and future works over the SAC are reduced compared to painted carbon steel.

Site activities near the river would be minimised as the majority of the deck superstructure steelwork can be fabricated off site in factory conditions and launched incrementally into position. An advantage of this method is the increased speed of construction as multiple setups associated with crane lifting or balanced cantilever construction are not required.

4.1.2 Option 1 – Disadvantages

Incremental launching usually utilises intermediate temporary supports to limit the length of deck that cantilevers during the launch process. Temporary intermediate supports are not possible within the River Finn to support the launch nose of the superstructure over a length of approximately 85m. It is therefore likely that temporary intermediate supports would not be used within any of the spans during the launch. A king post system can be used to facilitate launching over these span lengths without temporary supports by supporting the tip of the launch nose and limiting deflections.

The launching construction method has greater risks associated with the accuracy required for the position and alignment of the supports and the temporary launch bearings.

The intermediate pier foundation locations are in proximity to the SAC on both sides of the river. Temporary works may be required to ensure excavations for the foundations do not encroach on the SAC.

The constant depth box girders mean the structure is quite deep at the midspan regions and is not as aesthetically pleasing as the varying depth options.

The change in plan curve in the southern sections would make the launching operation beyond the intermediate pier to the south of the river very difficult. The two most southern spans would need to be lifted into position by crane.

4.2 Option 2 – 7-span varying depth steel plate girders

4.2.1 Option 2 – Advantages

This option provides a technical solution to satisfy the constraints outlined in Section 2 and all the requirements of the brief.

The span arrangement provides reasonably good overall symmetry and a structurally efficient ratio of secondary span to main span of 0.65 is achieved.

The varying depth girder mean a reduced depth of structure at the midspan regions giving a more open aspect, improving aesthetics and structural efficiency while also increasing headroom clearance.

The plate girders would be fabricated from weathering steel which means the maintenance requirements and future works over the SAC are reduced compared to painted carbon steel.

The construction of steel plate girders is relatively straight-forward, and although the steel girders are large and a very large crane will be required, it is a relatively well understood construction methodology.

4.2.2 Option 2 – Disadvantages

It is likely that some intermediate temporary supports will be required (outside of the SAC) during the lifting operation, to support one end of the pier sections prior to lifting in the central sections. A very large crane (600 tonnes or greater) will be required to allow the central sections of the main span over the River Finn to be lifted into position without temporary intermediate supports. It is assumed that girders will be lifted in braced pairs. The crane would require multiple set up locations to lift in each of the spans.

The intermediate pier foundation locations are in proximity to the SAC on both sides of the river. Temporary works may be required to ensure excavations for the foundations do not encroach on the SAC.

4.3 Option 3 – 7-span varying depth post-tensioned concrete box girder

4.3.1 Option 3 – Advantages

This option provides a technical solution to satisfy the constraints outlined in Section 2 and all the requirements of the brief.

The span arrangement provides reasonably good overall symmetry and a structurally efficient ratio of secondary span to main span of 0.65 is achieved.

The varying depth girder mean a reduced depth of structure at the midspan regions giving a more open aspect, improving aesthetics and increasing headroom clearance.

The concrete deck structure means little to no maintenance requirements.

This option's cross-section arrangement will have piers which are slenderer than Options 1 and 2.

4.3.2 Option 3 – Disadvantages

This option will require deeper piled foundations for the two main piers compared to Options 1 and 2.

Balanced cantilever construction is a significant construction operation and is extremely specialised and not an everyday form of construction. Post tensioned concrete is also not a commonly used form of construction in Ireland so a very skilled and experienced Contractor will be required, most likely with international experience of similar forms of construction.

Construction of the side spans beyond the balanced cantilevers will most likely require conventional ground supported falsework as these cannot be constructed by cantilever methods.

4.4 Option 4 – 4-span varying depth post-tensioned concrete box girder

4.4.1 Option 4 – Advantages

This option provides a technical solution to satisfy the constraints outlined in Section 2 and all the requirements of the brief. This option is similar to Option 3.

The span arrangement provides excellent overall symmetry and a structurally efficient ratio of end span to main span of 0.71 is achieved.

The varying depth girder mean a reduced depth of structure at the midspan regions giving a desirable aesthetic.

The concrete deck structure requires little to no maintenance.

This option has fewer spans, piers and foundation locations compared to the other options.

4.4.2 Option 4 – Disadvantages

Balanced cantilever construction is a significant construction operation and is extremely specialised and not an everyday form of construction. Post tensioned concrete is also not a commonly used form of construction in Ireland so a very skilled and experienced Contractor will be required, most likely with international experience of similar forms of construction. This option would significantly increase the scale of the balanced cantilever construction compared to Option 3.

The increase in cross-section depth would give this option a heavier appearance. This option would also require larger piled foundations and substructures than Option 3.

4.5 Option 5 – 5-span cable stayed steel plate girder

4.5.1 Option 5 – Advantages

An advantage of this option is the introduction of an iconic landmark structure into the landscape which can help to enhance the road user experience while also providing Ballybofey / Stranorlar with a strong visual identifier that can be used to promote increased interest and tourism in the area.

An additional advantage of this option is that the bridge footprint is moved further away from the SAC both during construction and in the permanent case compared to a multi-span option, there is also potential reduction of impact on the R252 as the bridge will span over it with greater clearance and headroom.

4.5.2 Option 5 – Disadvantages.

There are several disadvantages associated with this form of bridge. The complexity in the design and construction would require highly skilled specialist consultants and contractors most likely with international experience of similar forms of design and construction.

The pylon of this bridge would require significant piled foundations. The increased scale of both the bridge superstructure and foundations and earthworks required for this bridge would have obvious knock-on effects on the expected cost and duration of the construction works and therefore the environmental impacts associated with the construction stage.

There will be increased inspection and maintenance requirements associated with monitoring and maintaining the cables on this form of bridge therefore increasing the whole life costs of the structure. Bearing and expansion joint maintenance and replacement will also be required like the other.

High-level landmark bridges of this nature will generally be designed to have additional lighting along the cable and up lighting of the pylons. The high-level pylons, cables and lighting have potential negative impact on local wildlife and bird flight paths. They will also have highly negative impacts visually for local landowners particularly the residential properties along the R252 which would be in close proximity to the high-level pylon at the southern end of the crossing.

4.6 Summary

The options being considered as viable for the Finn Crossing are similar from a technical perspective, with the exception of Options 5, with associated advantages and disadvantages for each. It is likely that construction methodology and associated environmental impact, aesthetics and cost will dictate the preferred option.

5 ECONOMIC EVALUATION

5.1 Construction Costs

A summary of the estimated costs of each option is outlined below in Table 5-1. Further details are given in Appendix 3.

In considering the economic evaluation of the proposed options, it is also prudent to consider the out-turn cost certainty. The scale of the bridges proposed means some cost-uncertainty is associated with each of the options.

Options 1 has medium cost certainty. Although a relatively uncomplicated structure is proposed, the specialist nature of bridge launching has an element of cost uncertainty associated with it.

Option 2 has high-cost certainty as steel plate girders are a relatively well-known form of structure and there is considerable experience of this form of construction particularly in the UK.

Options 3 and 4 have medium cost certainty due to the highly specialist nature of the balanced cantilever construction method.

Options 5 has low-cost certainty due to the scale of the bridge and the highly specialist nature of the cable stayed bridge construction.

Table 5-1: Bridge Drawings

Option	Estimated Cost Ex. Vat	Out-turn Cost Certainty
1 - 7-span constant depth steel box girders	€36.73m	Medium
2 - 7-span varying depth steel plate girders	€34.11m	High
3 - 7-span varying depth post-tensioned concrete box girder	€40.55m	Medium
4 - 4-span varying depth post-tensioned concrete box girder	€42.93m	Medium
5 - 5-span cable stayed steel plate girder	€62.96m	Low

It should be noted that the above cost estimates are construction costs only, and do not include other scheme costs such as design, supervision, land acquisition, client costs etc. A significant increase in cost estimates across all options is seen when compared to earlier versions of this report. Following receipt of TII's comments on the original report and arising from recent significant fluctuations in market rates, inflation and cost increases during and exiting the COVID-19 pandemic a detailed exercise was undertaken to assess previous construction cost estimates. This included:

- Discussions with contractors, material suppliers and fabricators,
- A high-level breakdown of materials for each option,
- A review of recent tender prices received on large scale bridge projects.

RPS is satisfied that the construction cost estimates presented in Table 14-1 accurately represent today's construction cost.

5.2 Whole Life Costs

The whole life costs associated with routine maintenance, deck resurfacing and replacement of damaged parapets will be similar for all five options. Each option would have variations in their whole life costs associated with maintenance of other elements.

The whole life cost of Options 3 and 4 is the most favourable as the concrete superstructure will require less maintenance compared to the steel options, albeit the steel options would be fabricated from weathering steel which would reduce the associated maintenance compared with painted steel.

Inspection of the box girders of Option 1 would be more expensive than the plate girders of Option 2 as they would require internal inspection via confined space access into the interior of the boxes. Therefore, specialist access equipment would be needed to complete an interior inspection as well as an exterior inspection which would be similar for all options. Options 3, 4 and 5 would also require internal inspection via confined space access into the interior of the boxes/pylon.

Each option would have a different number of movement joints and bearings that would require inspection, maintenance and replacement over the lifetime of the bridge as follows; Option 1 would have six bearings at each support (48 in total), whereas Option 2 would require eight bearings at each support (64 in total); Options 3 and 4 would be integral at the pier to the north of the river with two bearings at each of the remaining supports (14 and 8 in total respectively). Option 5 will have two bearings at each support (12 in total).

There will be increased inspection and maintenance requirements associated with monitoring and maintaining the cables on Option 5 therefore increasing the whole life costs of the structure making it the least favourable.

6 AESTHETIC EVALUATION

The five bridge options considered are in steel or concrete. With the exception of Option 5, each option has taken an understated approach to the detailing. A visualisation model carried out by RPS will confirm the full landscape and visual assessment and visual impact of the new proposed bridge option as part of the Environmental Assessment of the scheme.

6.1 Option 1 – 7-span constant depth steel box girders

Architecturally, the merit of this option lies in the relative symmetry of its spans and uncomplicated form. Structurally efficient and architecturally pleasing ratios of secondary spans to main span of 0.65 are achieved. The clearances to the SAC, River Finn, R252 and potential greenway are all satisfactory.

Transverse deck cantilevers will overhang and shadow the main structural members, disguising the structural depth of the bridge, giving a slimmer, less intrusive appearance however the aesthetic limitations of this option are that the overall elevation will still be a 3.2m constant depth angular form across the valley. The constant depth means that the structure has a heavy appearance in the midspan regions.

The box girders fabricated from weathering steel provide a rustic appearance. The clean lines of a box girder are well known to be aesthetically pleasing when viewed from close by or from underneath when compared to a multi-girder deck.

6.2 Option 2 – 7-span varying depth steel plate girders

Option 2 benefits from the same relative symmetry and span ratios as Option 1. The varying depth girders have a curved bottom flange which form an appealing arched elevation on both the main span and secondary spans. This improves the aesthetics of this option compared to Option 1 by removing the angular elevation of the structure. The varying depth also allows the depth of the beams to be reduced at the middle of the main span to 2.25m, the slenderest of the options proposed, further improving the open aspect nature of the structure.

Transverse deck cantilevers will again overhang and shadow the main structural members, disguising the structural depth of the bridge, giving a slimmer, less intrusive appearance.

The plate girders fabricated from weathering steel provide a rustic appearance. Although the appearance of a multi-girder bridge is not as neat as a box girder when viewed up close or from underneath, there is also some architectural merit in a structure that doesn't hide its load carrying members and these are fully on display in a multi-girder bridge.

6.3 Option 3 – 7-span varying depth post-tensioned concrete box girder

Option 3 consists of 3 spans of varying depths and 4 shallower constant depth approach spans. The varying depth spans achieve good aesthetics while the bridge achieves the required clearances to the SAC, River Finn, R252 and potential greenway.

Structurally efficient and architecturally pleasing ratios of secondary spans to main span of 0.65 are achieved and the structure has relatively good symmetry as per Options 1 and 2. The bridge deck's varying depth arched elevation on both the main and secondary spans has a satisfactory aspect ratio.

Transverse deck cantilevers will again overhang and shadow the main structural members, disguising the structural depth of the bridge, giving a slimmer, less intrusive appearance in elevation.

A concrete box girder offers clean lines and is known to be aesthetically pleasing when viewed from close by or from underneath with no fussy details on display and a consistency of materials across the girder, deck slab and substructure.

6.4 Option 4 – 4-span varying depth post-tensioned concrete box girder

Option 4 consists of 4 spans of varying depths. The varying depth spans achieve good aesthetics while the bridge achieves the required clearances to the SAC, River Finn, R252 and potential greenway.

Structurally efficient and architecturally pleasing ratios of end span to main span of 0.71 are achieved and the structure has excellent symmetry. The bridge deck's varying depth arched elevation on both the main and end spans has a satisfactory aspect ratio.

Transverse deck cantilevers will again overhang and shadow the main structural members, disguising the structural depth of the bridge, giving a slimmer, less intrusive appearance in elevation. At 5.5m deep at the intermediate pier supports, Option 4 has the deepest deck cross-section of all the proposed options and may have a heavy appearance.

A concrete box girder offers clean lines and is known to be aesthetically pleasing when viewed from close by or from underneath with no fussy details on display and a consistency of materials across the girder, deck slab and substructure.

6.5 Option 5 – 5-span cable stayed steel plate girder

An advantage of this option is the introduction of an iconic landmark structure into the landscape which can help to enhance the road user experience while also providing Ballybofey / Stranorlar with a strong visual identifier that can be used to promote increased interest and tourism in the area.

An asymmetrical single pylon cable-stayed bridge with main span of 145m and reinforced concrete A-frame pylon would be visually striking. The superstructure could be clad in a GRP enclosure to improve aesthetics by offering simplicity and consistency of materials across the soffit of the bridge.

High-level landmark bridges of this nature will generally be designed to have additional lighting along the cable and up lighting of the pylons. The high-level pylons, cables and lighting have potential negative impact on local wildlife and bird flight paths. They will also have highly negative impacts visually for local landowners particularly the residential properties along the R252 which would be in close proximity to the high-level pylon at the southern end of the crossing.

6.6 Summary

Although aesthetics can be regarded as somewhat subjective, this is not the case when it comes to symmetry and slenderness of the structure in midspan regions. Therefore, it is clear that the symmetrical and varying depth options are more aesthetically pleasing. The clean lines of a box girder are also desirable for locations such as the Finn Crossing where there are close up views of the structure from the underside.

Consultation with TII on previous schemes has confirmed that a curved soffit or varying depth girder is preferred for multi-span bridges of this scale and that box cross-sections are generally preferable to multi-girders.

Therefore, it can be concluded that the symmetry and varying depth soffit of Option 3 and Option 4 have clear aesthetic advantages over the other options. Option 1 is the least desirable. Option 5 has the potential to be an iconic landmark structure which would be aesthetically pleasing however the proposed crossing location is not considered suitable for such a high level, large structure.

7 DURABILITY AND MAINTENANCE

A summary of the maintenance considerations for each option is outlined in Table 7-1.

Table 7-1: Maintenance Considerations

Option	Maintenance Considerations
Option 1: 7-span constant depth steel box girders	<p>Option 1 would be fabricated from weathering steel which means that maintenance painting will not be required over the lifetime of the structure. Weathering steel structures are designed with a sacrificial thickness for corrosion and therefore can be regarded as very durable away from marine environments.</p> <p>Specialist access equipment is required to access the box girder internal cells to facilitate future inspection and maintenance.</p> <p>Other elements such as deck surfacing will need maintenance and replacement after 20 years.</p> <p>Bridge bearings and movement joints will need to be inspected and maintained regularly and replaced after 50 and 20 years respectively. This option has 48 bearings in total that will need inspection, maintenance and replacement. To facilitate these works permanent access will be required to the piers and abutments.</p>
Option 2: 7-span varying depth steel plate girders	<p>Option 2 would be fabricated from weathering steel which means that maintenance painting will not be required over the lifetime of the structure. Weathering steel structures are designed with a sacrificial thickness for corrosion and therefore can be regarded as very durable away from marine environments.</p> <p>Other elements such as deck surfacing will need maintenance and replacement after 20 years.</p> <p>Bridge bearings and movement joints will need to be inspected and maintained regularly and replaced after 50 and 20 years respectively. This option has 64 bearings in total that will need inspection, maintenance and replacement. To facilitate these works permanent access will be required to the piers and abutments.</p>
Option 3: 7-span varying depth post-tensioned concrete box girder	<p>The exposed concrete faces of Option 3 will require nominal maintenance over its entire lifespan. Concrete is recognised as being a durable material with little maintenance required.</p> <p>Specialist access equipment is required to access the box girder internal cells to facilitate future inspection and maintenance.</p> <p>Other elements such as deck surfacing will need maintenance and replacement after 20 years.</p> <p>Bridge bearings and movement joints will need to be inspected and maintained regularly and replaced after 50 and 20 years respectively. This option has 14 bearings in total that will need inspection, maintenance and replacement. To facilitate these works permanent access will be required to the piers and abutments.</p>
Option 4: 4-span varying depth post-tensioned concrete box girder	<p>The exposed concrete faces of Option 4 will require nominal maintenance over its entire lifespan. Concrete is recognised as being a durable material with little maintenance required.</p> <p>Specialist access equipment is required to access the box girder internal cells to facilitate future inspection and maintenance.</p> <p>Other elements such as deck surfacing will need maintenance and replacement after 20 years.</p> <p>Bridge bearings and movement joints will need to be inspected and maintained regularly and replaced after 50 and 20 years respectively. This option has 8 bearings in total that will need inspection, maintenance and replacement. To facilitate these works permanent access will be required to the piers and abutments.</p>

Option 5: 5-span
cable stayed
steel plate girder

The steel girders of Option 5 would be fabricated from weathering steel which means that maintenance painting will not be required over the lifetime of the structure. Weathering steel structures are designed with a sacrificial thickness for corrosion and therefore can be regarded as very durable away from marine environments.

There will be increased inspection and maintenance requirements associated with monitoring and maintaining the cables. Specialist access equipment and personnel will be required for this and to access the interior of the pylon to facilitate future inspection and maintenance.

Other elements such as deck surfacing will need maintenance and replacement after 20 years.

Bridge bearings and movement joints will need to be inspected and maintained regularly and replaced after 50 and 20 years respectively. This option has 12 bearings in total that will need inspection, maintenance and replacement. To facilitate these works permanent access will be required to the piers and abutments.

8 HYDRAULIC CONSIDERATIONS

8.1 Hydraulic Modelling for Span Arrangement

Flood modelling has been used to design the optimum span arrangement for the Finn Crossing bridge options. The High End Future Scenario (HEFS) has been modelled as the worst-case scenario allowing for unknown increases in flood levels by adding 30% climate change allowance onto the 2015 flood levels. As outlined in Section 2.6.6 the 2015 flood levels are the current worst-case levels and were in excess of the predicted 100-year flood levels.

Modelling the 360m long bridge options as described in Section 3.2, the water levels will increase by approximately 0.5m above the 2015 levels for the HEFS. Any reduction of the length of the bridge would require a corresponding increase of the footprint of the approach embankments within the flood plain, the modelling has shown that the effect of this would increase the levels of the HEFS significantly. For example for Bridge Options 1, 2 or 3, which have similar substructure and span arrangements, if the most northern span was to be removed and replaced with additional approach embankment the increase in HEFS flood levels will be more than 0.5m upstream which would impact property and land.

While there is sufficient freeboard underneath the bridge deck to accommodate the HEFS, a potential further increase of flood levels of more than 0.5m above the 2015 levels would be unacceptable in Phase 4 Statutory Processes. Additionally, any increase of the approach embankments footprint within the flood plain to accommodate a shorter bridge would require additional flood compensation areas to be identified to accommodate the storage displaced by the extended embankment.

8.2 Hydraulic Modelling of Options

The model geometry for the existing hydraulic scenario was modelled using topographical cross-section survey data provided by Murphy Surveys in September 2020. The survey covers a reach of the River Finn approximately 930m long that includes the Mill Cottage bridge. The cross-sections do not extend to the confluence with the Drumboe Lower where the Catchment Flood Risk and Management (CFRAM) programme has indicated flooding in the vicinity of a proposed attenuation area. The cross-sections also don't extend as far as the hydrometric gauge 01043 and so calibration of the model wasn't achievable.

The cross-sections were imported into HEC-RAS and suitable manning coefficients were applied for the main channel (0.035) and the overbanks (0.05). The existing bridge at Mill Cottage was built into the model using the bridge data editor.

The model was run as steady state with a downstream boundary condition that calculates the water level at normal depth for the design peak flow when given the downstream slope of the channel.

The Mid-Range Future Scenario corresponding to the 100-year (1% AEP) flow level inclusive of 20% allowance for climate change, in accordance with OPW guidelines, was the design flow used in the model. The model output resulted in a water level of 21.45mOD at the Upstream face of the proposed bridge crossing and 20.84mOD at the Downstream face of the proposed bridge crossing.

The modelling also confirms that the Finn Crossing will introduce a negligible hydraulic constraint into the River Finn channel. All five bridge options considered for the proposed Finn Crossing achieved the OPW recommendation of having a minimum 300mm freeboard above the 100-year (1% AEP) level to the soffit of any new structure and all options span an equal length of the floodplain. The options do not include a footprint within the river and all options maintain additional setback to the river channel on both banks. There is therefore little preference between the various proposed bridge options from a hydraulic/flooding impact point of view.

The Preliminary Flood Risk Assessment (PFRA) 100-year flood extents are illustrated in **Figure 8-2: River Finn Crossing – PFRA 100 Year Flood Extents**

. The proposed route alignment encroaches upon the 100-year flood extents at the low-lying lands surrounding the River Finn confluence with the Drumboe Lower watercourse. It is important to note that these maps were

based on broad-brush datasets and course methodologies in order to flag areas of potential flood risk. The Ballybofey/Stranorlar urban area was highlighted as an area for further assessment (AFA) as a result of the PFRA process and as such was included in the North Western - Neagh Bann CFRAM Study. The outputs and recommendations from the CFRAM study supersede the information provided by the PFRA.



Figure 8-1: River Finn flood model

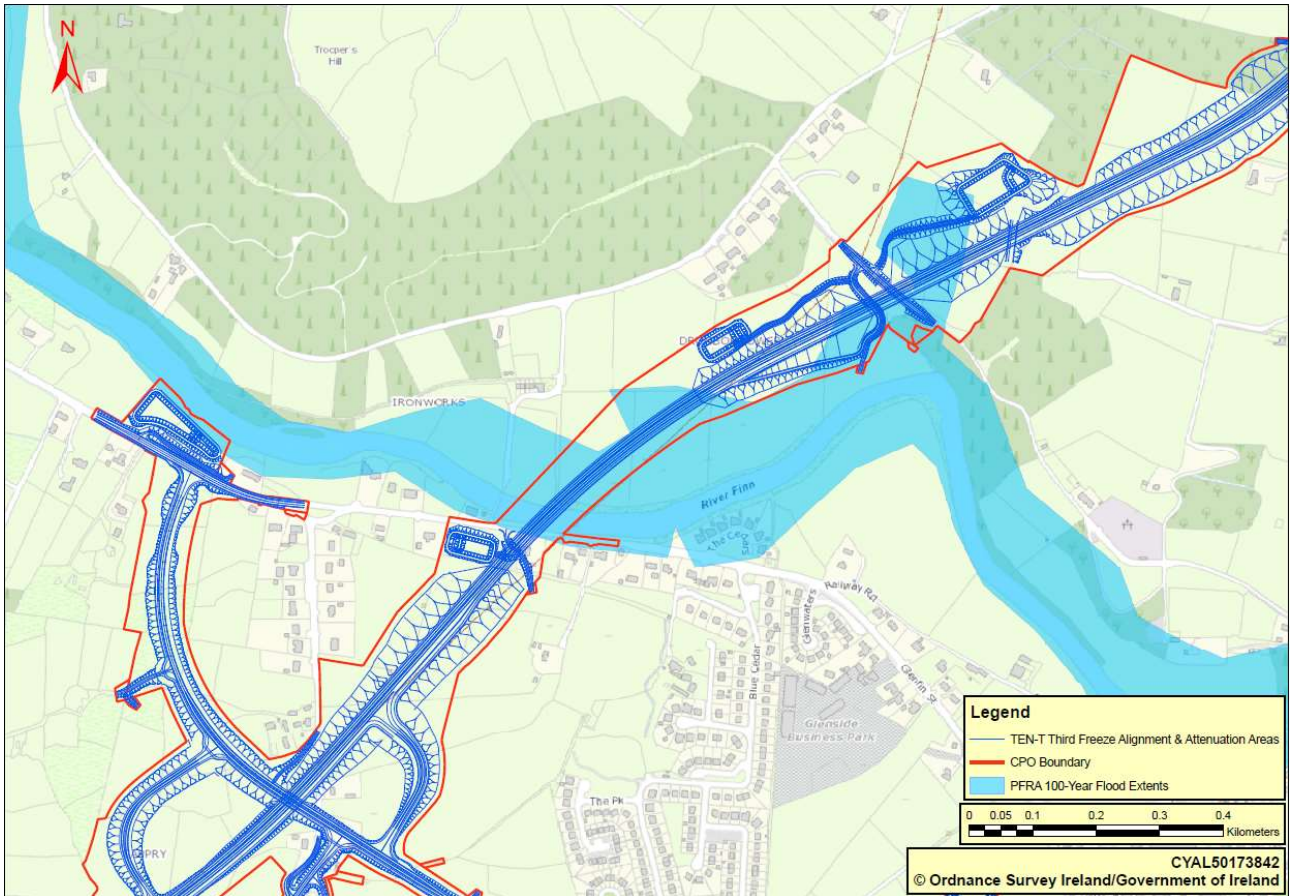


Figure 8-2: River Finn Crossing – PFRA 100 Year Flood Extents

The outputs from the CFRAM current scenario fluvial modelling for the predictive 0.1%, 1% and 10% AEP events can be seen in **Figure 8-3: River Finn Crossing – CFRAM current fluvial flood extents with proposed route alignment**. The proposed route alignment has been overlaid to illustrate the foreseeable impacts on flooding.

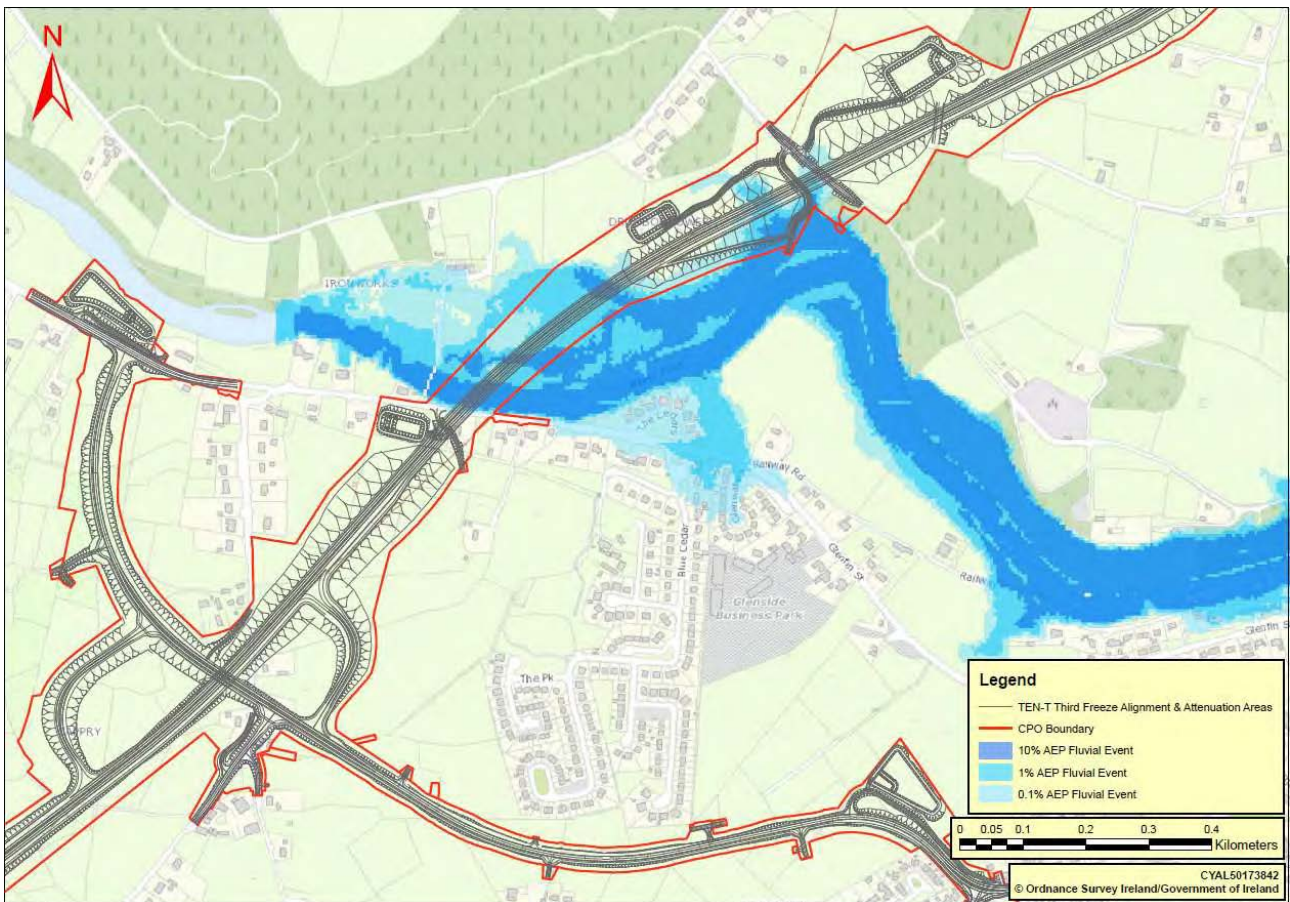


Figure 8-3: River Finn Crossing – CFRAM current fluvial flood extents with proposed route alignment

8.3 Construction

Temporary flood mitigation measures may be required during construction to protect the hardstanding working areas from flooding as well as control dewatering and run-off during all stages of construction to avoid direct discharge to the river. This may include the construction of temporary bunds around the edges of hardstanding areas, geotextile layers installed beneath hardstanding areas as well as measures such as settling ponds to treat water to remove suspended solids prior to controlled discharge to the river. These measures would be required during the entire construction stage of the bridge.

9 ENVIRONMENTAL EVALUATION

As the location of the proposed development is within the River Finn SAC, including an environmentally sensitive watercourse, there is potential for adverse environmental impacts with all options, particularly during the construction phase. These impacts will need to be fully mitigated in order to reach a conclusion of “no adverse effect” at Stage 2 (Natura Impact Statement) of the Appropriate Assessment. It should also be noted that in-stream works will not be required or permitted for any of the proposed bridge options. The construction footprint of the bridge needs to be viewed collectively with the construction footprint of the temporary and permanent drainage infrastructure which will also be located adjacent to the SAC, which includes proposed discharge into the River Finn.

A summary of the environmental advantages and disadvantages for each option is outlined in **Table 9-1**.

Table 9-1: Environmental Considerations

Environmental Aspect	Feedback	Option 1 - Rating	Option 2 - Rating	Option 3 - Rating	Option 4 - Rating	Option 5 - Rating
Population & Human Health	From a population perspective the options do not have any differences in direct impact. All are in the same location with the same direct impacts on properties and on general connectivity. The main difference in impact for population is indirect impact on the basis of visibility. Option 5 will have greatest visibility and therefore greatest potential for indirect impact. Option 4 is the least impactful visually in terms of its structures so indirectly the least impact on local population.	Intermediate (2nd)	Intermediate (2nd)	Intermediate (2nd)	Preferred (1st)	Least preferred (3rd)
Biodiversity (Terrestrial)	Protected species such as kingfisher and bat species forage and commute up and down the river corridor. Interfering with commuting corridors is likely to increase disturbance and interfere with natural flight lines/fly ways of bat and bird species, thereby creating a barrier effect. Option 5 (cable stay) is least preferred on this basis. Otter is a qualifying interest of the River Finn SAC and the extent of otter habitat, in addition to the aquatic habitat, comprises a 10m riparian buffer (both banks). Therefore, Option 4 is preferred as it provides a greater set back distances from the riverbank and fewer piles will reduce the noise and disturbance impact. Option 1, 2 and 3 are comparative with regards to a terrestrial ecology perspective, and therefore rated as intermediate.	intermediate (3rd)	intermediate (2nd)	intermediate (4th)	Preferred (1st)	Least preferred (5th)
Biodiversity (Aquatic)	Option 4 is preferred. It has three piled structures on the floodplain, with abutments set back from the river channel a greater distance (compared to Options 1,2 and 3). The setback distance reduces potential construction phase impact, as there is a longer pathway between the construction site and the river channel along which mitigation (treatment of runoff) can be implemented. The increased set back of abutments also reduces potential for scouring and erosion during flooding in the operation phase. The increased abutment setback is also preferable from an amenity (angling) perspective. Options 5 is intermediate owing similarly to the increased set back distance of abutments. Options 1, 2 and 3 are similar and are all similarly least preferred.	Least preferred (4th)	Least preferred (4th)	Least preferred (3rd)	Preferred (1st)	Intermediate (2nd)
Land and Soil	No Preference					
Water	No Preference					
Air & Climate	No Preference					
Noise	No Preference					

Environmental Aspect	Feedback	Option 1 - Rating	Option 2 - Rating	Option 3 - Rating	Option 4 - Rating	Option 5 - Rating	
Material Assets – Agriculture	No Preference						
Material Assets – Non-agriculture	No Preference						
Cultural Heritage	No Preference						
Landscape & Visual	<p>Option 1 - Intermediate option – deck is similar depth across whole crossing, with large pier foundation base to accommodate 3 stanchion arrangement</p> <p>Option 2 - intermediate option - reduction in bridge deck depth between piers, however depth of deck at piers greater than Option 3.</p> <p>Option 3 - Intermediate option - deck depth less than Option 2 between piers, however deck depth slightly increased at piers when compared with option 2. Option 3 pier base less than that required for Option 2.</p> <p>Option 4 - reduced number of piers associated with this option when compared with either Option 1, Option 2 or Option 3.</p> <p>Option 5 - is a potential option as this could be viewed as a positive development / identifiable new feature – e.g., becomes a recognised feature / gateway marker on the route, however visual impact increased due to Cable Stay configuration and only to be considered if other options not preferred during option sifting</p>	Intermediate (4th)	Intermediate (3rd)	Intermediate (2nd)	Preferred (1st)	Least preferred (5th)	
		Overall	3rd	2nd	2nd	1st	4th

10 HEALTH & SAFETY CONSIDERATIONS

10.1 Traffic Management During Construction

All the options will require some form of traffic management on the R252 during the works period in accordance with Chapter 8 of the Traffic Signs Manual to facilitate access to the site from the south. Short duration road closures may also be required for periods of time subject to the contractor's chosen construction methodology.

10.2 Safety During Construction

In-stream works are not required or permitted for any of the proposed options.

All options will require access to the land to the north and south of the River Finn during the construction stage, works platforms in these areas will be the responsibility of the Contractor/PSCS.

All options require piled foundations, which limits the size of excavations needed for foundations. Piling operations and construction of pile caps will be constructed from constructed areas of hardstanding.

In addition to the general obligations and duties under the Safety, Health and Welfare at Work Act 2005, the consultant carrying out the detailed design of the proposed crossing will also undertake the duties of Project Supervisor Design Process (PSDP) and prepare a Preliminary Safety & Health Plan for the works. The works will also be designed taking account of the principles of prevention.

It is envisaged that the appointed contractor will be experienced in bridge construction and will be appointed Project Supervisor Construction Stage (PSCS) for the duration of the works.

10.3 Safety in Use

All options are currently shown with minimum 1.25m high vehicle and pedestrian parapets. These systems have been widely used and climbing can be prevented by providing an inward incline on the parapet posts.

Inspection of the bridge superstructure can be undertaken safely from the bridge itself, from the ground below the bridge and from the river using boat access when required. Inspection of abutments and bearings can be undertaken from ground level and appropriate access for inspection will be provided in the design.

The likely significant maintenance operations required during the life span of the bridge will vary depending on the chosen option. These are summarised in Section 7. The primary maintenance operation for each option will be the replacement of expansion joints and bearings. Each maintenance operation required are commonplace in the industry and management of the related health and safety issues is well understood.

11 CONSTRUCTION & BUILDABILITY

All options considered are readily constructible by a contractor suitably experienced in bridge construction of this scale and form. No issues have been identified that would not be inherent in comparable bridge schemes completed elsewhere in Ireland or the UK.

Each option will require bored pile foundations down to rock meaning a large piling rig and crawler crane will require access to each side of the river. Areas of hardstanding will be required throughout the proposed bridge location to facilitate the piling process and will need to be maintained throughout the construction stage. Conventional construction of the reinforced concrete substructure will also require plant such as concrete lorries and pumps to operate throughout the site on both sides of the river.

To reduce the potential impact on the SAC during the construction stage certain items and methods could be stipulated to the contractor such as the use of precast concrete rather than in-situ concrete where possible. For options 1, 2, and 5 it could be a specific contract requirement that, following steel superstructure installation, the reinforced concrete deck is constructed over the river completely from on top of the bridge rather than from the ground. This could be done with precast or in-situ concrete and would involve starting at the ends of the bridge and lifting or pouring one section at a time, allowing it to come up to sufficient strength before moving further along to repeat the process. This will add significantly to the programme but could be done from north and south concurrently with a fast-setting concrete mix design to reduce construction time as much as possible.

11.1 Option 1 - 7-span constant depth steel box girders

Option 1 will be incrementally launched from the northern end of the valley. Site activities in the flood plain will be minimised as the majority of the deck superstructure steelwork will be fabricated off site in factory conditions.

Incremental launching usually utilises intermediate temporary supports to limit the length of deck that cantilevers during the launch process. Temporary intermediate supports are not possible within the River Finn/SAC to support the launch nose of the superstructure over a length of approximately 85m. It is therefore likely that temporary intermediate supports would not be used within any of the spans during the launch. A king post system can be used to facilitate launching over these span lengths without temporary supports by supporting the tip of the launch nose and limiting deflections of the cantilever.

The launching construction method has greater risks associated with the accuracy required for the position and alignment of the supports and the temporary launch bearings.

The intermediate pier foundation locations are in proximity to the SAC on the northern side of the River Finn. Temporary works may be required to ensure excavations for the foundations do not encroach on the SAC

In total Option 1 would take approximately 28 months to construct.

The change in plan curve in the southern sections would make the launching operation beyond the intermediate pier to the south of the river very difficult. The two most southern spans would need to be lifted into position by a mobile crane.

11.2 Option 2 - 7-span varying depth steel plate girders

Option 2 will be lifted in to place in sections by crane. A very large crawler crane (600 tonnes or greater) will be required to allow the central sections of the main span over the River Finn to be lifted into position without temporary intermediate supports. It is assumed that girders will be lifted in braced pairs. The crane would be located on the west side of the proposed alignment away from the high voltage cables on the west however there are also overhead electrical lines to the east of the proposed alignment which would need to be avoided or diverted. Multiple crane set ups would be required to lift in the various sections, the areas of hardstanding would need to be extended to facilitate the crane set ups and girder assembly. A smaller mobile crane could be used to lift in the northern and southern end span sections. As outlined in Section 13, specific consideration

has been given to the crane set up and lifting arrangement given the proximity to the 110kv ESB overhead transmission line crossing the river including consultation with the ESB.

It is likely that some intermediate temporary supports will be required (outside of the SAC) during the lifting operation, to support one end of the pier sections prior to lifting in the central sections.

The construction of steel plate girders is relatively straight-forward, and although the steel girders are large and a very large crane will be required, it is a relatively well understood construction methodology.

The intermediate pier foundation locations are in proximity to the SAC on the northern sides of the River Finn. Temporary works may be required to ensure excavations for the foundations do not encroach on the setback zones.

An advantage of this option is the improves speed of construction, in total Option 2 would take approximately 26 months to construct.

11.3 Option 3 - 7-span varying depth post-tensioned concrete box girder

Balanced cantilever construction is a significant construction operation and is extremely specialised. Post tensioned concrete is also not a commonly used form of construction in Ireland so a very skilled and experienced Contractor will be required, most likely with international experience of similar forms of construction.

Construction of the side spans beyond the balanced cantilevers will most likely require conventional ground supported falsework as these cannot be constructed by cantilever methods.

This option will require deeper piled foundations for the two main piers compared to Options 1 and 2.

In total Option 3 would take approximately 30 months to construct.

11.4 Option 4 - 4-span varying depth post-tensioned concrete box girder

Balanced cantilever construction is a significant construction operation and is extremely specialised. Post tensioned concrete is also not a commonly used form of construction in Ireland so a very skilled and experienced Contractor will be required, most likely with international experience of similar forms of construction.

Construction of the end spans beyond the balanced cantilevers will most likely require conventional ground supported falsework as these cannot be constructed by cantilever methods.

This option will require deeper piled foundations for the two main piers compared to Options 3.

In total Option 4 would take approximately 32 months to construct.

11.5 Option 5 - 5-span cable stayed steel plate girder

This option would require a combination of complex construction methodologies. The main pylon would require significant piled foundations far greater than any of the other options. The reinforced concrete A-frame pylon would be constructed via travelling/climbing formwork. The main span could be assembled to the south of the southern abutment and launched across the river to its final position. Temporary cable stays connected to the pylon would facilitate the launching operation.

The northern approach spans would be constructed via traditional means with the ladder deck being lifted into position by large crane operating within the flood plain, similar to Option 2.

In total Option 5 would take approximately 34 months to construct.

12 GROUND CONDITIONS

A ground investigation for the proposed Finn Crossing bridge area has been completed comprising geophysical surveys, boreholes and trial pits. The investigation logs are available in Appendix 2. The geophysical survey on the northern bank of the river consisting of 2D resistivity, seismic refraction and MASW was undertaken as intrusive investigations were not permitted due to the proximity of the Special Area of Conservation.

Investigation logs on the southern bank indicate gravelly sand and silt overlying weathered rock recovered as gravel. Competent rock was encountered at between 3.8 and 8m BGL. Investigation results from the northern banks of the Finn indicate competent rock at approximately 5m below ground level overlain by gravelly overburden. Ground investigations to date indicate that all proposed options will require piled foundations to be constructed down to the rock strata at a minimum. It is not envisaged at this time that further detailed ground investigations will materially alter the proposed type of bridge foundation.

It is expected that for all proposed options a 0.5m depth of topsoil and soft material will need to be excavated and replaced with a suitable fill such as Clause 804 to create areas of hardstanding for access and construction of foundations, piers, abutments and bridge superstructure.

13 CONSULTATION WITH RELEVANT AUTHORITIES

13.1 General

There are a significant number of stakeholders in the scheme as outlined in section 2.6.5. To date, both formal and informal consultations have been held with a number of authorities and private landowners.

The scheme will be subject to the planning permission process which includes a statutory consultation process with prescribed bodies. This will act as the primary medium for formal consultation with the majority of the relevant authorities. The remainder will be consulted with during preliminary design stage.

13.2 ESB

There has been extensive stakeholder consultation with the ESB during the Phase 3 design process regarding the position of the diversion position of the 110 kV overhead line and associated pylons in relation to proposed road alignment of the scheme. While ESB’s internal design processes are ongoing an expected final position of the diverted overhead line has been made available. Further consultation with ESB has confirmed the requirements in terms of plant and crane positions in relation to the reposition over headlines and pylons. As illustrated in Figure 13-1, a 10m minimum separation distance is required on top of the height/falling height of the crane or plant.

Table 1: **Hazard zone** minimum distances

Nominal phase-to-phase voltage of overhead line	Minimum horizontal distance (A) in metres
LV, 10kV, 20kV and 38kV	6.0
110kV, 220kV, 400kV (and other voltages in this range)	10.0

Figure 3: Plant and machinery minimum safe distance

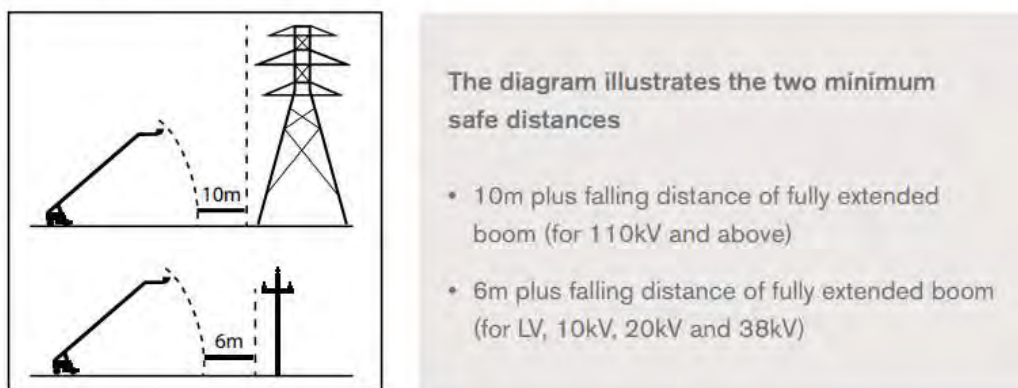


Figure 13-1: ESB requirements ²

² [Code of Practice for Avoiding Danger from Overhead Electricity Lines](#)

These requirements are particularly relevant to Option 2 where the construction method would require the use of a large crawler crane to lift in the girders in braced pairs. An exercise has been undertaken to check the safety and viability of this girder lift. The results of this exercise are presented in Table 13-1 based on the Option 2 crane drawing included in Appendix 5. We have assumed a Liebherr LR1600/2 crawler crane will be used, this is the largest available in Ireland currently and was recently used for the bridge beam lift on the River Moy Bridge on the N26 Realignment Scheme. The biggest lifts to consider are the main span lifts of the pier sections and the mid span drop in section. It has been confirmed that the lifts are achievable while remaining outside the SAC boundary and more than the falling height of the crane plus 10m away from the proposed overhead line diversion route.

Table 13-1: Bridge Options Assessment Results

Lift Position	Lift	Lift Weight	Crane Height	Lift Radius	Distance to Proposed ESB Diversion
North Side	Pier braced pair – 44.5m	161.5t	42m	38m	22m
South Side 1	Pier braced pair – 44.5m	161.5t	54m	38m	16m
South Side 2	Midspan braced pair – 51m	143.0t	60m	58m	16m

14 CLIMATE ASSESSMENT

Section 15 outlines the ranking of each of the options under the various criteria considered in this report, during the options design process discussion with TII Structures highlighted the need to consider the Carbon Footprint and Climate Assessment of the highest ranked options. As Option 2, 7-span varying depth steel plate girders, and Option 3, 7-span varying depth post-tensioned concrete box girder, were emerging as the most favourable options these two were considered for a detailed quantitative climate assessment based on the options design. The report and results of this assessment are included in Appendix 4 and summarised below. Options 1, 4 and 5 have been assessed qualitatively based on the results of the quantitative assessment of Options 2 and 3.

The climate assessment used the Transport Infrastructure Ireland (TII) Carbon Tool, which is TII's proprietary software for carrying out carbon assessments on road and rail infrastructure projects. The Tool uses a combination of default assumptions and user-defined inputs to generate an estimated, carbon footprint for the project. The results of the quantitative comparison assessment of Options 2 and 3 are set out in Table 14-1 below.

Table 14-1: Total Carbon Emissions by Life Cycle Stage (kgCO₂e)

Option	Before Use (kgCO ₂ e)			Use (kgCO ₂ e)	Total (kgCO ₂ e)
	Pre-Construction	Embodied Carbon	Construction Activities	Use	
Option 2 – Multi-girder	474.51	10,064,539.98	363,480.00	229,637.02	10,658,131.51
Option 3 - Concrete Box	474.51	5,939,848.87	419,400.00	229,637.02	6,589,360.40

Option 3, 7-span varying depth post-tensioned concrete box girder, is the preferred option from a climate perspective. This is mainly due to the lower embodied carbon of the materials. Option 2 – 7-span varying depth steel plate girders uses steel extensively in its superstructure design. Steel, as a material, has a high carbon footprint due to the energy required in extracting raw materials, processing and manufacturing the final product. Additionally, the type of structural steel used in bridge building is usually imported from other countries due to lack of manufacturing in Ireland. This adds higher transport emissions to the embodied carbon footprint, compared to sourcing materials closer to the site.

Comparatively, Option 3 relies mostly on structural concrete in its construction. This can be sourced within Ireland, which lowers transport emissions. More importantly, structural concrete has a lower carbon footprint than steel, even when rebar is included. The use of concrete over steel is the main reason why Option 3 has a lower carbon footprint than Option 2, therefore it is the preferred option.

Of the other options, Option 5 is the least desirable option from a climate assessment perspective given the quantity of both steel and concrete required to construct the 5-span cable stayed steel plate girder signature bridge. Option 1 is similar in materials to Option 2 however it receives a less desirable ranking due to the added complexity of processing and manufacturing the steel box girders. Option 4 is a similar form to Option 3 but has a larger climate impact due to the increase in materials required for the longer spans of the 4-span varying depth post-tensioned concrete box girder.

15 OVERALL EVALUATION OF PROPOSED OPTIONS

15.1 Evaluation of Options

The five proposed Finn Crossing options were assessed under various headings as set out below in Table 15-1 and as discussed in previous sections of this report. The options were ranked 1-5 against each criterion in terms of preference, with 1 being the most desirable option for that criterion and 5 being the least desirable option for that criterion.

Table 15-1: Bridge Options Assessment Matrix

Criterion	Description	Ranking – 1 Most Desirable	2	3	4	Ranking – 5 Least Desirable
1	Bridge Aesthetics	Option 4	Option 3	Option 2	Option 5	Option 1
2	Structural Efficiency	Option 3	Option 2	Option 1	Option 4	Option 5
3	Hydraulics/Flooding Impact	-	-	-	-	-
4	Foundation and substructure Requirements	Option 3	Option 1	Option 2	Option 4	Option 5
5	Construction & Buildability	Option 2	Option 3	Option 1	Option 4	Option 5
6	Maintenance Requirements	Option 4	Option 3	Option 2	Option 1	Option 5
7	Environmental Impact	Option 4	Option 2/3	Option 1	Option 5	
8	Construction Health and Safety	Option 2	Option 1	Option 3	Option 4	Option 5
9	Capital Cost	Option 2	Option 1	Option 3	Option 4	Option 5
10	Risk	Option 2	Option 1	Option 3	Option 4	Option 5
11	Carbon Footprint	Option 3	Option 4	Option 2	Option 1	Option 5

The scores for each option are added and the option with the lowest overall score is the most desirable option when assessed against the criteria listed in Table 15-1 above. The minimum possible score is 10 and the maximum possible score is 50. The results are shown in Table 15-2 below. The criteria are not weighted, and so if the scores are close between a number of options, consideration may be given to weighting some of the more important criteria.

Table 15-2: Bridge Options Assessment Results

Option	Score	Ranking
1	30	3 rd
2	20	1 st
3	20	1 st
4	29	2 nd
5	48	4 th

16 CONCLUSIONS & RECOMMENDATIONS

16.1 Conclusion

It is clear from the preceding chapters there are a significant number of competing constraints that need to be carefully balanced in order to ensure that the optimum solution to meet the brief is proposed.

In assessing the preferred option, all of the constraints highlighted in Chapter 2 have been carefully considered and several feasible options were evaluated. These options were developed into a shortlist of five options for assessment in this options report under a number of criteria. Based on the evaluation undertaken in Section 15, Options 2 and 3 rank equally.

Option 2 has been selected in favour of Option 3. As both options were considered equal in terms of Environmental Impact, it was concluded that Capital Costs and Construction & Buildability should be weighted as more important than the other remaining criteria. Option 2 had the best ranking of all options for both of these criteria and so is considered the best option.

Option 2 is therefore considered as the most adequate options to address the constraints for the Finn Crossing which can be simplified to the following points:

- The structure is considered safe and useable for all users,
- The structure is cost effective,
- The option is buildable,
- The structure provides sufficient headroom and clearance to the River Finn channel, the R252 and the proposed greenway.
- It has aesthetic merit with minimal negative visual impact on the local landscape,
- The development has minimal impact on the local environment and the SAC.

It is further concluded that a shorter bridge structure with embankments and flood culverts constructed within the flood plain, rather than a multi-span structure crossing the entire flood plain, would result in increased risk to flooding and potential impact on the River Finn SAC, and would require a significant increase in land take. For these reasons, the shorter bridge option was ruled out during Stage 2 Option Selection Stage.

16.2 Recommendation

The outcome of the River Finn Structures Options Report indicates that a 7-span varying depth weathering steel multi-girder bridge (Option 2) should be considered as the preferred option. It is recommended that Option 2 is taken forward to preliminary design and planning stage as the preferred option.

17 DRAWINGS & DOCUMENTS

17.1 Bridge Option Drawings

Table 17.1 lists the Finn Crossing Options drawings included in Appendix 1 of this report.

Table 17-1: Bridge Drawings

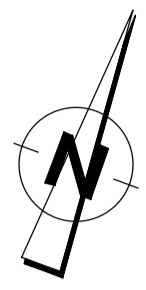
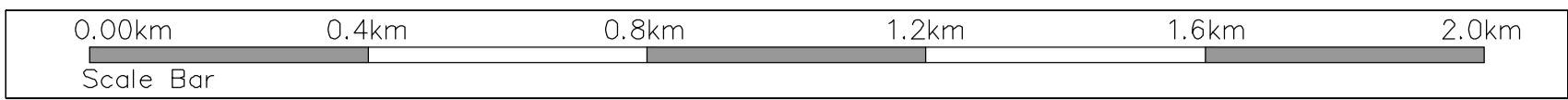
Drg. No.	Rev	Title
TT_MGT0337-RPS-P3-S1-DR-C-BR0101	P04	Section 1 Bridge Locations
TT_MGT0337-RPS-P3-S1-DR-C-BR0121	P02	River Finn Crossing Bridge Option 1
TT_MGT0337-RPS-P3-S1-DR-C-BR0122	P02	River Finn Crossing Bridge Option 2
TT_MGT0337-RPS-P3-S1-DR-C-BR0123	P02	River Finn Crossing Bridge Option 3
TT_MGT0337-RPS-P3-S1-DR-C-BR0124	P02	River Finn Crossing Bridge Option 4
TT_MGT0337-RPS-P3-S1-DR-C-BR0125	P02	River Finn Crossing Bridge Option 5

17.2 Documents

The Appendices to this Report are:

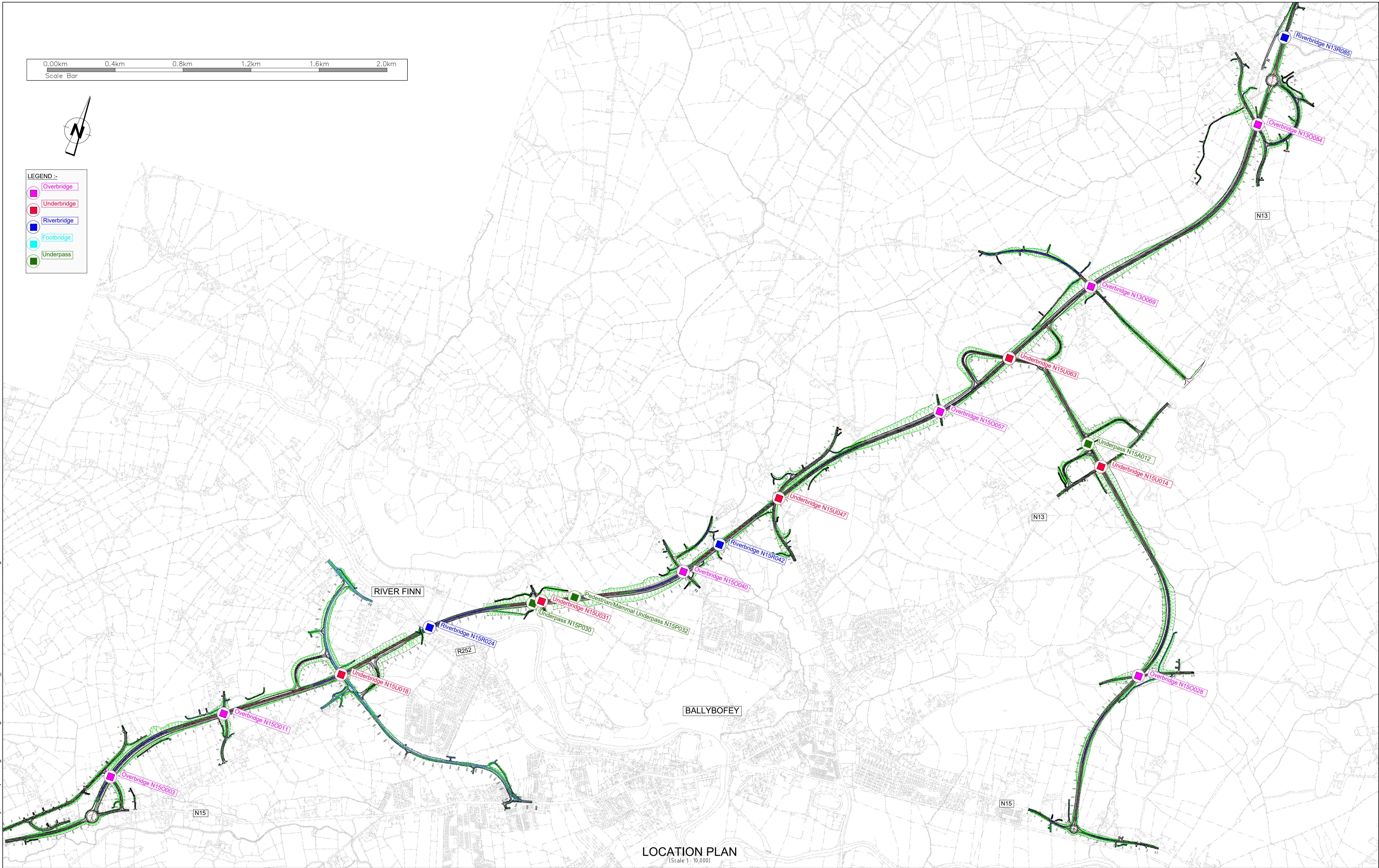
- Appendix 1 Location Map & Bridge Options Drawings
- Appendix 2 Geotechnical Information
- Appendix 3 Cost Estimate
- Appendix 4 Climate Assessment
- Appendix 5 Option 2 Crane Drawing

APPENDIX 1: LOCATION MAP & BRIDGE OPTIONS DRAWINGS



LEGEND :-

- Overbridge
- Underbridge
- Riverbridge
- Footbridge
- Underpass



LOCATION PLAN
(Scale 1 : 10,000)

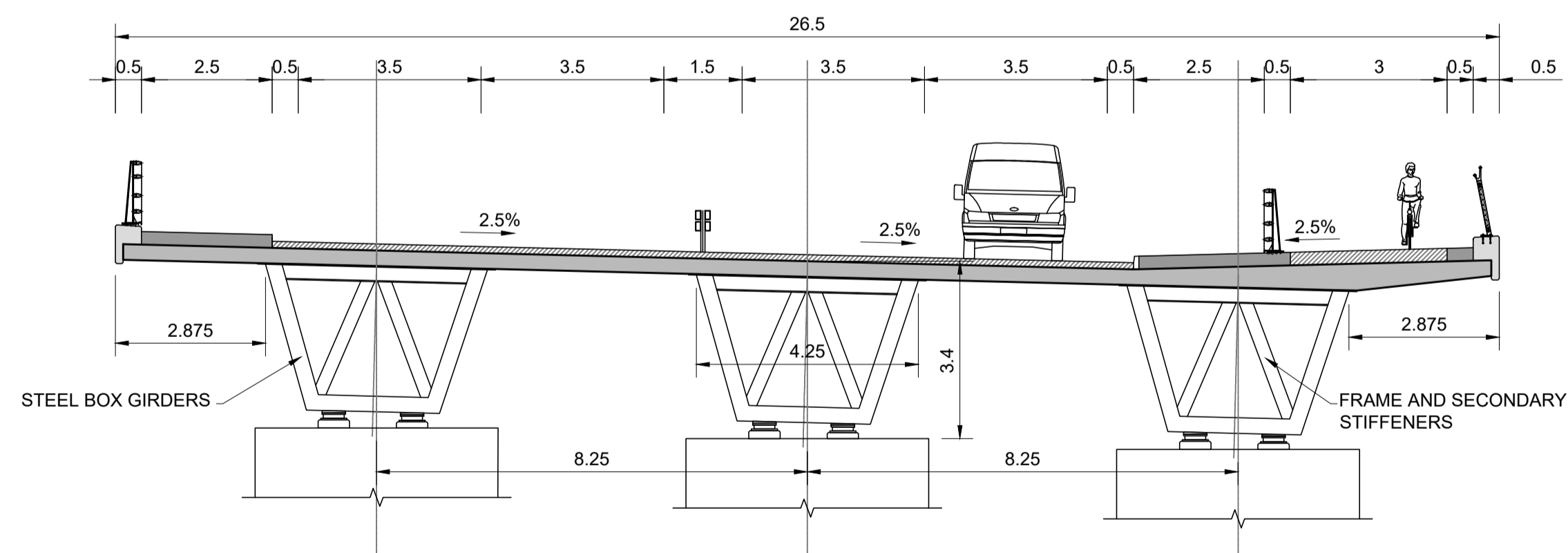
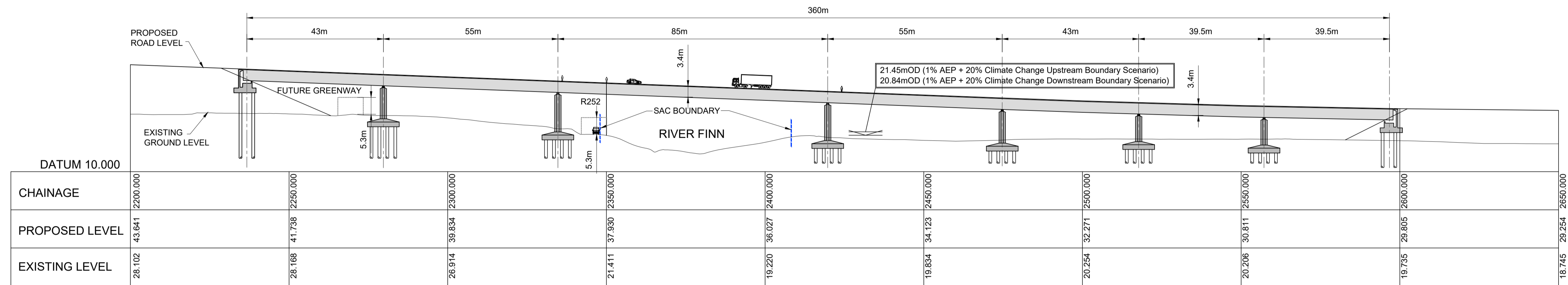
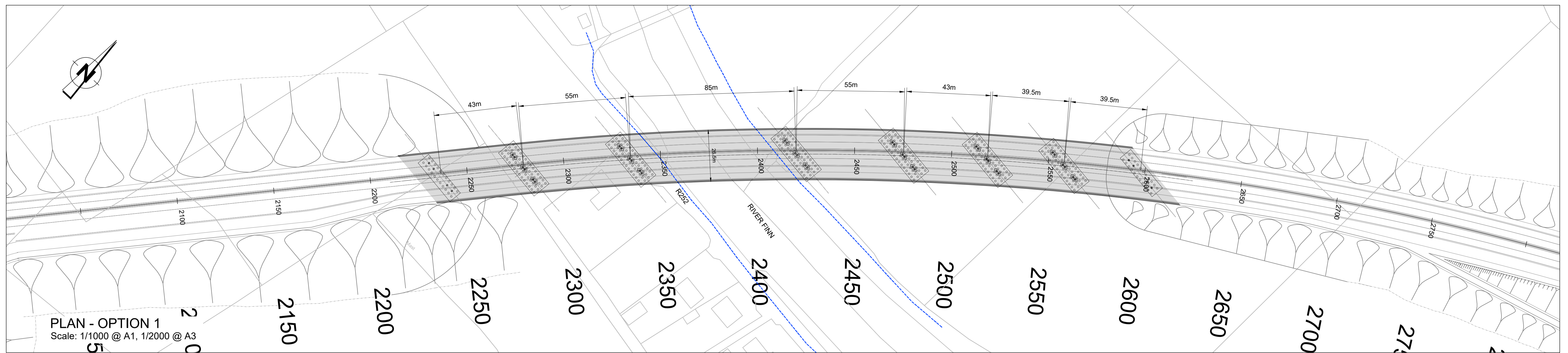
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NOTES
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Rev.	Date	Drawn	Description	Chk'd	Appr.
P06	30.11.21	DC	ISSUE FOR REVIEW & COMMENT	JM	EC
P05	12.11.21	DC	ISSUE FOR REVIEW & COMMENT	JM	EC
P04	15.10.21	DC	ISSUE FOR REVIEW & COMMENT	JM	EC
P03	01.10.21	DC	ISSUE FOR REVIEW & COMMENT	JM	EC
P02	30.06.21	PH	ISSUE FOR REVIEW & COMMENT	JM	EC
P01	04.05.21	PH	ISSUE FOR REVIEW & COMMENT	JM	EC

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Drawing Title: SECTION 1 BRIDGE LOCATIONS		Rev: P06
Designed: JM	Date: Feb '21	Model File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-BR0101
Drawn: DC	Scale @ A1: As Shown	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-BR0101
Approved: TP	@ A3: Half	
Checked: MM	Sheet: 01 of 01	

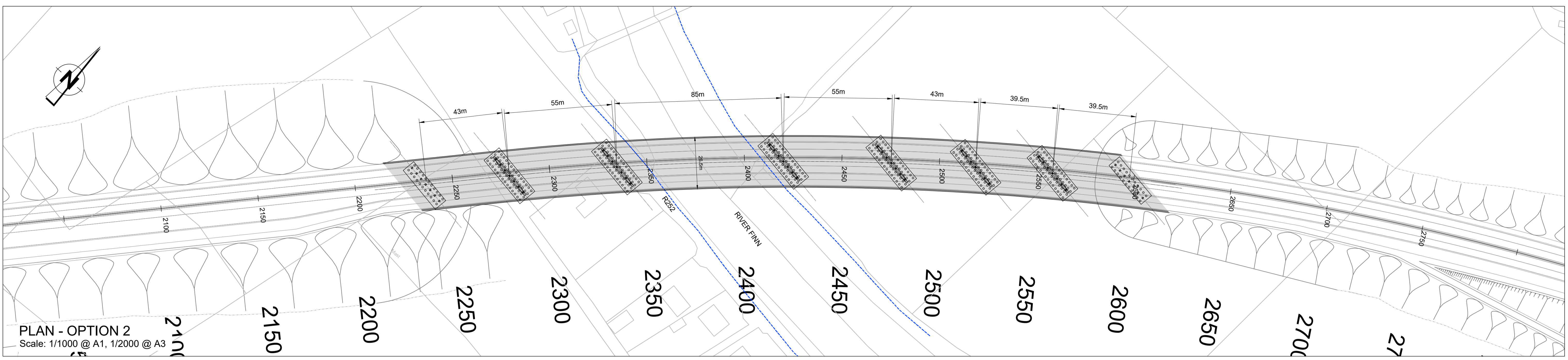


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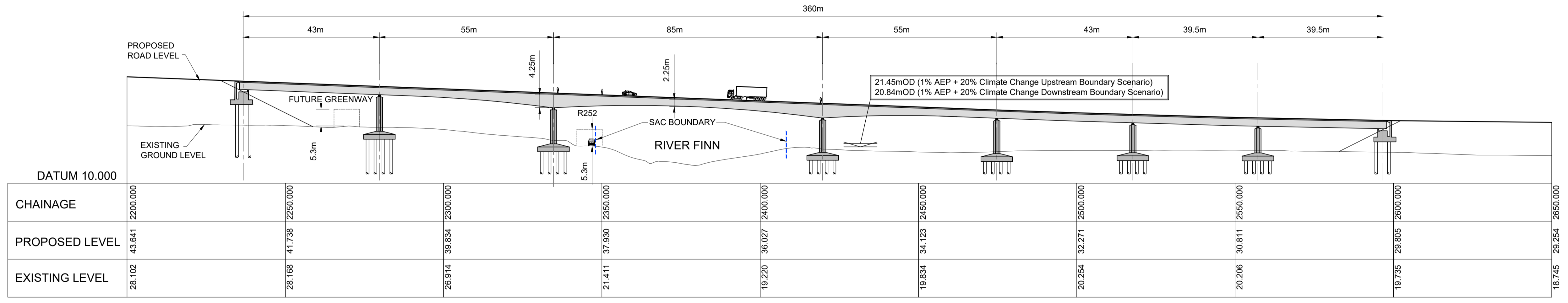
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Rev.	Date	Drawn	Description	Chk'd	Appr.
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P01	09.09.21	PH	ISSUE FOR REVIEW & COMMENT	JM	EC

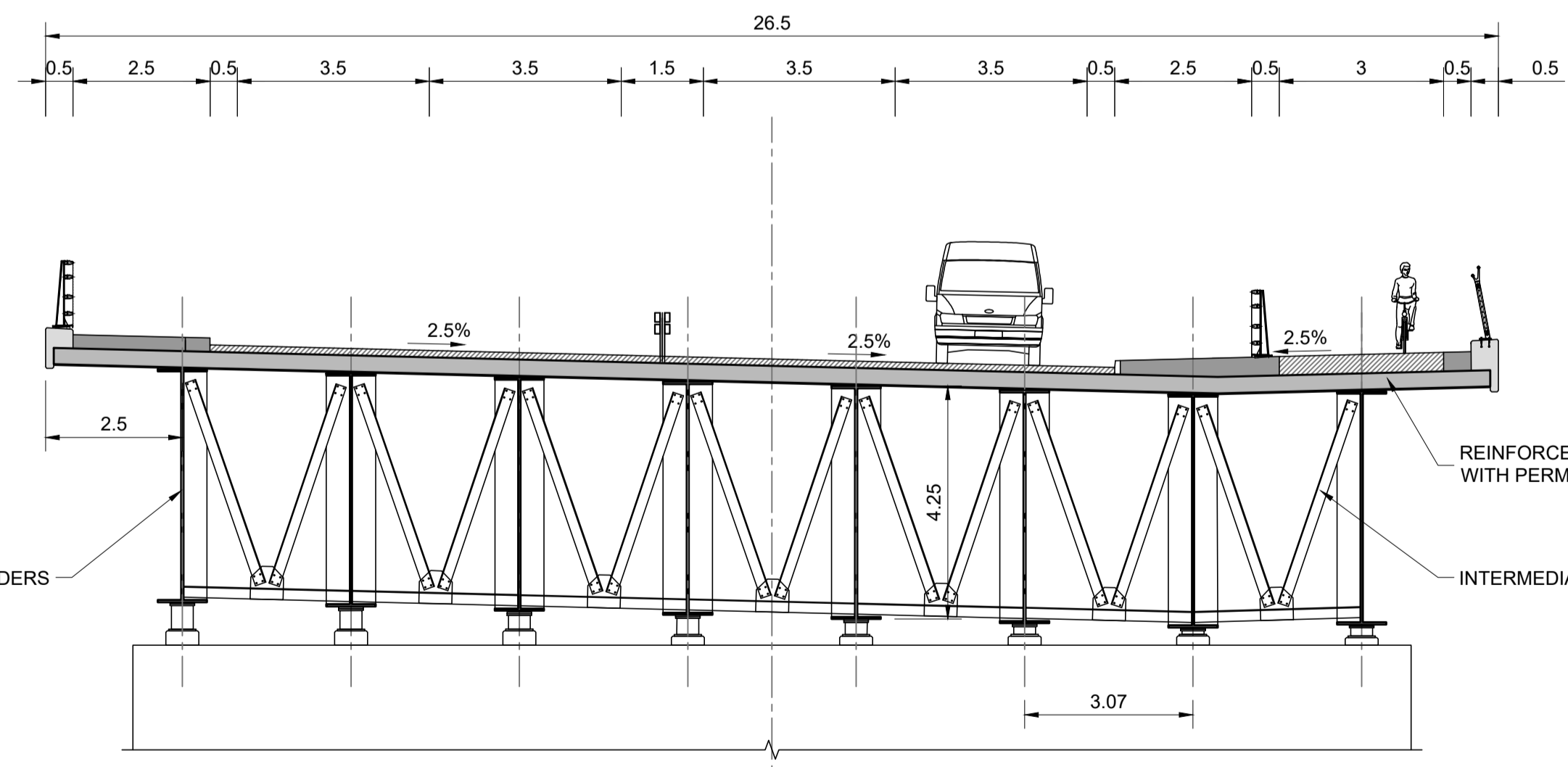
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Drawing Title: RIVER FINN CROSSING BRIDGE OPTION - 1 (STEEL BOX)		Rev: P02
Designed: JM	Date: FEB 2021	Model File Identifier: N/A
Drawn: PH	Scale @ A1: AS	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-BR0121
Approved: EC	@ A3: AS	
Checked: JM	Sheet: 01 of 01	



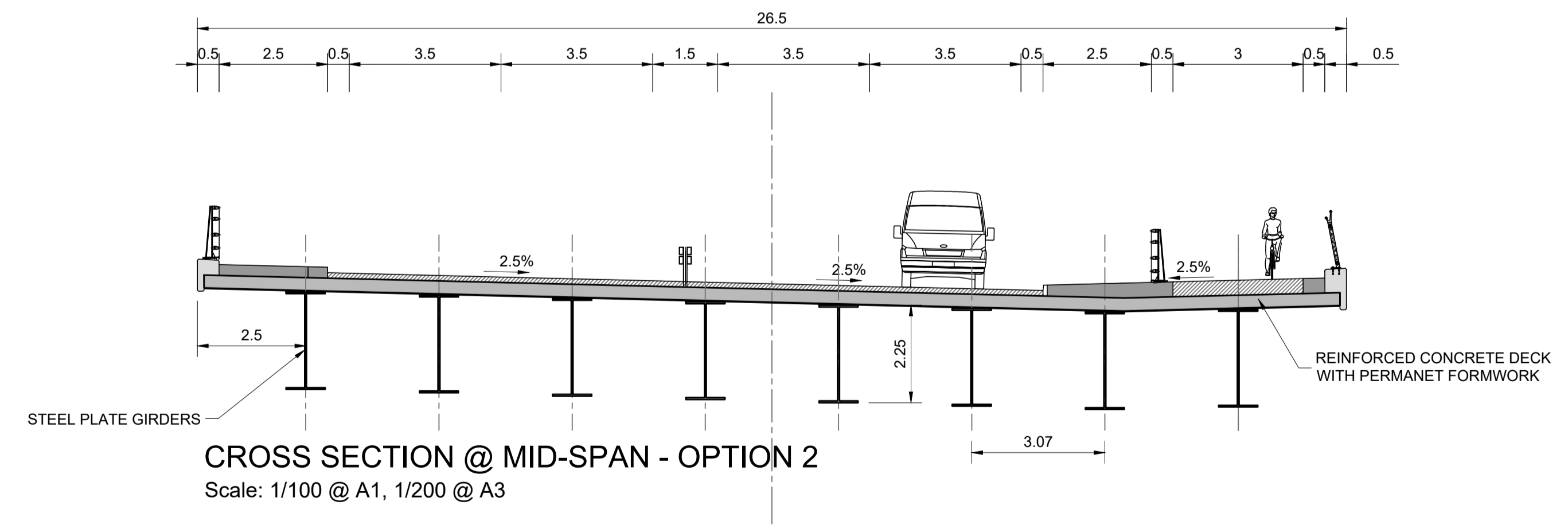
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Scale: 1/100 @ A1, 1/200 @ A3



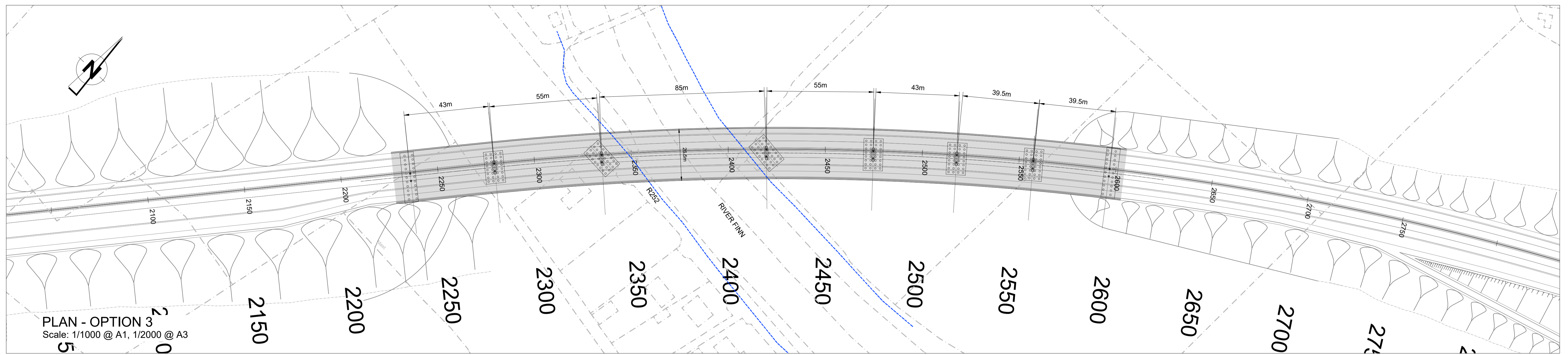
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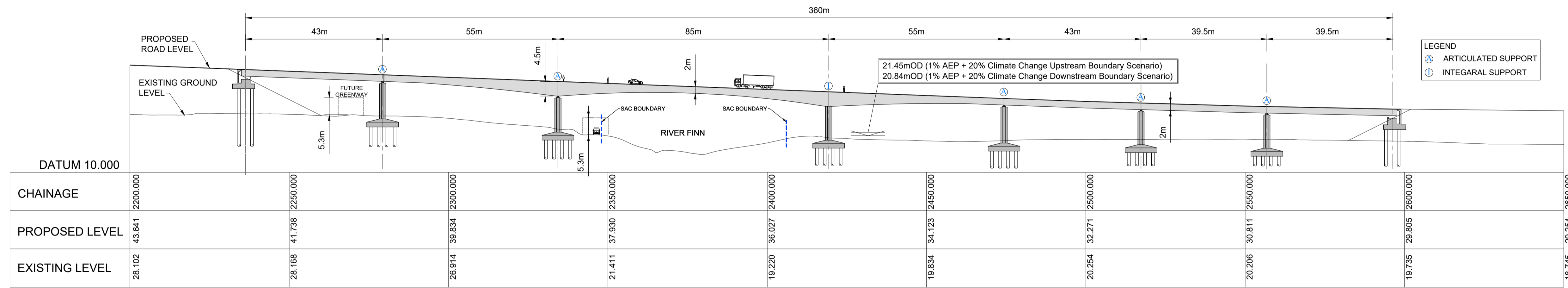
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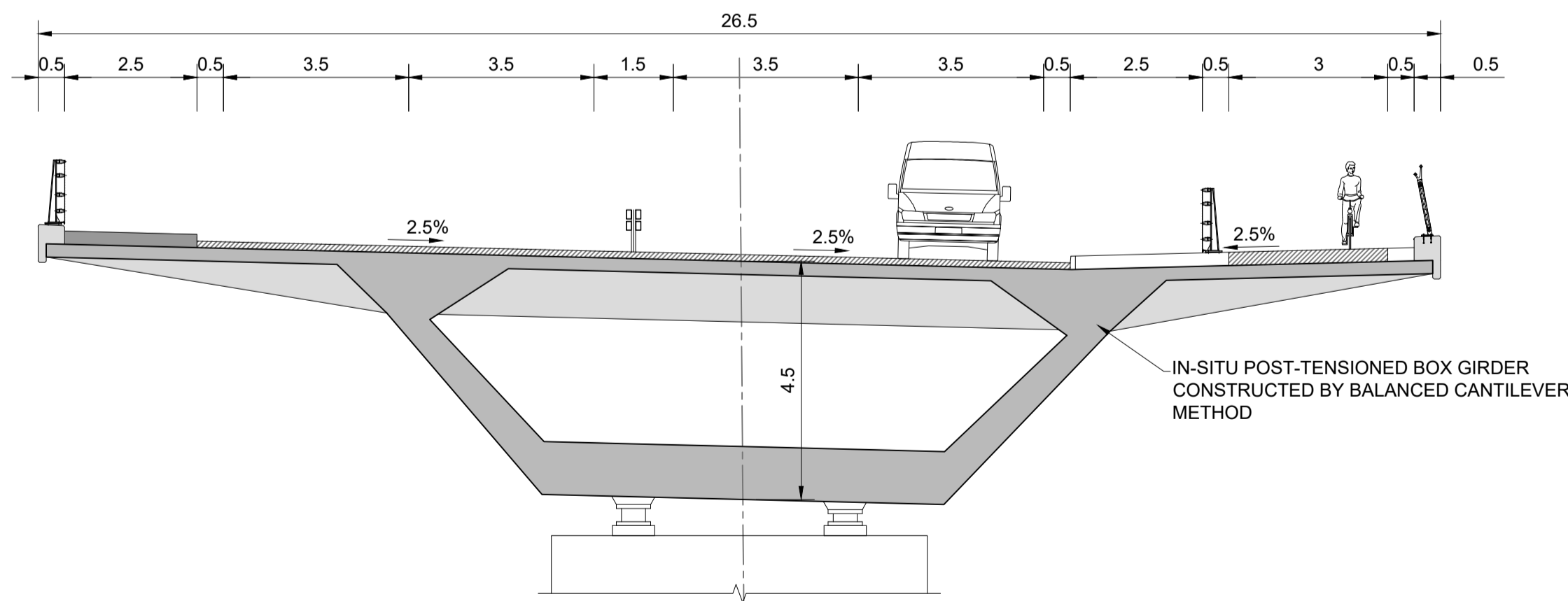
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Designed: JM	Date: FEB 2021	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-BR0122	
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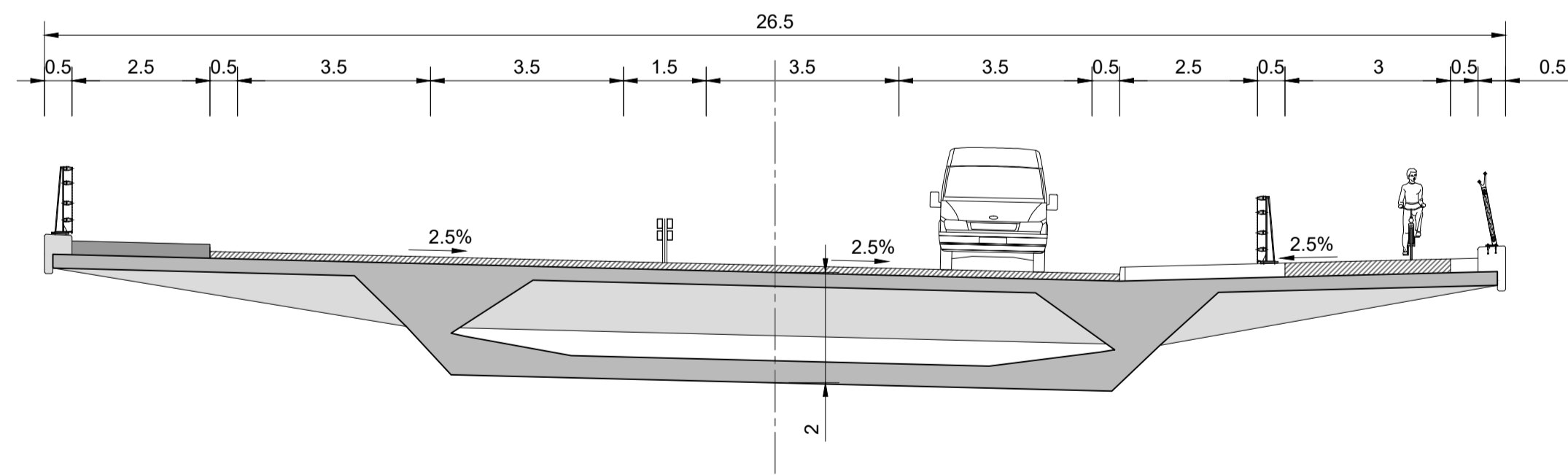
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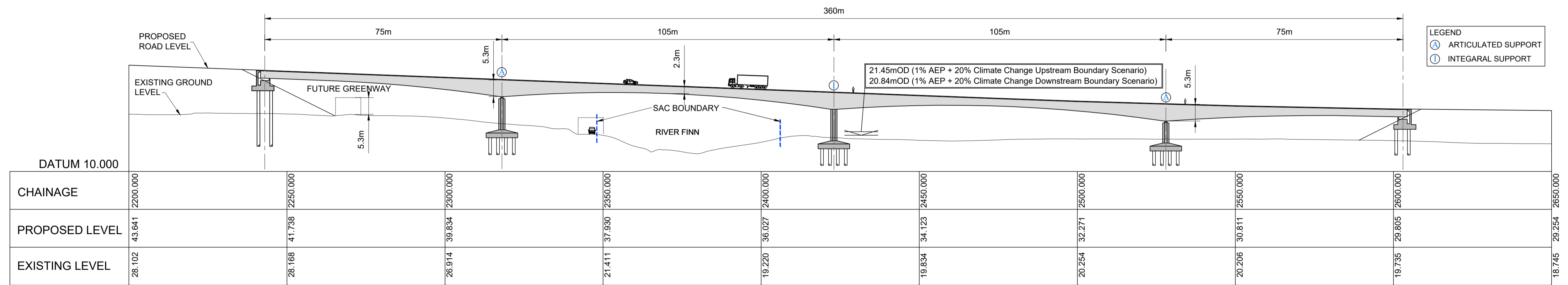
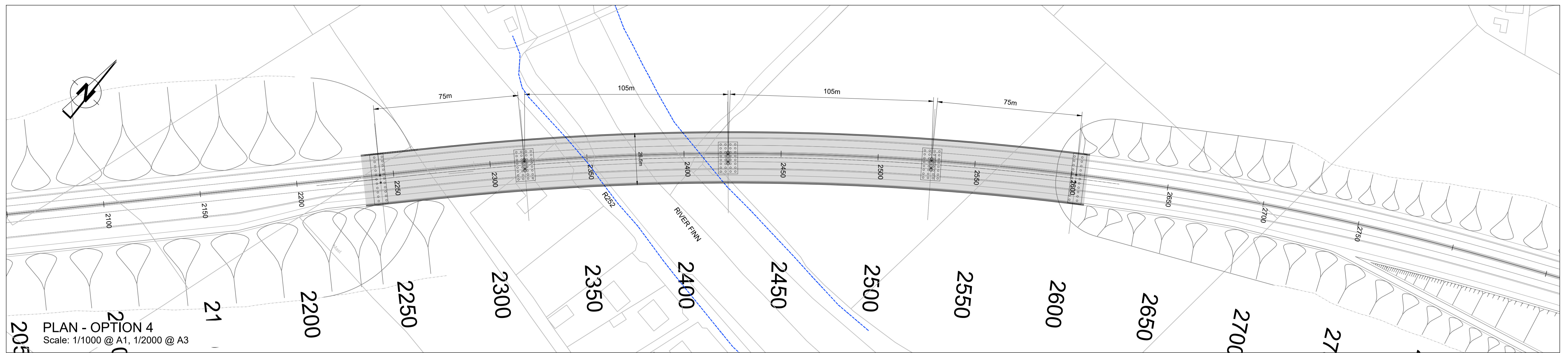
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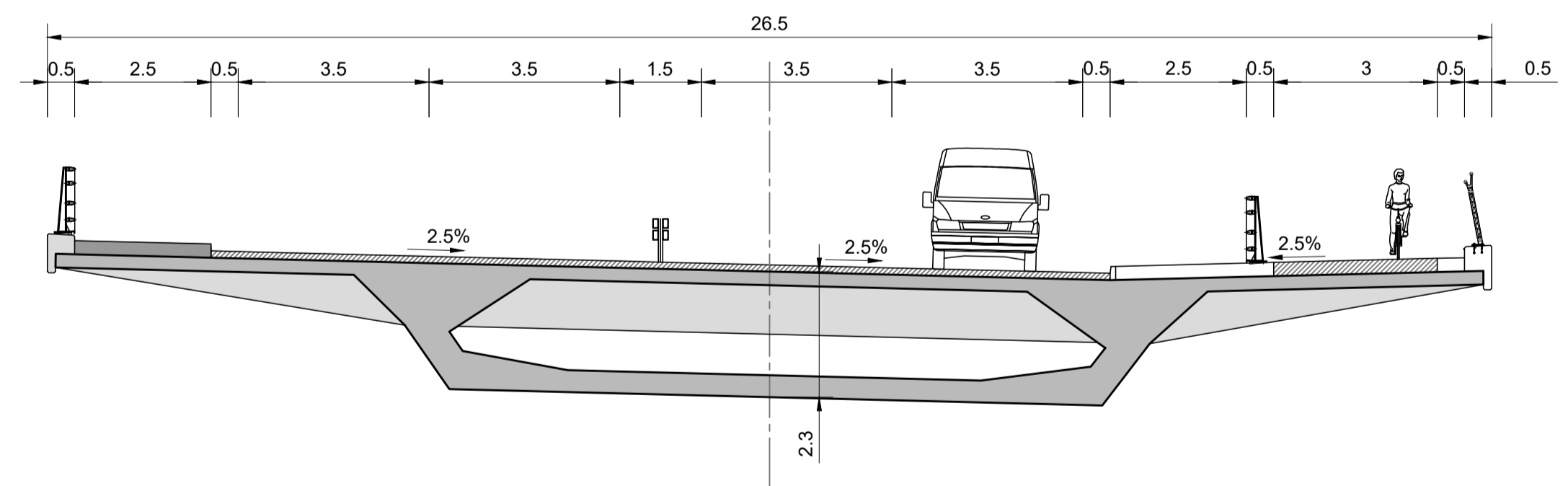
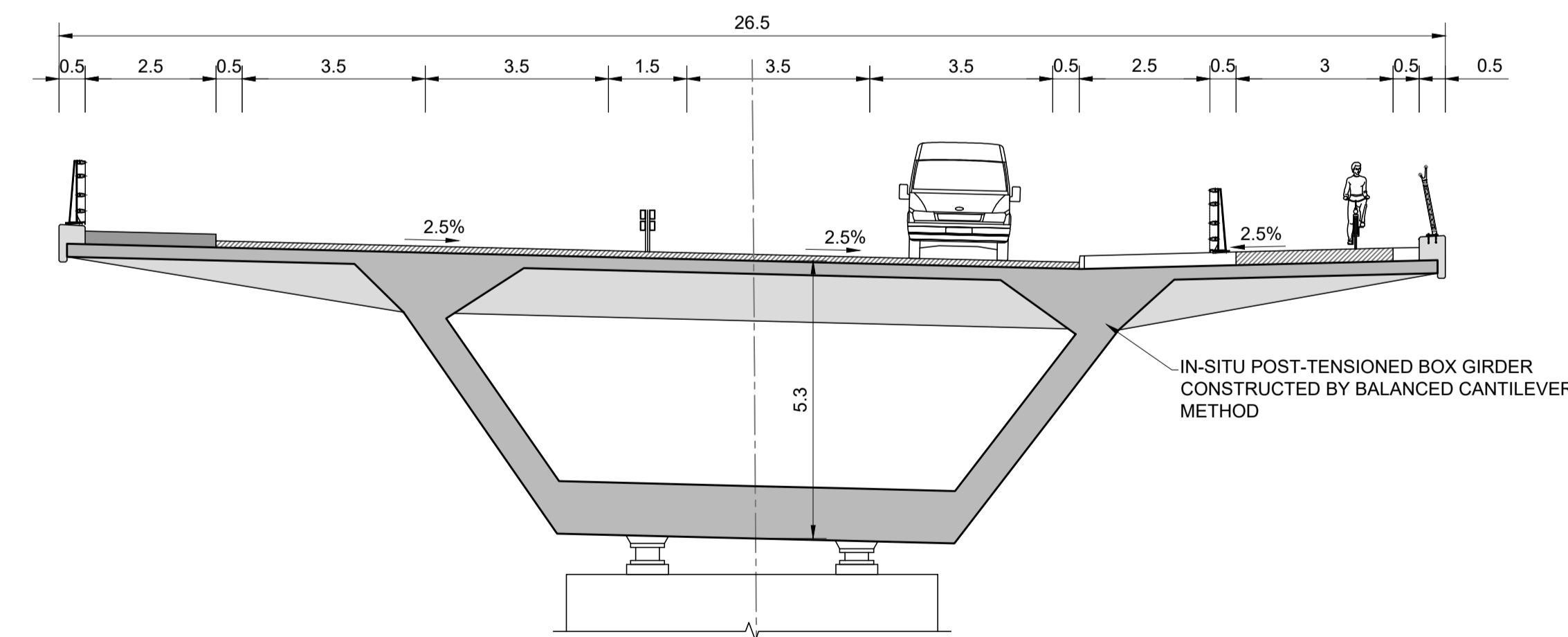
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Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13		Model File Identifier: N/A	
Drawing Title: RIVER FINN CROSSING BRIDGE OPTION - 3 (POST TENSIONED CONCRETE BOX)		Rev: P02	
Designed: JM	Date: FEB 2021	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-BR0123	
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LONG SECTION - OPTION 4
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CROSS SECTION @ ARTICULATED PIER SUPPORT - OPTION 4
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CROSS SECTION @ MID SPAN - OPTION 4
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Project Ireland
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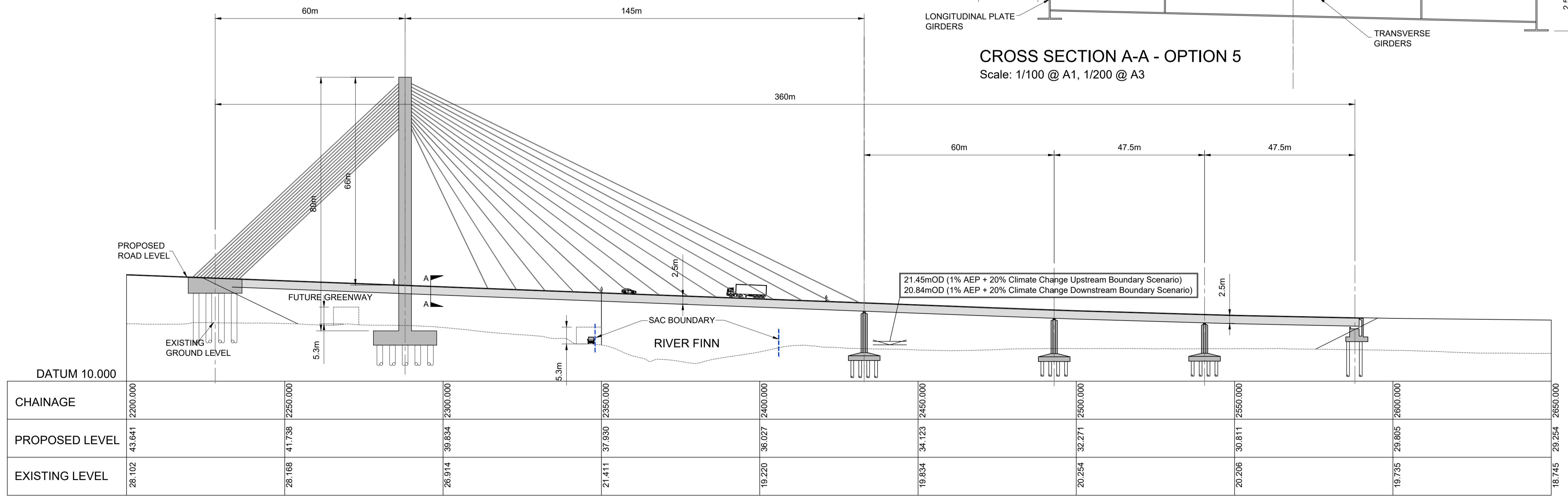
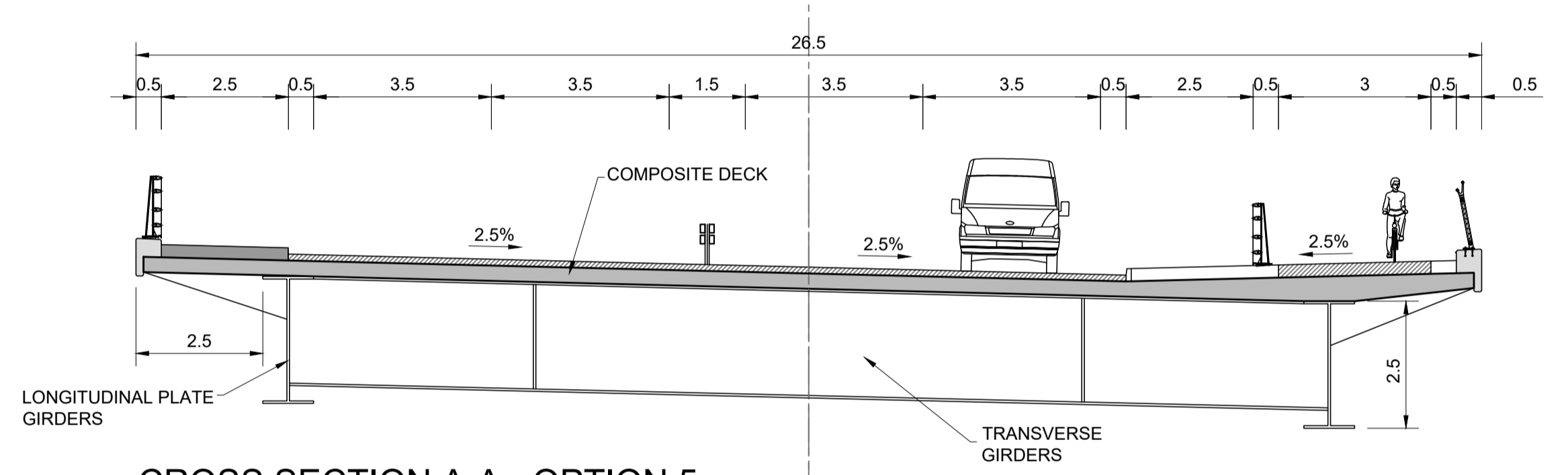
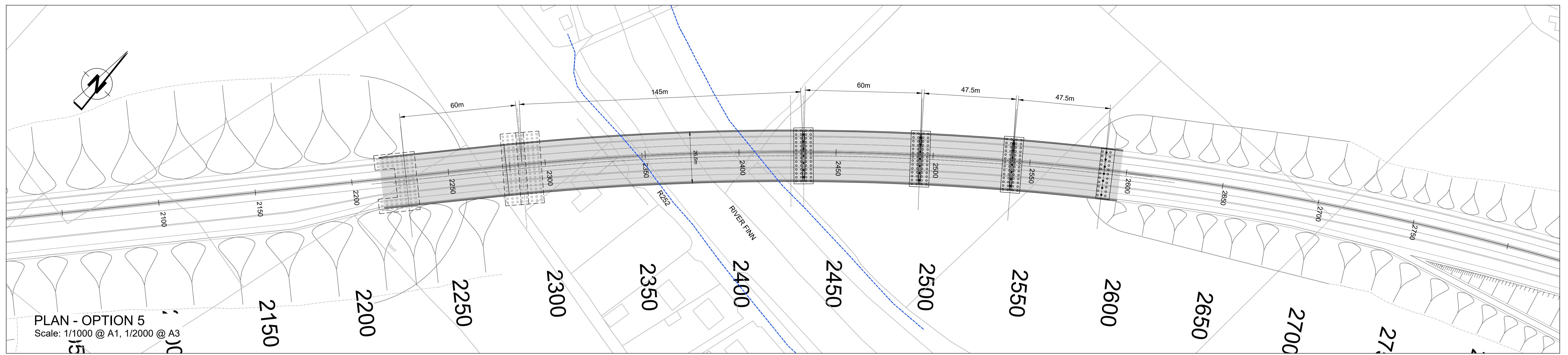
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Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13		Status: S3
Drawing Title: RIVER FINN CROSSING BRIDGE OPTION - 4 (IN-SITU POST TENSIONED BOX)		Rev: P02
Designed: JM	Date: FEB 2021	Model File Identifier: N/A
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LONG SECTION - OPTION 5
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Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13		Model File Identifier: N/A	
Drawing Title: RIVER FINN CROSSING BRIDGE OPTION - 5 (CABLE STAY)		Rev: P02	
Designed: JM	Date: FEB 2021	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-BR0125	
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APPENDIX 2: GEOTECHNICAL INFORMATION

TEN-T
Co. Donegal
Geophysical Survey

Report Status: Draft

MGX Project Number: 6400

MGX File Ref: 6526d-005.doc

30th October 2020

Confidential Report To:

Irish Drilling Ltd.
Old Galway Road
Pollroeback
Loughrea
Co. Galway

**Report submitted by :
Minerex Geophysics Limited**

Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare, W23X7Y5
Ireland
Tel.: 01-6510030
Email: info@mgx.ie

Issued by:

Author: John Connaughton (Geophysicist)

Reviewer: Hartmut Krahn (Senior Geophysicist)



Subsurface Geophysical Investigations

EXECUTIVE SUMMARY

1. Minerex Geophysics Ltd. (MGX) carried out a geophysical survey consisting of 2D-Resistivity, seismic refraction (p-wave) and MASW (s-wave) surveying for the ground investigation for the TEN-T project in County Donegal.
2. The survey was done at eight separate locations.
3. The main objectives of the survey were to determine the ground conditions under the site, determine the depth to rock and the overburden thickness and to estimate the strength/stiffness/compaction of overburden and the rock quality.
4. The 2D-Resistivity data was displayed with a scale ranging from low resistivity clay and silt overburden to high resistivity sand and gravel and also rock at depth.
5. The seismic refraction data was modelled with a four-layer model.
6. Layer one is described as soft or loose topsoil, soil or made ground. Layers 2 and 3 are subdivided into three material types using the 2D-Resistivity data while Layer 4 is divided in two types.
7. Layer 2 is described as firm to stiff or medium dense to dense overburden. Layer 3 is interpreted as either very stiff to hard or very dense overburden or poor to fair weathered rock while layer 4 is described as slightly weathered to fresh rock.
8. The shallowest good to very good rock is found at Area C and at the structure at CH1900 – 1250 as shallow as 1.5 – 2 m. Weathered rock may be even shallower in some areas.
9. The good rock layer is not found within the survey depth in Areas A, D & E where layer 3 is the deepest layer modelled. It is interpreted as primarily very consolidated overburden rather than weathered rock.
10. This report will be reviewed and finalised after the complete direct ground investigation data has been received.

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Figure 3a: Results of MASW Survey for Area A	1 x A3	6526d_MapsFigs.dwg
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Figure 3e: Results of MASW Survey for Area E	1 x A3	6526d_MapsFigs.dwg
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Figure 3h: Results of MASW Survey for River Finn Crossing N	1 x A3	6526d_MapsFigs.dwg

1. INTRODUCTION

1.1 Background

Minerex Geophysics Ltd. (MGX) carried out a geophysical survey for the TEN-T Project in Co. Donegal. The survey consisted of 2D-Resistivity, seismic refraction (p-wave) and MASW (s-wave) measurements. The survey was commissioned by Irish Drilling Ltd.

The survey was done at eight separate locations:

Location	Townland	Design Feature
Area A	Drumcarn/Drumoghill	Side Road Underbridge
Area B	Moondooy Lower	Side Road Underbridge
Area C	Drumbeg	Side Road Underbridge
Area D	Drumboe Lower	Side Road Overbridge
Area E	Ballyraine	Side Road Overbridge
River Swilly Crossing North	Drumany/Dromore	Bridge
Structure at CH 1900 – 2150	Ballyholey Far	Bridge
River Finn Crossing North	Carrickdawson	Bridge

The survey employed various geophysical methods that complement each other and improve the interpretation. The role of geophysics as a non-destructive fast method is to provide a geological interpretation in areas where access for direct ground investigations was limited at specific locations. The survey was aimed at investigating the ground stability and to determine the general geology in particular locations.

1.2 Objectives

The main objectives of the geophysical survey were:

- To determine the ground conditions under the site
- To determine the depth to rock and the overburden thickness
- To estimate the strength/stiffness/compaction of overburden materials and the rock quality
- To determine the type of overburden and rock
- To detect lateral changes within the geological layers
- To determine the s-wave velocity and to calculate the small strain shear modulus G_{max}

1.3 Site Description

The survey was carried out at eight locations across Donegal stretching from Ballybofey in the South to Letterkenny in the North. Most profiles were carried out in grass fields. Area D consisted of two profiles which crossed the L1214 road. Area A consisted of two lines which were carried out on the verge of the N14 while the profiles at CH 1900 – 2150 crossed a small local access road. There was a stream crossing the lines in Area C.

1.4 Geology

As the survey is spread over a wide area, the geology varies between the survey locations. The bedrock geology is generally metamorphic rock types such as marble, quartzite and psammities while the overburden consists of till derived from metamorphic rock and alluvium near rivers and streams. A description of the geology (GSI, 2020) for each area is given in Table 2 attached to this report.

1.5 Report

This report includes the results and interpretation of the geophysical survey. Maps, figures and tables are included to illustrate the results of the survey. More detailed descriptions of geophysical methods and measurements can be found in GSEG (2002), Milsom (1989) and Reynolds (1997).

The description of soil and rock and the use of geotechnical terms (like soft, stiff, dense etc) follows the standards (Eurocode 2007, BSI 2015). Geophysical parameters are used to determine these terms by using guidelines and from experience. The geophysical survey has been acquired, processed, interpreted and reported on in accordance with these guidelines.

The client provided maps of the site and the digital version was used as the background map in this report. Elevations were surveyed on site and are used in the vertical sections.

The interpretative nature and the non-invasive survey methods must be taken into account when considering the results of this survey and Minerex Geophysics Limited, while using appropriate practice to execute, interpret and present the data, give no guarantees in relation to the existing subsurface.

2. GEOPHYSICAL SURVEY

2.1 Methodology

The methodology consisted of using 2D-Resistivity, Seismic Refraction and MASW surveying across all proposed lines. Some proposed very short lines such as lines 6 and 7 at the River Swilly Crossing North were extended to allow meaningful data to be collected. The results from MASW profiles 3 – 5 at the River Swilly Crossing North site are 11.5 m short as the river stopped the profiles from being extended past the start of the proposed line as is required to acquire the data. It was not possible to carry out MASW profiles across the road at Area D as this would have required the closure of the road. At Area C, the MASW profiles were stopped at the river as the noise from the river and the sudden elevation change would interfere with the collection of surface wave information.

At Area B, Line 2 was diverted along a local road as the proposed line crossing the road would not have been feasible. At Area C, Line 19 was curved around a derelict house and large mound of topsoil which obstructed the proposed line.

The survey locations are indicated on Maps 1a and 1b. The lines, locations and parameters are tabulated in Table 1 attached to this report.

2.2 2D-Resistivity (ERT)

2D-Resistivity lines were surveyed with electrode spacing of 3 m, up to 64 electrodes per set-up and a maximum length of 189 m per set-up. The readings were taken with a Tigre Resistivity Meter, Imager Cables, stainless steel electrodes, laptop and ImagerPro acquisition software.

In sealed tarmac/concrete/hard standing areas small holes (12 mm) were drilled to place the electrodes in them and saline water was added to make a good electrical connection.

During 2D-Resistivity surveying, data is acquired in the form of linear arrays using a suite of metal electrodes. A current is injected into the ground via a pair of electrodes while a potential difference is measured across a second pair of electrodes. This allows for the recording of the apparent resistivity in a two-dimensional arrangement below the line. The data is inverted after the survey to obtain a model of subsurface resistivities. The generated model resistivity values and their spatial distribution can then be related to typical values for different geological materials.

The penetration depth of a resistivity set-up increases towards the centre where it reaches an approx. value of $1/6^{\text{th}}$ of the array length.

2.3 Seismic Refraction

Seismic refraction lines were surveyed with geophone spacing of 3 m and 24 geophones per set-up resulting in a 69 m length per set-up. The recording equipment consisted of a 24 Channel GEOMETRICS ES-3000 engineering seismograph with 4.5 Hz vertical geophones. The seismic energy source consisted of a hammer and plate. A zero-delay trigger was used to start the recording. Normally 7 shot points per p-wave set-up were used.

Some set-ups were acquired in longer continuous lines using common shot points between set-ups and concatenating into longer lines at the processing stage.

In the seismic refraction survey method, a p-wave is generated by a source at the surface resulting in energy travelling through surface layers directly and along boundaries between layers of differing seismic wave velocities. Processing of the seismic data allows geological layer thicknesses and boundaries to be established.

Seismic Refraction generally determines the depth to horizontal or near horizontal layers where the compaction/strength/rock quality changes with an accuracy of 10 – 20% of depth to that layer. Where low velocity layers or shadow zones are present (e.g. below solid ground surface) or where layers dip with more than 20 degrees angle the accuracy becomes much less.

The seismic refraction set-ups with 69 m individual length have a reasonable penetration depth of around 15m. An internationally accepted maximum depth estimate for a seismic refraction set-up is 1/6 of the set-up length including off-shots. The depth penetration varies according to the velocity structure of the subsurface. In this report we used a depth of 10m bgl. where the seismic modelling was ended as deeper modelling becomes less meaningful.

2.4 2D-MASW (Multichannel Analysis of Surface Waves)

The seismic shear wave velocity was determined by active 2D-MASW surveying. MASW (Multi-Channel Analysis of Surface Waves) determines the bulk seismic shear wave velocity versus depth. The velocities are used to determine the small strain shear modulus and to compute other geotechnical parameters.

The MASW arrays consisted of a 1 m geophone spacing and a 24 channels set-up, resulting in an individual array length of 23m. Shots were carried out 8m after the last geophone in the array. The whole set-up was then advanced by 8m and the process repeated across the full survey line.

The recording equipment consisted of a 24 Channel GEOMETRICS GEODE engineering seismograph with 4.5 Hz vertical geophones. The seismic energy source consisted of a hammer and plate. A zero-delay trigger was used to start the recording.

Each set-up provides information for the middle of the geophone array. The displayed results therefore cover the distance from 11.5 m after the first geophone of the first array and 11.5 m before the last geophone of the

last array. Table 1 shows the total length of the set-ups from the first geophone in the first array along a line to the last geophone of the final array. It is therefore 23 m longer than the displayed line on Map 1 which shows the locations of the midpoints of the MASW arrays.

The depth surveyed by the MASW method depends more on the ground itself rather than on the geophone spacing. The ground conditions determine the frequency of surface waves spreading through the subsurface. The frequency and the surface wave velocity determine the survey depth. The geophone spacing of 1m used for this survey ensures that all relevant wave form data can be captured. A low velocity ground (like very soft and soft ground) will give a shallow shear wave depth section while a high velocity ground (like shallow rock) will give a deeper section.

Many constraints exist for the MASW method and the main factors on this site that affect the methods are strong vertical velocity gradients and changing velocity structure and layer thicknesses along the lines.

2.5 Site Work

The data acquisition was carried out between the 28th of September and 8th of October 2020. The weather conditions were varied throughout the acquisition period. Health and safety standards were adhered to at all times. While working on roadways the area was clearly highlighted by the use of warning signs and cones and a traffic management system was in place.

The locations and elevations were surveyed with a Carlson NR3 RTK-GPS to accuracy < 0.05 m.

3. RESULTS AND INTERPRETATION

The interpretation of geophysical data was carried out utilising the known response of geophysical measurements, typical physical parameters for subsurface features that may underlay the site, and the experience of the authors.

The interpretation is based on the methods of 2D-Resistivity and Seismic Refraction while the MASW data is given some additional information where the ground conditions are favourable for the method. It must be considered that the first two methods work everywhere on this site while the MASW method is very dependent on having suitable ground conditions.

3.1 2D-Resistivity (ERT)

The 2D-Resistivity data was positioned and inverted with the RES2DINV inversion package. The programme uses a smoothness constrained least-squares inversion method to produce a 2D model of the subsurface resistivities from the recorded apparent resistivity values. Three variations of the least squares method are available and for this project the Jacobian Matrix was recalculated for the first three iterations, then a Quasi-Newton approximation was used for subsequent iterations. Each dataset was inverted using seven iterations resulting in a typical RMS error of <3.0%. The resulting models were colour contoured with the same resistivity scale for all lines and they are displayed as cross sections (Figure 1).

Resistivities are characteristic for certain overburden and rock types. If there is a high content of clay minerals (which are electrically conductive) then the overburden resistivity will be lower than as if there is a high content of clastic grains like sand or gravel. The purer the clay and the lower the sand/gravel content the lower the resistivity. The water content in the overburden also influences the resistivities but generally the clay content has a larger effect.

Within bedrock types like marble, quartzite and psammite, high resistivities indicate a fresh strong unweathered rock. As the weathering in the rock increases the resistivity gets lower because of weathering products, remineralisation of rock and infill of cracks, faults and voids with clay and water. Weathering within rock is typically indicated by lower resistivity values in the cross sections.

The resistivities cover a range typical for materials from clay rich overburden (low resistivities) to fresh strong unweathered bedrock (high resistivities). The ranges have been taken into the consideration for the interpretation. Low resistivity values (<180 Ωm) typically indicate overburden with high clay content. Medium values (180 to 1500 Ωm) show gravelly clay overburden and weathered bedrock. High resistivities (>1500 Ωm) indicate unweathered bedrock types like marble, quartzite and psammite or clean sand and gravel in overburden.

3.2 Seismic Refraction

The seismic refraction data was positioned and processed with the SEISIMAGER software package to give a layered model of the subsurface. The number of layers has been determined by analysing the seismic traces and between 2 and 4 layers were used in the models. All seismic lines were subject to a standardised processing sequence which consisted of a topographic correction which was based on integrated elevation data, first break picking, tomographic inversion, travel-time computation via ray-tracing and velocity modelling. Residual deviations of typically 0.4 to 1.8 msec RMS have been obtained for each line. Following each processing stage QC procedures were adhered to. The resulting layer boundaries are shown as thick lines overlaid on the 2D-Resistivity cross sections (Figures 1a – 1h). The average seismic velocities obtained within the layers are annotated on the sections as bold black numbers.

The p-wave seismic velocity is closely linked to the density of subsurface materials and to parameters like compaction, stiffness, strength and rock quality. The higher the density of the subsurface materials the higher the seismic velocity. Similarly, for the other parameters it is generally valid that a more compacted, stiffer and stronger material will have a higher seismic velocity. For rock, the seismic velocity is higher when the rock is stronger, less weathered and has a higher quality. If the rock is more weathered, broken or fractured then the seismic velocity will be reduced compared to that of intact fresh rock.

Because of the above relationship, the seismic refraction method and seismic velocities are suitable to investigate ground where the layers get denser, more compacted and stronger with depth. A disadvantage is that some materials may have the same seismic velocity. Very stiff to hard or very dense highly consolidated overburden and a weathered rock can have the same seismic velocity range (as is the case in the layer 3 below).

The modelled seismic data has created the following layered ground model:

Layer 1 has seismic velocities of 100 - 300 m/s. This overburden would be topsoil, soil or made ground with a soft or loose stiffness or compaction.

Layer 2 was modelled with a velocity range of 800 - 1600 m/s. The velocity indicates overburden material with firm to stiff or medium dense to dense strength or compaction.

Layer 3 velocities of 1800 - 2600 m/s indicate weathered rock or very stiff to hard or very dense overburden.

Strong rock (Layer 4) is indicated by seismic velocities of >3000 m/s.

3.3 Interpretation of Resistivity and Seismic Refraction

Table 3 below summarises the interpretation. The stiffness or compaction and the rock strength or quality have been estimated from the seismic velocity. The estimation of the excavatability for the bedrock has been made according to the caterpillar chart published in Reynolds (1997). The geotechnical assessment for rippability will have to take factors like rock type and jointing into account and the estimation in this report is solely based on the seismic velocities.

Interpreted cross sections are shown in Figure 2a – 2h. The interpretation has been made from all available information. For overburden layers and the top of the rock the seismic refraction data has been used because jumps in the seismic refraction velocities are the best method to delineate layer boundaries. The resistivity models have been used, within the seismic refraction layers, to delineate three generalised overburden types and to indicate weathering of rock. Along short sections where only one data type is available an interpolation for the interpreted layers was made.

Table 3: Summary of Interpretation

Layer	General Seismic Velocity Range (m/sec)	General Resistivity Range (Ohmm)	Stiffness/ Compaction or Rock Strength/ Quality	Interpretation	Estimated Excavation Method
1	100 - 300	Any	Soft or loose	Topsoil, Soil or Made Ground	Diggable
2a	800 - 1600	<180	Firm to stiff	Clay or Silt Overburden	Diggable
2b	800 - 1600	180 - 1500	Firm to stiff	Gravelly Clay Overburden	Diggable
2c	800 - 1600	>1500	Medium dense to dense	Sand and Gravel Overburden	Diggable
3a	1800 - 2600	<180	Very stiff to hard	Clay or Silt Overburden	Diggable
3b	1800 - 2600	180 - 1500	Very stiff to hard Or poor to fair Rock	Gravelly Clay Overburden or Weathered Metamorphic Rock	Diggable or rippable to marginal rippable
3c	1800 - 2600	>1500	Poor to fair Rock	Weathered Metamorphic Rock	Breaking & Blasting
4b	3000 - 4500	180 - 1500	Good to very good Rock	Slightly Weathered Metamorphic Rock	Breaking & Blasting
4c	3000 - 4500	>1500	Good to very good Rock	Metamorphic Rock	Breaking & Blasting

3.4 2D-MASW (Multichannel Analysis of Surface Waves)

The MASW data was positioned, processed, analysed and modelled with the SURFSEIS6 software packages. The objective is to obtain a model of shear wave velocity versus depth and to calculate the small strain shear modulus G_{max} from the shear wave velocities (using an assumed density of 2000 kg/m³ typical for overburden). This is achieved for individual shot records acquired along a line and the results are then combined and displayed as a 2D-Contour image on cross-sections (Figures 3a – 3h).

Following processing steps are done to achieve this:

1. Edit the shot point geometry and display the shot points for each array set-up along a line.
2. A dispersion curve (phase velocity versus frequency plot or dispersion image) is computed.
3. The quality is analysed and only acceptable data is used in the next steps.
4. For each shot the maximum amplitude at each frequency of the dispersion image is selected and then saved.
5. An elevation file using the elevations surveyed at the centre of each array is imported into the program.
6. An initial model of shear-wave velocity V_s versus depth is computed from the saved picks.
7. An inversion is carried out to create the final V_s curve (Shear wave versus depth).
8. The small strain shear modulus (also named G_{max}) for each shot point and depth is computed by using a density of 2000 kg/m^3 typical for highly consolidated overburden (Eq. 1)

$$\text{(Eq. 1)} \quad G = V_s^2 * \rho * 10^{-6}$$

where G = Shear Modulus (MPa)

V_s = Seismic Shear Wave Velocity (m/s)

ρ = Density (kg/m^3)

9. The values for shear velocity (m/s) and small strain shear modulus (in MPa) are then gridded and contoured versus the distance on the line and the depth.
10. The contour section for shear wave velocity and small strain shear modulus are then displayed with a colour scale that ranges from 100 – 1200 m/s for the shear wave velocities and from 20 – 2880 MPa for the shear modulus on Figures 3a – 3h.

The surface waves and dispersion curves produced on this site were ranging from bad to good. Changes can occur between adjacent shot points (8 m apart), or even within a geophone layout. The quality can be seen in the seismic waveforms (surface wave fan) and in the overtone data.

Good data was obtained where the ground is laterally relatively homogeneous and has a gradual velocity increase with depth.

Bad data occurs where the ground does not allow surface waves to propagate. If there are no surface waves then it is obvious that the surface wave method cannot be applied. This case happens when there are no velocity increases with depth (deep rock, homogeneous overburden), where the velocity increases too much

(shallow rock), where there are sudden large jumps in velocity with depth (layer boundaries), at topographical changes and deep ditches or road crossings.

The model depth depends on the frequency and wavelength of the surface wave. MASW deriving values at ground level would require an indefinitely high frequency which is not possible. The colour contours start at the depth of the shallowest model values derived from the software. This leaves a data 'gap' between the ground surface and the top of the model. The deeper penetration into rock is not realistic as the jump in density and velocity from overburden to solid rock would not accommodate surface waves (this is what the seismic refraction method is used for).

The relationship between shear wave velocities and material stiffness is summarised below:

Shear Wave Velocity Vs Range in m/s	Material Stiffness
< 150	Soft
150 to 300	Firm
300 to 500	Stiff
> 500 m/s	Very Stiff

4. RESULTS AND INTERPRETATION BY LOCATION

In this chapter each of the eight survey areas is discussed.

4.1 Area A

Two lines were surveyed at area A on either side of the N14 Road. Possible outcropping rock or boulders were observed at the start of profile 8 along the embankment beside the road in the west. The models show a very thin layer of topsoil underlain by 4 – 7.5 m layer of overburden or weathered rock. It is likely this layer consists primarily of overburden towards the east where the resistivities are lower and weathered rock towards the northwest where the possible outcrop or boulders was observed and there are higher resistivities. Good rock is found at a depth of 5 – 8 m below ground level across both lines.

The MASW data was poor at the start of line 8 but became better towards the east which conforms with the interpretation of weathered rock to the northwest and overburden to the east. Line 9 shows similar MASW results but with better data from the start of the line.

4.2 Area B

Lines in Area B were surveyed in a single field in the townland of Moondooey Lower. The seismic refraction models show a three-layer model with no good rock being encountered to a depth of 15m. The 2D-Resistivity data shows homogeneous resistivities to depth which indicates little change in the subsurface composition. Low resistivities at depth in the NE of both lines indicate seismic Layer 3 consists primarily of very stiff to hard or very dense overburden with a high clay content rather than weathered rock.

The MASW data was generally good across these lines with information to a depth of 10 m in most places. Results indicate increasing stiffness of materials with depth with very stiff material within seismic Layer 3.

4.3 Area C

The survey in the townland of Drumbeg was carried out in fields on either side of a local road off the N14. In the field to the north the line was diverted around an old cottage and mound of topsoil. Both lines crossed a stream which flows south near the east side of the lines.

High seismic velocities indicate shallow rock across both lines. The layers used are layers 1, 3b, 4b and 4c. Soft and loose topsoil is between 0.5 and 3 m deep and is thickest in the SW on the higher ground. Layer 3b likely contains weathered rock and is between 1 and 4.5 m thick. The top of the good to very good rock layer is found between 2 and 6 m below ground level.

The MASW data in this area was poor and no surface waves were detected. This is due to the shallow rock found throughout this location.

4.4 Area D

Two lines were surveyed crossing a local road in the townland of Ballyholey Far. The seismic models used 2 – 3 layers and the 2D-Resistivity data shows little change with depth in subsurface composition. No good rock was encountered and it is likely layer 3 is composed of very stiff to hard clay rich overburden and very dense gravelly clay.

The MASW survey was not possible across the road which means there is a gap in the data through the middle of both lines. Where MASW data was acquired it shows a gradual stiffening of overburden material with depth from stiff to very stiff.

4.5 Area E

Lines in Area E were carried out primarily in one field just to the west of the N14 in Carrickdawson. Line 13 extended into a second field to the north. There was a ditch with flowing water between the fields. The ground was very wet and marshy at the time of surveying.

The 2D-Resistivities data shows low resistivities to depths of up to 15 m. The seismic refraction data was modelled with 2 – 3 layers. No good rock was encountered. The model is interpreted as deep clay rich overburden primarily very stiff or hard material. The GSI online geological maps indicate this overburden is alluvium.

The MASW data was good in this area and shows deep overburden increasing from stiff to very stiff with depth.

4.6 River Swilly Crossing North

Five lines were surveyed in Ballyrairie along the floodplain, north of the River Swilly. The river is tidal in this area and the riverbed shows significant mud along the bank. Lines 3 – 5 were surveyed perpendicular to the river, starting close to the riverbank while lines 6 and 7 were surveyed parallel to the river. Lines 3 - 5 show shallow high resistivities towards the NW with very low resistivities near the surface close to the river. Line 7 was located close to the river. This line shows very low resistivities to depth. This is likely due to interference from saline water in the river rather than an indication of rock change. Line 6 was carried out away from the river on higher ground and shows medium to high resistivities throughout.

The seismic models were modelled with 4 layers. The topsoil layer is between 1 and 2.5 m thick across all lines. Layer 2 is between 1.5 and 3.5 m thick. This layer is predominantly sand and gravel on the higher ground to the NW and changes to clay and silt rich alluvium towards the river. Layer 3 is between 1 and 4.5 m thick and most likely consists primarily of weathered rock. The top of the good to very good rock is between 3.5 and 8.5 m below ground level.

The MASW data usefulness varies across the profiles due to changes in layer thicknesses. The models become better away from the river and show a gradual increase in stiffness into the rock layer.

4.7 Structure at CH 1900 - 2150

The survey at Drumany/Drumore consisted of two lines which crossed a small local access road. The field SW of the road was a grass field which rose towards the south. The land NE of the road was overgrown and marshy with standing water in a number of places.

The 2D-Resistivity data shows medium - high resistivities near the surface and at depth. The resistivities vary from medium to high laterally at all depths with the highest conductivities found in the middle of the lines. The seismic refraction models were modelled with a three layer model.

The soft or loose topsoil layer is thin with a maximum thickness of 1 m. Layer 2, interpreted as medium dense to dense gravelly clay and clean sand and gravel, is generally very thin but is up to 5 m thick, particularly to the SW at the higher ground. Layer 3 is between 1 and 10 m thick and is interpreted as primarily weathered metamorphic rock. This layer is thickest towards the SW and is thin towards the NE. Layer 4 is described as good to very good slightly weathered or fresh metamorphic rock. The top of this layer is 1.5 and 11 m below ground level and is shallowest in the NE.

The MASW data shows that no surface waves were detected on the NE end of the lines due to the shallow rock. The surface waves become better towards the SW where they show increased overburden stiffness with depth.

4.8 River Finn Crossing North

Five profiles were carried out across two fields north of the River Finn near Ballybofey in the townland of Drumboe Lower. The seismic refraction data was modelled with a 3-layer model for all profiles. The top two layers are described as soft or loose topsoil and medium dense to dense sandy gravelly clay or sand and gravel. This is underlain by slightly weathered to fresh metamorphic rock at a depth of 4.5 – 6.5 m below ground level.

MASW data shows the overburden consists of primarily stiff material.

5. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made:

- The geophysical surveys were carried out at eight separate locations across the TEN-T scheme which showed varied geology from deep clay rich overburden to shallow good rock.
- Online geological maps indicate the underlying rock consists of various metamorphic rock types such as marble, quartzite and psammite. Overburden is described generally as glacial till and alluvium near the two rivers.
- Seismic refraction, 2D-Resistivity and MASW surveying was carried out at all locations. Due to varying ground conditions, surface waves do not exist everywhere and the MASW method does not work in all locations leading to some 'gaps' in data in some areas and no MASW results at all for area C.
- Seismic refraction data was modelled with four layers ranging from soft and loose topsoil to good to very good rock. The good to very good rock layer was found in 5 of the 8 sites.
- Seismic refraction layers 2 – 4 were subdivided using the 2D-Resistivity data to provide information on the subsurface composition.
- Layer 2 is subdivided into firm to stiff clay and silt, medium dense to dense gravelly clay and clean sand and gravel. Layer 3 is interpreted as very stiff to hard clay or silt, very dense gravelly clay or poor to fair weathered metamorphic rock. Layer 4 is described as either slightly weathered or fresh good to very good metamorphic rock.
- The shallowest good to very good rock is found at Area C and the structure at CH1900 – 2150 where the good to very good rock layer is as shallow as 1.5 – 2 m below ground level in some parts.
- Area B, Area D and Area E have seismic layer 3 as their deepest layer which is interpreted as primarily very stiff to hard or very dense overburden rather than weathered rock.
- The lowest resistivities are found at Area E which is interpreted as clay rich overburden to depths of up to 15 m.
- The interpretation presented here should be reviewed after direct ground investigation data becomes available.

6. REFERENCES

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3. **GSEG 2002.** Geophysics in Engineering Investigations. Geological Society Engineering Geology Special Publication 19, London, 2002.
4. **GSI, 2020.** Online Bedrock Geological Map of Ireland. Geological Survey of Ireland 2020.
5. **Milsom, 1989.** Field Geophysics. John Wiley and Sons.
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Table 1: Geophysical Survey Locations and Acquisition Parameters

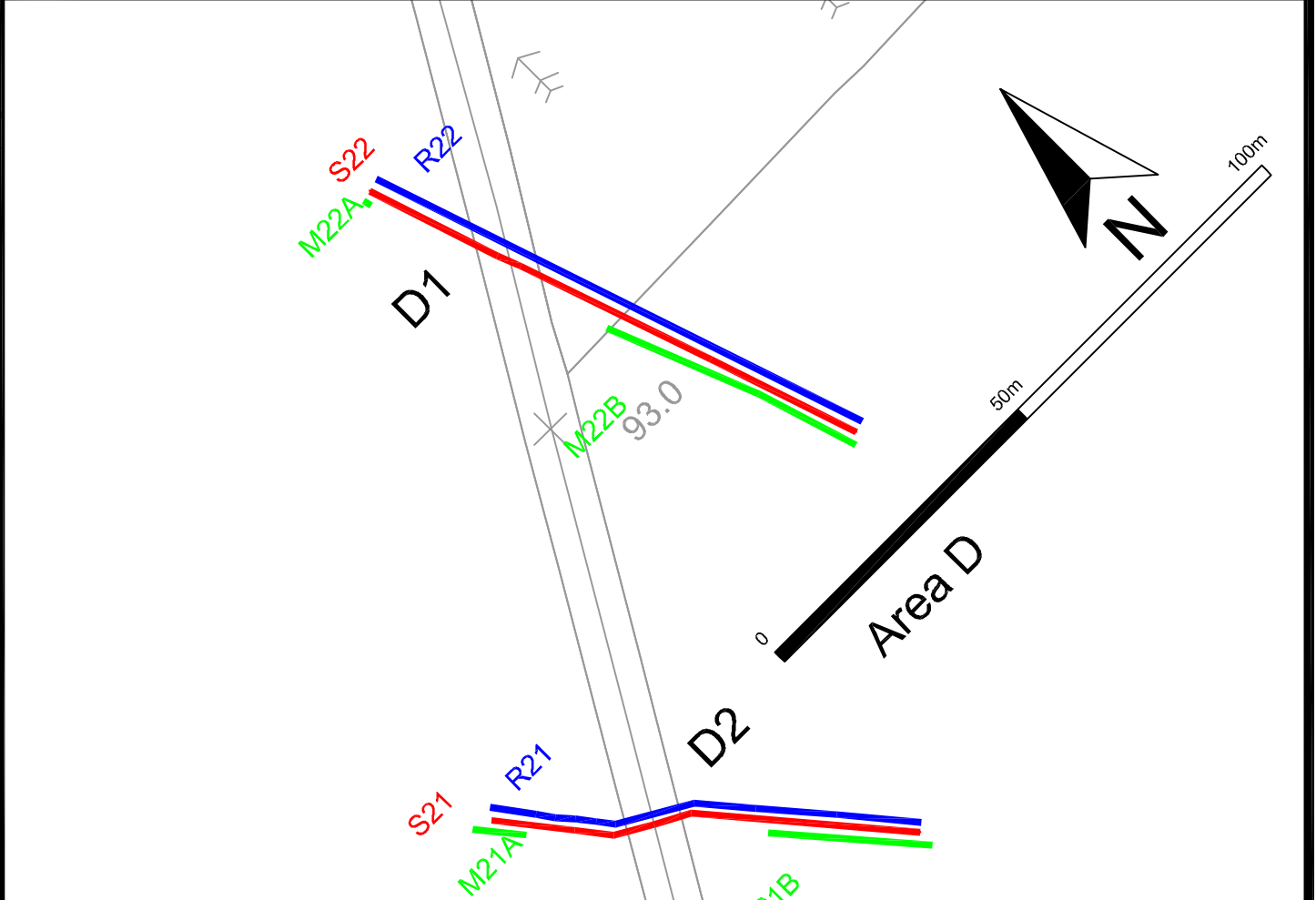
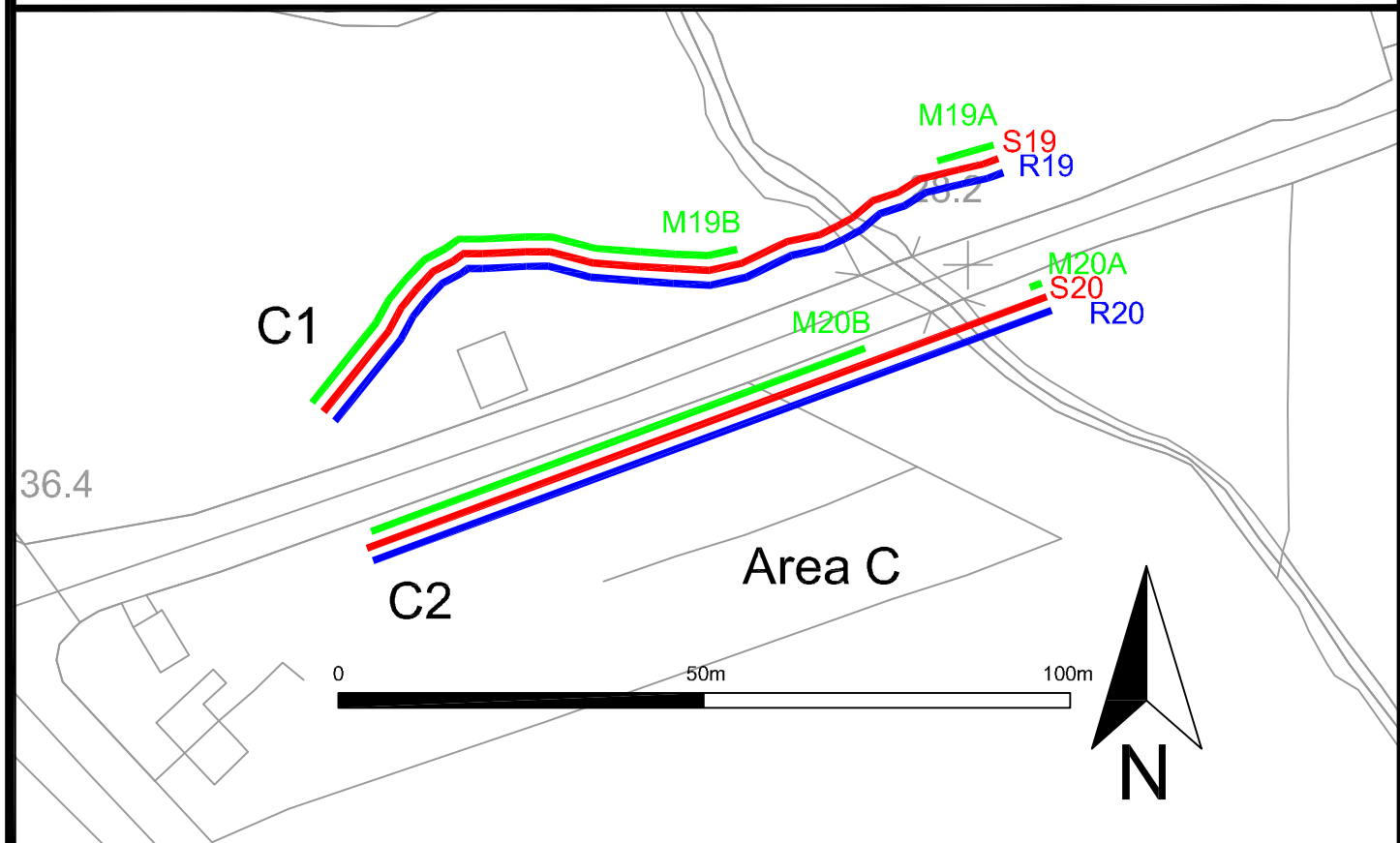
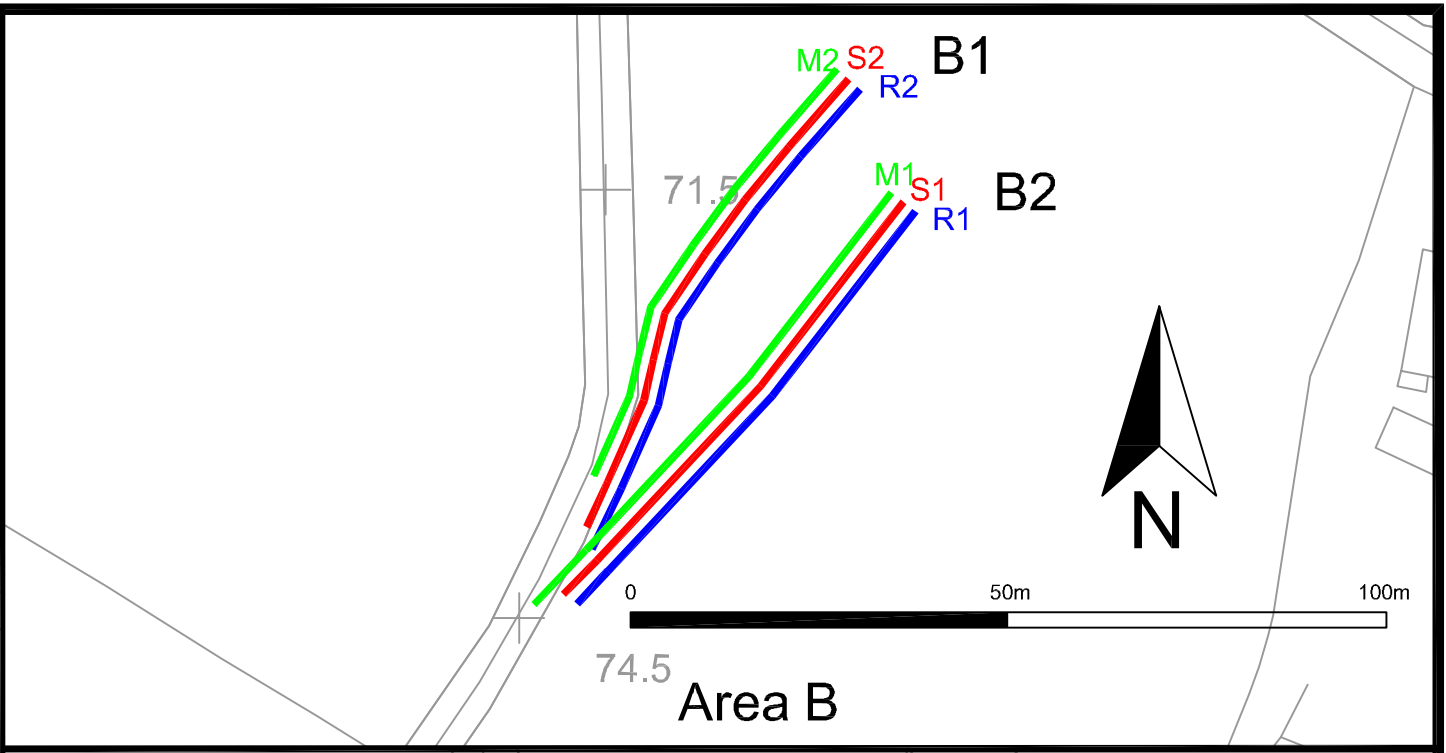
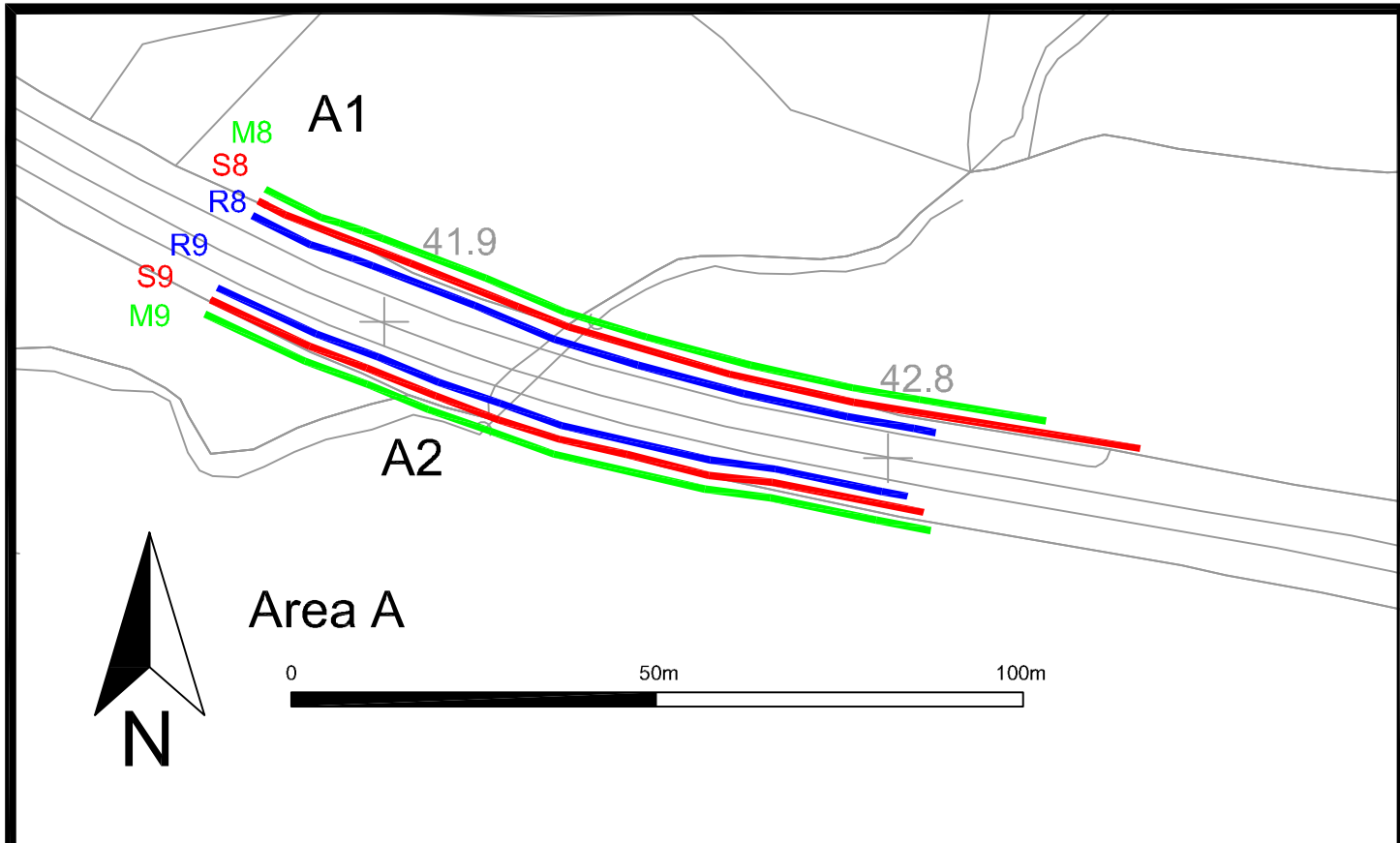
2D-Resistivity Survey				
Area	Line	Profile	Electrode Spacing (m)	Length (m)
Area B	B2	R1	3	69
Area B	B1	R2	3	72
River Swilly Crossing North	A	R3	3	105
River Swilly Crossing North	B	R4	3	102
River Swilly Crossing North	C	R5	3	99
River Swilly Crossing North	D	R6	3	93
River Swilly Crossing North	E	R7	3	93
Area A	A1	R8	3	99
Area A	A2	R9	3	102
Structure at CH 1900 - 2150	B	R10	3	189
Structure at CH 1900 - 2150	A	R11	3	177
Area E	E2	R12	3	156
Area E	E1	R13	3	108
River Finn Crossing North	A	R14	3	57
River Finn Crossing North	B	R15	3	51
River Finn Crossing North	C	R16	3	48
River Finn Crossing North	E	R17	3	72
River Finn Crossing North	D	R18	3	72
Area C	C1	R19	3	105
Area C	C2	R20	3	99
Area D	D2	R21	3	63
Area D	D1	R22	3	81
			SUM	2112
Seismic Refraction Survey				
Area	Line	Profile	Geophone Spacing (m)	Length (m)
Area B	B2	S1	3	69
Area B	B1	S2	3	69
River Swilly Crossing North	A	S3	3	105
River Swilly Crossing North	B	S4	3	102
River Swilly Crossing North	C	S5	3	99
River Swilly Crossing North	D	S6	3	69
River Swilly Crossing North	E	S7	3	69
Area A	A1	S8	3	99
Area A	A2	S9	3	102
Structure at CH 1900 - 2150	B	S10	3	189
Structure at CH 1900 - 2150	A	S11	3	174
Area E	E2	S12	3	141
Area E	E1	S13	3	108
River Finn Crossing North	A	S14	3	57
River Finn Crossing North	B	S15	3	51
River Finn Crossing North	C	S16	3	48
River Finn Crossing North	E	S17	3	69

Table 1: Geophysical Survey Locations and Acquisition Parameters

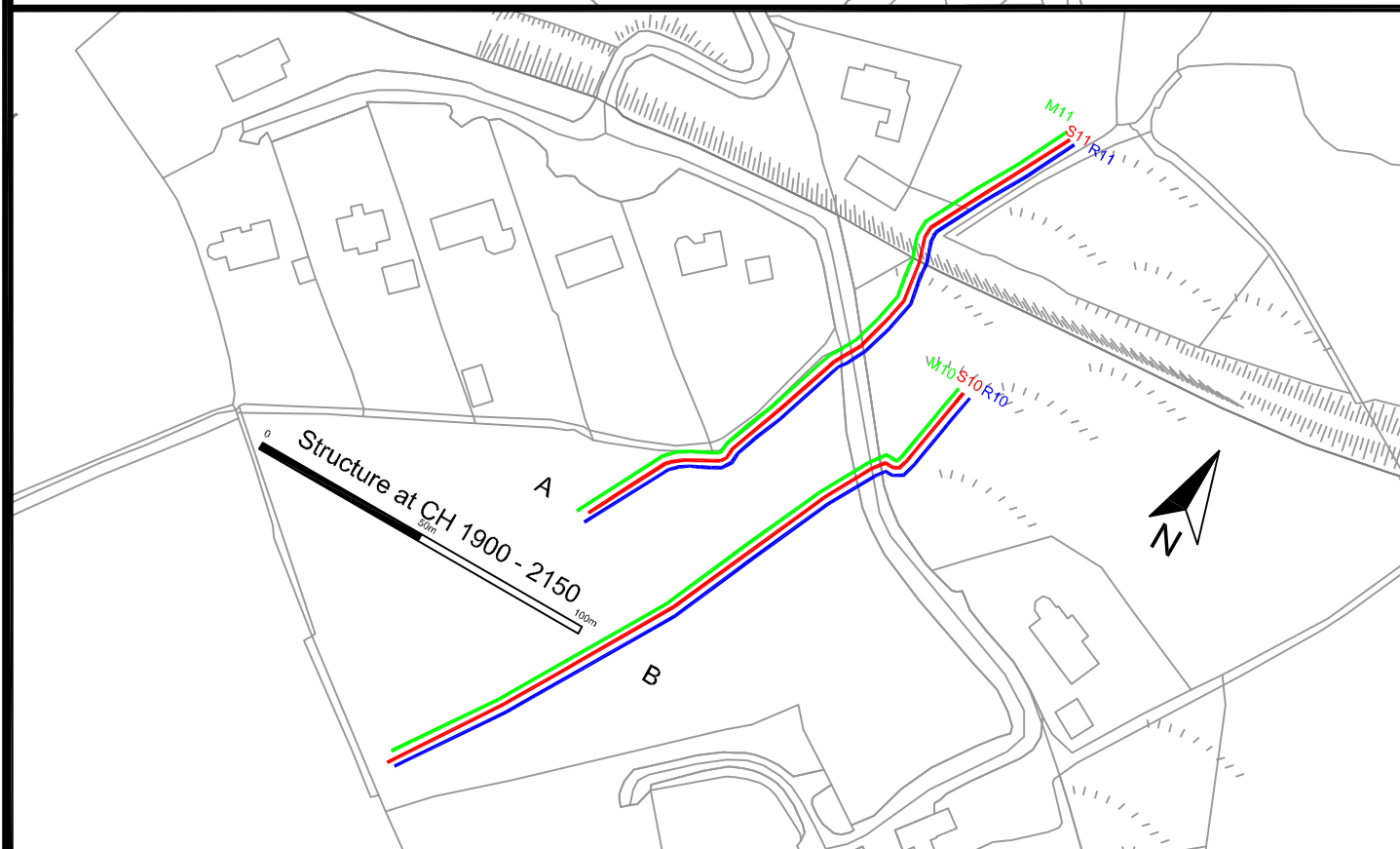
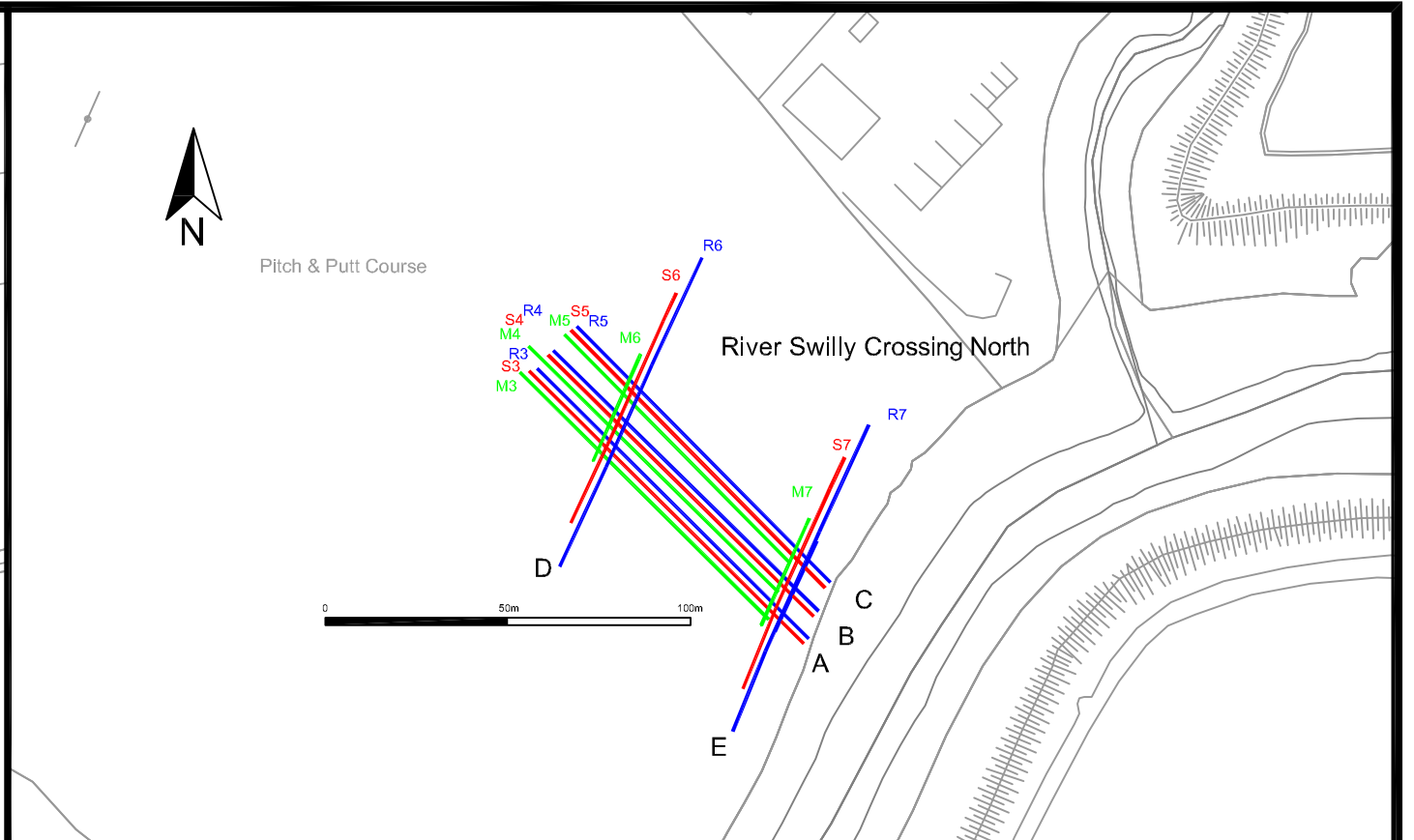
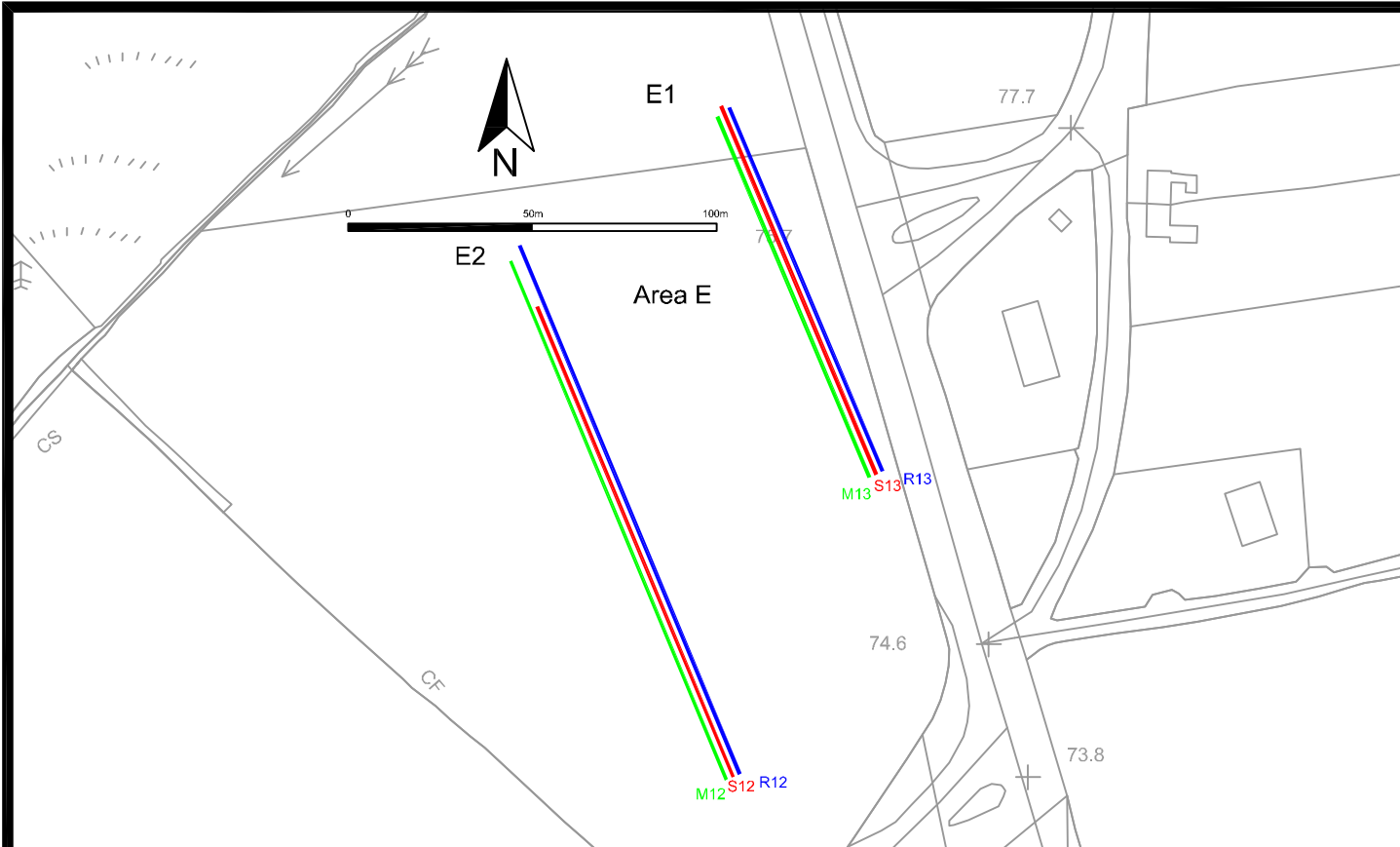
River Finn Crossing North	D	S18	3	69
Area C	C1	S19	3	105
Area C	C2	S20	3	99
Area D	D2	S21	3	63
Area D	D1	S22	3	81
			SUM	2037
MASW Survey				
Area	Line	Profile	Electrode Spacing (m)	Set out Length (m)
Area B	B2	M1	1	95
Area B	B1	M2	1	95
River Swilly Crossing North	A	M3	1	119
River Swilly Crossing North	B	M4	1	119
River Swilly Crossing North	C	M5	1	111
River Swilly Crossing North	D	M6	1	55
River Swilly Crossing North	E	M7	1	55
Area A	A1	M8	1	127
Area A	A2	M9	1	127
Structure at CH 1900 - 2150	B	M10	1	204
Structure at CH 1900 - 2150	A	M11	1	199
Area E	E2	M12	1	175
Area E	E1	M13	1	135
River Finn Crossing North	A	M14	1	79
River Finn Crossing North	B	M15	1	79
River Finn Crossing North	C	M16	1	71
River Finn Crossing North	E	M17	1	95
River Finn Crossing North	D	M18	1	95
Area C	C1	M19A	1	31
Area C	C1	M19B	1	95
Area C	C2	M20A	1	23
Area C	C2	M20B	1	95
Area D	D2	M21A	1	31
Area D	D2	M21B	1	47
Area D	D1	M22A	1	23
Area D	D1	M22B	1	63
				2443

Table 2: Structure Locations and Geological Background

Location Name	Subsoils	Bedrock	Outcrop (Rock < 2m bgl)	Faults
A	Till derived from metamorphic Rocks	Aghyaran & Killygordon Limestone Formation - Marble, quartzite, psammite; graphitic	Yes - East side of profiles	No
B	Till derived from metamorphic Rocks	Aghyaran & Killygordon Limestone Formation - Marble, quartzite, psammite; graphitic	No	No
C	Till derived from metamorphic Rocks and Alluvium close to stream	Aghyaran & Killygordon Limestone Formation - Marble, quartzite, psammite; graphitic	Yes	No
D	Till derived from metamorphic Rocks	Aghyaran & Killygordon Limestone Formation - Marble, quartzite, psammite; graphitic	No	No
E	East: Till derived from metamorphic Rocks West: Alluvium	Aghyaran & Killygordon Limestone Formation - Marble, quartzite, psammite; graphitic	230 m to East	No
River Swilly Crossing North	Urban, Alluvium near river	Termon Formation - Banded semi-pelitic & psammitic Schist	Yes	No
Structure at CH 1900 - 2150	Till derived from metamorphic Rocks	North: Killeter Quartzite Formation - Slightly Impure Quartzite South: Termon Formation - Banded semi-pelitic & psammitic Schist	200 m to North	No
River Finn Crossing North	Alluvium	Lough Eske Psammite Formation - Feldspathic psammite; quartzite, marble	No	No
All Information is from the Geological Survey of Ireland Database and Maps (GSI 2020)				



<p>Unit F4, Maynooth Business Campus Maynooth, Co. Kildare Tel. (01) 6510030 Email: info@mgx.ie Web: www.mgx.ie</p>	CLIENT	Irish Drilling Ltd.	SCALE:	1:1000 @ A3	LEGEND: Geophysical Survey Locations: R2 2D-Resistivity Profile S1 Seismic Refraction Profile M3 MASW Profile
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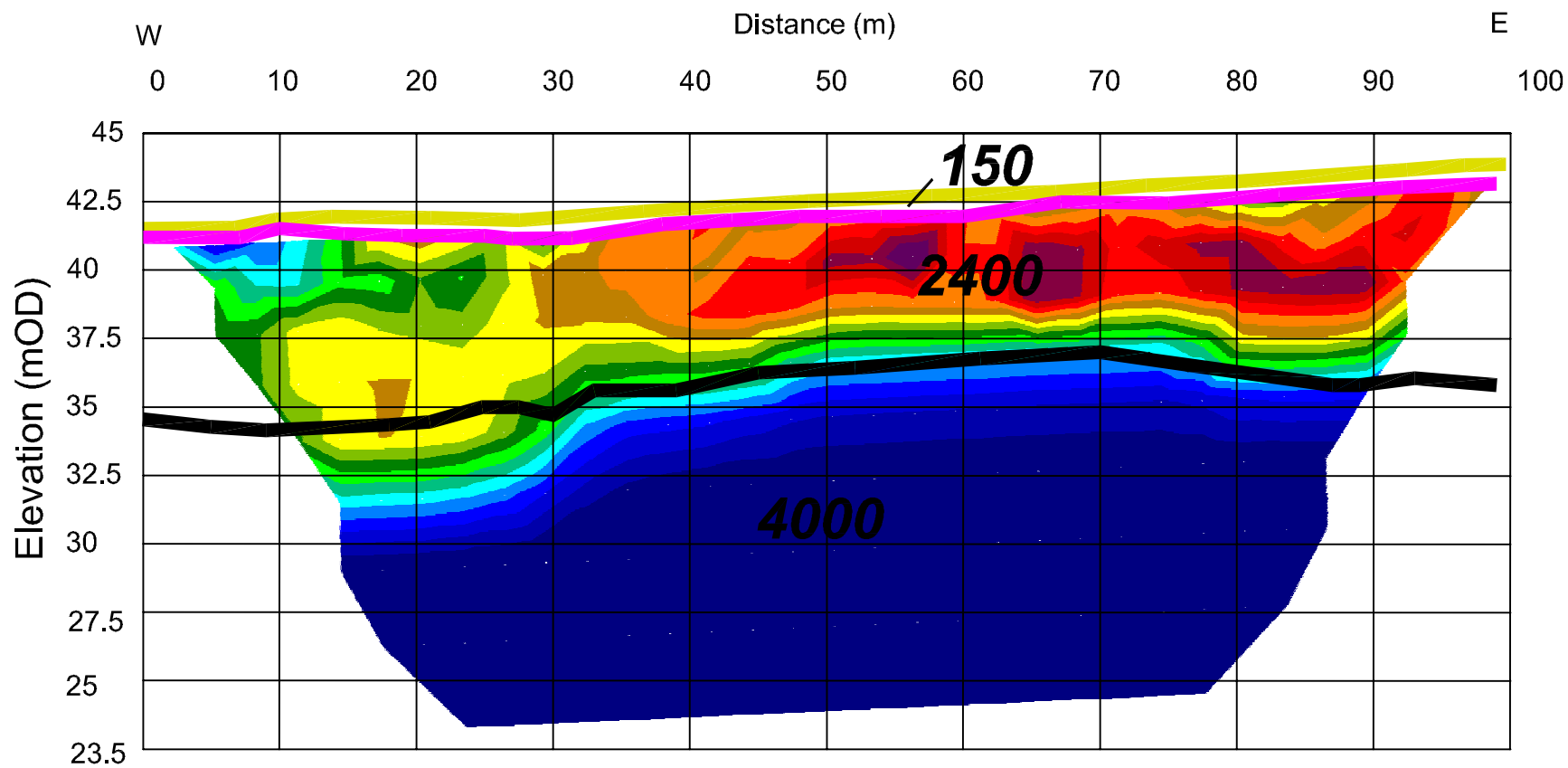
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PROJECT Ten-T Co. Donegal Geophysical Survey
TITLE Map 1b: Geophysical Surevy Location Map

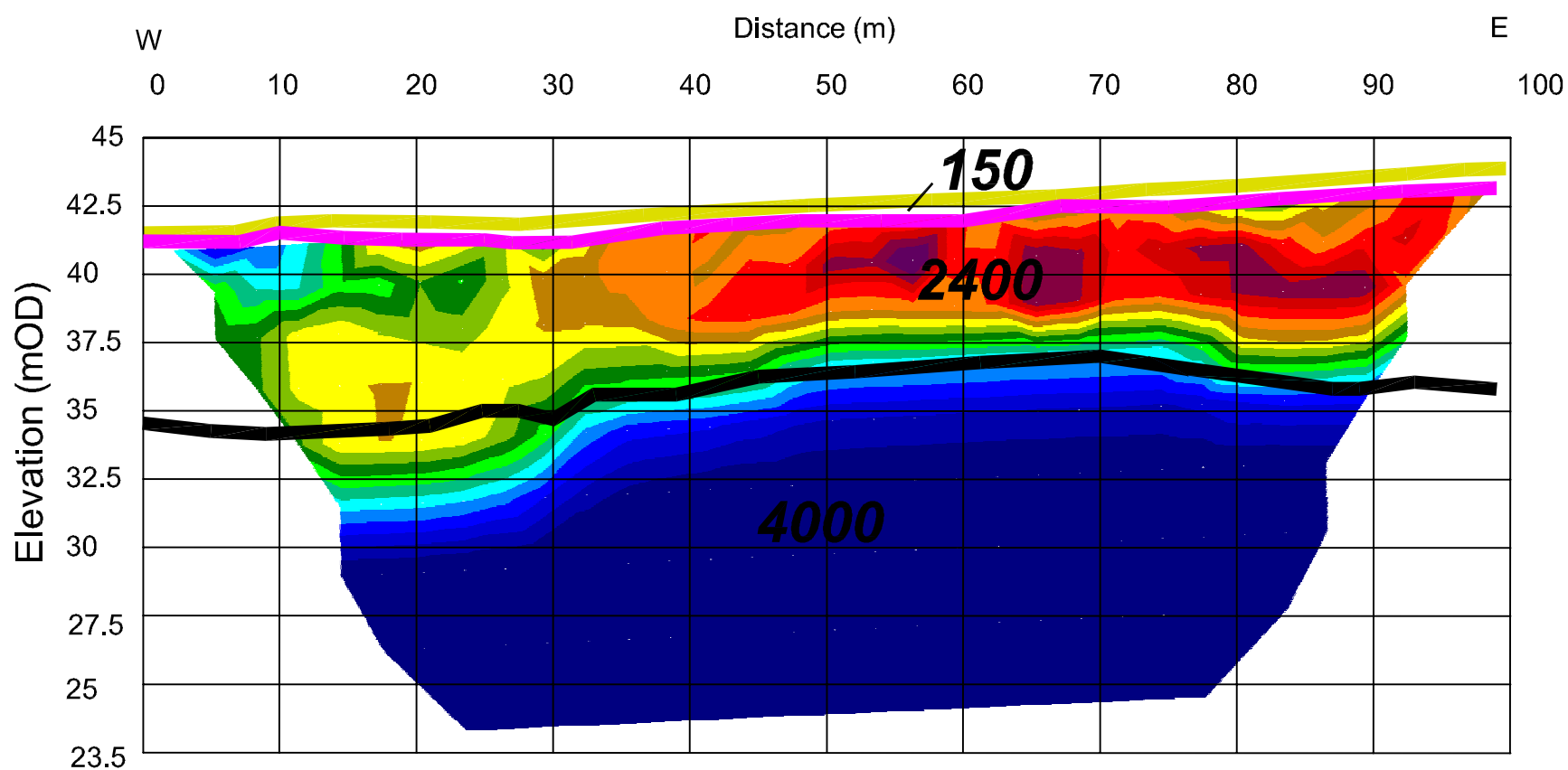
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— R2 2D-Resistivity Profile
— S1 Seismic Refraction Profile
— M3 MASW Profile

2D-Resistivity Profile R8 and Seismic Refraction Profile S8 Model



2D-Resistivity Profile R8 and Seismic Refraction Profile S8 Model



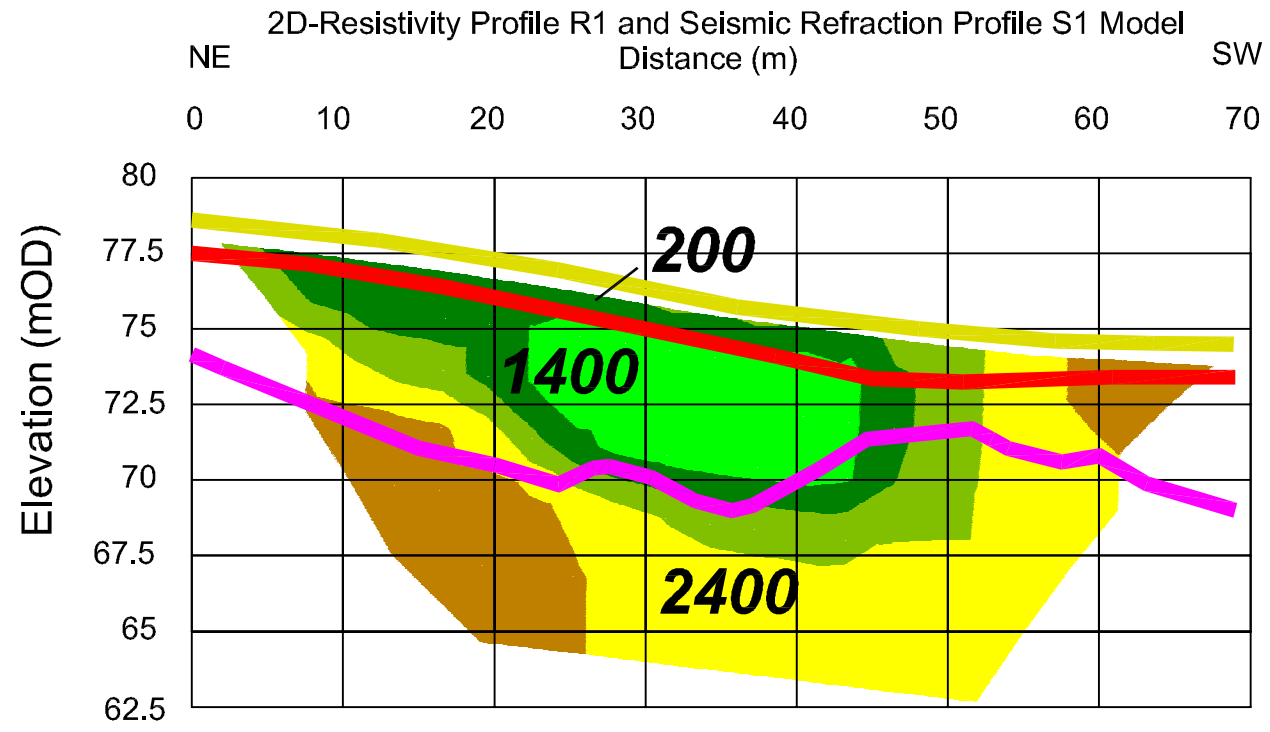
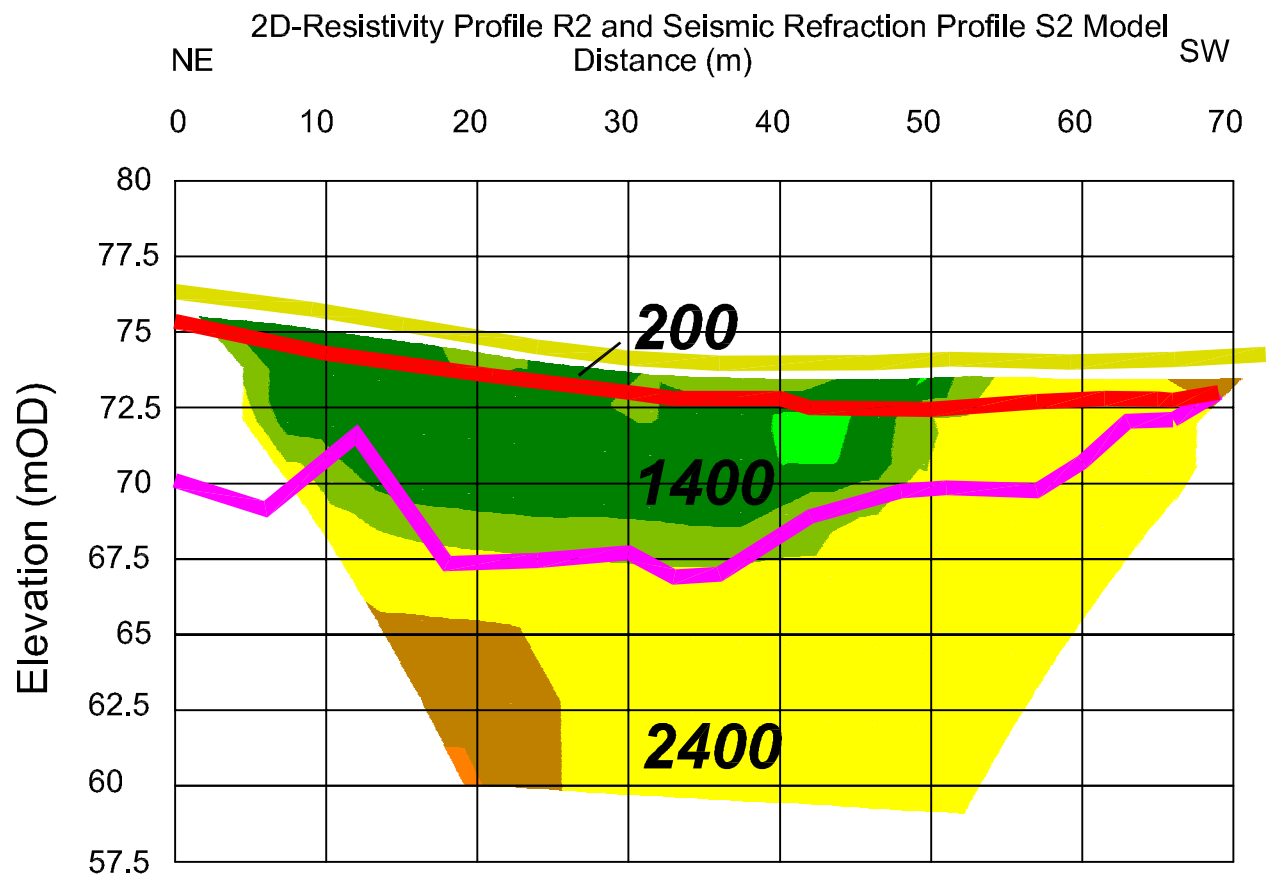
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Email: info@mgx.ie
Web: www.mgx.ie

CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
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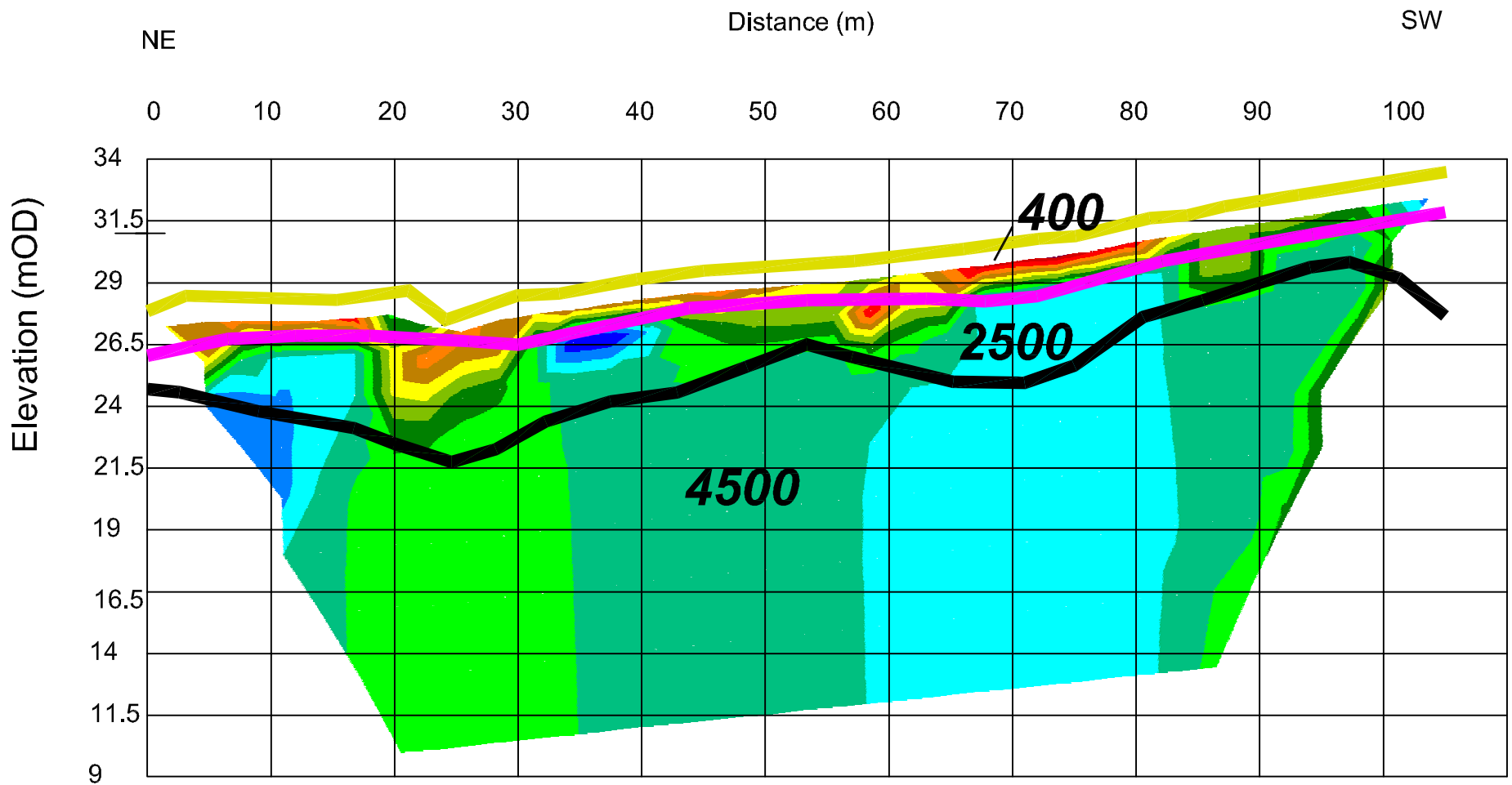
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LEGEND: Layers from Seismic Refraction Model:
 — Ground Surface/Top of Layer 1 (100 - 300 m/s)
 — Top of Layer 2 (800 - 1600 m/s)
 — Top of Layer 3 (1800 - 2600 m/s)
 — Top of Layer 4 (3000 - 4500 m/s)

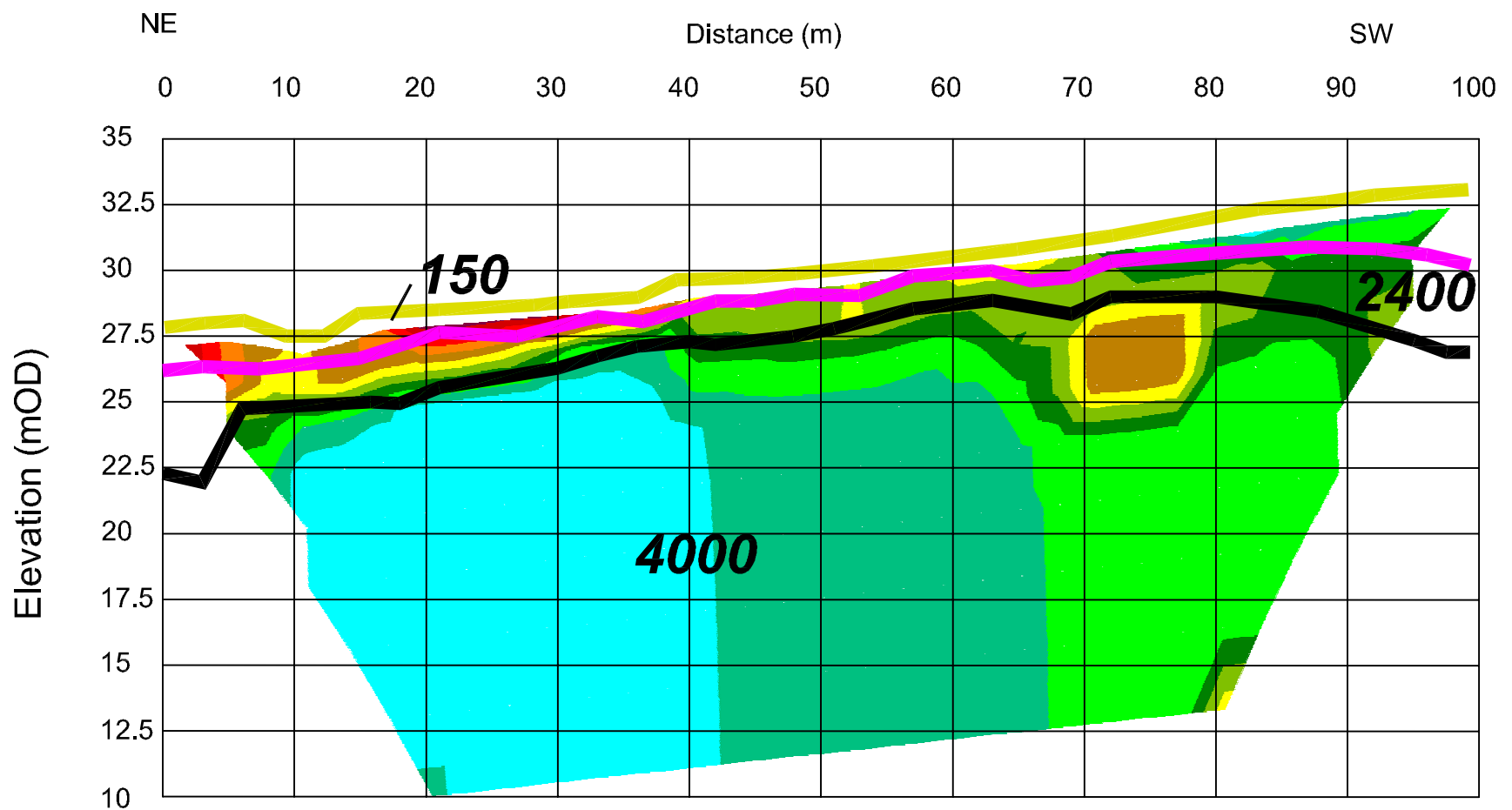
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2D-Resistivity Profile R20 and Seismic Refraction Profile S20 Model

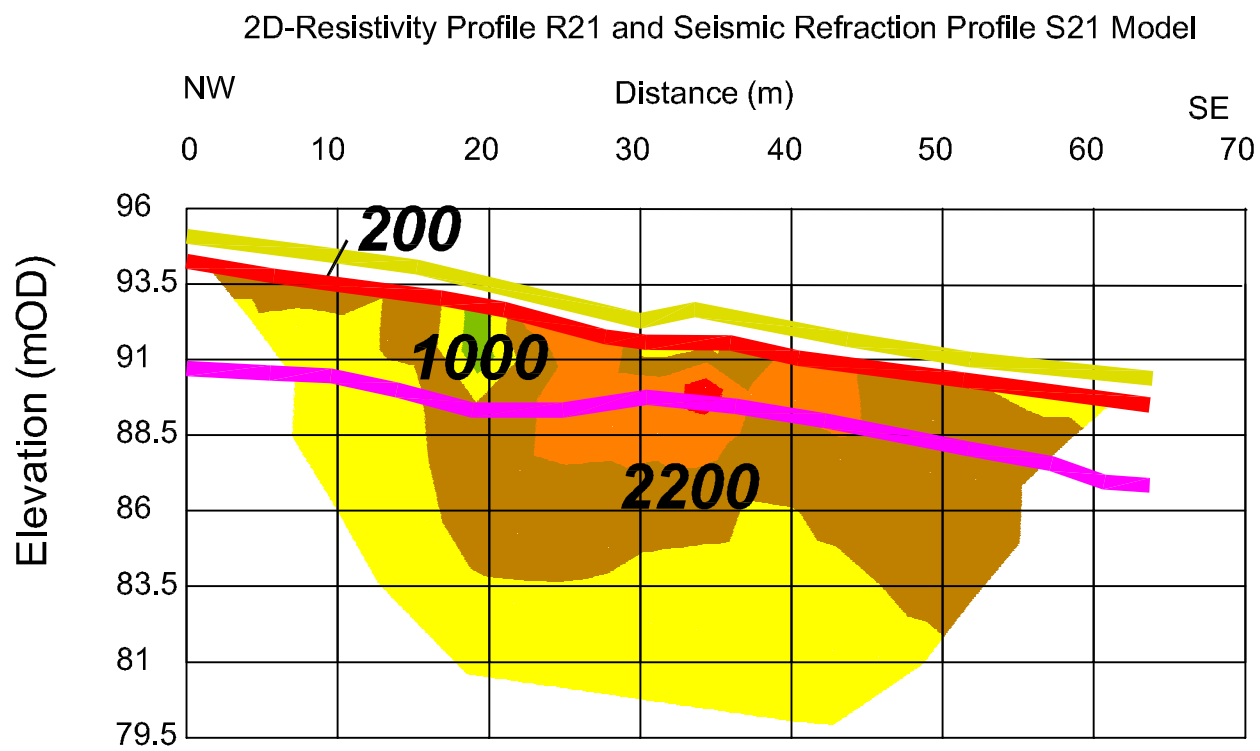
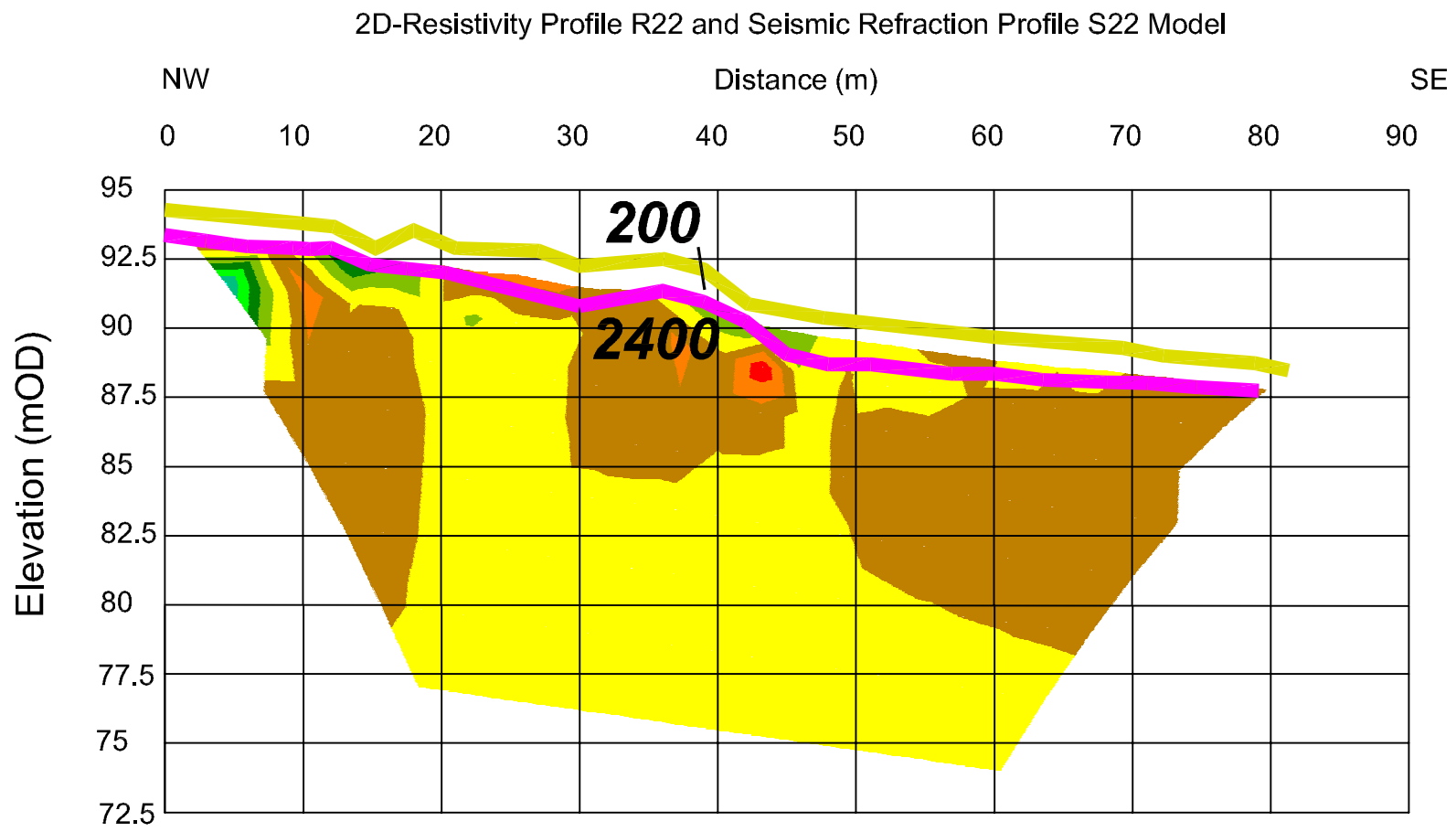


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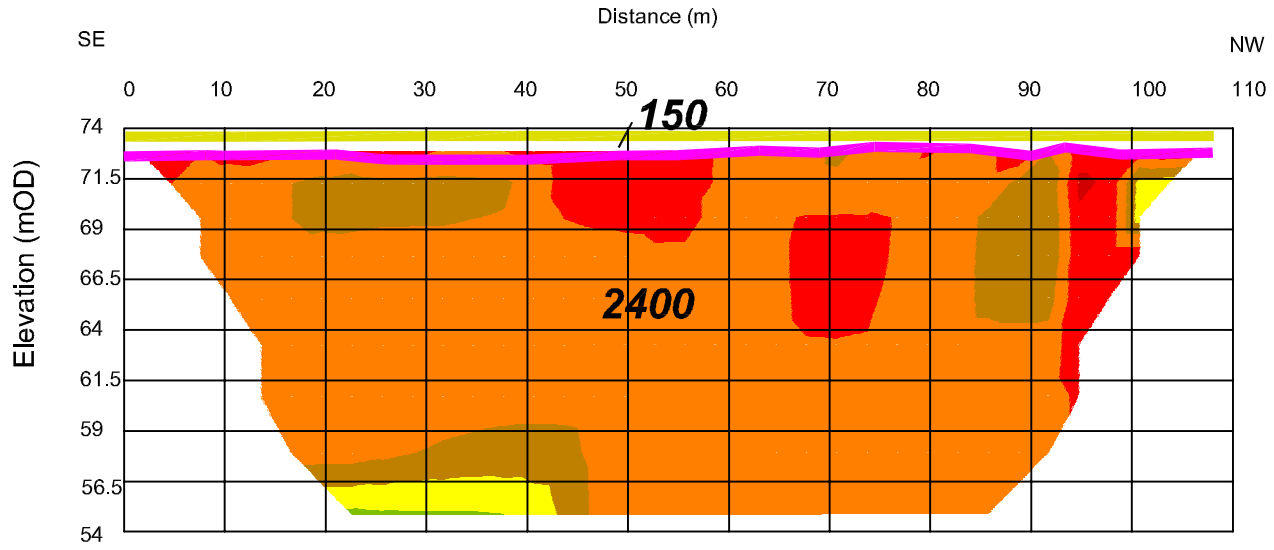
CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 1c: Models of
Geophysical Survey for Area C

SCALE: 1:500 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

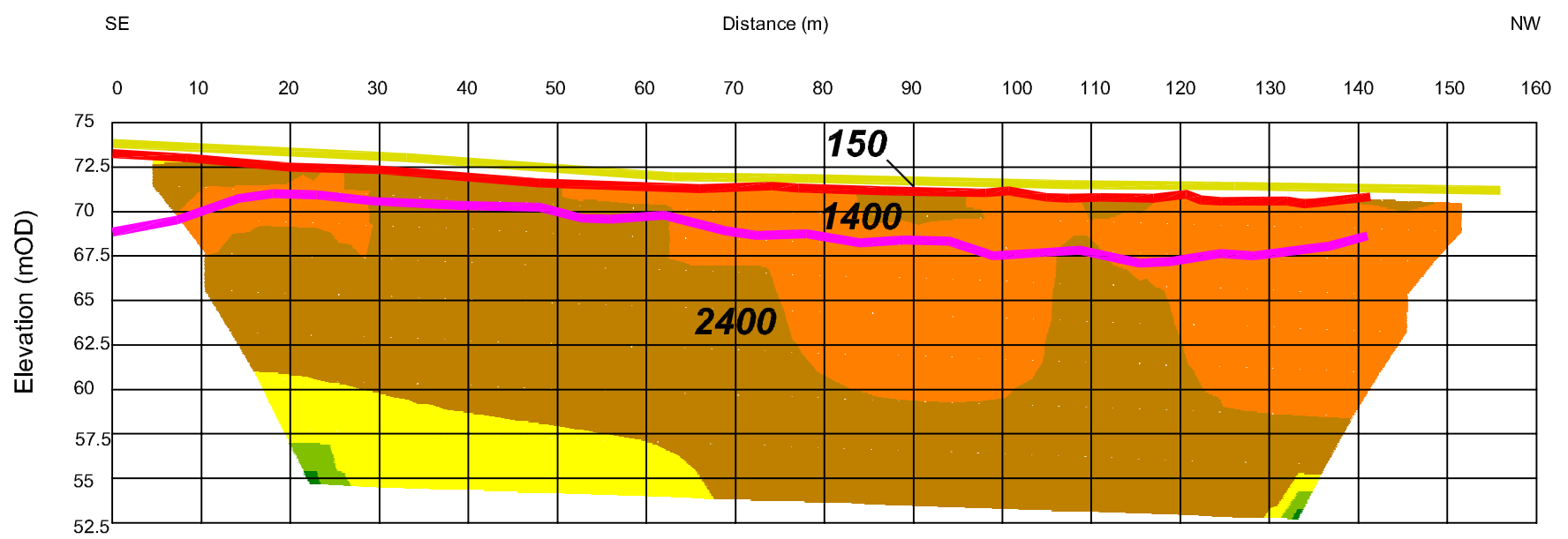
LEGEND: Layers from Seismic Refraction Model:
 — Ground Surface/Top of Layer 1 (100 - 300 m/s)
 — Top of Layer 2 (800 - 1600 m/s)
 — Top of Layer 3 (1800 - 2600 m/s)
 — Top of Layer 4 (3000 - 4500 m/s)
 2D-Resistivity Model Values:
 Resistivities (Ohmm) for 2D-Resistivity Model
 31.3 62.5 125 250 500 1000 2000 4000

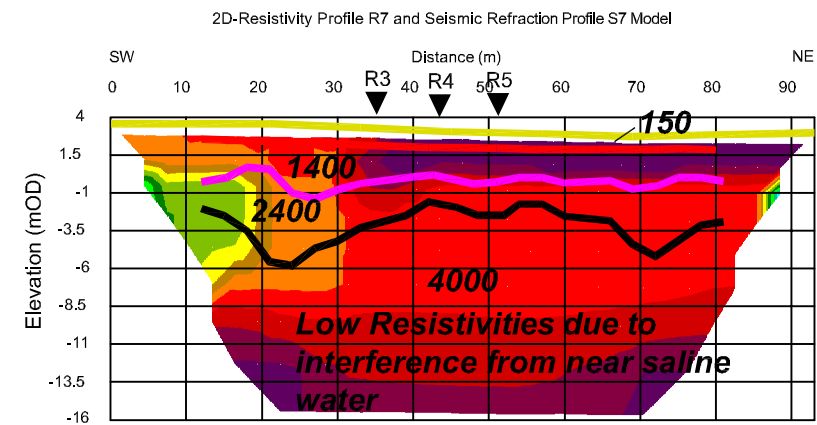
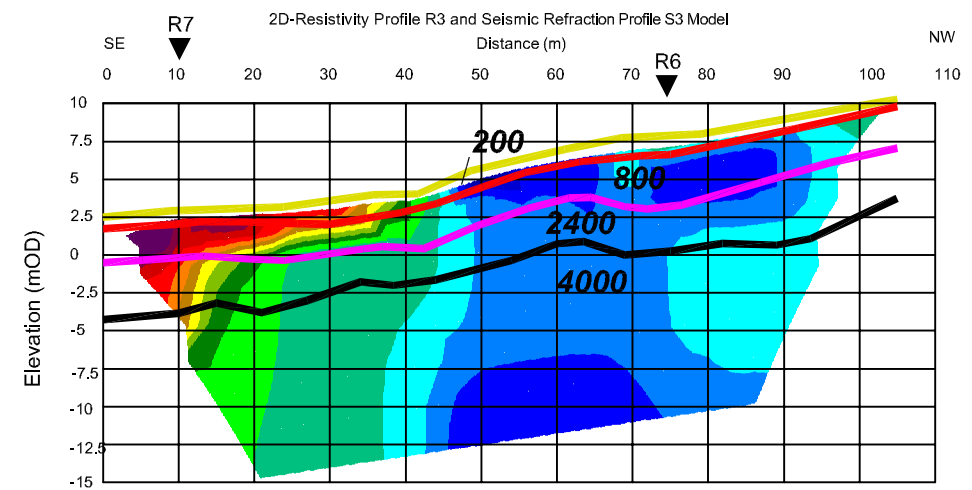
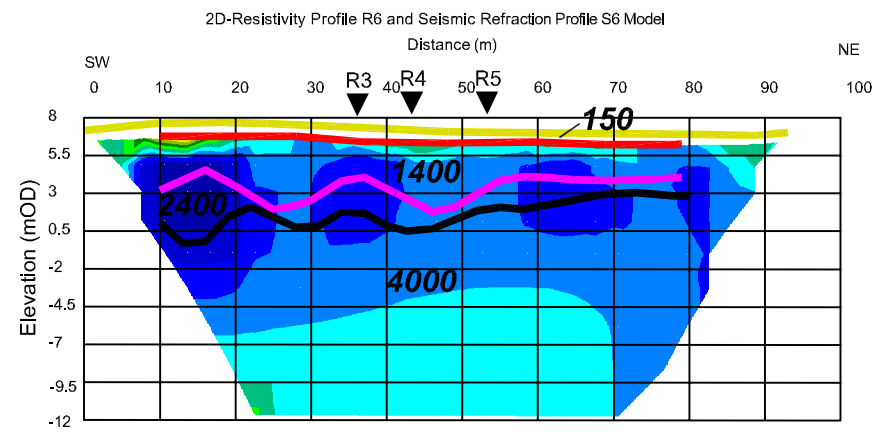
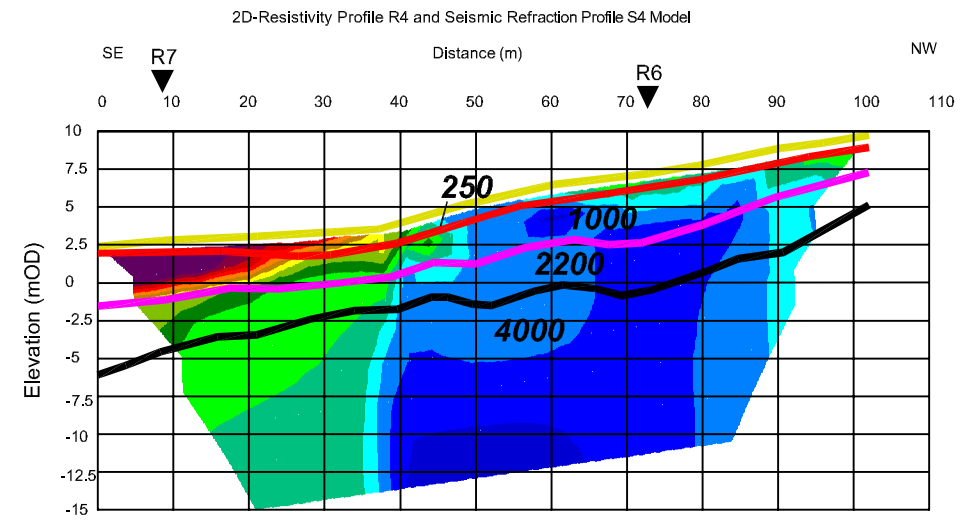
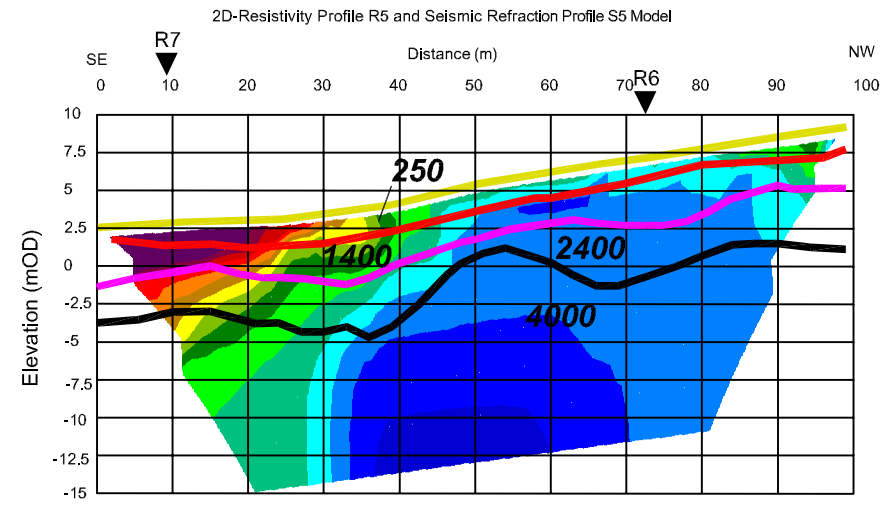


2D-Resistivity Profile R13 and Seismic Refraction Profile S13 Model



2D-Resistivity Profile R12 and Seismic Refraction Profile S12 Model





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CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 1f: Models of Geophysical
Survey for River Swilly Crossing N

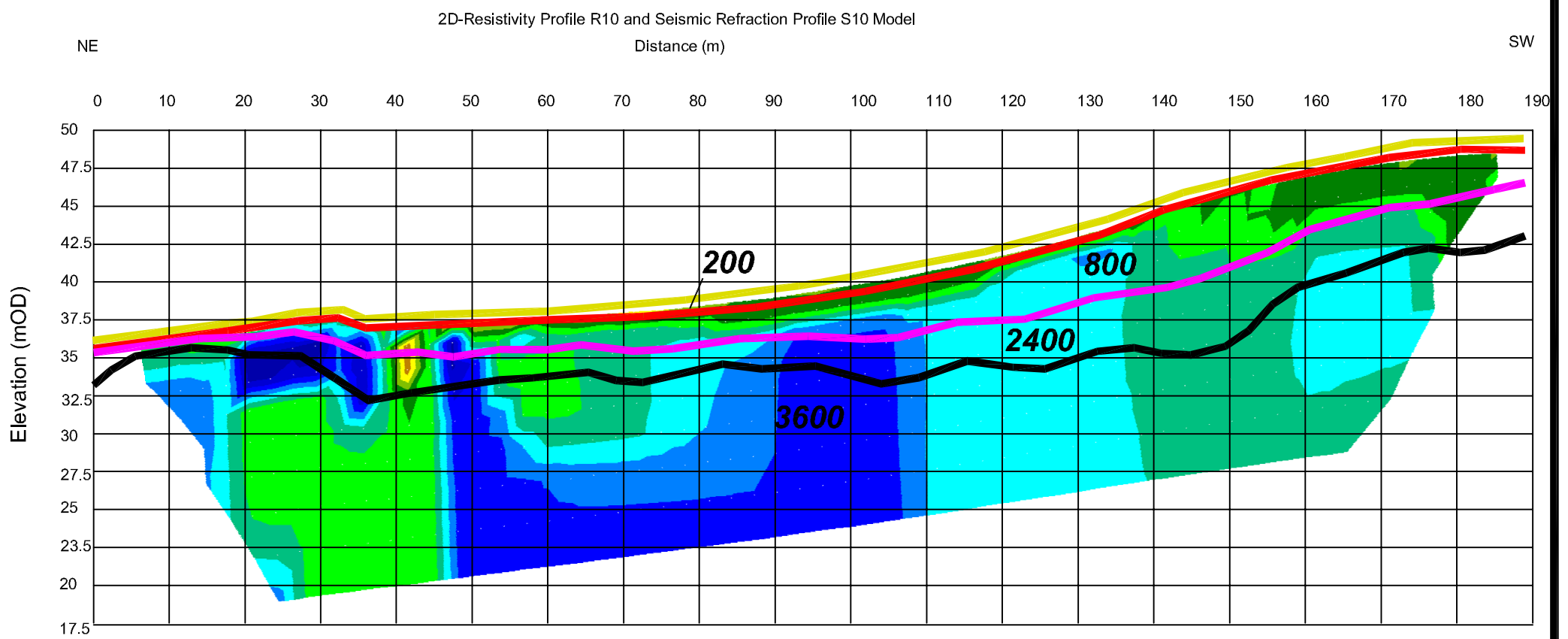
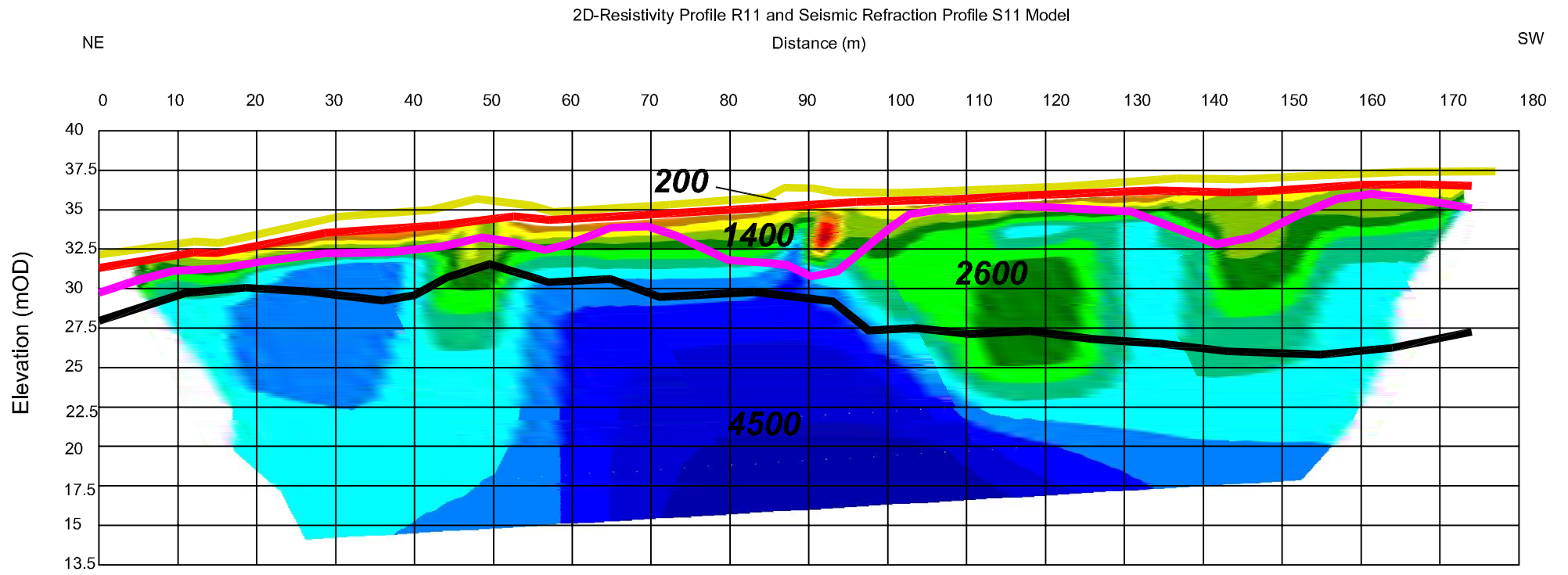
SCALE: 1:1000 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

LEGEND: Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (100 - 300 m/s)
- Top of Layer 2 (800 - 1600 m/s)
- Top of Layer 3 (1800 - 2600 m/s)
- Top of Layer 4 (3000 - 4500 m/s)

2D-Resistivity Model Values:
Resistivities (Ohmm) for 2D-Resistivity Model

- 31.3
- 62.5
- 125
- 250
- 500
- 1000
- 2000
- 4000



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PROJECT TEN-T, County Donegal
Geophysical Survey

TITLE Figure 1g: Models of Geophysical
Survey for CH 1+900 - 2+150

SCALE: 1:750 @ A3, VE x 2

PROJECT: 6526

DRAWN: JC

DATE: 27/10/2020

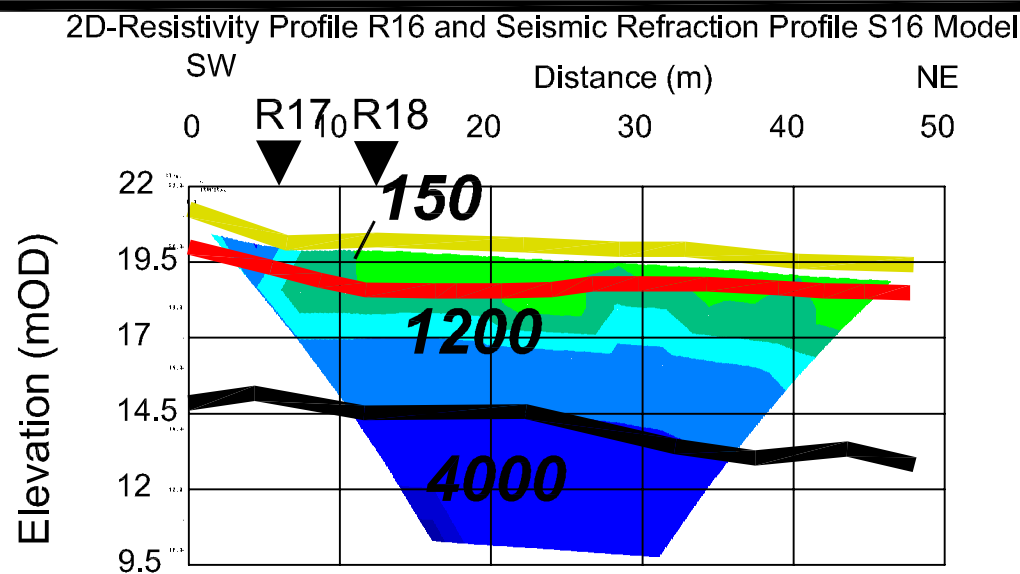
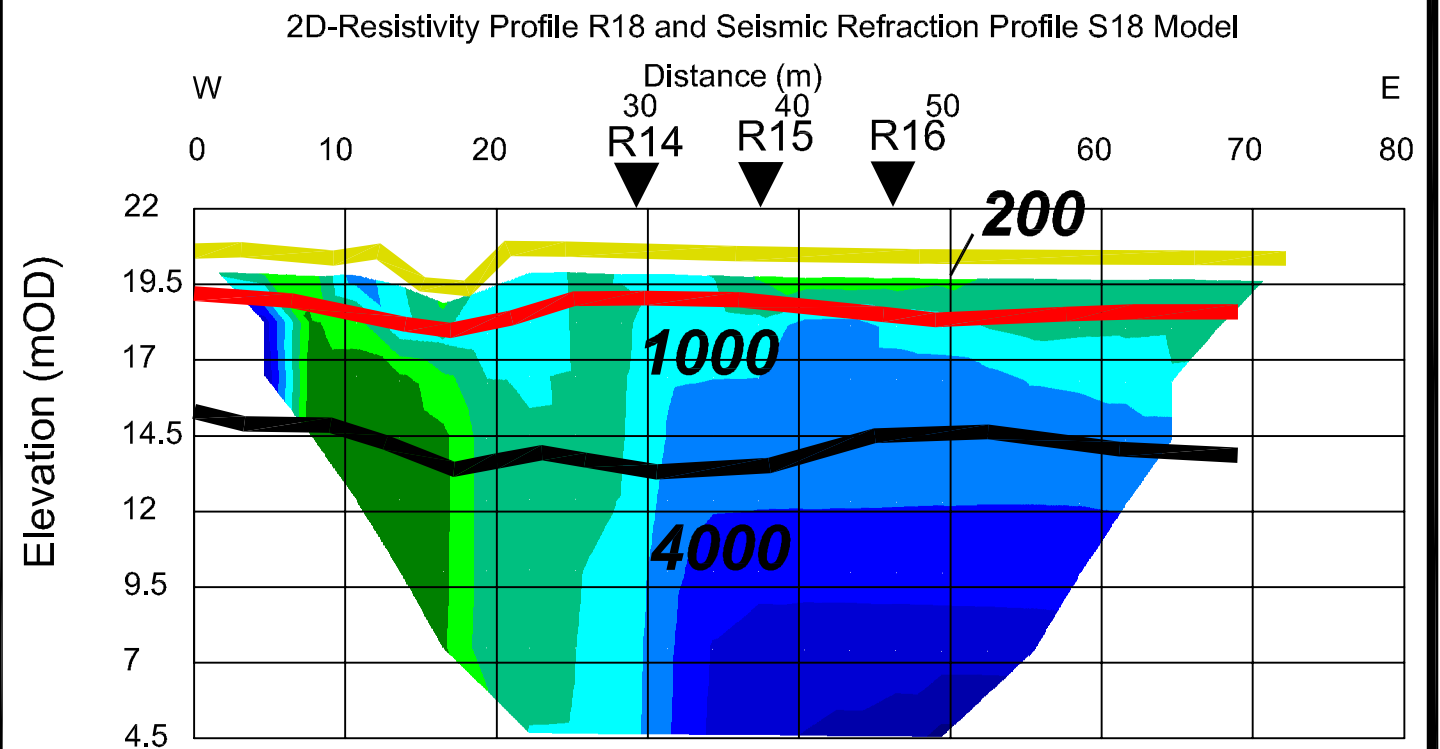
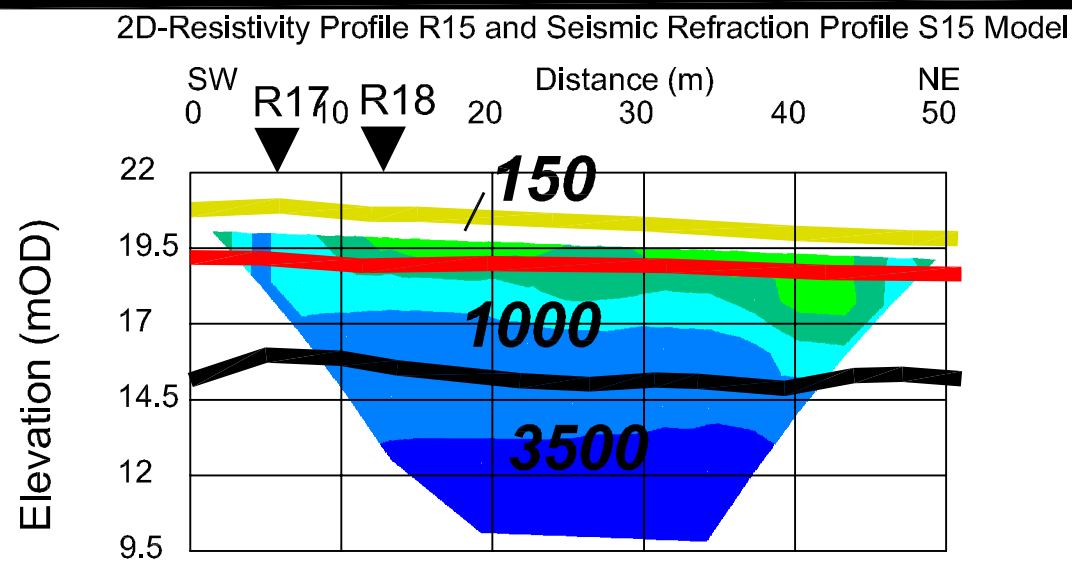
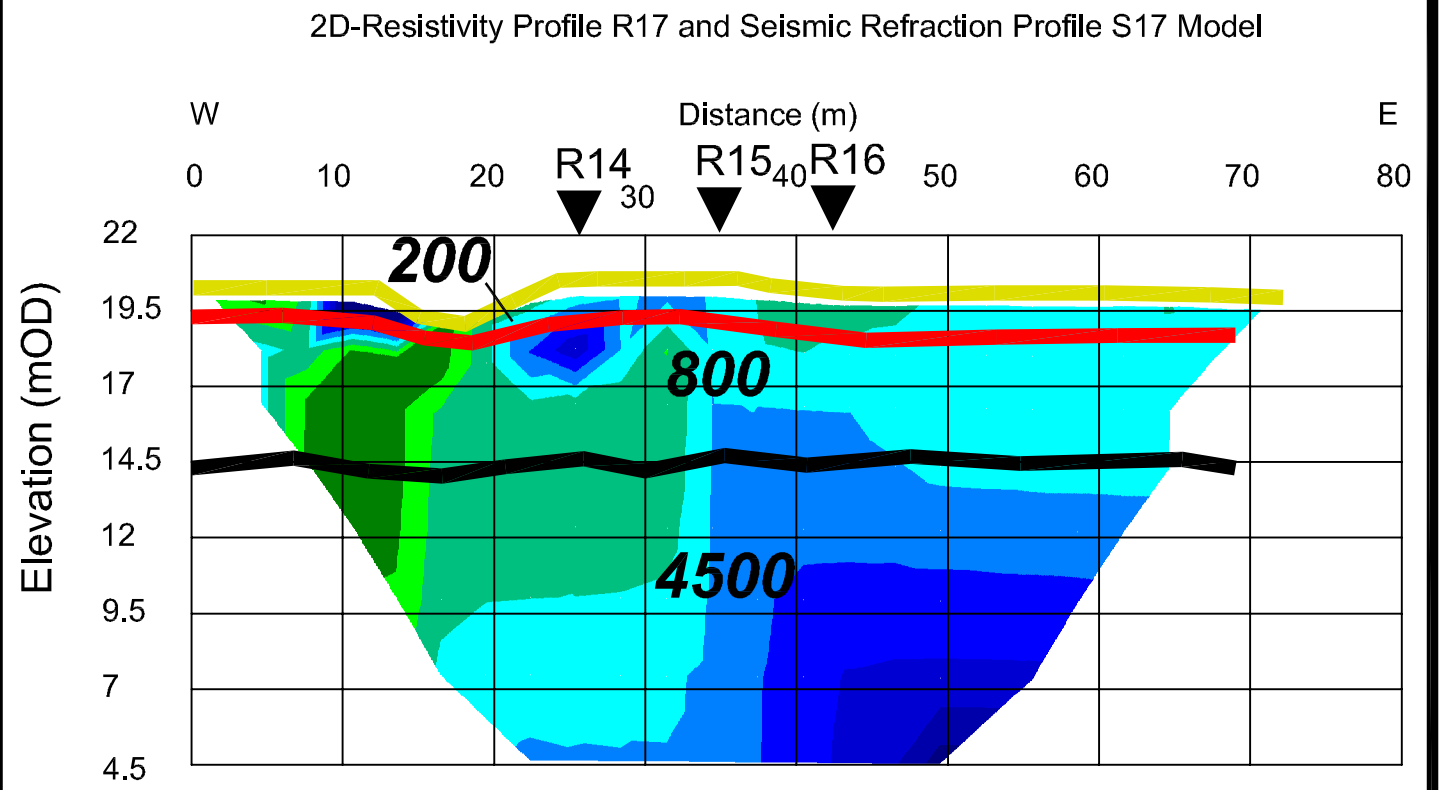
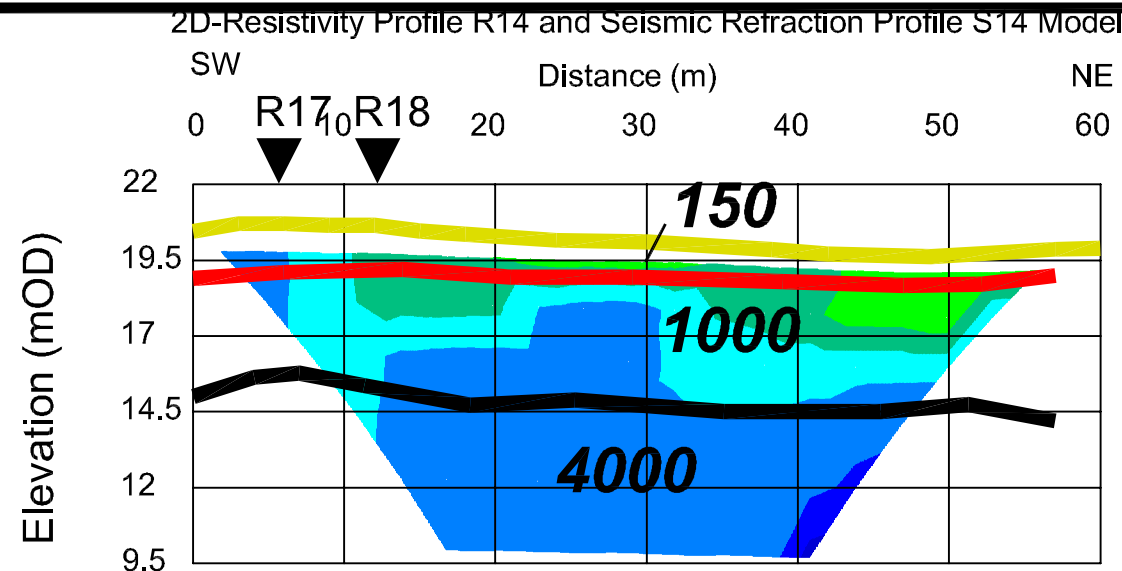
MGX FILE: 6526d_MapsFigs.dwg

STATUS: Draft

LEGEND: Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (100 - 300 m/s)
- Top of Layer 2 (800 - 1600 m/s)
- Top of Layer 3 (1800 - 2600 m/s)
- Top of Layer 4 (3000 - 4500 m/s)

2D-Resistivity Model Values:
Resistivities (Ohmm) for 2D-Resistivity Model



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PROJECT TEN-T, County Donegal
Geophysical Survey

TITLE Figure 1h: Models of Geophysical
Survey for River Finn Crossing N

SCALE: 1:500 @ A3, VE x 2

PROJECT: 6526

DRAWN: JC

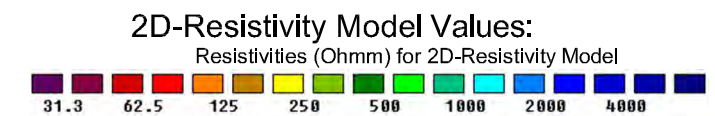
DATE: 27/10/2020

MGX FILE: 6526d_MapsFigs.dwg

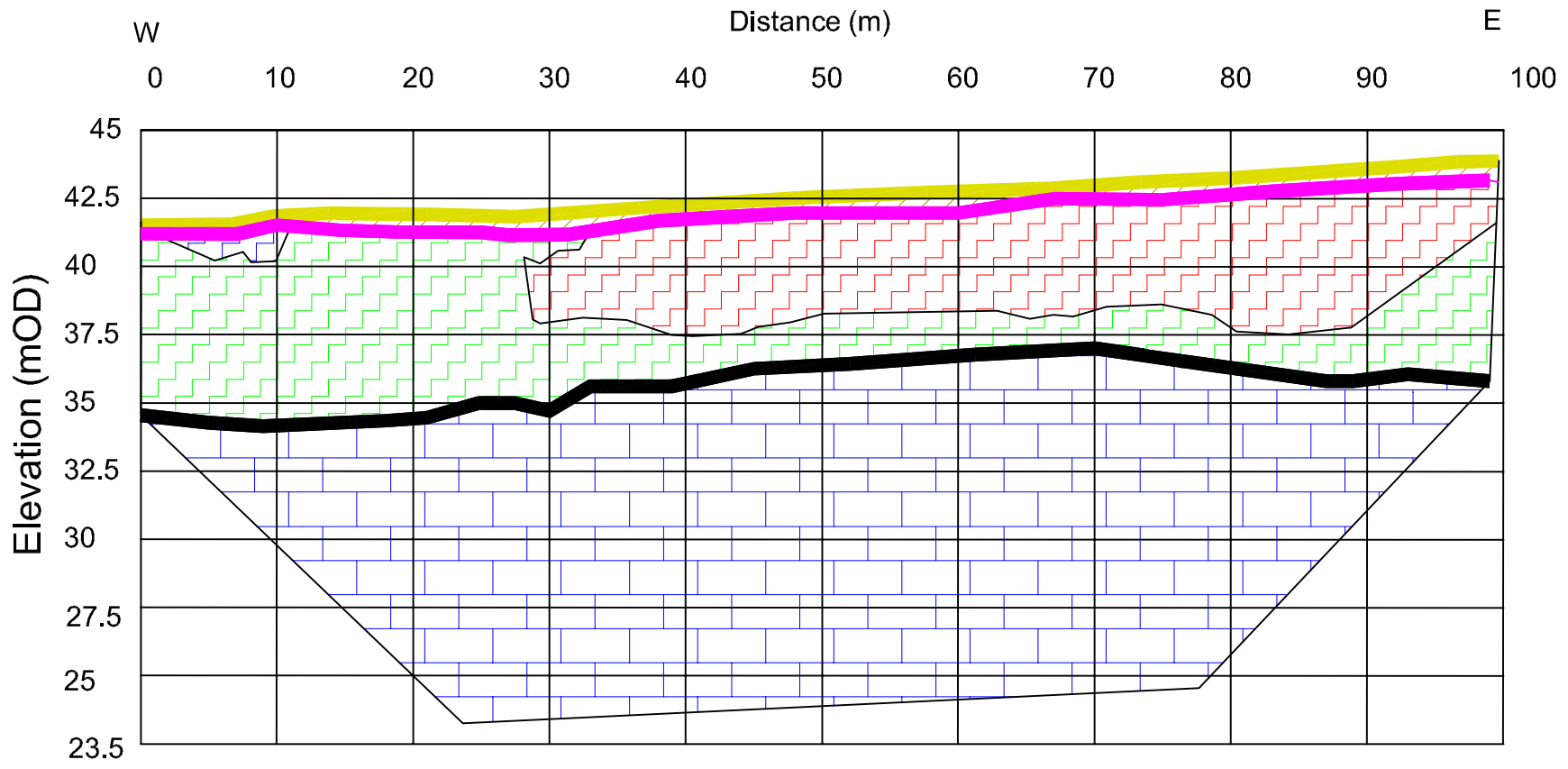
STATUS: Draft

LEGEND: Layers from Seismic Refraction Model:

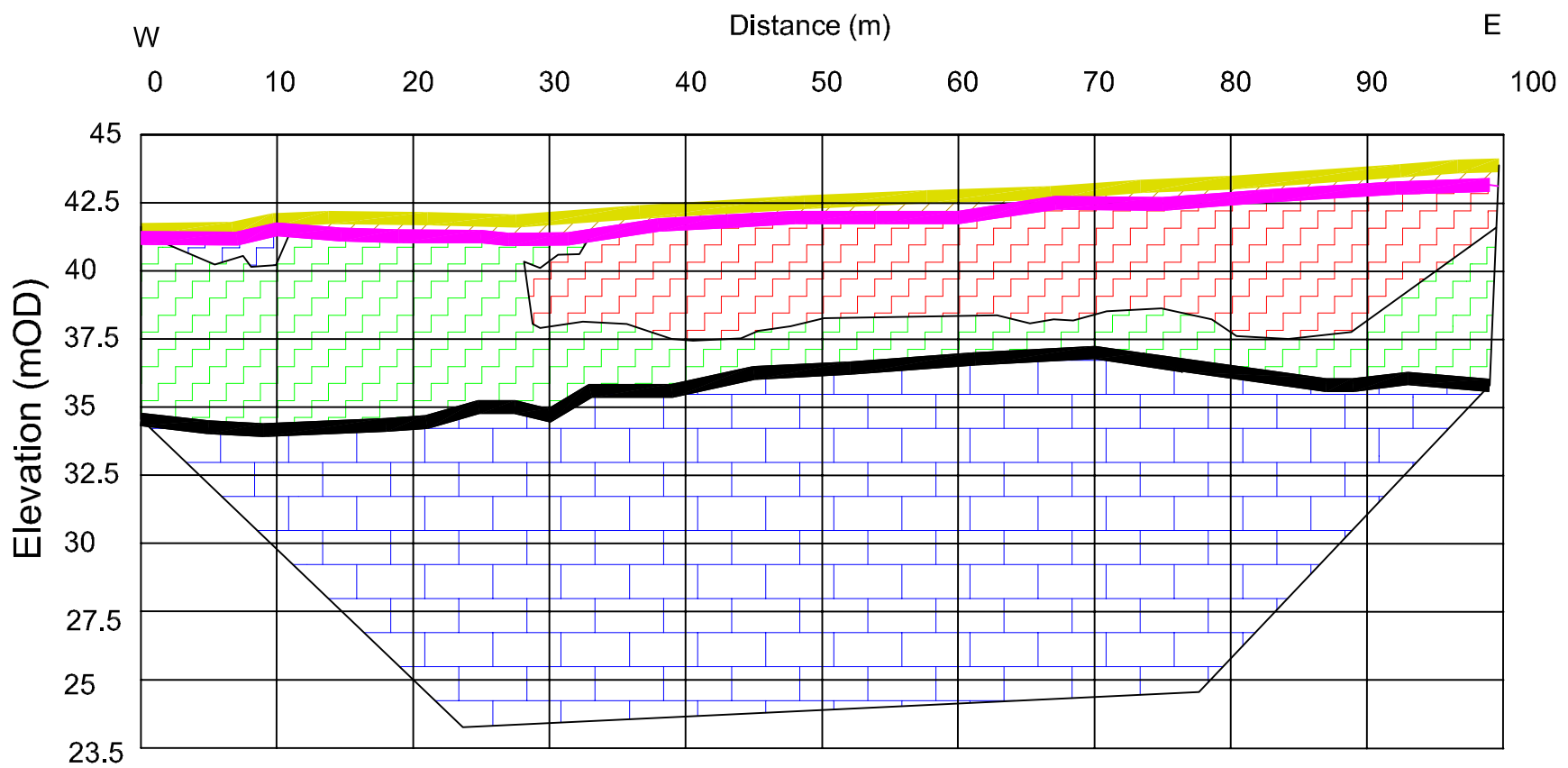
- Ground Surface/Top of Layer 1 (100 - 300 m/s)
- Top of Layer 2 (800 - 1600 m/s)
- Top of Layer 3 (1800 - 2600 m/s)
- Top of Layer 4 (3000 - 4500 m/s)












2D-Resistivity Profile R8 and Seismic Refraction Profile S8 Interpretation



2D-Resistivity Profile R8 and Seismic Refraction Profile S8 Interpretation



Interpretation: Resistivity and Seismic Area

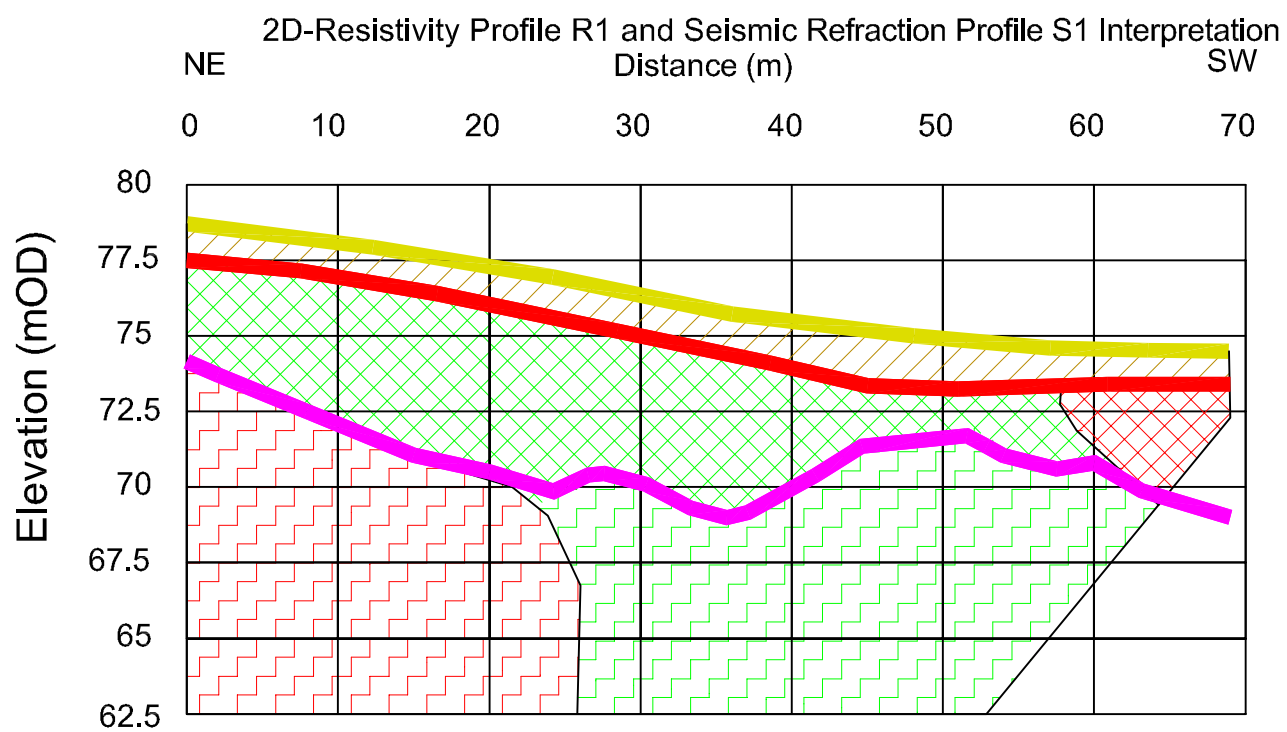
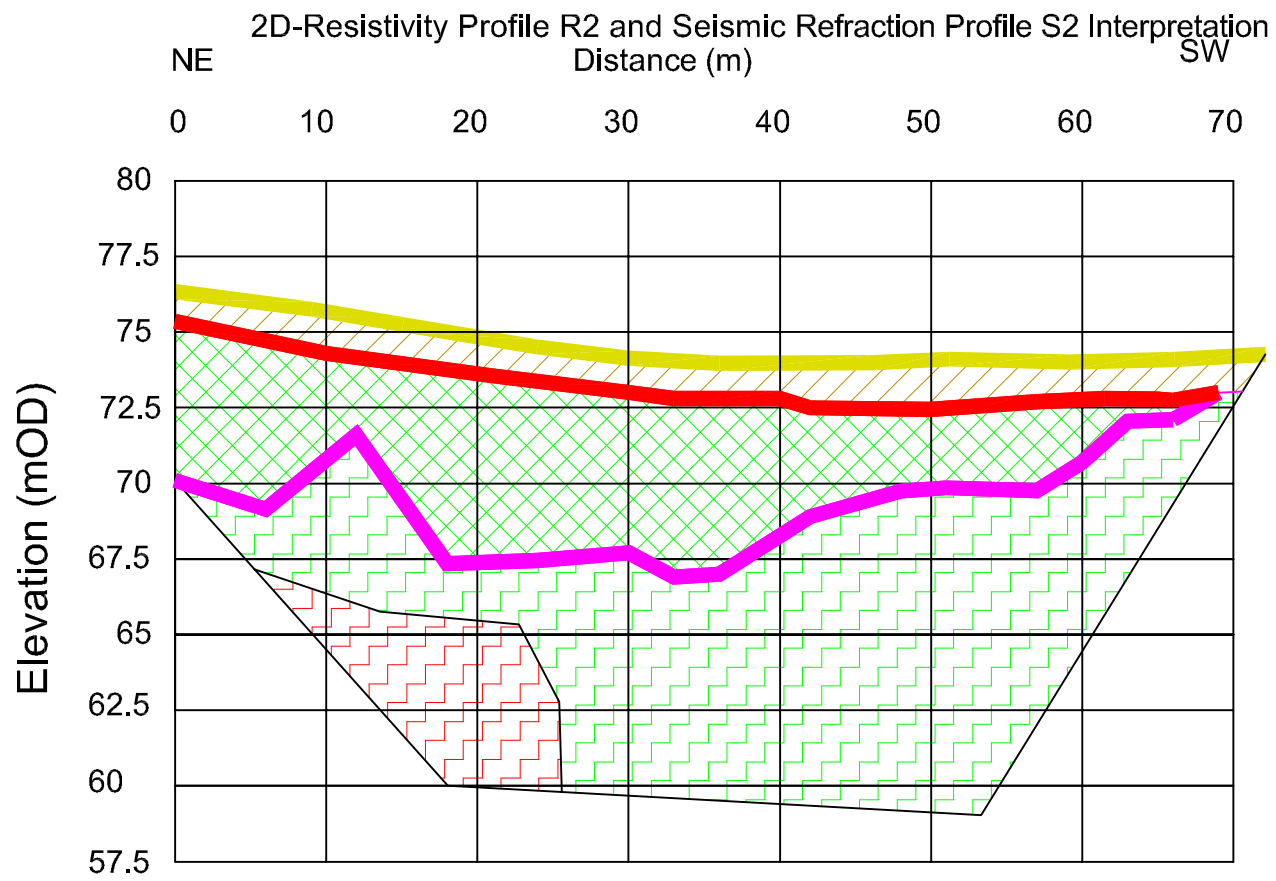
- | | | | | | |
|---|--|---|---|---|--|
|  | 1 Soft or loose Topsoil, Soil or Made Ground |  | 3a Very Stiff to Hard Clay or Silt Overburden |  | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
|  | 2a Firm to Stiff Clay or Silt Overburden |  | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden |  | 4c Good to Very Good Fresh Metamorphic Rock |
|  | 2b Firm to Stiff Gravelly Clay Overburden |  | 3c Poor to Fair Weathered Metamorphic Rock | | |
|  | 2c Medium Dense to Dense Sand or Gravel Overburden | | | | |

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CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 2a: Interpretation of
Geophysical Survey for Area A

SCALE: 1:500 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

LEGEND:



Interpretation: Resistivity and Seismic Area

- | | | |
|--|---|--|
| 1 Soft or loose Topsoil, Soil or Made Ground | 3a Very Stiff to Hard Clay or Silt Overburden | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
| 2a Firm to Stiff Clay or Silt Overburden | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden | 4c Good to Very Good Fresh Metamorphic Rock |
| 2b Firm to Stiff Gravelly Clay Overburden | 3c Poor to Fair Weathered Metamorphic Rock | |
| 2c Medium Dense to Dense Sand or Gravel Overburden | | |

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PROJECT TEN-T, County Donegal
Geophysical Survey

TITLE Figure 2b: Interpretation of
Geophysical Survey for Area B

SCALE: 1:500 @ A3, VE x 2

PROJECT: 6526

DRAWN: JC

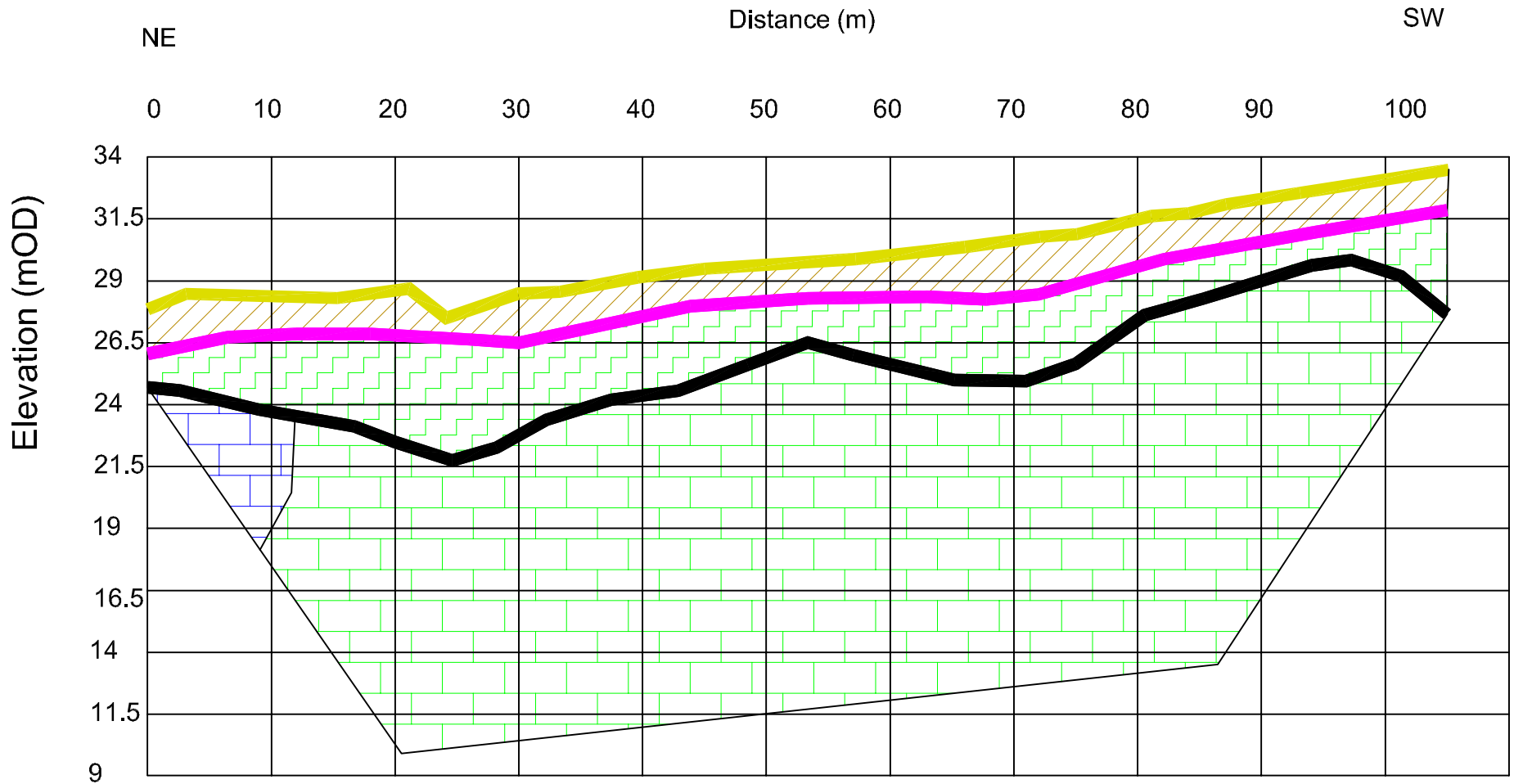
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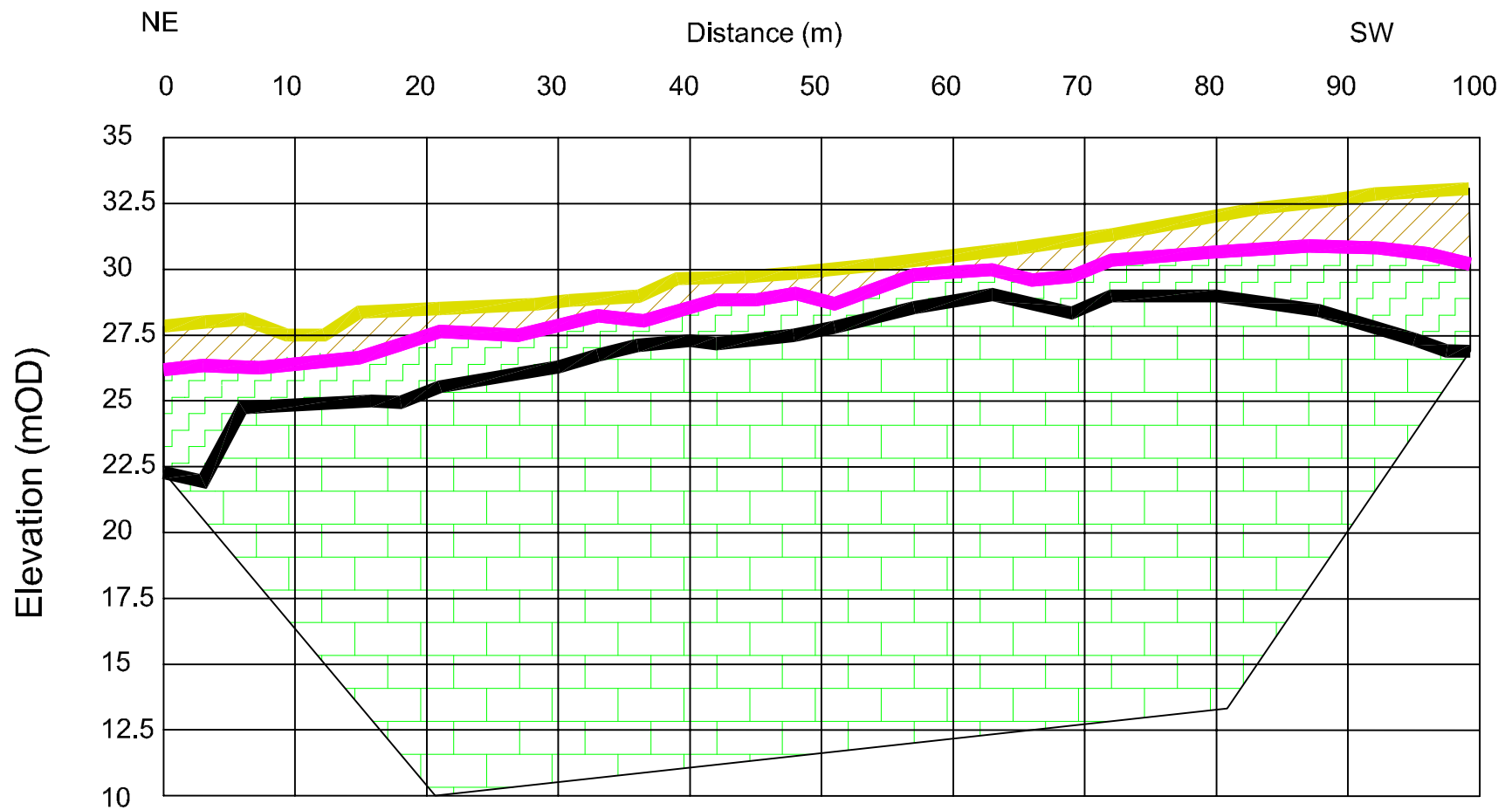
STATUS: Draft

LEGEND:










2D-Resistivity Profile R19 and Seismic Refraction Profile S19 Interpretation



2D-Resistivity Profile R20 and Seismic Refraction Profile S20 Interpretation



Interpretation: Resistivity and Seismic Area

- | | | | | | |
|---|--|---|---|---|--|
|  | 1 Soft or loose Topsoil, Soil or Made Ground |  | 3a Very Stiff to Hard Clay or Silt Overburden |  | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
|  | 2a Firm to Stiff Clay or Silt Overburden |  | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden |  | 4c Good to Very Good Fresh Metamorphic Rock |
|  | 2b Firm to Stiff Gravelly Clay Overburden |  | 3c Poor to Fair Weathered Metamorphic Rock | | |
|  | 2c Medium Dense to Dense Sand or Gravel Overburden | | | | |

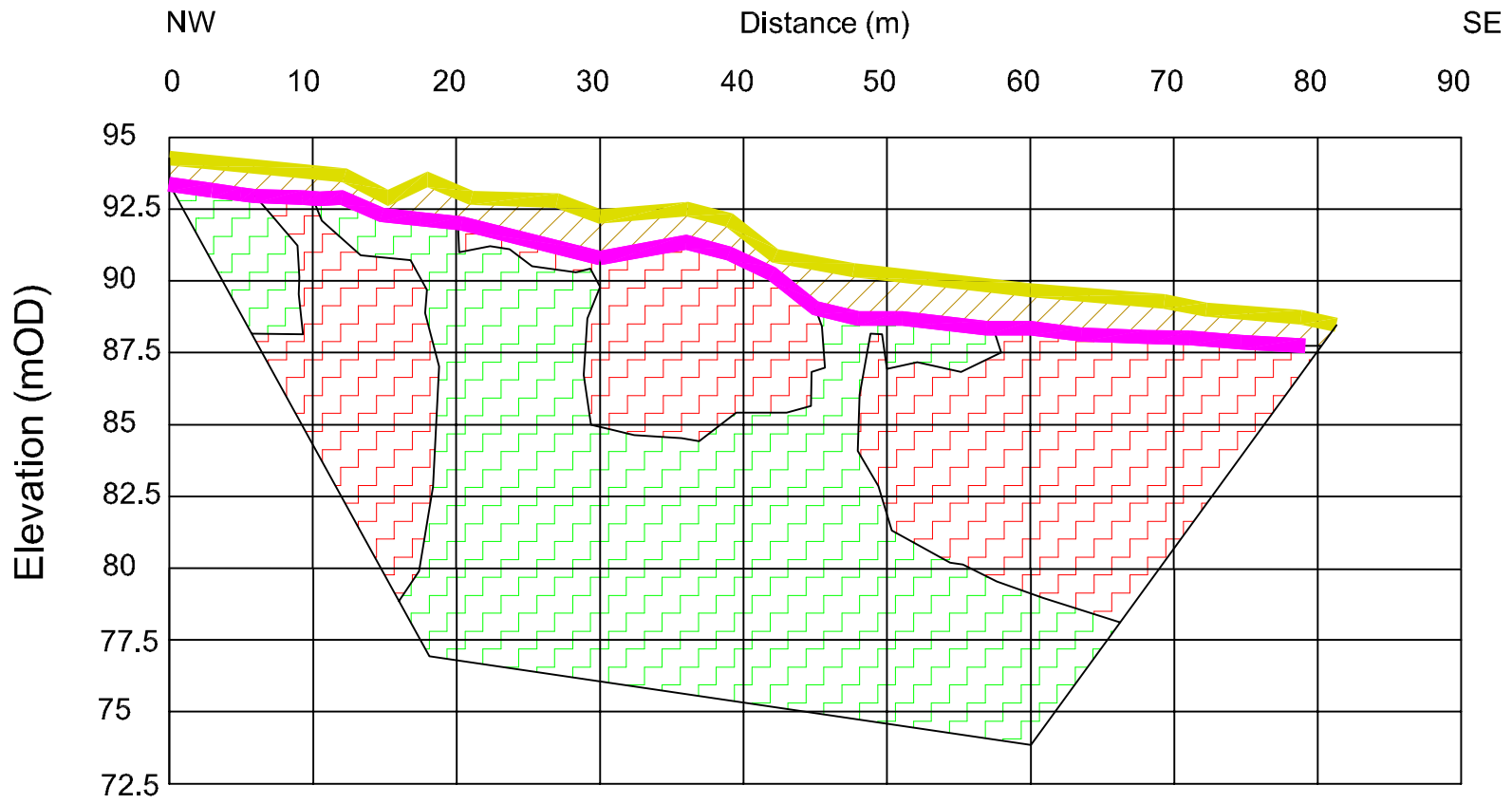
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PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 2c: Interpretation of
Geophysical Survey for Area C

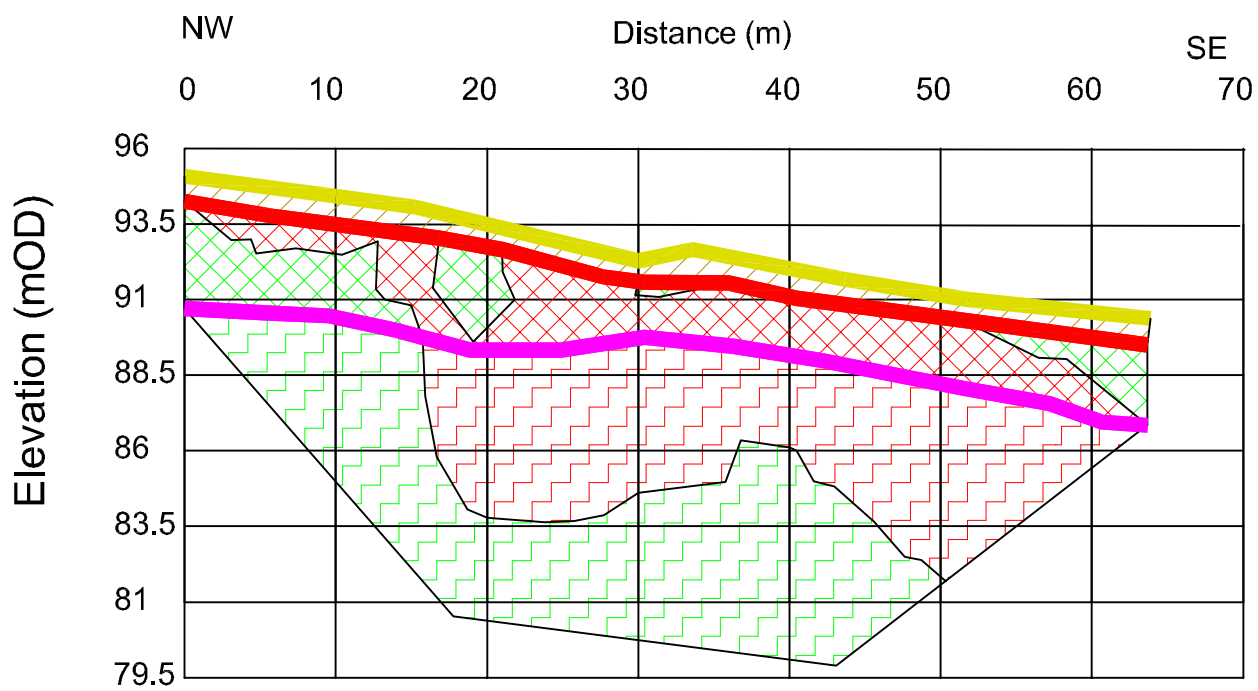
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PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

LEGEND:

2D-Resistivity Profile R22 and Seismic Refraction Profile S22 Interpretation



2D-Resistivity Profile R21 and Seismic Refraction Profile S21 Interpretation



Interpretation: Resistivity and Seismic Area

- 1 Soft or loose Topsoil, Soil or Made Ground
- 2a Firm to Stiff Clay or Silt Overburden
- 2b Firm to Stiff Gravelly Clay Overburden
- 2c Medium Dense to Dense Sand or Gravel Overburden
- 3a Very Stiff to Hard Clay or Silt Overburden
- 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden
- 3c Poor to Fair Weathered Metamorphic Rock
- 4b Good to Very Good Slightly Weathered Metamorphic Rock
- 4c Good to Very Good Fresh Metamorphic Rock

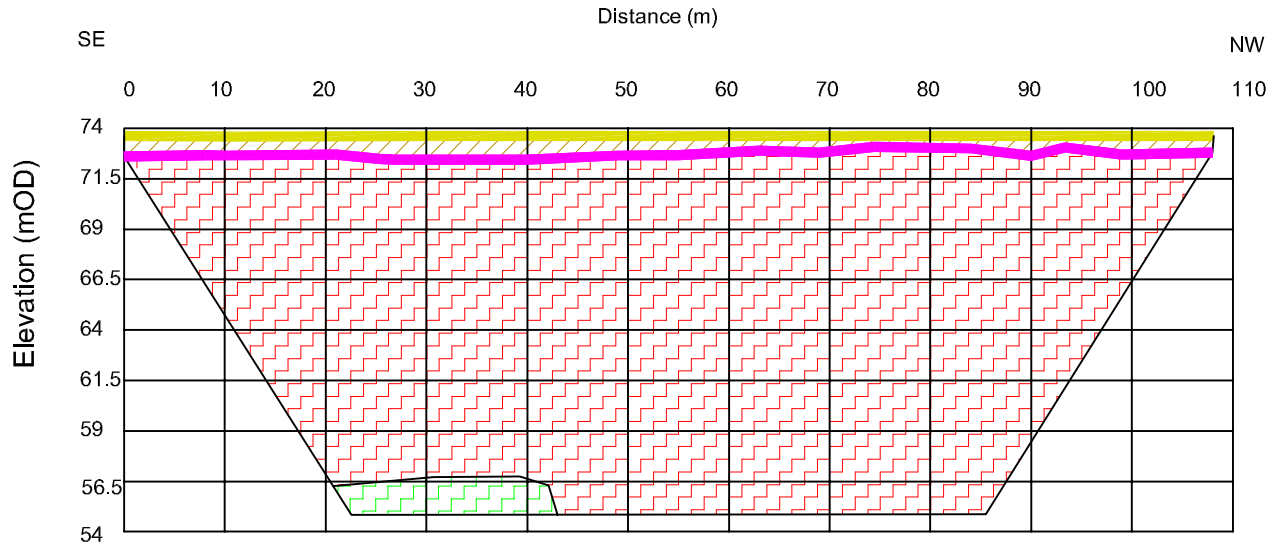
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CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 2d: Interpretation of
Geophysical Survey for Area D

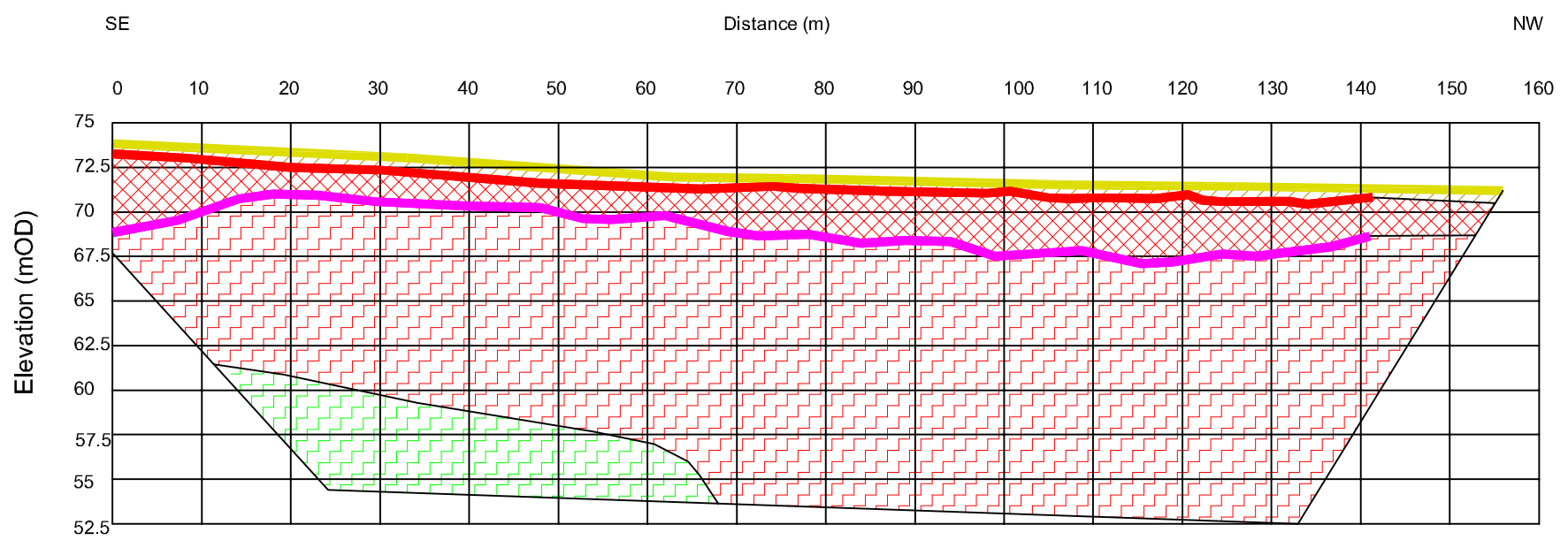
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PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

LEGEND:










2D-Resistivity Profile R13 and Seismic Refraction Profile S13 Interpretation



2D-Resistivity Profile R12 and Seismic Refraction Profile S12 Interpretation



Interpretation: Resistivity and Seismic Area

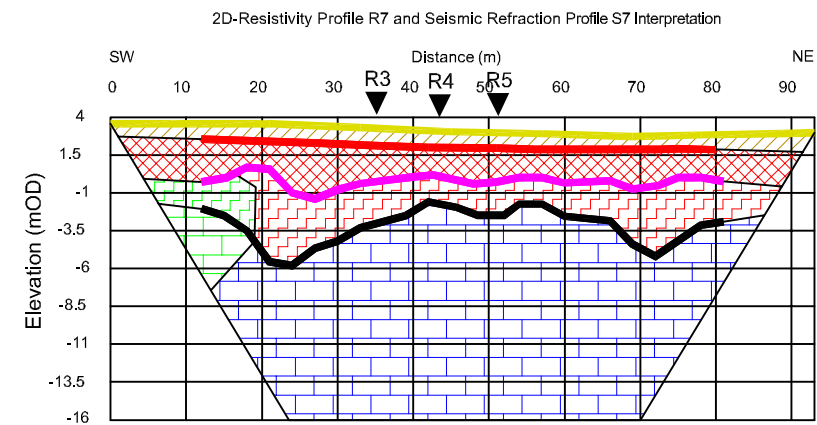
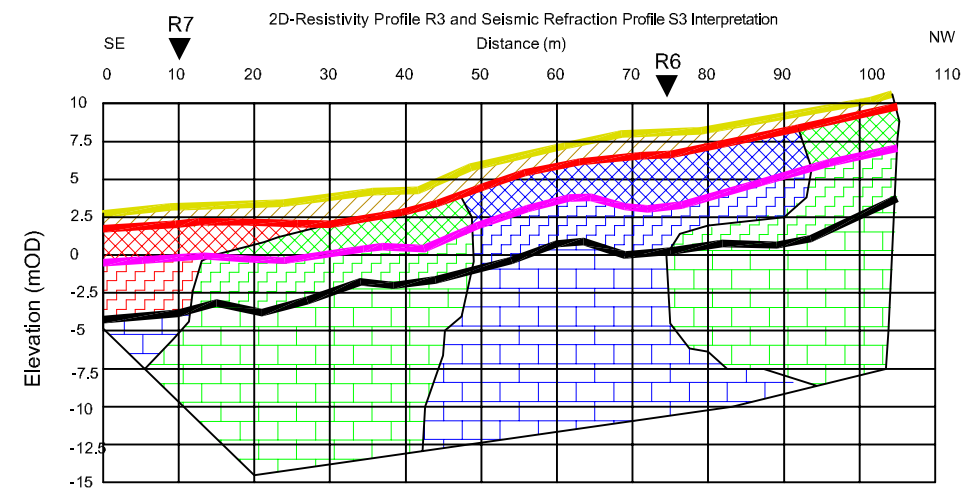
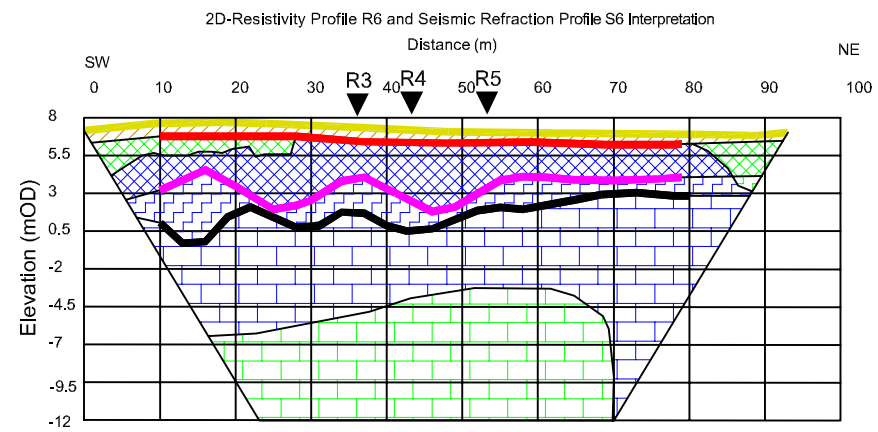
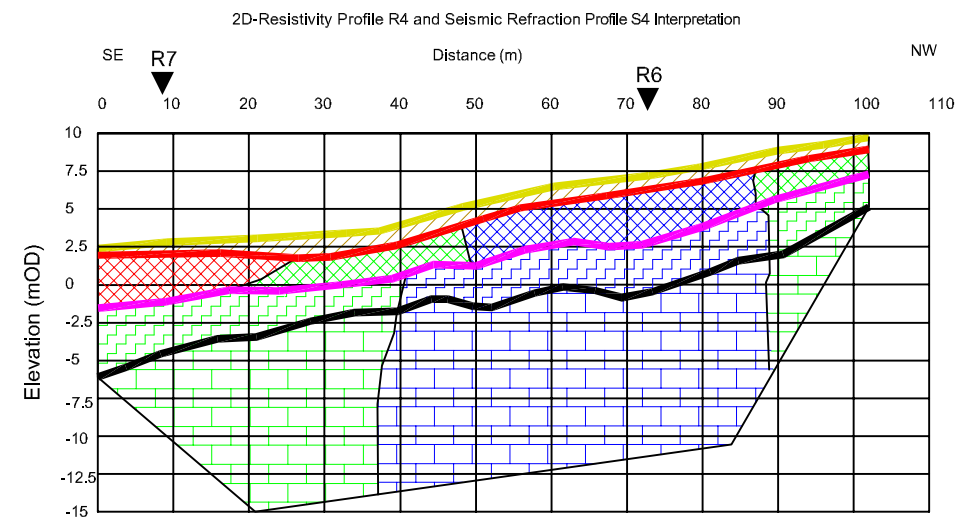
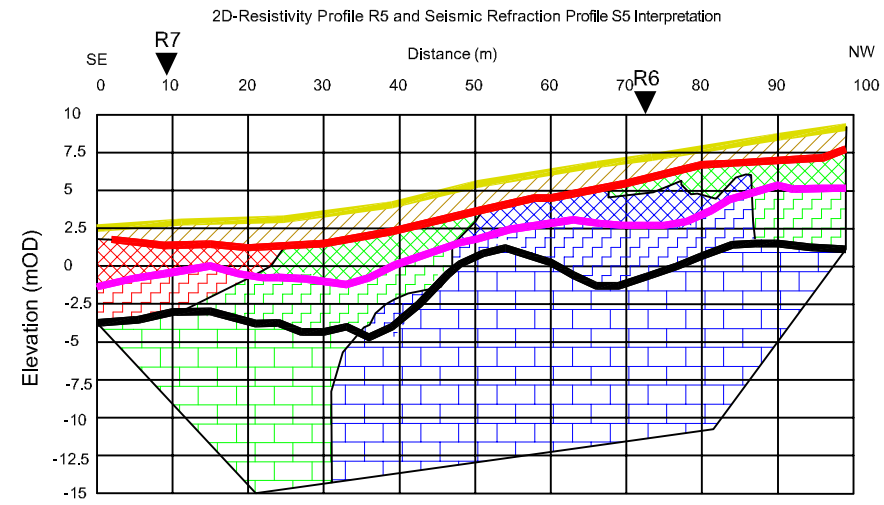
- | | | | | | |
|---|--|---|---|---|--|
|  | 1 Soft or loose Topsoil, Soil or Made Ground |  | 3a Very Stiff to Hard Clay or Silt Overburden |  | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
|  | 2a Firm to Stiff Clay or Silt Overburden |  | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden |  | 4c Good to Very Good Fresh Metamorphic Rock |
|  | 2b Firm to Stiff Gravelly Clay Overburden |  | 3c Poor to Fair Weathered Metamorphic Rock | | |
|  | 2c Medium Dense to Dense Sand or Gravel Overburden | | | | |

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PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 2e: Interpretation of
Geophysical Survey for Area E

SCALE: 1:750 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

LEGEND:



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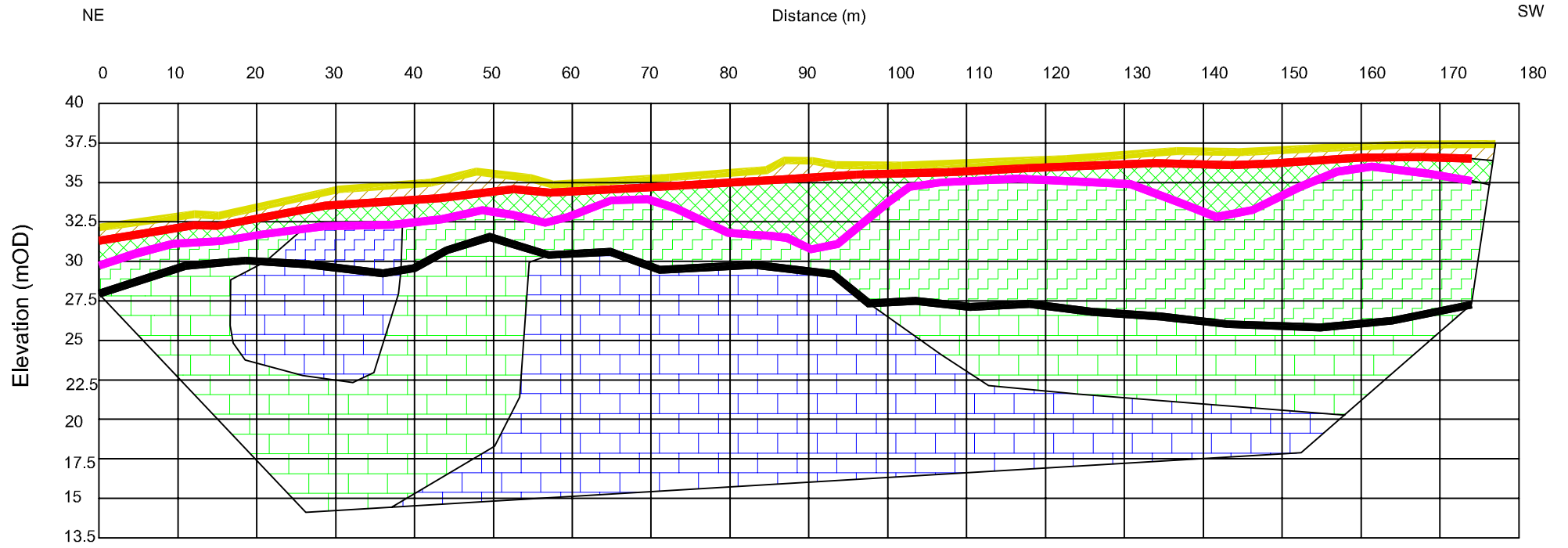
CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 2f: Interpretation of Geophys
Survey for River Swilly Crossing N

SCALE: 1:1000 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft

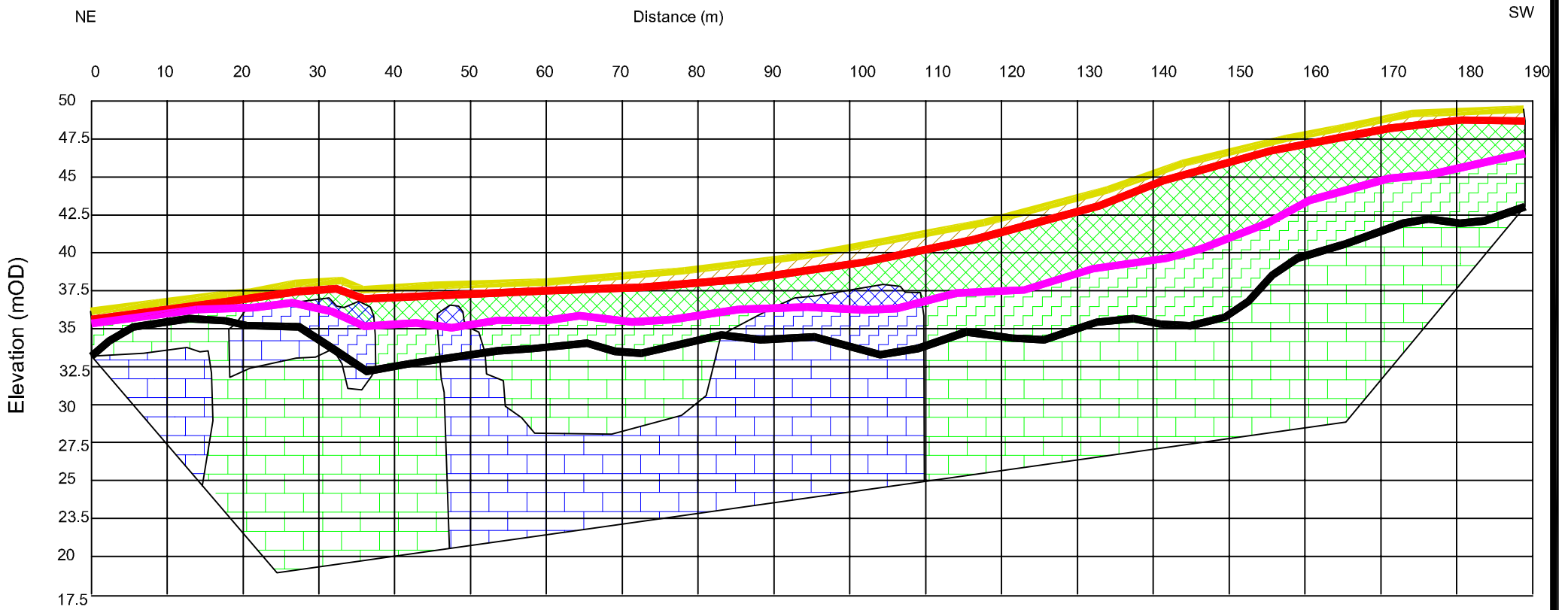
LEGEND: Interpretation: Resistivity and Seismic Area

- | | | | |
|--|--|--|---|
| | 1 Soft or loose Topsoil, Soil or Made Ground | | 3a Very Stiff to Hard Clay or Silt Overburden |
| | 2a Firm to Stiff Clay or Silt Overburden | | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden |
| | 2b Firm to Stiff Gravelly Clay Overburden | | 3c Poor to Fair Weathered Metamorphic Rock |
| | 2c Medium Dense to Dense Sand or Gravel Overburden | | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
| | | | 4c Good to Very Good Fresh Metamorphic Rock |

2D-Resistivity Profile R11 and Seismic Refraction Profile S11 Interpretation



2D-Resistivity Profile R10 and Seismic Refraction Profile S10 Interpretation



Interpretation: Resistivity and Seismic Area

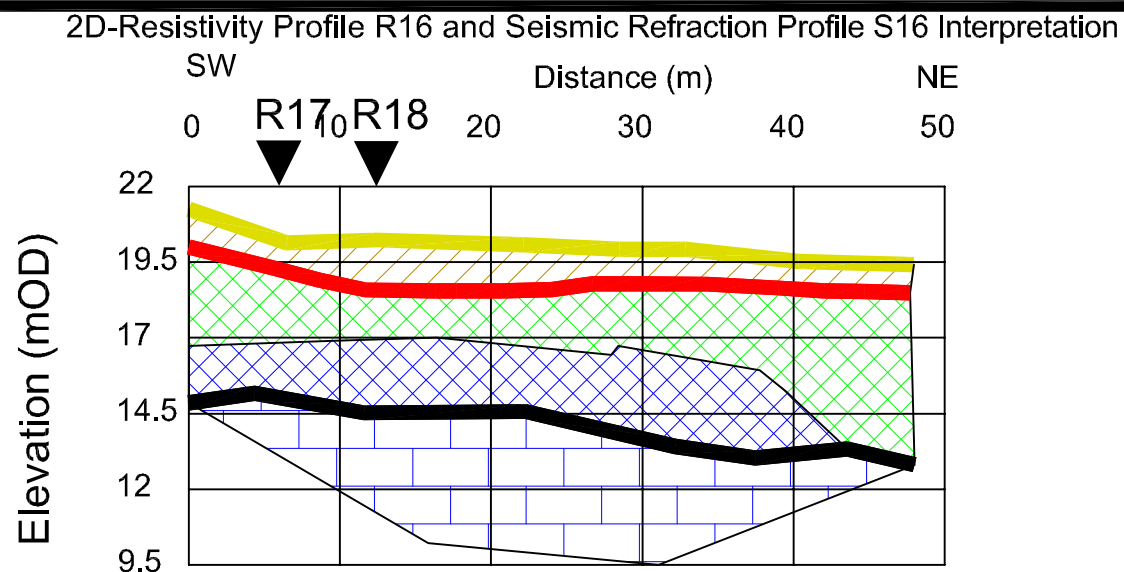
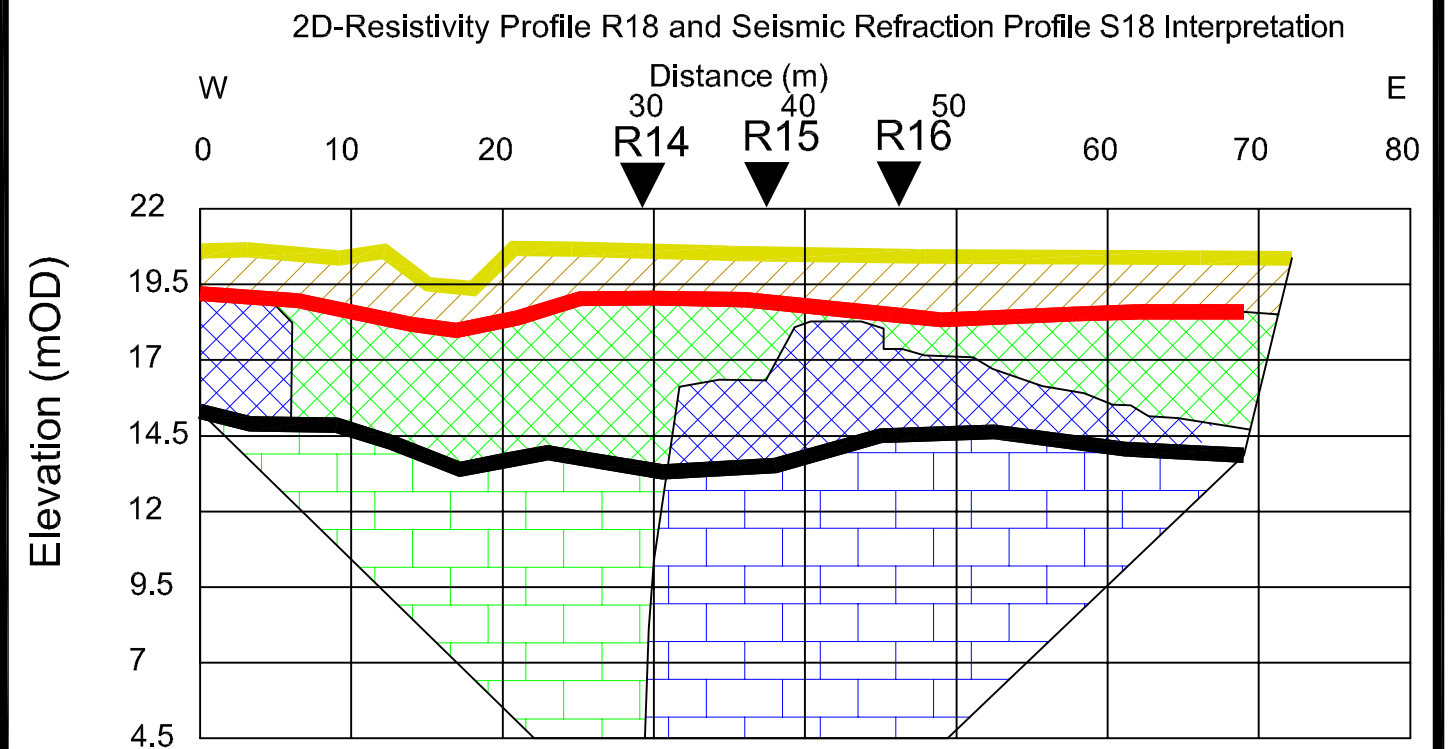
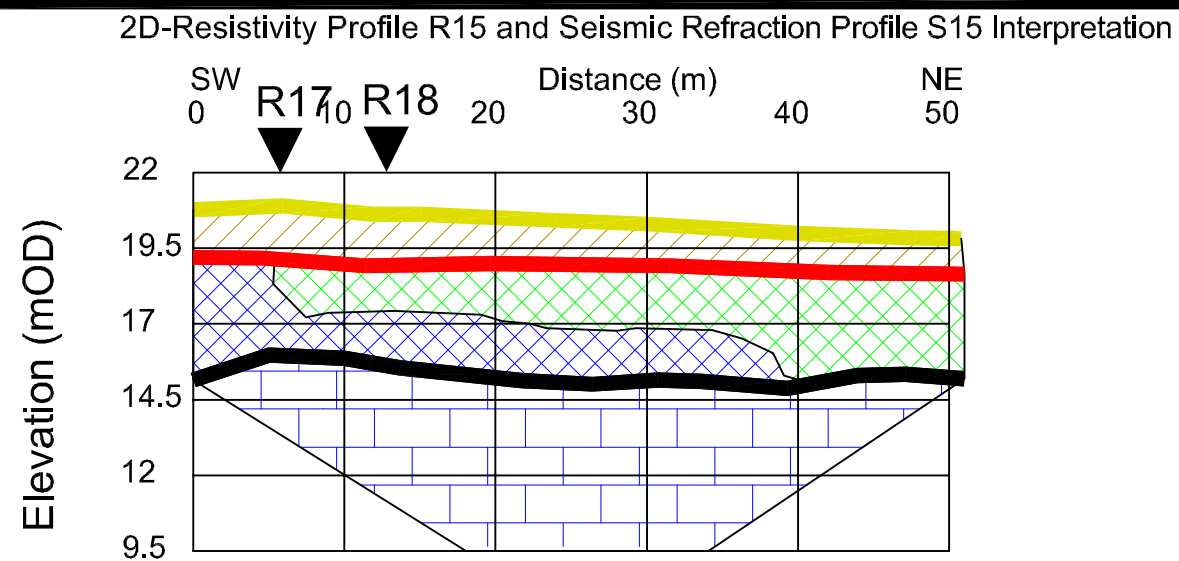
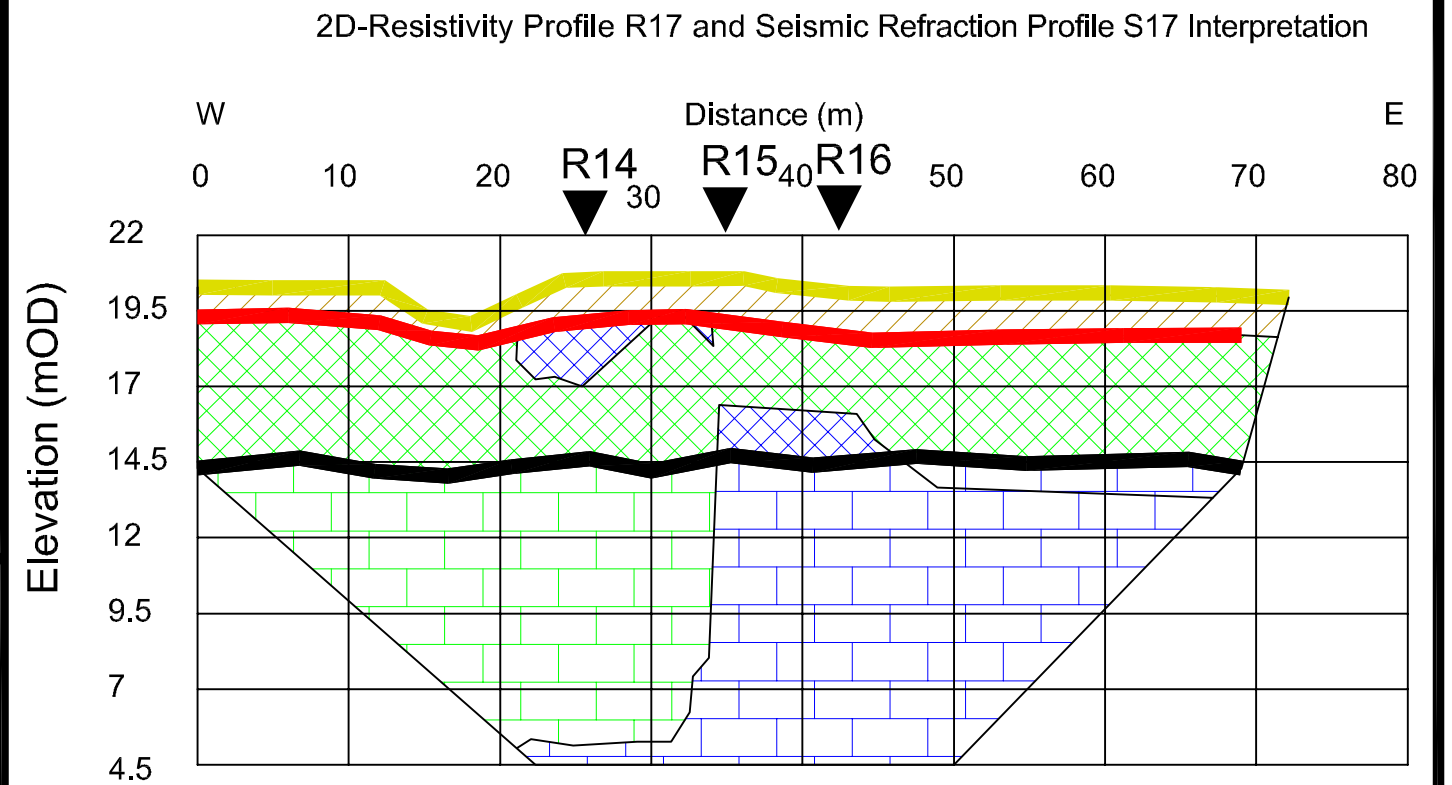
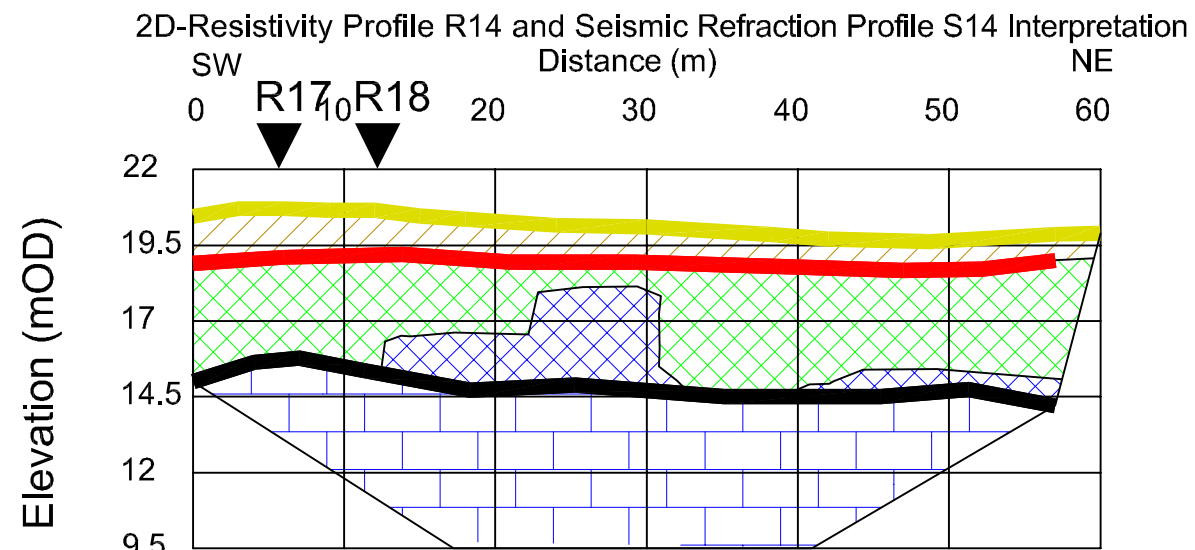
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|--|--|--|---|--|--|
| | 1 Soft or loose Topsoil, Soil or Made Ground | | 3a Very Stiff to Hard Clay or Silt Overburden | | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
| | 2a Firm to Stiff Clay or Silt Overburden | | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden | | 4c Good to Very Good Fresh Metamorphic Rock |
| | 2b Firm to Stiff Gravelly Clay Overburden | | 3c Poor to Fair Weathered Metamorphic Rock | | |
| | 2c Medium Dense to Dense Sand or Gravel Overburden | | | | |

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CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 2g: Interpretation of Geophys
Survey for CH 1+900 - 2+150

SCALE: 1:750 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
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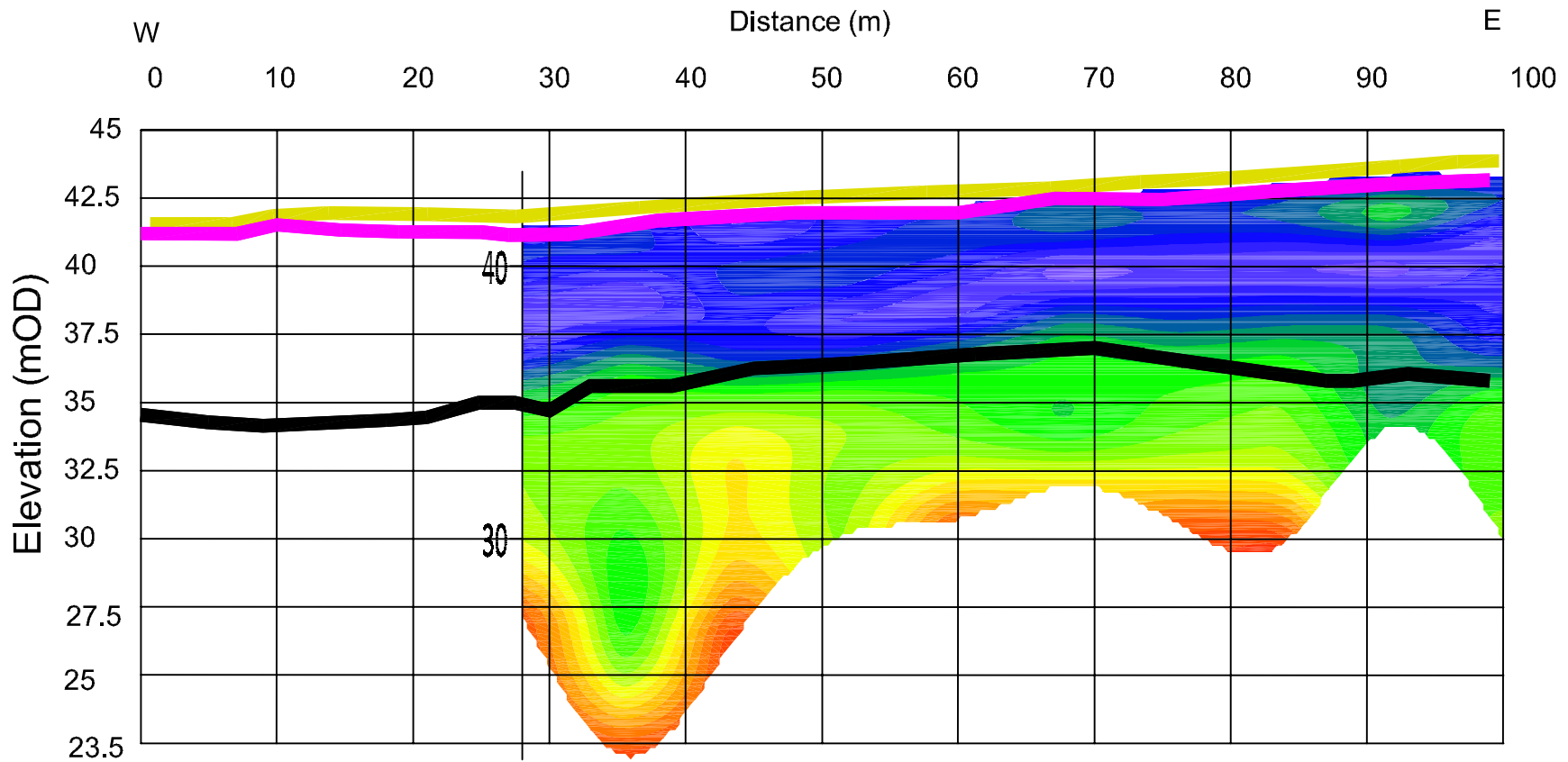
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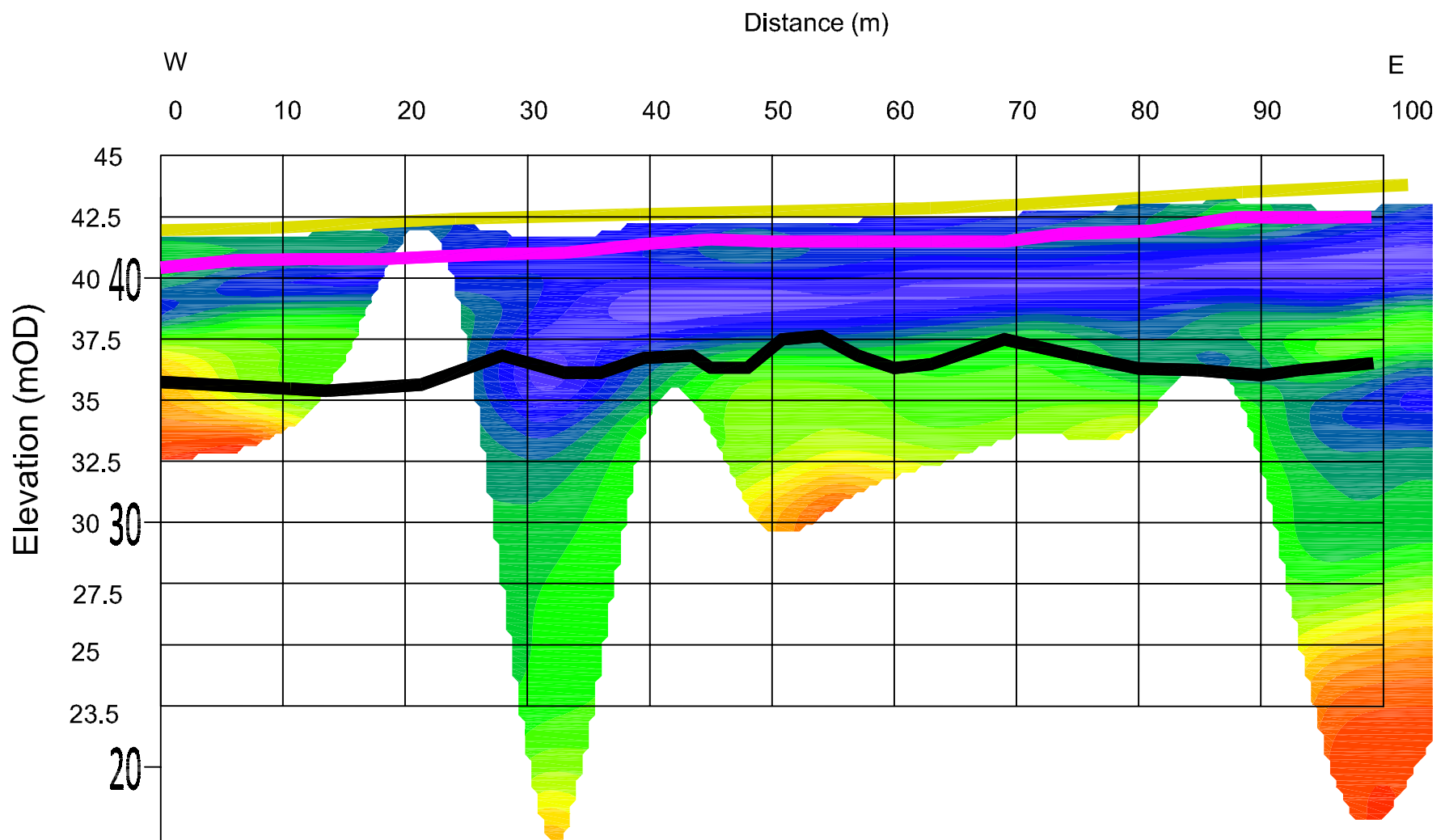
LEGEND: Interpretation: Resistivity and Seismic Area

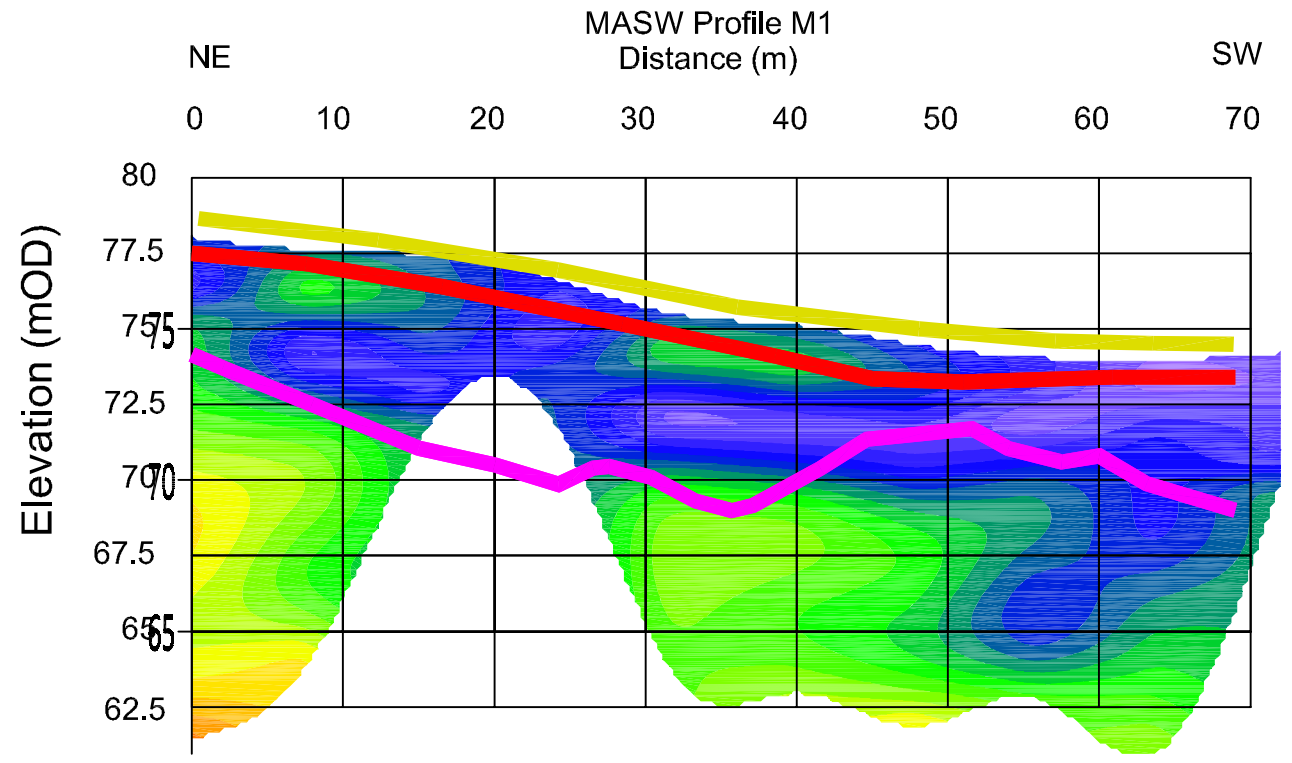
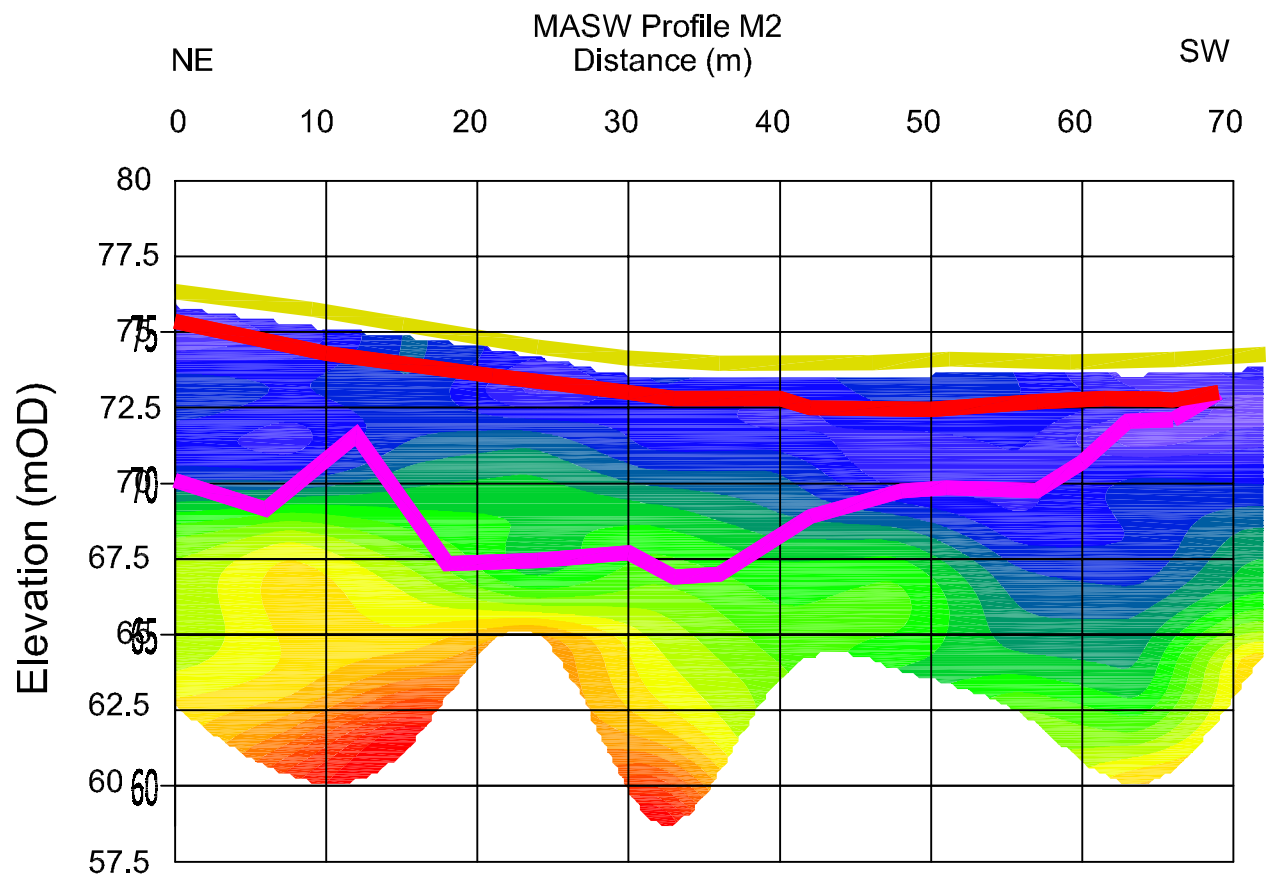
- | | | | |
|--|--|--|---|
| | 1 Soft or loose Topsoil, Soil or Made Ground | | 3a Very Stiff to Hard Clay or Silt Overburden |
| | 2a Firm to Stiff Clay or Silt Overburden | | 3b Poor to Fair Weathered Metamorphic Rock or Very Stiff to Hard Gravelly Clay Overburden |
| | 2b Firm to Stiff Gravelly Clay Overburden | | 3c Poor to Fair Weathered Metamorphic Rock |
| | 2c Medium Dense to Dense Sand or Gravel Overburden | | 4b Good to Very Good Slightly Weathered Metamorphic Rock |
| | | | 4c Good to Very Good Fresh Metamorphic Rock |

MASW Profile M8



MASW Profile M9





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CLIENT	Irish Drilling Ltd.
PROJECT	TEN-T, County Donegal Geophysical Survey
TITLE	Figure 3b: Models of MASW Survey for Area B

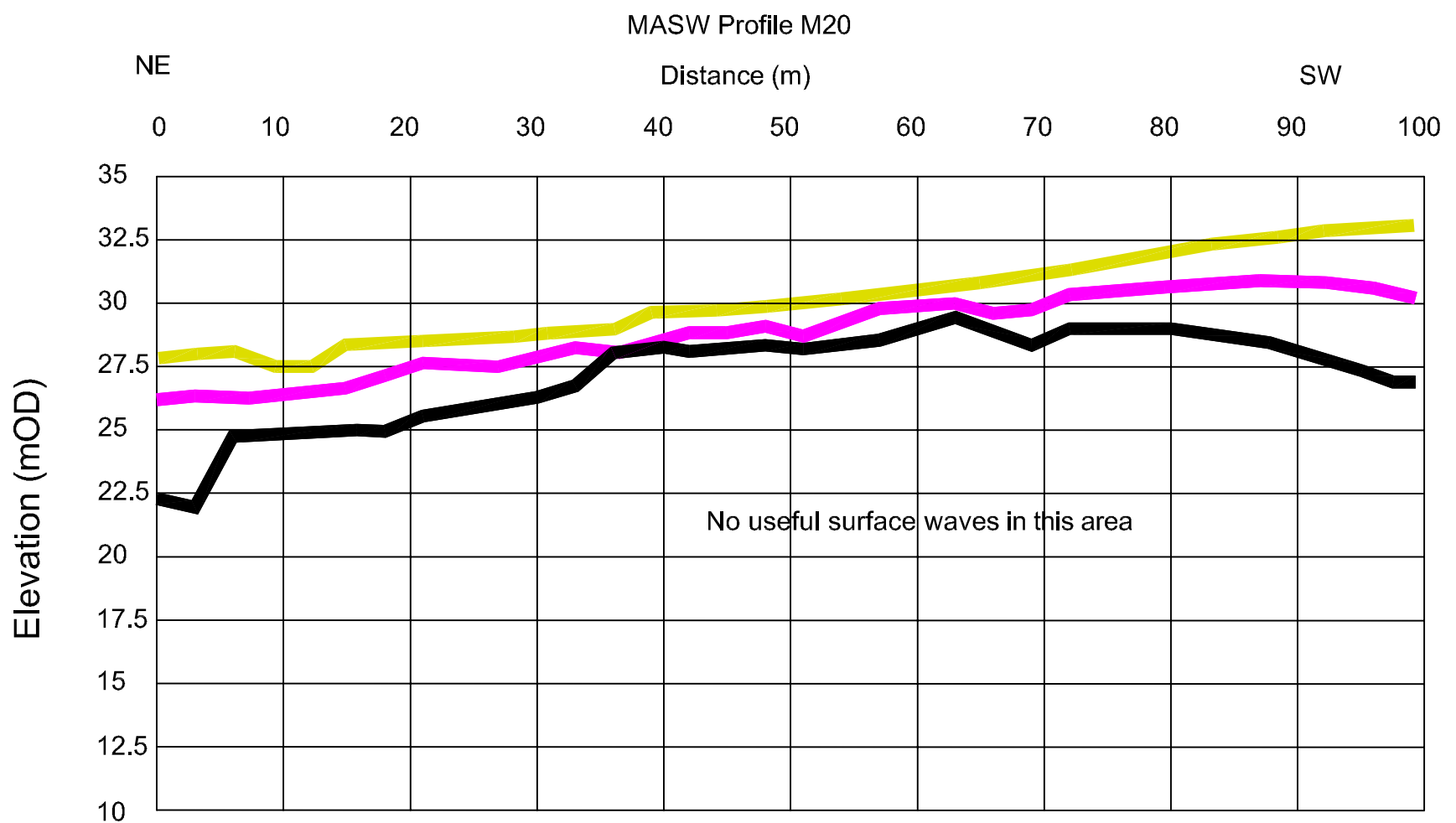
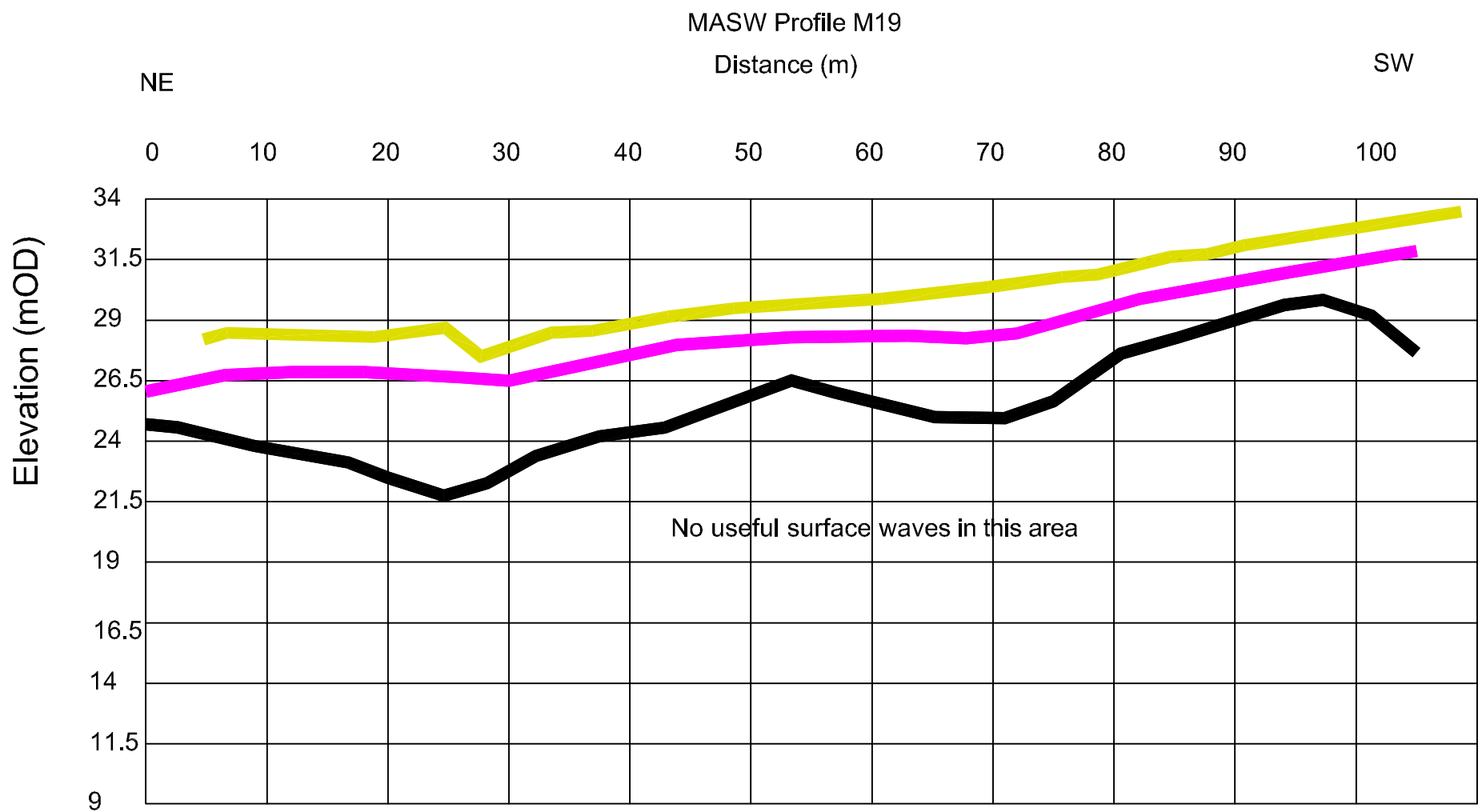
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STATUS:	Draft

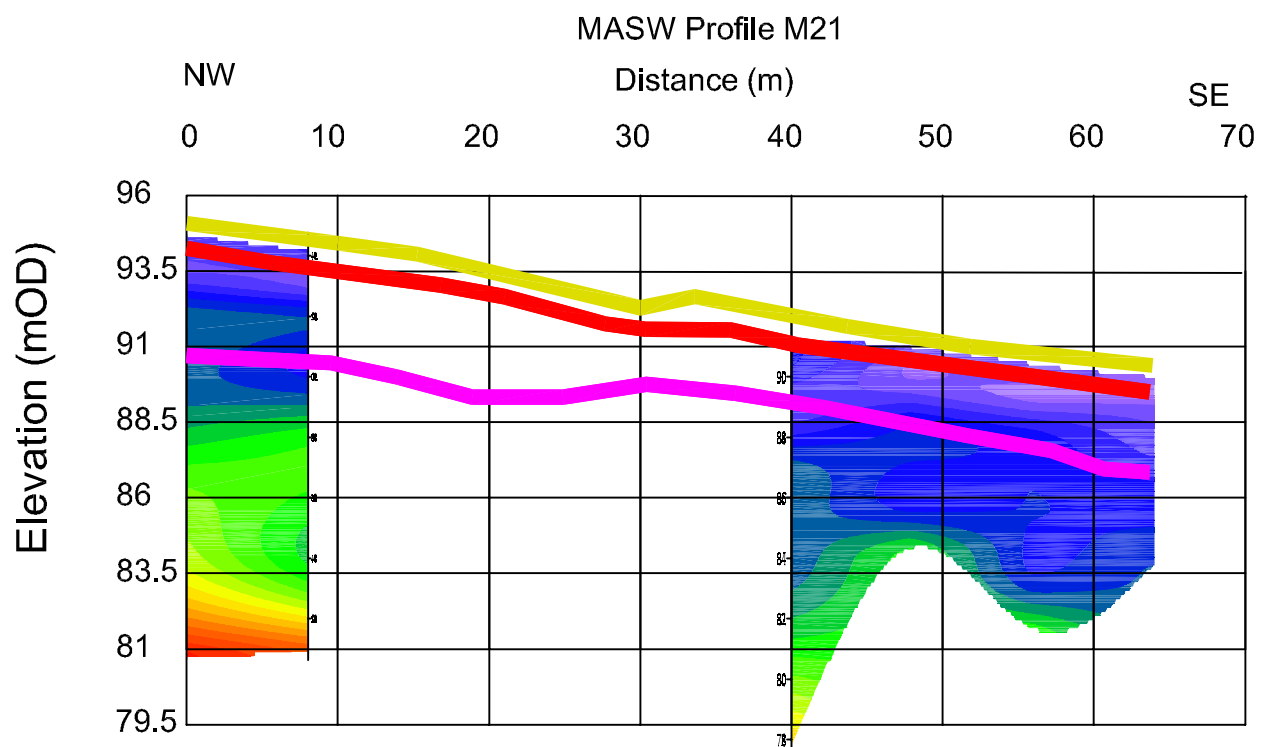
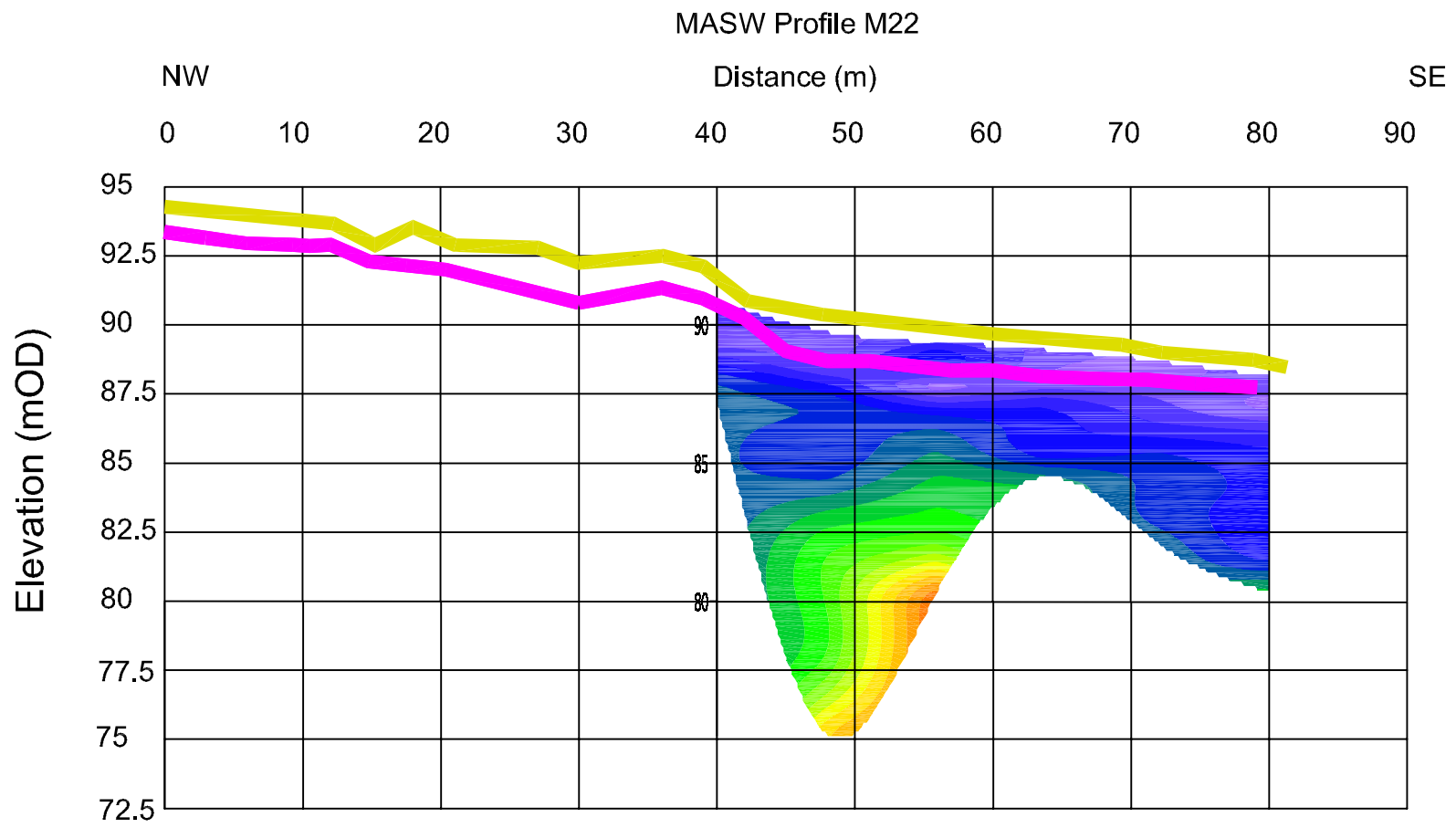
LEGEND: **MASW Models & Results:**

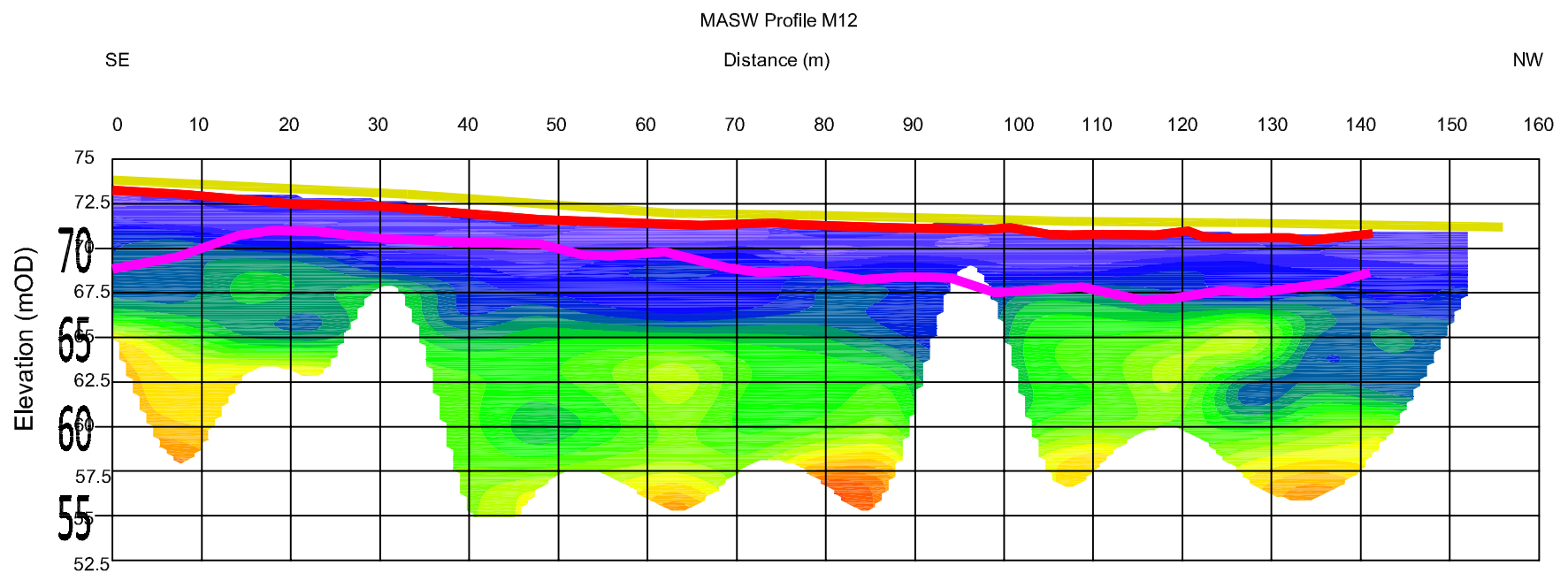
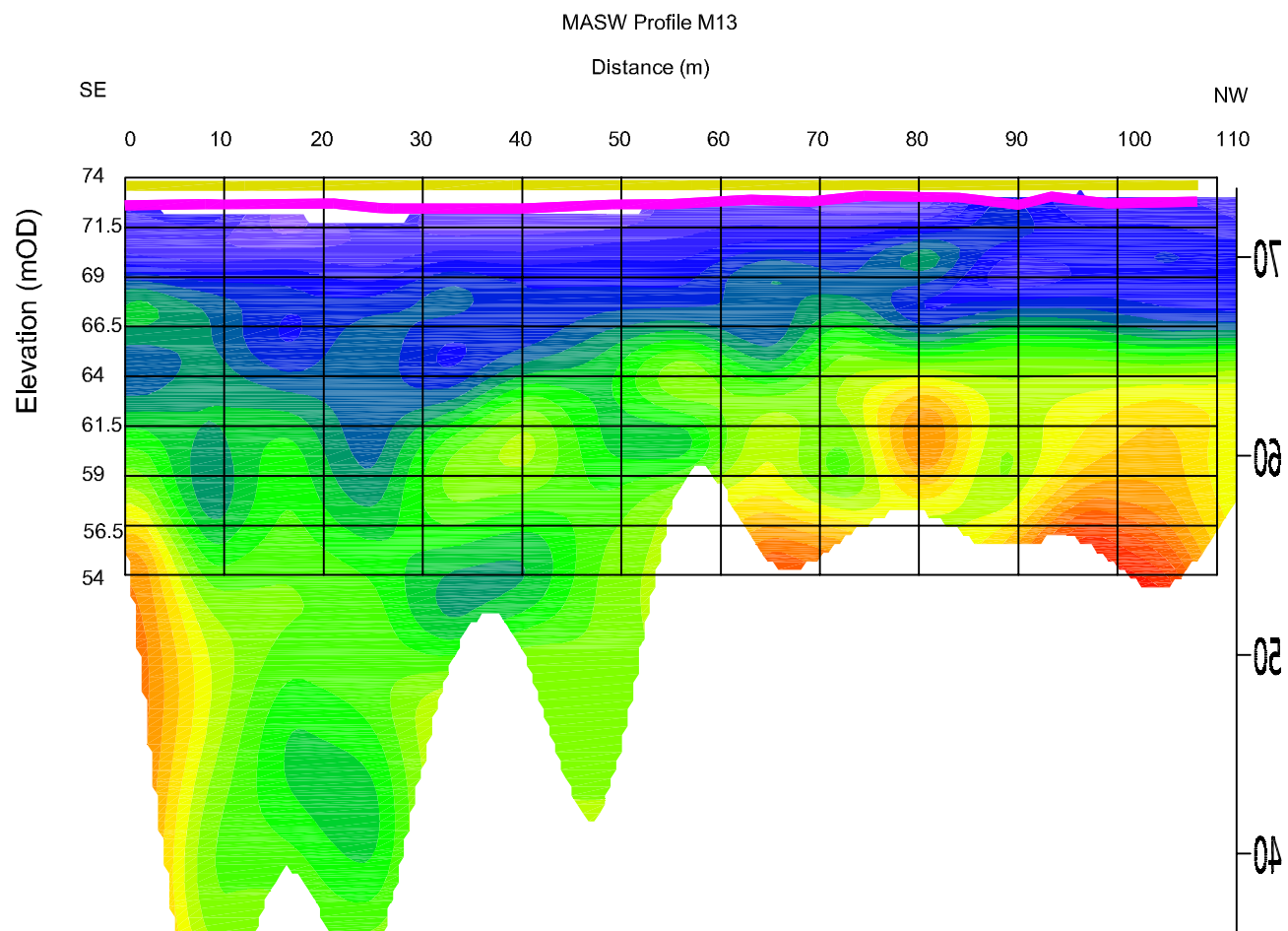
Shear Modulus (MPa) Computed with 2000 kg/m³

20	45	80	125	180	245	320	405	500	605	720	845	980	1125	1280	1445	1650	1805	2000	2205	2420	2645	2880
100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200

Shear Wave Velocity (m/s)







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CLIENT Irish Drilling Ltd.

PROJECT TEN-T, County Donegal
Geophysical Survey

TITLE Figure 3e: Models of MASW
Survey for Area E

SCALE: 1:750 @ A3, VE x 2

PROJECT: 6526

DRAWN: JC

DATE: 27/10/2020

MGX FILE: 6526d_MapsFigs.dwg

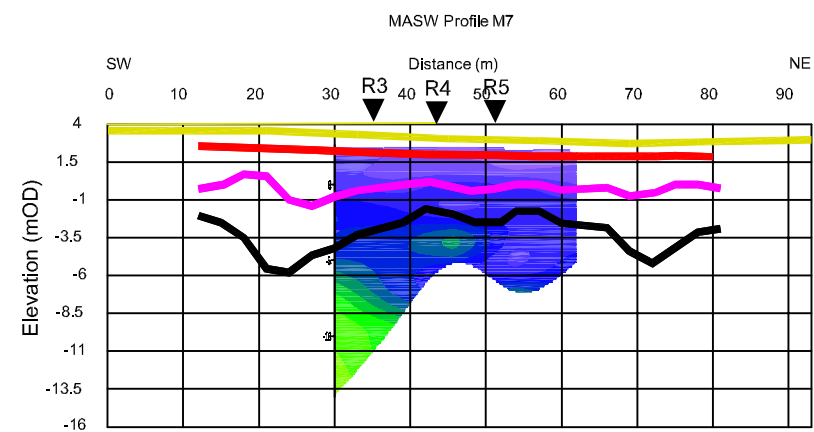
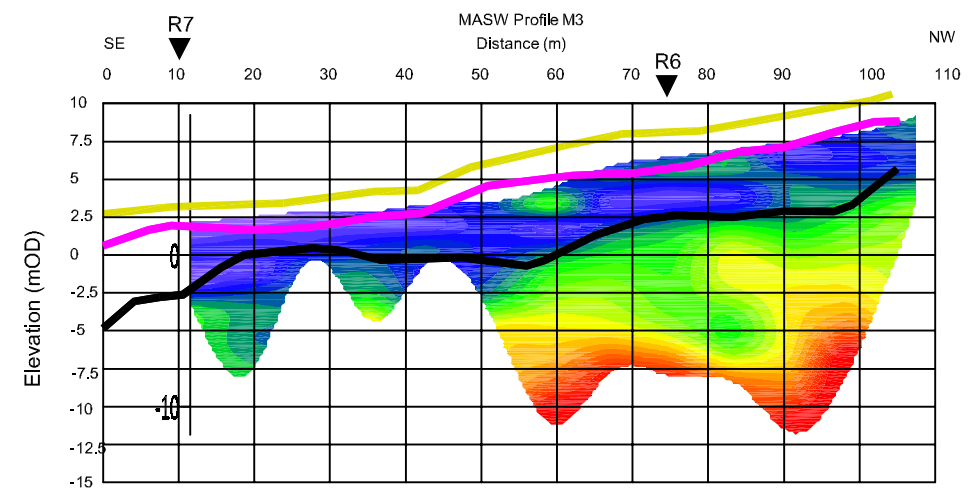
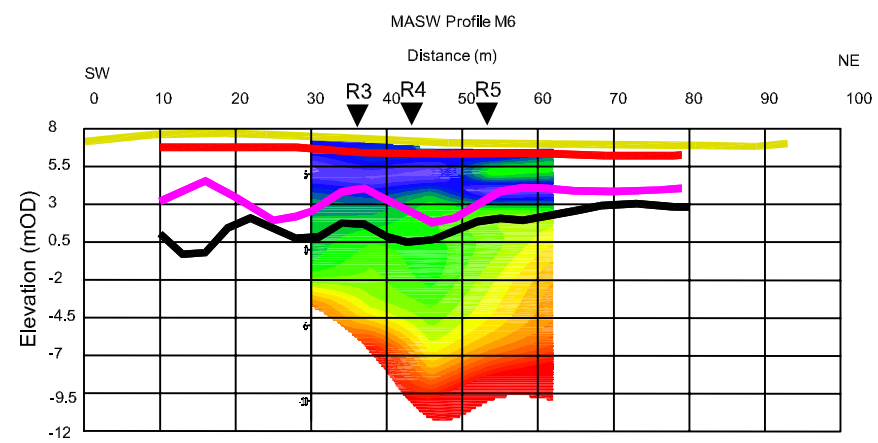
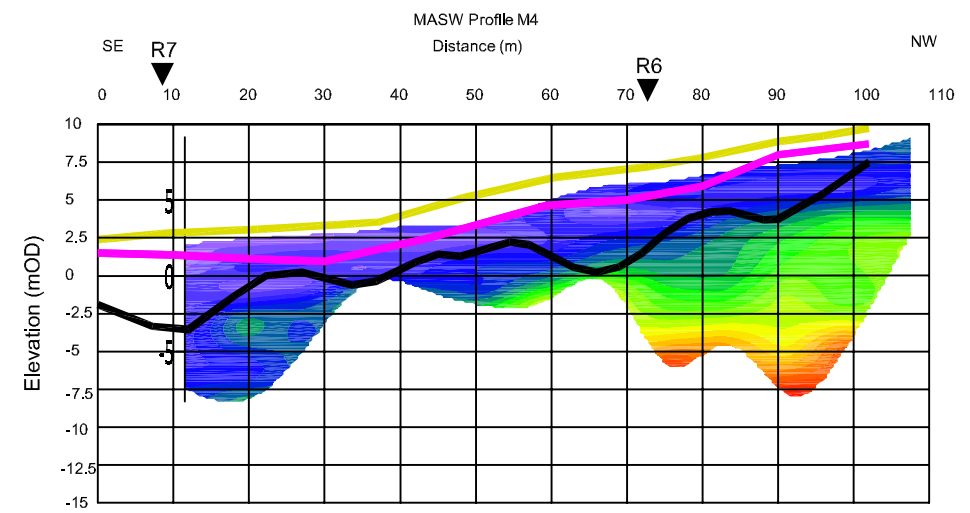
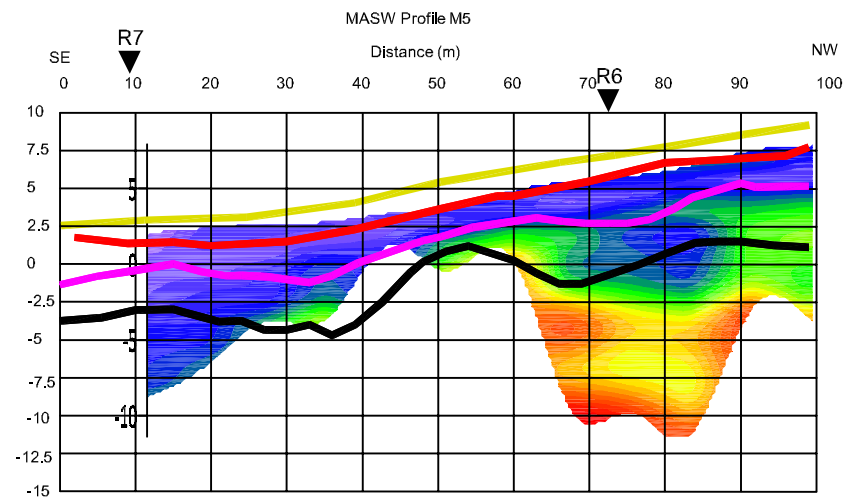
STATUS: Draft

LEGEND: **MASW Models & Results:**

Shear Modulus (MPa) Computed with 2000 kg/m³

20	45	80	125	180	245	320	405	500	605	720	845	980	1125	1280	1445	1650	1805	2000	2205	2420	2645	2880	
100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	

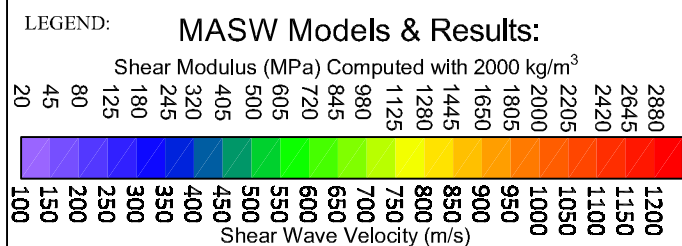
Shear Wave Velocity (m/s)

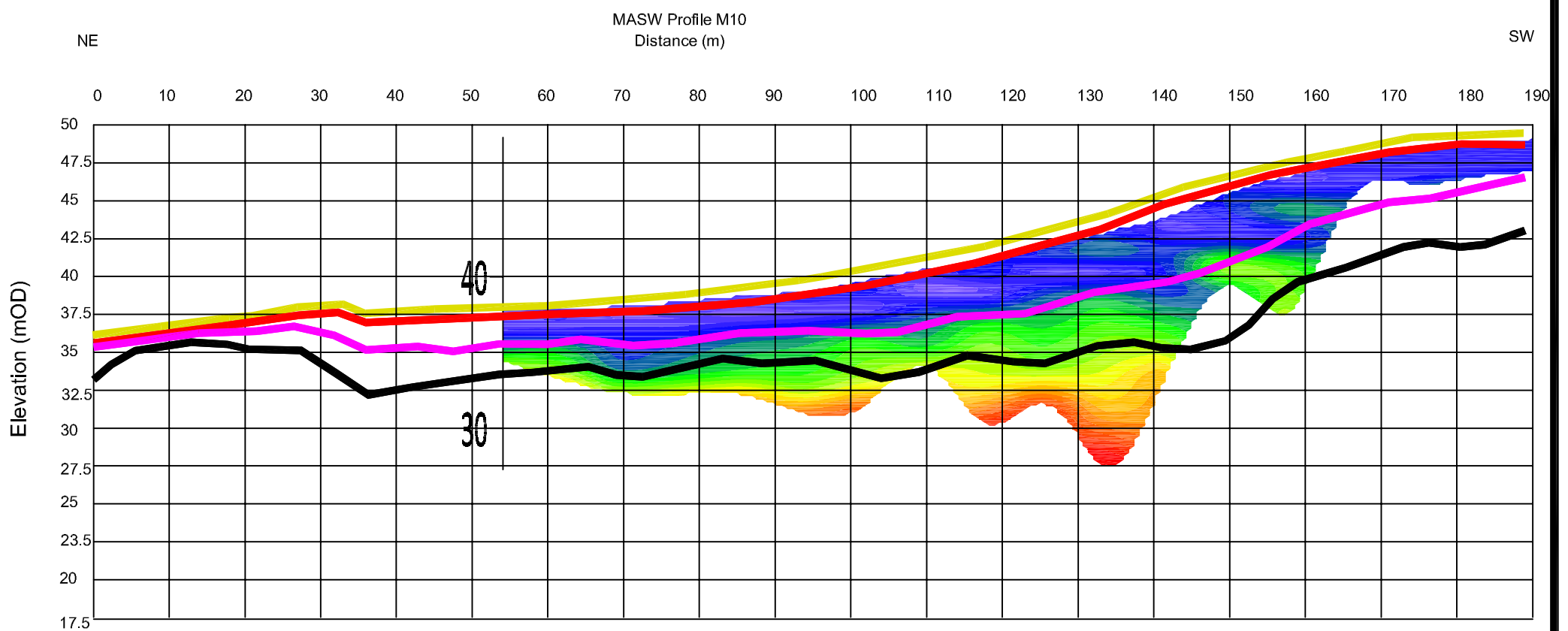
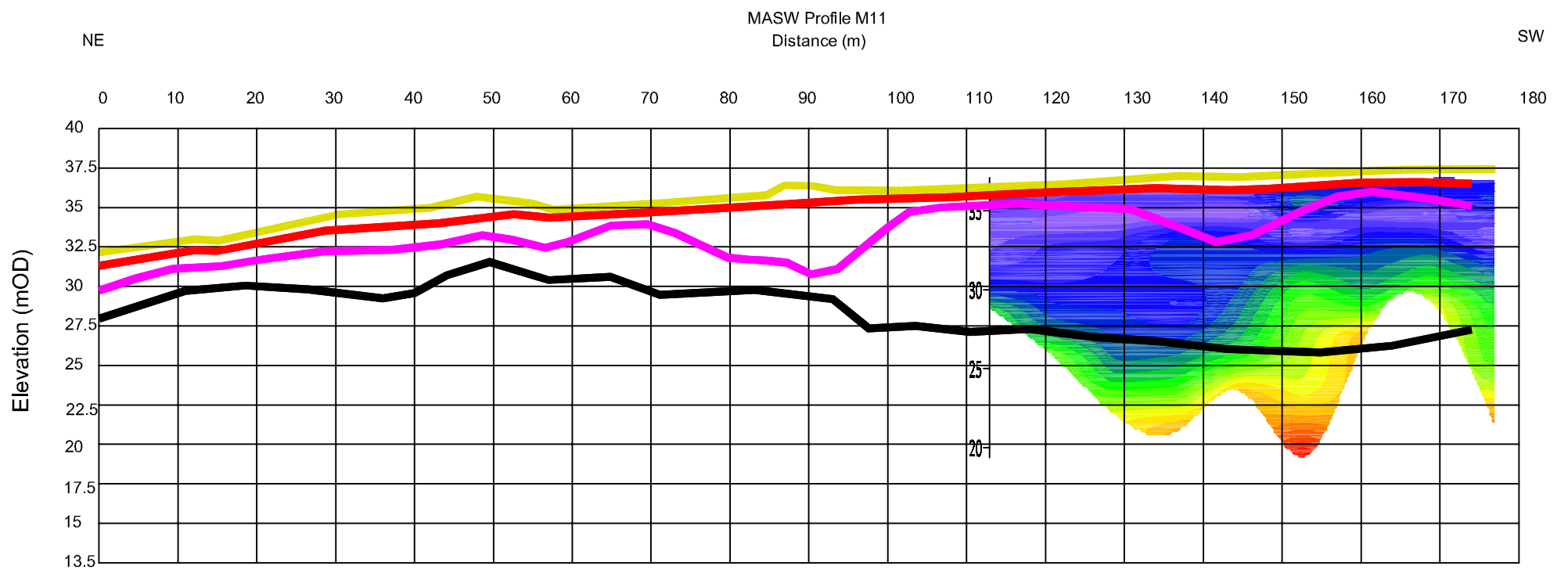


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CLIENT Irish Drilling Ltd.
PROJECT TEN-T, County Donegal
Geophysical Survey
TITLE Figure 3f: Models of MASW
Survey for River Swilly Crossing N

SCALE: 1:1000 @ A3, VE x 2
PROJECT: 6526
DRAWN: JC
DATE: 27/10/2020
MGX FILE: 6526d_MapsFigs.dwg
STATUS: Draft





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CLIENT Irish Drilling Ltd.

PROJECT TEN-T, County Donegal
Geophysical Survey

TITLE Figure 3g: Models of MASW
Survey for CH 1+900 - 2+150

SCALE: 1:750 @ A3, VE x 2

PROJECT: 6526

DRAWN: JC

DATE: 27/10/2020

MGX FILE: 6526d_MapsFigs.dwg

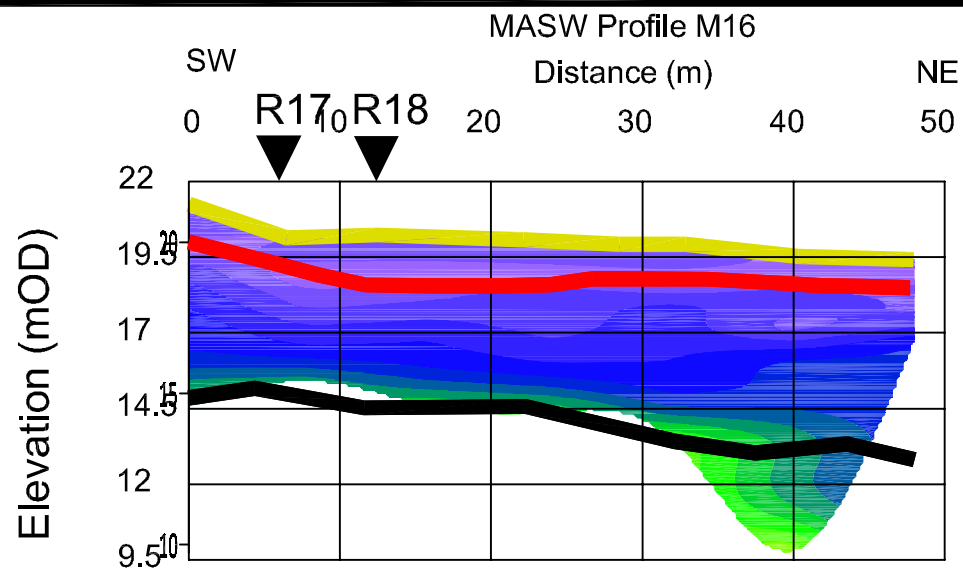
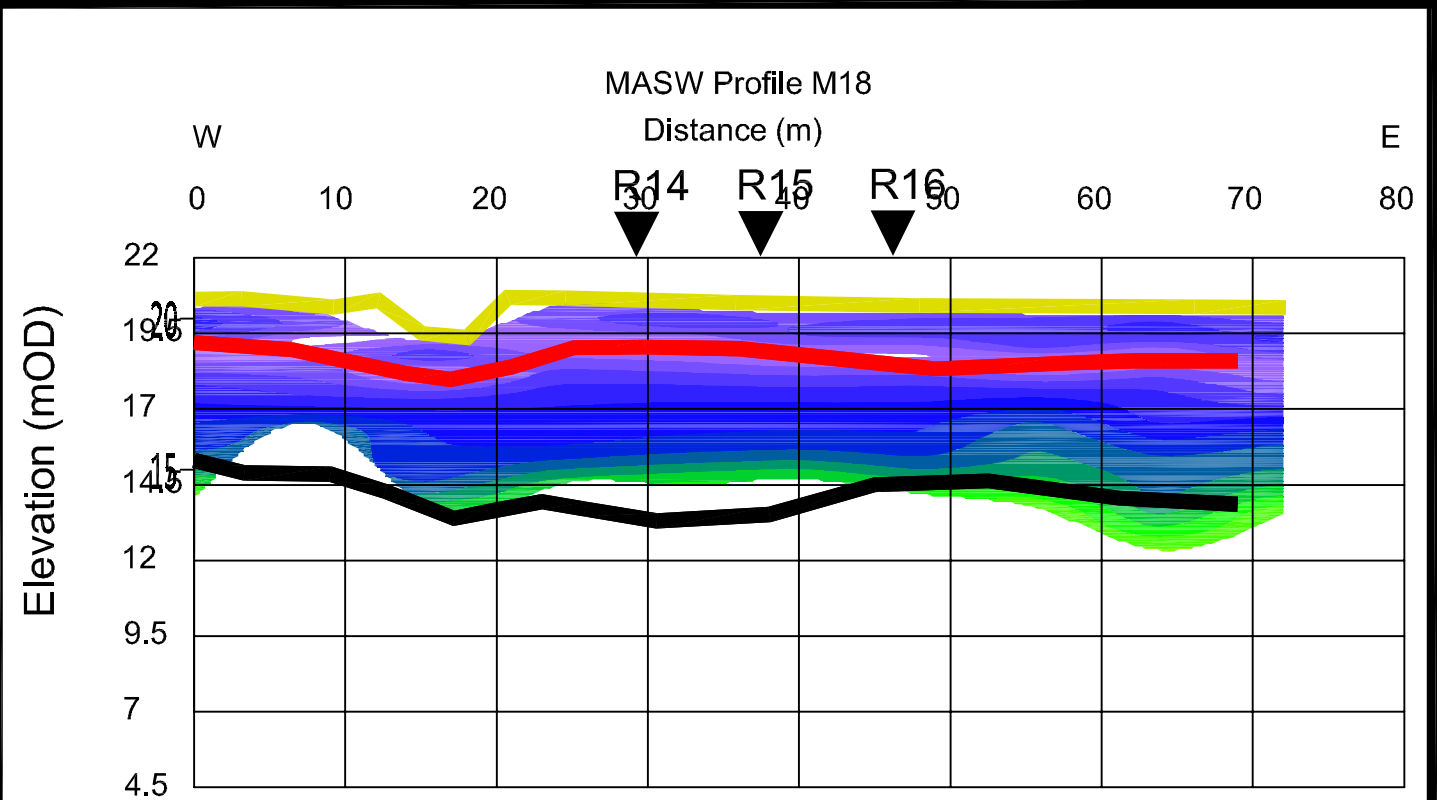
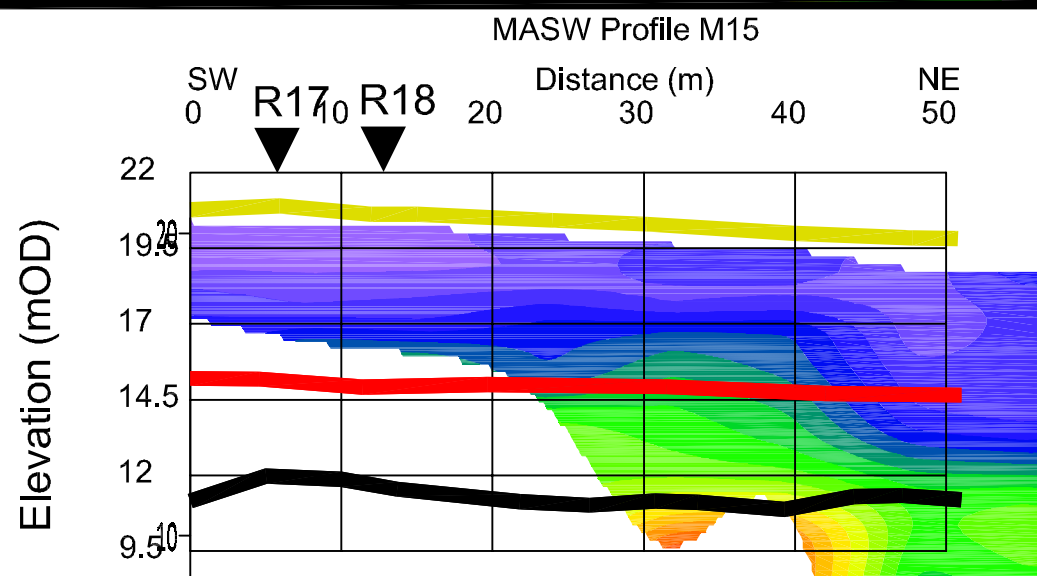
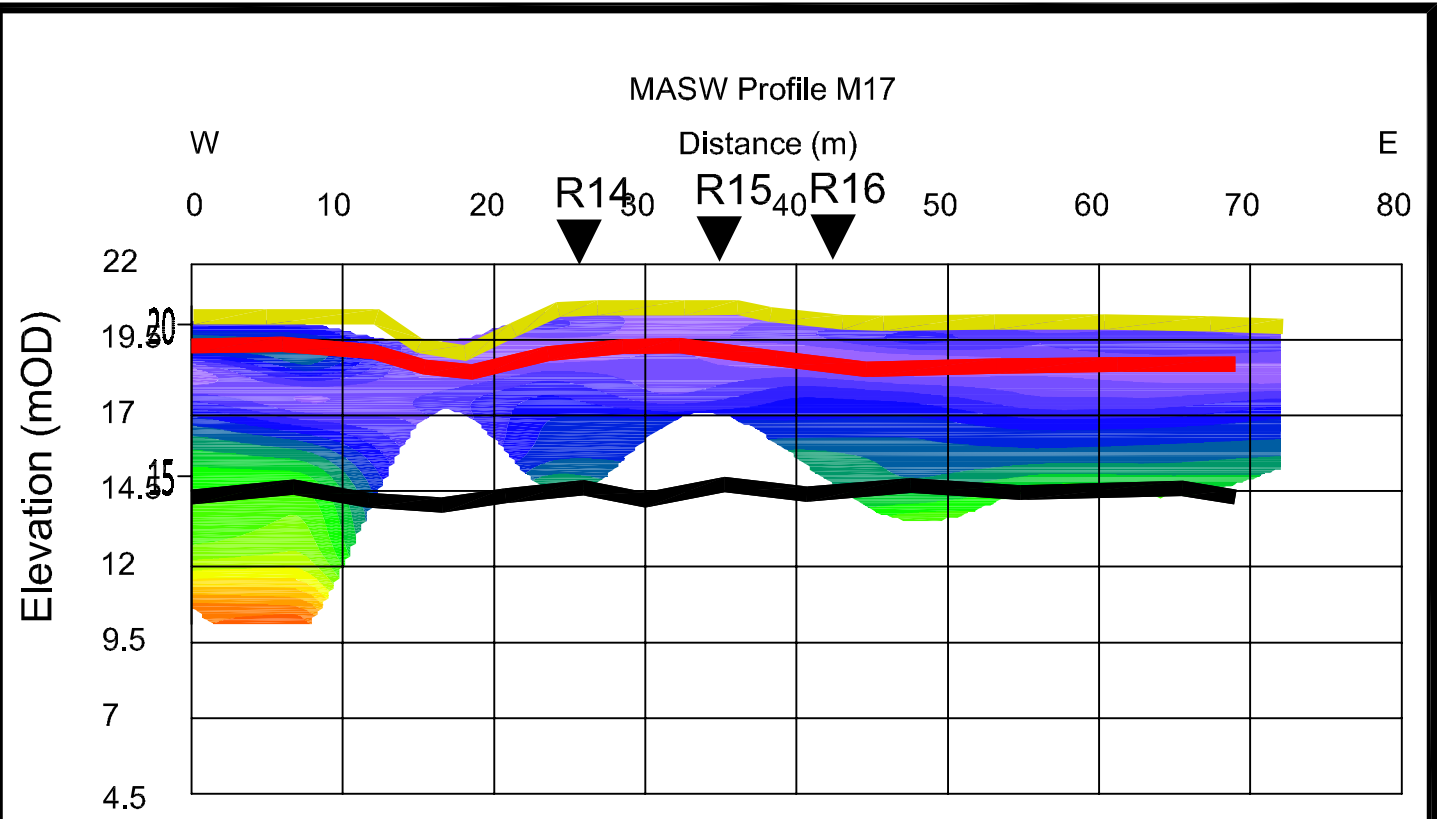
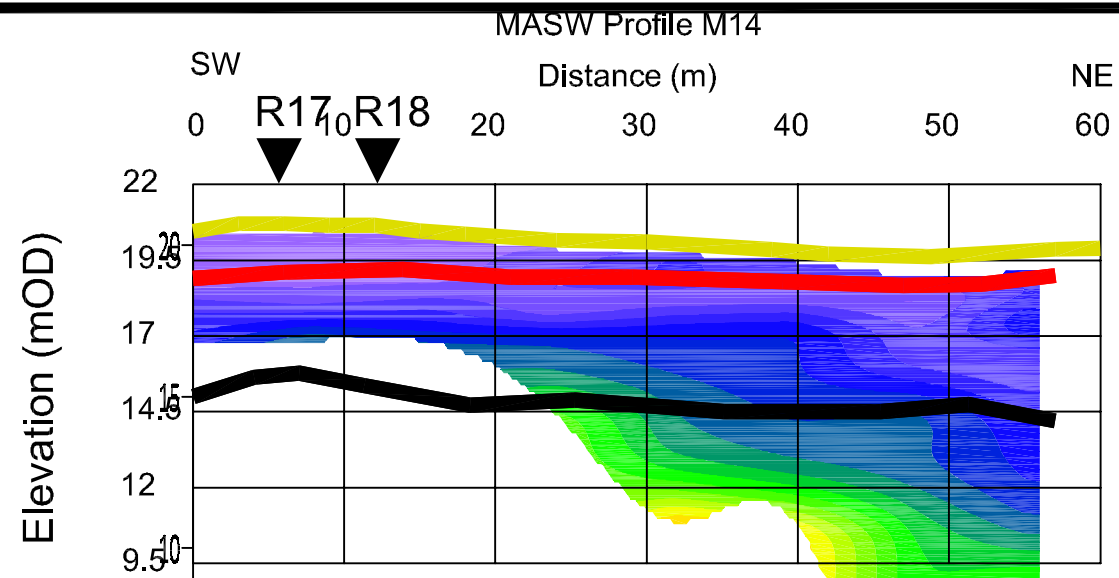
STATUS: Draft

LEGEND: **MASW Models & Results:**

Shear Modulus (MPa) Computed with 2000 kg/m³

20	45	80	125	180	245	320	405	500	605	720	845	980	1125	1280	1445	1650	1805	2000	2205	2420	2645	2880	
100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	

Shear Wave Velocity (m/s)



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PROJECT TEN-T, County Donegal
Geophysical Survey

TITLE Figure 3h: Models of MASW
Survey for River Finn Crossing N

SCALE: 1:500 @ A3, VE x 2

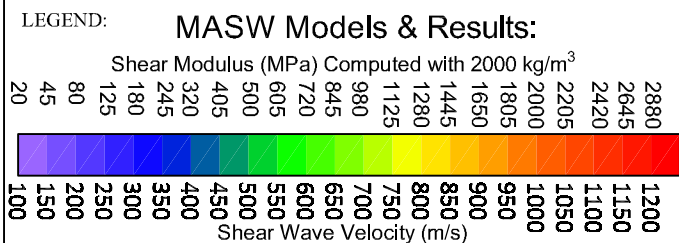
PROJECT: 6526

DRAWN: JC

DATE: 27/10/2020

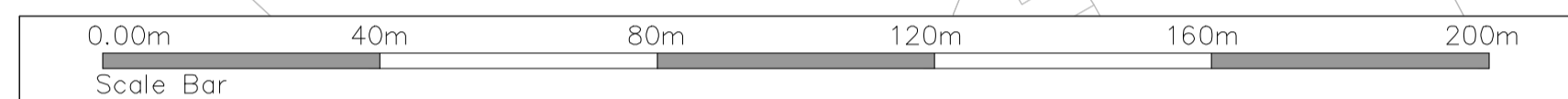
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STATUS: Draft



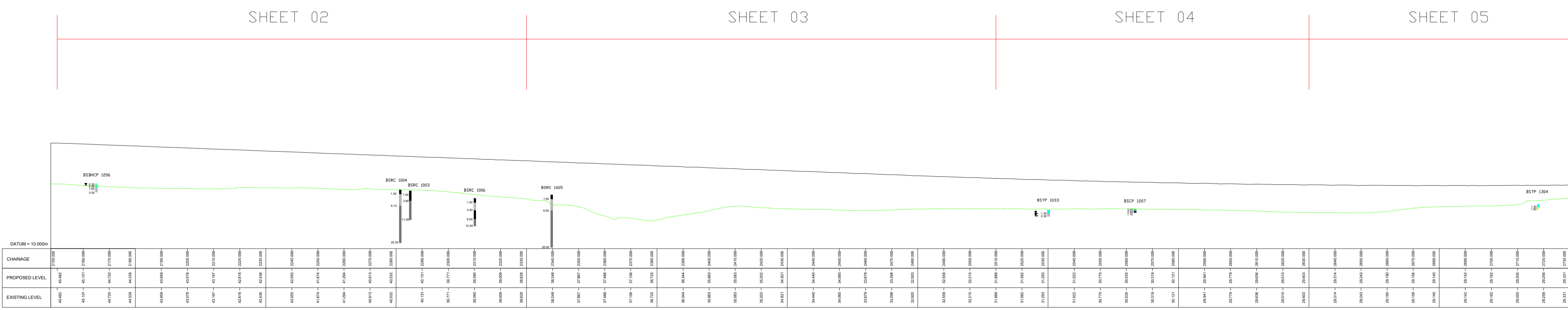


PLAN HORIZONTAL SCALE 1:1000 @ A1; 1:2000 @ A3



LEGEND

PLAN		PROFILE	
	CABLE PERCUSSIVE/ ROTARY CORE BOREHOLE		TOPSOIL
	TRIAL PIT		CLAY
	GEOPHYSICS PROFILE LINE		SILT
			SAND
			GRAVEL
			ROCK
			NO RECOVERY
	PIEZOMETER / STANDPIPE MEASUREMENT		WATER STRIKE
			WATER LEVEL 20 MINUTES AFTER STRIKE
			EXISTING GROUND LEVEL
			PROPOSED LEVEL
			N = N-VALUE



LONG SECTION
Scale: 1/1000 @ A1, 1/2000 @ A3

I:\Gis\Bip-10\Work_Transport\MGT0337_Ten-T Priority Route Imp - Donegal\0 Drawings\Phase 3\GITTT_MGT0337-RPS-P3-S1-DR-C-GI0002 River Finn crossing.dwg

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	08.04.21	JOC	ISSUE FOR INFORMATION	KC	CMcG

Project Title: **TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13**

Drawing Title: **FINN CROSSING**

Status: **S2**

Designed: **KC** Date: **APRIL 2021** Model File Identifier: **N/A**

Drawn: **JOC** Scale @ A1: **As Shown** @ A3: **As Shown** File Identifier: **TT_MGT0337-RPS-P3-S1-DR-C-GI0002**

Approved: **KC** Sheet: **01 of 07**

Checked: **CMcG** Rev: **P01**

LEGEND

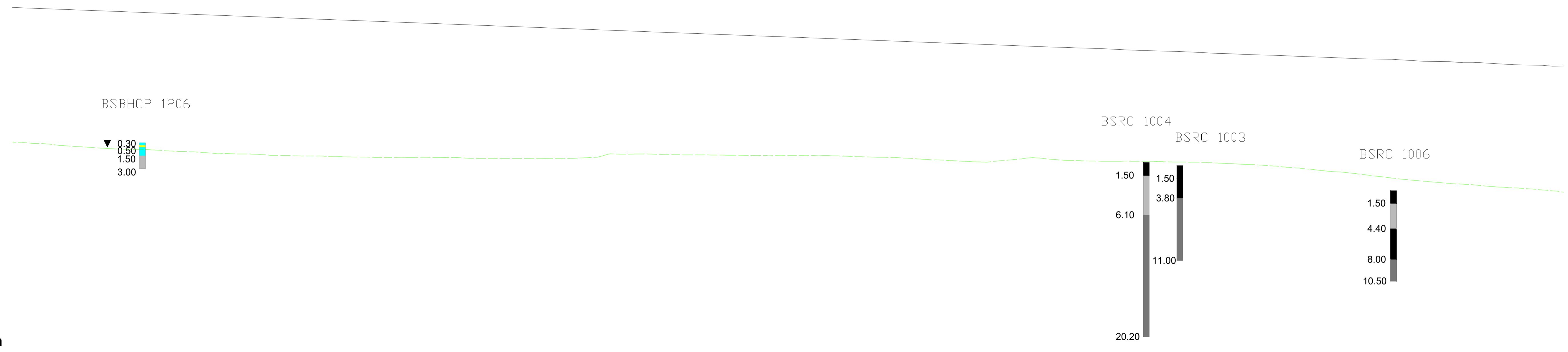
PLAN

- CABLE PERCUSSIVE/ ROTARY CORE BOREHOLE
- TRIAL PIT
- GEOPHYSICS PROFILE LINE

PROFILE

- TOPSOIL
- CLAY
- SILT
- SAND
- GRAVEL
- ROCK
- NO RECOVERY

- PIEZOMETER / STANDPIPE MEASUREMENT
- WATER STRIKE
- WATER LEVEL 20 MINUTES AFTER STRIKE
- EXISTING GROUND LEVEL
- PROPOSED LEVEL
- N = N-VALUE



CHAINAGE	2150.000	2160.000	2170.000	2180.000	2190.000	2200.000	2210.000	2220.000	2230.000	2240.000	2250.000	2260.000	2270.000	2280.000	2290.000	2300.000	2310.000	2320.000	2330.000
PROPOSED LEVEL	45.482	45.101	44.720	44.339	43.959	43.578	43.197	42.816	42.436	42.055	41.674	41.294	40.913	40.532	40.151	39.771	39.390	39.009	38.628
EXISTING LEVEL	45.482	45.101	44.720	44.339	43.959	43.578	43.197	42.816	42.436	42.055	41.674	41.294	40.913	40.532	40.151	39.771	39.390	39.009	38.628

LONG SECTION
Scale: 1/250 @ A1 , 1/500 @ A3

M:\a1w-Bip-10\11\Work_Tranport\MGT0337 - Ten-T Priority Route Imp - Donegal\0 Drawings\Phase 3\ITT_MGT0337-RPS-P3-S1-DR-C-GI0002 River Finn crossing.dwg

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	08.04.21	JOC	ISSUE FOR INFORMATION	KC	CMcG

Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13

Drawing Title: FINN CROSSING

Designed: KC Date: APRIL 2021 Model File Identifier: N/A

Drawn: JOC Scale @ A1: As Shown @ A3: As Shown File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-GI0002

Checked: CMcG Sheet: 02 of 07

Status: S2

Rev: P01

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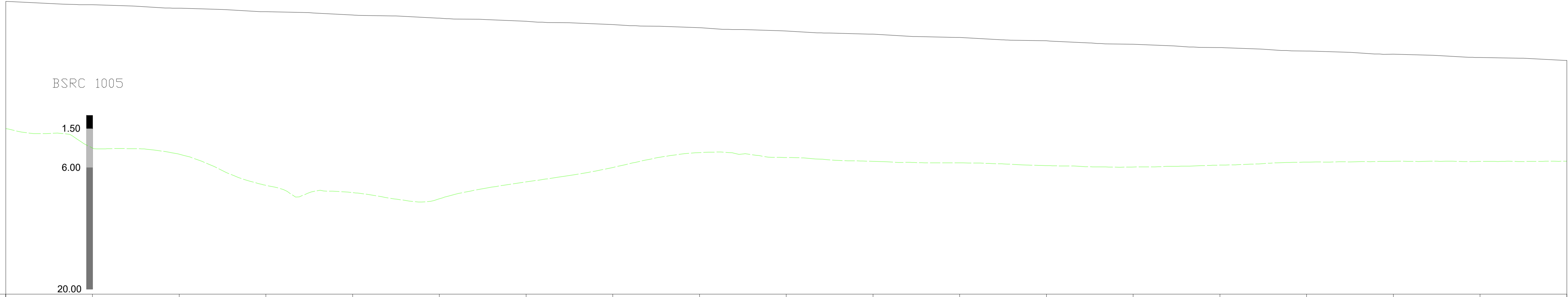
PLAN

- CABLE PERCUSSIVE/ ROTARY CORE BOREHOLE
- TRIAL PIT
- GEOPHYSICS PROFILE LINE

PROFILE

- TOPSOIL
- CLAY
- SILT
- SAND
- GRAVEL
- ROCK
- NO RECOVERY

- PIEZOMETER / STANDPIPE MEASUREMENT
- WATER STRIKE
- WATER LEVEL 20 MINUTES AFTER STRIKE
- EXISTING GROUND LEVEL
- PROPOSED LEVEL
- N = N-VALUE



CHAINAGE	2330.000	2340.000	2350.000	2360.000	2370.000	2380.000	2390.000	2400.000	2410.000	2420.000	2430.000	2440.000	2450.000	2460.000	2470.000	2480.000	2490.000	2500.000	2510.000
PROPOSED LEVEL	38.628	38.248	37.867	37.486	37.106	36.725	36.344	35.963	35.583	35.202	34.821	34.440	34.060	33.679	33.298	32.920	32.558	32.215	31.889
EXISTING LEVEL	38.628	38.248	37.867	37.486	37.106	36.725	36.344	35.963	35.583	35.202	34.821	34.440	34.060	33.679	33.298	32.920	32.558	32.215	31.889

LONG SECTION
 Scale: 1/250 @ A1 , 1/500 @ A3

M:\a1w-Bip-10\1\Work_Transport\MGT0337 - Ten-T Priority Route Imp - Donegal\0 Drawings\Phase 3\GITTT_MGT0337-RPS-P3-S1-DR-C-GI0002 River Finn crossing.dwg

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	08.04.21	JOC	ISSUE FOR INFORMATION	KC	CMcG

Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13		Drawing Title: FINN CROSSING		Status: S2
Designed: KC	Date: APRIL 2021	Model File Identifier: N/A		Rev: P01
Drawn: JOC	Scale @ A1: As Shown	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-GI0002		
Approved: KC	@ A3: As Shown			
Checked: CMcG	Sheet: 03 of 07			

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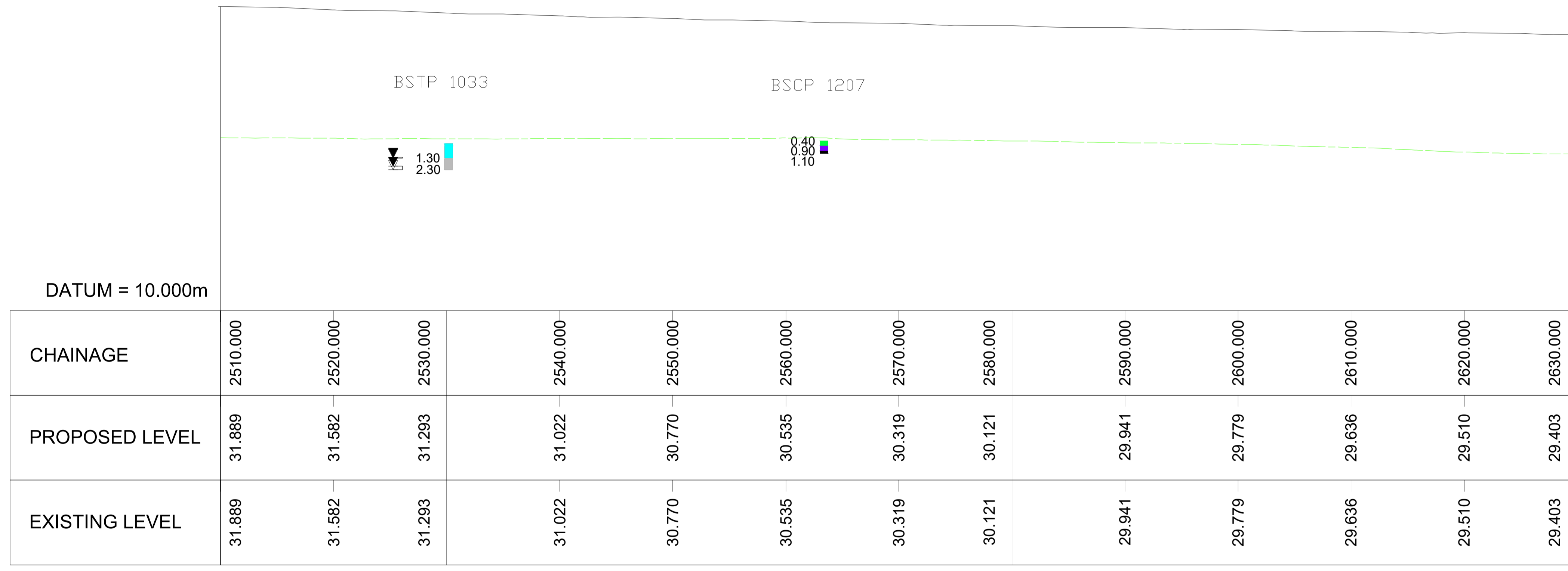
PLAN

- CABLE PERCUSSIVE/ ROTARY CORE BOREHOLE
- TRIAL PIT
- GEOPHYSICS PROFILE LINE

PROFILE

- TOPSOIL
- CLAY
- SILT
- SAND
- GRAVEL
- ROCK
- NO RECOVERY

- PIEZOMETER / STANDPIPE MEASUREMENT
- WATER STRIKE
- WATER LEVEL 20 MINUTES AFTER STRIKE
- EXISTING GROUND LEVEL
- PROPOSED LEVEL
- N = N-VALUE



LONG SECTION
Scale: 1/250 @ A1 , 1/500 @ A3

M:\a1w-Bip-10\11\Work_Transport\MGT0337 - Ten-T Priority Route Imp - Donegal\0 Drawings\Phase 3\GITTT_MGT0337-RPS-P3-S1-DR-C-GI0002 River Finn crossing.dwg

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	08.04.21	JOC	ISSUE FOR INFORMATION	KC	CMcG

Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13

Drawing Title: FINN CROSSING

Designed: KC
Drawn: JOC
Approved: KC
Checked: CMcG

Date: APRIL 2021
Scale @ A1: As Shown
@ A3: As Shown
Sheet: 04 of 07

Model File Identifier: N/A
File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-GI0002

Status: S2
Rev: P01

LEGEND

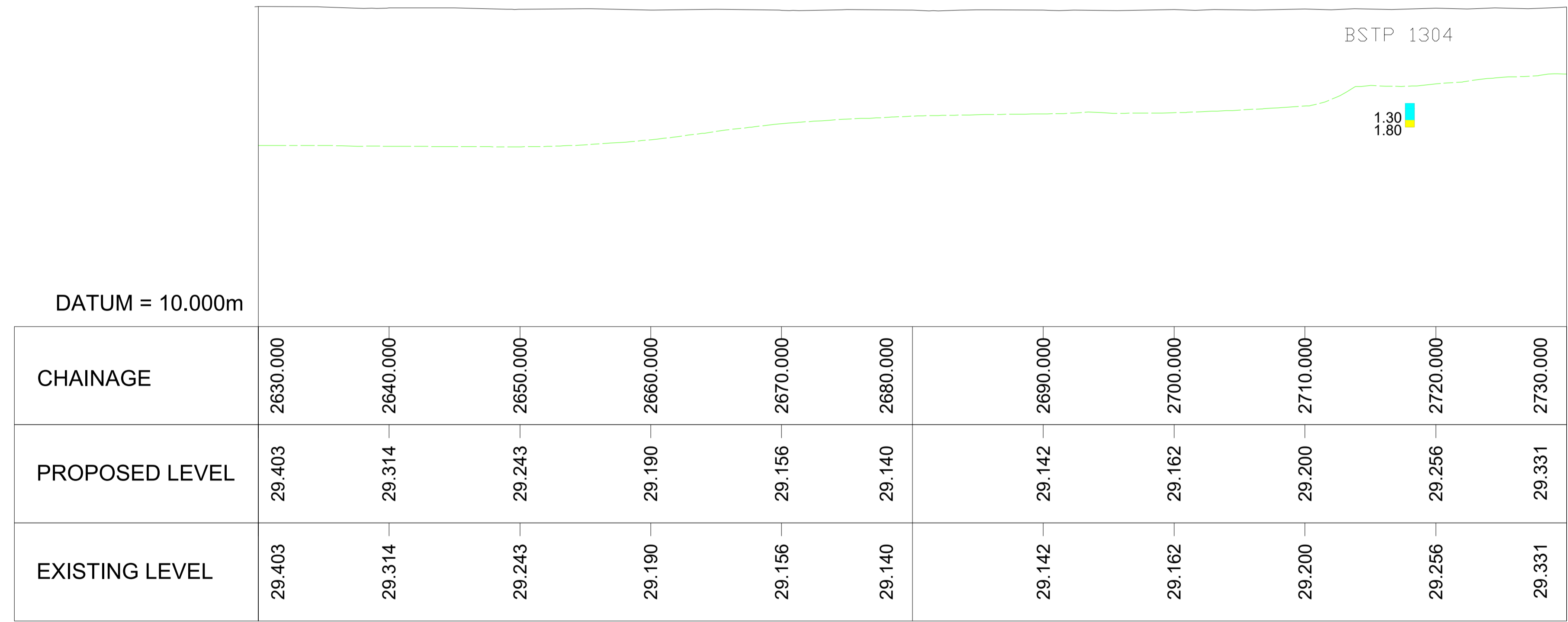
PLAN

- CABLE PERCUSSIVE/ ROTARY CORE BOREHOLE
- TRIAL PIT
- GEOPHYSICS PROFILE LINE

PROFILE

- TOPSOIL
- CLAY
- SILT
- SAND
- GRAVEL
- ROCK
- NO RECOVERY

- PIEZOMETER / STANDPIPE MEASUREMENT
- WATER STRIKE
- WATER LEVEL 20 MINUTES AFTER STRIKE
- EXISTING GROUND LEVEL
- PROPOSED LEVEL
- N = N-VALUE



LONG SECTION
Scale: 1/250 @ A1 , 1/500 @ A3

M:\Gallw-Bip-10\11\Work_Transport\MGT0337 - Ten-T Priority Route Imp - Donegal\0 Drawings\Phase 3\GINTT_MGT0337-RPS-P3-S1-DR-C-GI0002 River Finn crossing.dwg

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NOTES

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Rev.	Date	Drawn	Description	Chk'd	Appr.
P01	08.04.21	JOC	ISSUE FOR INFORMATION	KC	CMcG

Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13		
Drawing Title: FINN CROSSING		Status: S2
Designed: KC	Date: APRIL 2021	Model File Identifier: N/A
Drawn: JOC	Scale @ A1: As Shown	Rev: P01
Approved: KC	@ A3: As Shown	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-GI0002
Checked: CMcG	Sheet: 05 of 07	



TRIAL PIT LOG

Pit No.
BSBHCP1206
Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 11/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612355	Equipment:	Orientation: 230°
Location:	Donegal	Northing:	894839	Zaxis 130 LCN	Pit Length: 4.20 m
Client:	Donegal NRDO	Ground Level (mAOD):	29.79	Logged By: PC	Pit Width: 1.70 m
					Scale: 1:25

Backfill	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
					0.00		29.79	Grass and moss over firm damp dark brown SILT. (SILT)		
	▼	0.50 - 1.00	B1		0.30	(0.30)	29.49	Orangish grey gravelly fine to medium SAND with low cobble content and low boulder content. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded of psammite. Boulders are subrounded of psammite. Boulders are up to 1000mm in length. (SAND)		
					0.50	(0.20)	29.29		Soft damp brownish orange gravelly SILT with medium cobble content and low boulder content. Gravel is subangular to subrounded fine to coarse of schist and psammite. Cobbles are subrounded of schist and psammite. Boulders are up to 450mm in length. (SILT)	1
		1.50 - 2.00	B2		1.50	(1.00)	28.29	Damp bluish grey silty sandy subangular to subrounded fine to coarse psammite and gneiss GRAVEL with medium cobble content and low boulder content. Cobbles are subrounded to subangular of psammite schist and gneiss. Boulders are subangular to subrounded of psammite and gneiss. Boulders are up to 500mm in length. (GRAVEL)	2	
					3.00	(1.50)	26.79	TP terminated at 3.00m bgl. Obstruction as probable rock. (.) End of Pit at 3.00m	3	
									4	
									5	

Remarks: Damp from 0.50m to 3.00m bgl. TP backfilled with arisings.

Groundwater:

Stability: Pit unstable. Sidewall collapse from 1.50m bgl.





BOREHOLE LOG

Borehole No.

BSCP1207

Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 04/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612624	Drilling Method:	
Location:	Donegal	Northing:	895131	Dando 2000	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	20.01	Logged By: BT	

Well	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
		0.00 - 0.90	B1		0.00	(0.40)	20.01		TOPSOIL: Grass over firm dry brown CLAY. (TOPSOIL)	
					0.40	(0.50)	19.61		Stiff brown sandy CLAY with cobbles. (CLAY)	
		0.90	CPT3		0.90	(0.20)	19.11		Obstruction as possible rock. (BEDROCK)	1
		0.90	D2		1.10		18.91		BH terminated at 1.10m bgl - obstruction as possible rock.()	
		0.90	SPT()	N = 75					End of Borehole at 1.10m	

Remarks: BH backfilled.	Groundwater			Chiselling			
	Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Duration (hh:mm)	Top Depth (m)	Base Depth (m)	
				00:00	0.90	1.10	



BOREHOLE LOG

Borehole No.

BSCP1208

Sheet 1 of 1

Project Name:	Ballybofey Stranolar TenT	Co-ordinates:	Date(s): 03/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612929	Drilling Method:	
Location:	Donegal	Northing:	895307	Dando 2000	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	20.07	Logged By: BT	

Well	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
		0.00 - 0.80	B1		0.00	(0.30)	20.07		TOPSOIL: Grass over blackish brown CLAY. (TOPSOIL)	
					0.30		19.77		Angular COBBLES and BOULDERS. (COBBLES AND BOULDERS)	
		0.80	CPT3							
		0.80	D2							
		1.00	SPT()	N = 28	1.00	(0.20)	19.07		Obstruction as possible rock. (BEDROCK)	1
					1.20		18.87		BH terminated at 1.20m bgl - obstruction as possible rock.()	
									End of Borehole at 1.20m	
		2.00	SPT()	N = 61						2
										3
										4
										5
										6
										7
										8
										9
										10

Remarks:
BH backfilled.

Groundwater			Chiselling		
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Duration (hh:mm)	Top Depth (m)	Base Depth (m)
			00:00	0.90	1.20





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1003

Sheet 1 of 2

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 20/05/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612436	Drilling Method:	11.00m
Location:	Donegal	Northing:	894923	Hydreq	Casing Diameter (mm)
Client:	Donegal NRDO	Ground Level (mAOD):	27.14	Logged By:	EAT
					Scale:
					1:50

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		0.00 – 1.50	0				0.00	(1.50)	27.14		Open hole drilling - no recovery.()	1
		1.50 – 3.00	40				1.50	(2.30)	25.64		Weathered PHYLLITE rock. Recovered as angular fine to coarse gravel and cobble sized clasts of strong and medium strong thinly foliated bluish grey fine and medium grained phyllite. (BEDROCK)	2
		3.00 – 4.50	53	34	27		3.80		23.34		Very strong thinly foliated bluish grey fine and medium grained PHYLLITE with fine and medium gravel sized white quartz globules. (ROCK)	4
		4.50 – 5.50	60	24	0							5
		5.50 – 6.60	72	20	0							6
		6.60 – 8.20	100	95	93			(7.20)				7
		8.20 – 9.70	100	94	81							9
												10

Continued on next sheet

Remarks:
BH backfilled.

Groundwater

Drilling Progress

Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			11.00	





ROTARY CORE BOREHOLE LOG

Borehole No.
BSRC1003
Sheet 2 of 2

Project Name: Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 20/05/2020		Final Depth:
Project No: MGT0337 Ballybofey	Easting: 612436	Drilling Method:	11.00m	
Location: Donegal	Northing: 894923	Hydreq	Casing Diameter (mm)	Casing Depth (m)
Client: Donegal NRDO	Ground Level (mAOD): 27.14	Logged By: EAT	Scale: 1:50	

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		9.70 – 11.00	100	96	86		11.00		16.14		BH terminated at 11.00m bgl on REs instruction. End of Borehole at 11.000m	11
												12
												13
												14
												15
												16
												17
												18
												19
												20

Remarks:
BH backfilled.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			11.00	





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1004

Sheet 1 of 3

Project Name: Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 25/03/2020 - 26/03/2020		Final Depth:
Project No: MGT0337 Ballybofey	Easting: 612419	Drilling Method:	20.20m	
Location: Donegal	Northing: 894938	Hydreq	Casing Diameter (mm)	Casing Depth (m)
Client: Donegal NRDO	Ground Level (mAOD): 27.49	Logged By: EAT	Scale: 1:50	

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		0.00 - 1.50	0				0.00	(1.50)	27.49		Open hole drilling - no recovery.()	
		1.50 - 3.00	40				1.50		25.99		Subangular to subrounded fine to coarse assorted metamorphic GRAVEL with cobbles and boulders. Cobbles are of assorted metamorphic clasts. (GRAVEL)	
		3.00 - 4.50	53				3.00	(4.60)	24.49			
		4.50 - 6.00	40				4.50					
		6.00 - 7.50	100	89	63		6.10		21.39		Core Run - 3.00m to 4.50m: 1 No grey phyllite boulder 330mm in length.() Very strong thinly foliated bluish grey fine and medium grained PHYLLITE with fine to coarse gravel sized white quartz globules. (ROCK)	
		7.50 - 9.00	100	86	75							
		9.00 - 10.50	100	97	87							
							10.00		17.49			
			TCR	SCR	RQD	Fractures					Continued on next sheet	

Remarks: 50mm standpipe installed. Response zone - 5.50m to 20.20m bgl.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			6.00 20.20	





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1004

Sheet 2 of 3

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 25/03/2020 - 26/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612419	Drilling Method:	20.20m
Location:	Donegal	Northing:	894938	Hydreq	Casing Diameter (mm) Casing Depth (m)
Client:	Donegal NRDO	Ground Level (mAOD):	27.49	Logged By:	EAT
					Scale:
					1:50

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
											10.00m to 10.45m: strong displaying a well developed schistosity. BH terminated at 20.20m bgl on REs instruction.	
		10.50 – 12.00	100	85	61							
		12.00 – 13.50	100	95	82							
		13.50 – 15.00	100	87	75							
		15.00 – 16.50	100	93	65		(14.10)					
		16.50 – 18.00	100	92	63							
		18.00 – 19.50	100	97	96							
		19.50 – 20.20	100	96	49							

Continued on next sheet

Remarks: 50mm standpipe installed. Response zone - 5.50m to 20.20m bgl.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			6.00 20.20	





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1004

Sheet 3 of 3

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 25/03/2020 - 26/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612419	Drilling Method:	20.20m
Location:	Donegal	Northing:	894938	Hydreq	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	27.49	Logged By:	EAT 1:50
				Casing Diameter (mm)	Casing Depth (m)

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
							20.20		7.29		End of Borehole at 20.200m	21 22 23 24 25 26 27 28 29 30
			TCR	SCR	RQD	Fractures						

Remarks:
50mm standpipe installed. Response zone - 5.50m to 20.20m bgl.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			6.00 20.20	





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1005

Sheet 1 of 3

Project Name: Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 21/05/2020 - 22/05/2020		Final Depth:
Project No: MGT0337 Ballybofey	Easting: 612504	Drilling Method:	20.00m	
Location: Donegal	Northing: 894937	Hydreq	Casing Diameter (mm)	Casing Depth (m)
Client: Donegal NRDO	Ground Level (mAOD): 25.55	Logged By: EAT	Scale: 1:50	

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		0.00 – 1.50	0				0.00	(1.50)	25.55		Open hole drilling - no recovery.()	
		1.50 – 3.00	40				1.50	(4.50)	24.05		Dense subangular to subrounded fine to coarse assorted metamorphic GRAVEL. (GRAVEL)	1
		3.00 – 4.50	40									2
		4.50 – 6.00	40									3
		6.00 – 7.50	100	60	29		6.00		19.55		Very strong thinly foliated grey fine and medium grained PHYLLITE with fine and medium gravel sized white quartz globules. (ROCK)	4
		7.50 – 9.00	100	94	54							5
		9.00 – 10.50	100	73	61							6
			TCR	SCR	RQD	Fractures						7
												8
												9
												10

Continued on next sheet

Remarks: 50mm standpipe installed. Response zone - 4.50m to 20.00m bgl.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			20.00	





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1005

Sheet 2 of 3

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 21/05/2020 - 22/05/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612504	Drilling Method:	20.00m
Location:	Donegal	Northing:	894937	Hydreq	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	25.55	Logged By:	EAT
				Casing Diameter (mm)	Casing Depth (m)
					1:50

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		10.50 – 12.00	100	62	36							11
		12.00 – 13.50	100	45	11						12	
		13.50 – 15.00	100	89	44						13	
		15.00 – 16.50	100	95	82		(14.00)				14	
		16.50 – 18.00	100	92	63						15	
		18.00 – 20.00	100	82	63						16	
												17
											18	
												19
							20.00		5.55		Continued on next sheet	20

Remarks: 50mm standpipe installed. Response zone - 4.50m to 20.00m bgl.	Groundwater			Drilling Progress		
	Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks	
				20.00		



ROTARY CORE BOREHOLE LOG

Borehole No.
BSRC1005
Sheet 3 of 3

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 21/05/2020 - 22/05/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612504	Drilling Method:	20.00m
Location:	Donegal	Northing:	894937	Hydreq	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	25.55	Logged By:	EAT 1:50
				Casing Diameter (mm)	Casing Depth (m)

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
											BH terminated at 20.00m bgl on REs instruction. End of Borehole at 20.000m	21 22 23 24 25 26 27 28 29 30
			TCR	SCR	RQD	Fractures						

Remarks:
50mm standpipe installed. Response zone - 4.50m to 20.00m bgl.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			20.00	





ROTARY CORE BOREHOLE LOG

Borehole No.

BSRC1006

Sheet 1 of 2

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 18/05/2020		Final Depth:		
Project No:	MGT0337 Ballybofey	Easting:	612422	Drilling Method:		10.50m	
Location:	Donegal	Northing:	894974	Hydreq	Casing Diameter (mm)	Casing Depth (m)	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	24.25	Logged By:	EAT	1:50	

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		0.00 – 1.50	0				0.00	(1.50)	24.25		Open hole drilling - no recovery.()	1
		1.50 – 3.00	33				1.50	(2.90)	22.75		Medium dense subangular to subrounded fine to coarse assorted metamorphic GRAVEL with a little brown silt. (GRAVEL)	2
		3.00 – 4.50	67	0	0		4.40		19.85		Weathered PHYLLITE rock. Recovered as angular fine to coarse gravel and cobble sized clasts of strong and medium strong thinly foliated grey fine and medium grained phyllite. (BEDROCK)	3
		4.50 – 6.00	60	8	0		8.00	(3.60)	16.25		Very strong thinly foliated bluish grey fine grained PHYLLITE. (ROCK)	4
		6.00 – 7.50	100	69	12							5
		7.50 – 9.00	100	72	57							6
		9.00 – 10.50	100	83	23			(2.50)				7
												8
												9
												10

Continued on next sheet

Remarks:
BH backfilled.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			10.50	





ROTARY CORE BOREHOLE LOG

Borehole No.
BSRC1006
Sheet 2 of 2

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 18/05/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612422	Drilling Method:	10.50m
Location:	Donegal	Northing:	894974	Hydreq	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	24.25	Logged By: EAT	1:50

Well	Water Strike(s)	Core Depth (m)	TCR	SCR	RQD	Fractures	Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
							10.50		13.75		BH terminated at 10.50m bgl on REs instruction. End of Borehole at 10.500m	11 12 13 14 15 16 17 18 19 20
			TCR	SCR	RQD	Fractures						

Remarks:
BH backfilled.

Groundwater			Drilling Progress	
Depth Strike (m)	Depth Casing (m)	Level After 20 Mins	Depth	Remarks
			10.50	





TRIAL PIT LOG

Pit No.
BSTP1031
Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 11/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612291	Equipment:	Orientation: 220°
Location:	Donegal	Northing:	894747	Zaxis 130 LCN	Pit Length: 6.00 m
Client:	Donegal NRDO	Ground Level (mAOD):	38.37	Logged By: PC	Pit Width: 1.60 m
					Scale: 1:25

Backfill	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
					0.00		38.37		Grass over firm damp brown gravelly SILT with low cobble content. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded of schist and pelite. (SILT)	
		0.50 - 1.00	B1		0.30	(0.30)	38.07		Soft greyish brown gravelly sandy SILT with low cobble content and low boulder content. Sand is fine. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded. Boulders are subrounded of pelite and schist. Boulders are up to 400mm in length. (SILT)	
					0.50	(0.80)	37.87			
		1.10 - 1.60	B2		1.10	(0.50)	37.27		0.50m: stone drain. Damp light brown sandy silty fine to coarse schist and pelite GRAVEL with medium cobble content and low boulder content. Sand is fine to medium. Cobbles are subrounded of schist. Boulders are subangular to subrounded of schist and pelite. Boulders are up to 600mm in length. (GRAVEL)	1
					1.60		36.77		TP terminated at 1.60m bgl - obstruction as probable rock.() End of Pit at 1.60m	2
										3
										4
										5

Remarks: Ingress of water at 1.60m bgl. TP backfilled with arisings.

Groundwater:

Stability: Pit stable.





TRIAL PIT LOG

Pit No.
BSTP1032

Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 11/03/2020		Final Depth: 1.20m
Project No:	MGT0337 Ballybofey	Easting:	612294	Equipment:	
Location:	Donegal	Northing:	894829	Zaxis 130 LCN	Pit Length: 4.00 m
Client:	Donegal NRDO	Ground Level (mAOD):	30.69	Logged By: PC	Pit Width: 1.50 m
					Scale: 1:25

Backfill	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
					0.00		30.69		Grass over firm brown gravelly SILT with low boulder content and rootlets. Gravel is subangular to subrounded fine to coarse of schist and psammite. Boulders are subrounded of psammite. Boulders are up to 600mm in length.	
					0.25	(0.25)	30.44		(SILT)	
		0.50 - 1.00	B1		0.40	(0.15)	30.29		Light greyish brown gravelly fine to medium SAND. Gravel is subangular to subrounded fine to coarse of schist pelite and quartz.	
						(0.80)			Moist light brown silty sandy subangular to subrounded fine to coarse schist and psammite GRAVEL with low cobble content and low boulder content. Sand is fine to medium. Cobbles are subrounded of psammite and gneiss. Boulders are subangular to subrounded of psammite and gneiss. Boulders are up to 900mm in length.	1
					1.20		29.49		TP terminated at 1.20m bgl - obstruction as probable rock.()	
									End of Pit at 1.20m	2
										3
										4
										5

Remarks: Ingress of water at 0.50m bgl. TP backfilled with arisings.

Groundwater:

Stability: Pit stable.





TRIAL PIT LOG

Pit No.
BSTP1033

Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 06/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612622	Equipment:	2.30m
Location:	Donegal	Northing:	895081	Zaxis 130 LCN	Scale:
Client:	Donegal NRDO	Ground Level (mAOD):	19.77	Logged By: PC	1:25
			Pit Length: 3.80 m		
			Pit Width: 1.50 m		

Backfill	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
					0.00	(0.20)	19.77	Grass over firm brown gravelly SILT. Gravel is subrounded to rounded fine to medium of pelite. (SILT)		
		0.50 - 1.00	B1		0.20	(1.10)	19.57	Soft reddish brown gravelly sandy SILT with medium cobble content and low boulder content. Sand is fine. Gravel is subrounded to rounded. Boulders are subrounded to rounded of pelite and psammite. Boulders are up to 1000mm in length. (SILT)		
	▼	1.30 - 1.80	B2		1.30	(1.00)	18.47	Wet brown sandy subrounded to rounded fine to coarse pelite and psammite GRAVEL with medium cobble content and low boulder content. Sand is medium to coarse. Cobbles are subrounded to rounded of pelite and psammite. Boulders are up to 800mm in length. (GRAVEL)		
	▼				2.30		17.47	TP terminated at 2.30m bgl. Unable to progress TP due to ingress of water.()		
	▼							End of Pit at 2.30m		

Remarks: Ingress of water at 1.30m bgl. Ingress of water at 2.30m bgl. TP backfilled with arisings.

Groundwater:

Stability: Pit stable.





TRIAL PIT LOG

Pit No.
BSTP1034
Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 06/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612760	Equipment:	Orientation: 130°
Location:	Donegal	Northing:	895206	Zaxis 130 LCN	Pit Length: 4.00 m
Client:	Donegal NRDO	Ground Level (mAOD):	22.06	Logged By: PC	Pit Width: 1.50 m
					Scale: 1:25

Backfill	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
					0.00		22.06		Grass over firm brown SILT with rootlets. (SILT)	
		0.50 - 1.00	B1		0.40	(0.40)	21.66		Soft orangish brown gravelly sandy SILT with low cobble content and low boulder content. Sand is fine. Gravel is subangular to subrounded fine to coarse of pelite. Cobbles are subrounded of pelite. Boulders are subrounded to rounded of pelite. Boulders are up to 500mm in length. (SILT)	1
		1.30 - 1.80	B2		1.30	(0.50)	20.76		Light brown gravelly silty fine SAND with medium cobble content and low boulder content. Gravel is subangular to subrounded fine to coarse of pelite. Cobbles are subangular to subrounded of pelite. Boulders are subrounded to rounded of pelite. (SAND)	2
					1.80		20.26		TP terminated at 1.80m bgl - obstruction as probable rock.() End of Pit at 1.80m	3
										4
										5

Remarks: TP dry on excavation. TP backfilled with arisings.

Groundwater:

Stability: Pit stable.





TRIAL PIT LOG

Pit No.
BSTP1035
Sheet 1 of 1

Project Name:	Ballyboffey Stranolar TenT	Co-ordinates:	Date(s): 06/03/2020		Final Depth:
Project No:	MGT0337 Ballybofey	Easting:	612821	Equipment:	Orientation: 60°
Location:	Donegal	Northing:	895284	Zaxis 130 LCN	Pit Length: 4.00 m
Client:	Donegal NRDO	Ground Level (mAOD):	22.57	Logged By: PC	Pit Width: 1.50 m
					Scale: 1:25

Backfill	Water Strike(s)	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale
		Depth (m)	Type	Results						
					0.00		22.57		Grass over firm brown gravelly SILT. Gravel is subrounded to rounded fine to coarse. (SILT)	
		0.50 - 1.00	B1		0.40	(0.40)	22.17		Orangish brown silty sandy subangular to rounded fine to coarse GRAVEL with low cobble content and low boulder content. Sand is fine to coarse. Cobbles are subangular to subrounded of pelite. Boulders are subangular to subrounded of pelite. Boulders are up to 400mm in length. (GRAVEL)	
					1.10		21.47		TP terminated at 1.10m bgl - obstruction. End of Pit at 1.10m	

Remarks: Ingress of water at 1.10m bgl. TP backfilled with arisings.

Groundwater:

Stability: Pit stable.



APPENDIX 3: COST ESTIMATE

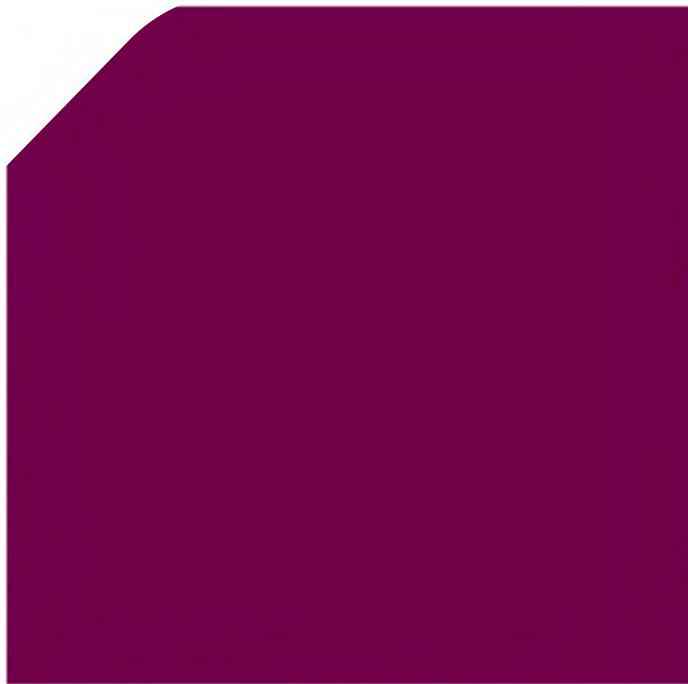
Cost Estimate for Ten-T Priority Route Improvement Project, Donegal: Finn Crossing Bridge Options

Option	Width	Length	Deck Area	Rate ex VAT	Sub-Total	10% Contingency for high level cost estimate	Total Cost
	m	m	m2	€/m2	€	€	€
1	26.5	360	9540	€ 3,500	€ 33,390,000	€ 3,339,000	€ 36,729,000
2	26.5	360	9540	€ 3,250	€ 31,005,000	€ 3,100,500	€ 34,105,500
3	26.5	360	9540	€ 3,864	€ 36,859,091	€ 3,685,909	€ 40,545,000
4	26.5	360	9540	€ 4,091	€ 39,027,273	€ 3,902,727	€ 42,930,000
5	26.5	360	9540	€ 6,000	€ 57,240,000	€ 5,724,000	€ 62,964,000

Rate ex VAT (incl contingency)
€/m2
€ 3,850
€ 3,575
€ 4,250
€ 4,500
€ 6,600

APPENDIX 4: CLIMATE ASSESSMENT

MGT0337 TEN-T - RIVER FINN BRIDGE CLIMATE ASSESSMENT



MGT0337
D02
25th January 2022

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1 SUMMARY

This report details the climate assessment of two proposed options for the River Finn bridge crossing. The project is currently at Phase 3 Design & Environmental Evaluation. As part of this phase, a number of design options for the River Finn crossing have been shortlisted for further evaluation. Specifically, this climate assessment is focussed on two of the shortlisted bridge options:

- BR0122 Option 2 – weathering steel multi-girder
- BR0123 Option 3 – post-tensioned concrete box

This climate assessment has been carried out using the Transport Infrastructure Ireland (TII) Carbon Tool, which is TII's proprietary software for carrying out carbon assessments on road and rail infrastructure projects. The Tool uses a combination of default assumptions and user-defined inputs to generate an estimated, carbon footprint for the project.

The results of this options comparison assessment are set out in **Table 1-1** below.

Table 1-1: Total Carbon Emissions by Life Cycle Stage (kgCO₂e)

Name	Before Use (kgCO ₂ e)			Use (kgCO ₂ e)	Total (kgCO ₂ e)
	Pre-Construction	Embodied Carbon	Construction Activities	Use	
Option 2 - Multigirder BR0122	474.51	10,064,539.98	363,480.00	229,637.02	10,658,131.51
Option 3 - Concrete Box BR0123	474.51	5,939,848.87	419,400.00	229,637.02	6,589,360.40

Overall, Option 3 – Concrete Box BR0123 is the preferred option from a climate perspective. This is mainly due to the lower embodied carbon of the materials. Option 2 – Multigirder BR0122 uses steel extensively in its design. Steel, as a material, has a high carbon footprint due to the energy required in extracting raw materials, processing and manufacturing the final product. Additionally, the type of structural steel used in bridge building is usually imported from other countries due to lack of manufacturing in Ireland. This adds higher transport emissions to the embodied carbon footprint, compared to sourcing materials closer to the site.

Comparatively, Option 3 relies mostly on structural concrete in its construction. This can be sourced within Ireland, which lowers transport emissions. More importantly, structural concrete has a lower carbon footprint than steel, even when rebar is included. The use of concrete over steel is the main reason why Option 3 has a lower carbon footprint than Option 2, therefore it is the preferred option.

2 RESULTS

TII’s Carbon Tool has been used to estimate and compare the carbon footprint of two crossing options over the River Finn. The tool has been specifically developed to model carbon emissions associated with large-scale infrastructure projects for TII. Reporting units are presented in equivalent kilograms of carbon dioxide (hereafter kgCO_{2e}). The results of the analysis are set out below.

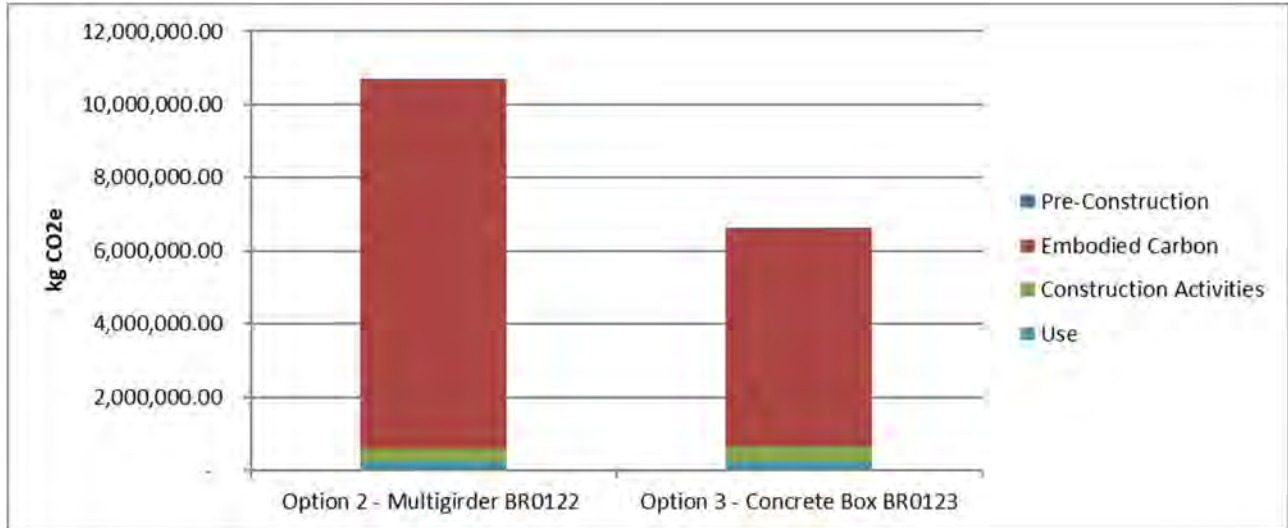


Figure 2-1: Total Carbon Emissions by Life Cycle Stage (kgCO_{2e})

Table 1-1 and **Figure 2-1** above show the total carbon emissions for Option 1 and Option 2 by life cycle stage. The results are presented by life cycle stage to emphasise where carbon is being generated for each option.

Overall, Option 2 (steel multigirder structure) is shown to have a greater carbon footprint than Option 3 (post-tensioned concrete box structure). Option 2 will generate a total of 10,658,131.51 kgCO_{2e} over its life cycle. Option 3 will generate a total of 6,589,360.40 kgCO_{2e} over the same period. This represents a difference of 4,068,771.11 kgCO_{2e}, or 38% fewer emissions for Option 3 versus Option 2.

Option 3 has a significantly lower carbon footprint than Option 2. This is mainly due to the lower carbon footprint of materials needed to construct this option. This is reflected in the ‘Embodied Carbon’ emissions in the graph above. Also, the ‘Construction Activities’ emissions for Option 3 are slightly lower than Option 2, which is due to less energy and resource consumption during the construction programme. These differences are further detailed in the following **Section 3**.

3 DISCUSSION

The results of the carbon assessments are split by life cycle stage in the following sections.

3.1 Before Use – Pre-Construction

The pre-construction impacts for both options are identical at 474.51 kgCO₂e. This is due to the same assumptions being applied to both options for site clearance activities (further detail in **Section 4** below). The pre-construction emissions capture the impact of site clearance activities, such as fuel use of heavy plant and other associated energy required to clear the site for construction. These assumptions may be refined as the project develops and more data becomes available e.g. water usage for site clearance and significant land use change.

3.2 Before Use – Embodied Carbon

The embodied carbon emissions represent the impact of construction materials and the transport of these materials to site. Typically, this life cycle stage has the largest carbon footprint of all stages in an infrastructure project. This is also the case for this assessment; Option 2 has an embodied carbon footprint of 10,064,539.98 kgCO₂e and Option 3 has an embodied carbon footprint of 5,939,848.87kgCO₂e. This is a difference of 4,124,691.11 kgCO₂e, or 41% fewer emissions for Option 3 versus Option 2.

3.2.1 Option 2

Option 2 is designed as a multi-girder steel structure. Steel has a high carbon footprint due to the energy required to extract, process and manufacture the raw materials into a final product. Steel has the highest embodied carbon emissions of all materials used for this option, at 7,909,809.80 kgCO₂e. As a proportion, steel alone is responsible for 79% of embodied carbon emissions for Option 2. This carbon footprint also contains emissions as a result of reinforcement for concrete elements (i.e. rebar). However, it is the structural steel beams and columns which result in the highest carbon emissions.

The material with the second highest carbon footprint is structural concrete. Structural concrete is used for elements such as piling, piers, abutments, wingwalls and the bridge deck for this option. The carbon footprint of structural concrete for Option 2 is 1,653,865.40 kgCO₂e, or 16% of embodied carbon emissions.

3.2.2 Option 3

Option 3 is designed as a post-tensioned concrete box structure. As a result, concrete has the largest carbon footprint of all materials used. In addition to the concrete elements listed for Option 2 above (piles, piers, etc.), Option 3 also requires concrete for the main box of the structure. The quantity of concrete required for Option 3 is significantly higher than Option 2. The carbon footprint of concrete used in the design amounts to 2,905,527.80 kgCO₂e, which is 52% of embodied carbon emissions.

Option 3 also makes use of steel in its design, but only in the form of reinforcement for the concrete elements. The carbon footprint of rebar in the design is 2,500,027 kgCO₂e, or 42% of total, embodied carbon emissions.

3.2.3 Option 2 and 3

A series of assumptions are made to estimate the carbon footprint of the remaining materials needed for each structure. Pavement layers and surfacing are assumed to be the same for both options, given that both options are the same length and width. Bridge deck waterproofing, buried concrete waterproofing, parapets and rubbing strips are also assumed to be the same for both options. These materials are not discussed in further detail in this section, as their associated emissions do not contribute to the option comparison process. For further detail on assumptions made for these materials, see **Section 4**.

3.3 Before Use – Construction Activities

The construction activities section of the tool captures carbon emissions associated with the construction phase of the project. These emissions are typically comprised of fuel, electricity and water usage on site during the construction phase, as well as more granular impacts such as employee travel to site. Given the preliminary design stage of this project, these data are not available nor have any estimates been made around these impacts. Therefore, the default calculation in the Tool is used to estimate the carbon footprint of the construction stage.

The Tool estimates construction emissions based on the size of the project and also its expected duration. Both Option 2 and Option 3 are assumed to be 'Very Large (construction cost > €10m, more than 25 people permanently on site)' as per TII definition in the Tool. As per Chapter 11 Construction and Buildability of the main report, the construction period for Option 2 is estimated at 104 weeks and for Option 3, 120 weeks. Using the TII calculation parameters, this estimates that Option 2 has a construction impact of 363,480 kgCO_{2e} and Option 3 has a construction impact of 419,400 kgCO_{2e}. This calculation does not take into account any nuanced differences in construction methodologies, rather it approximates the impact based on size of the construction site and time to complete the works.

3.4 Use – Maintenance

Emissions in the use phase account for maintenance of the structure over its design life i.e. 120 years. The maintenance frequency of different materials are default values within the TII tool. The user does have the option to change these values manually, but in the absence of specific information, the default TII values have been retained. These default values have been selected by TII based on project experience and industry averages. They provide an estimate of the maintenance emissions that will be accrued over the structure's lifespan.

Only three materials are deemed to require significant maintenance for both options: asphalt, surface dressing and steel parapets (more detail in **Table 3-1** below). The same quantities of these materials have been assumed for both Option 2 and Option 3, hence both options have the same total maintenance emissions of 229,637.02 kgCO_{2e}.

Table 3-1: Material maintenance frequency and associated emissions (kgCO_{2e})

Material	Default maintenance percentage	Maintenance emissions (kgCO _{2e})
Road pavement – hot rolled asphalt	408%	195,791.04
Road pavement – surface dressing	850%	27,193.18
Galvanised steel parapets	6%	6,652.8

4 ASSUMPTIONS AND LIMITATIONS

- The project value is estimated at €41,050,000, which is an estimated average cost of either option based on information in the structures options report TT_MGT0337-RPS-P3-ZZ-RP-S-BR0003;
- The design life of the structures is estimated to be 120 years (excluding any road surfacing material, which will require more frequent maintenance and replacement in line with the rest of the scheme);
- AADT modelling has been excluded, as this will be addressed in the overall carbon assessment;
- General site clearance is assumed to occur on land principally occupied by agriculture. A total of 1.08 ha of land is estimated to be cleared, based on the drawings for the 2 proposed options (TT_MGT0337-RPS-P3-S1-DR-C-BR0122-1 and TT_MGT0337-RPS-P3-S1-DR-C-BR0123-1). The area to be cleared has been estimated based on an assumed bridge width of 30 m and bridge length of 360 m. This calculation does not exclude the width of the River Finn, which will not require any clearance activity, so likely overestimates the area for site clearance. This calculation also assumes that all clearance takes place on agricultural land, even though there will be some clearance of existing road infrastructure (R252) and dwelling houses on the southern section of the crossing;
- No modelling of land use change/vegetation loss has been undertaken, as the River Finn crossing structure will be built on primarily agricultural land. This change of land use does not have a negative climate impact in the TII carbon tool, so the exclusion of land use change, in this instance, does not have any effect on overall calculations;
- Earthworks have not been included in the calculations, as quantities will be broadly similar for both bridge options;
- Bridge deck surfacing is assumed to cover an area of 5,580 m² (15.5 metre cross section x 360 metre bridge length). The assumed pavement construction and transport is as follows:
 - Cement bound granular material to a depth of 100-150 mm
 - Asphalt concrete (14 mm aggregates to a depth of 40 mm)
 - Surface chippings (coated, 14 mm, assumed depth of 5 mm)
 - Road pavement materials are assumed to be sourced within 50 km of the site. Road pavement materials will be delivered via rigid HGV. It is assumed that each HGV load will carry 20 tonnes of material. An average material density for road pavement materials is estimated at 2.1 tonnes per m³. These assumptions are necessary in estimating total kilometres required for the transportation of road materials
- A specific carbon factor for structural concrete has been added to the Carbon Tool. The design team has specified that the in situ concrete for structural elements uses 50% ground granulated blast furnace slag (GGBS) in its composition. The emissions factor used for this material has been taken from the Bath Inventory of Carbon and Energy (ICE) v3. This material assumes a strength class of C40/50 and 50% mix of GGBS in the concrete binders. This material is deemed to be the best match to the structural concrete specified for this scheme. The original emissions factor is expressed in kgCO₂e/kg (0.102). This is multiplied by the material density of the structural concrete (assumed 2,400 kg/m³). This gives an emissions factor of 244.8 kgCO₂e/m³. The same factor is used for both options across all structural concrete elements (piles, piers, abutments, wingwalls, deck, etc.).

It is assumed that the concrete will be transported via HGV to site. The TII tool does not have a factor for a concrete mixer truck, so HGV is chosen as the closest proxy. It is assumed that each load of concrete will be 8 m³ (taken from One Click LCA Ecoinvent datapoint for structural concrete). It is estimated that the concrete will be sourced 100 km from the site. The density of the structural concrete is estimated to be 2.4 tonnes per m³. This is used to calculate the number of trips (i.e. total distance in kilometres) required to transport all of the structural concrete to site.

- The TII tool does not contain an emissions factor for rebar (reinforcement steel). Rebar represents a significant proportion of the materials for the bridge designs. An external datapoint has been manually added to the tool based on information from this document https://www.igbc.ie/wp-content/uploads/2021/05/LIFE-Levels-CAR-Report_revA_29April-2021_clean.pdf. Section 5.4 (page 50) estimates the average GWP of rebar used in Ireland at 737 kgCO₂e/tonne. This estimate is used as a datapoint for the TII tool.

In calculating the associated transport emissions, it is assumed that the rebar will be transported from Dublin via HGV (due to the imported steel arriving in Dublin Port) to the site area. This is a distance of roughly 240 km. The truck is assumed to have a fill capacity of 40 tonnes. The density of the rebar is 7,850 kg/m³. According to the IGBC report, all rebar in Ireland is imported, with the majority from Portugal (37%). These transport emissions are included in the embodied carbon emissions factor, and so do not need to be counted in this transport to site phase.

- Structural steel (mainly for Option 1 Multigirder BR0122) uses the emissions factor for structural steel columns in the TII tool. For Option 1, the bridge deck and weathering steel girders use this emissions factor.

Post-tensioning materials for Option 2 are allocated the TII emissions factor for anchorages and holding down bolt assemblies.

In terms of transport emissions for structural steel, these have been calculated using the same assumptions as those set out above for rebar.

- Waterproofing is needed for both the bridge deck and buried concrete elements of the bridges. All waterproofing quantities are assumed to be the same for both options, as per guidance from the design team.

The waterproofing system uses a liquid resin which will be applied to the elements noted above. There is no carbon factor for waterproofing membranes in the TII carbon tool, so the material has been added manually as an external datapoint. A representative material has been selected from the Ecoinvent¹ database to estimate the carbon footprint of waterproofing the structural elements. The product selected is Resfoam 1K-M, a waterproofing, polyurethane resin manufactured by Mapei in Norway.

The design team have calculated that 25.67 tonnes of waterproofing resin will be needed for each option. This quantity is used for both options in the carbon tool calculations. The GWP (global warming potential) for this material is stated at 3.7 kgCO₂e/kg. This conversion factor is used to estimate the associated carbon emissions.

The transport emissions are calculated on the assumption that the material will be transported 240 km from Dublin (assumes that the material will be imported from outside of Ireland). In addition, it is assumed that the material will be delivered via a 9 tonne delivery truck (Ecoinvent datapoint parameter). These assumptions allow for the calculation of total kilometres travelled, therefore the transport impact for stage A4.

- Steel parapets will also be included as part of the final bridge design. In order to estimate the impact of parapets, galvanised steel handrails from the TII carbon tool are used as an equivalent material. This default material provides the best proxy for steel/aluminium parapets within the tool. The same quantity of steel for parapets is assumed for both options.

The design team has calculated the total of steel for parapets to be **72 tonnes**. This is a combination of both pedestrian and vehicle parapets. The calculations are based on the following assumptions:

- Vehicle (VSGH 2001 – galvanised steel or aluminium) – 360m * 2no. * 84.7kg/m = 61 tonnes
- PED/Cyclist – 360m*1no. * 30.8kg/m = 11 tonnes

For the transport impact, it is assumed that the steel will be sourced from Dublin (due to steel likely coming from abroad). Therefore, it is assumed that the steel will be transported via HGV with a capacity of 40 tonnes.

- Rubbing strip design and quantities will be the same for both options. The design team has specified that the strips will be made of concrete (assumed precast) and reinforced with rebar. A total of 1,166 tonnes of concrete is estimated to be needed. This will require 20 tonnes of rebar. The quantities have been worked out as per the formulae below:
 - Concrete – 9m*360m*0.15m = 486m³ * 2.4 = 1166 tonnes
 - Rebar – 9m*360m*6.16kg/m² = 20 tonnes

¹ <https://ecoinvent.org/the-ecoinvent-database/>

An external datapoint for precast concrete has been added to the tool to estimate the impact of the material. The external datapoint (taken from Ecoinvent database) estimates the GWP of precast concrete manufacturing at 0.13 kgCO₂e/kg.

The carbon factor for rebar (previously added to the tool – see earlier bullet points) will again be used to model the reinforcement required for the rubbing strips (737 kgCO₂e/tonne).

In terms of transport impact, it is assumed the materials will be sourced from a supplier within 100 km of the site. The materials will be delivered via HGV at a fill capacity of 40 tonnes. These assumptions are used to estimate total kilometres.

- Excavation activities have not been included, due to lack of data. Regardless, excavation for both options is likely to be very similar, so the effect of this exclusion will not impact comparison of the options.
- While energy usage (fuel, lighting, heating, etc.) is unknown for the duration of the construction periods, this is estimated using default assumptions in the TII tool. The tool calculates an estimated energy usage based on length of construction period (in weeks) for each option. Estimated construction programmes have been provided for both options in TT_MGT0337-RPS-P3-ZZ-RP-S-BR0003. Option 1 (Multigirder BR0122) will require 26 months to construct. Option 2 (Concrete Box BR0123) will take 30 months to construct. This methodology does not take into account different construction techniques/equipment required for each option, rather it calculates an estimate of energy usage based on time alone.
- Other variables during the construction period, such as worker travel to site, water use and landscaping, are also excluded due to lack of detailed information at this time.
- Construction waste is excluded from the calculations.
- Energy use during the operations phase (use phase for the bridge) has also been excluded. This includes activities such as maintenance, lighting, signs, vehicular use, etc.). These activities would be very similar for both options, so exclusion of these activities will not impact the comparison of both options.
- End of life (decommissioning) emissions have been excluded from the calculations due to lack of data.
- **Table 4-1** below outlines the methodology used for calculating transport distances of materials. Where 'Both' appears in the 'Option' column, this denotes that both options have used the same quantity of that material, and therefore the same transport distance is assumed.

REPORT

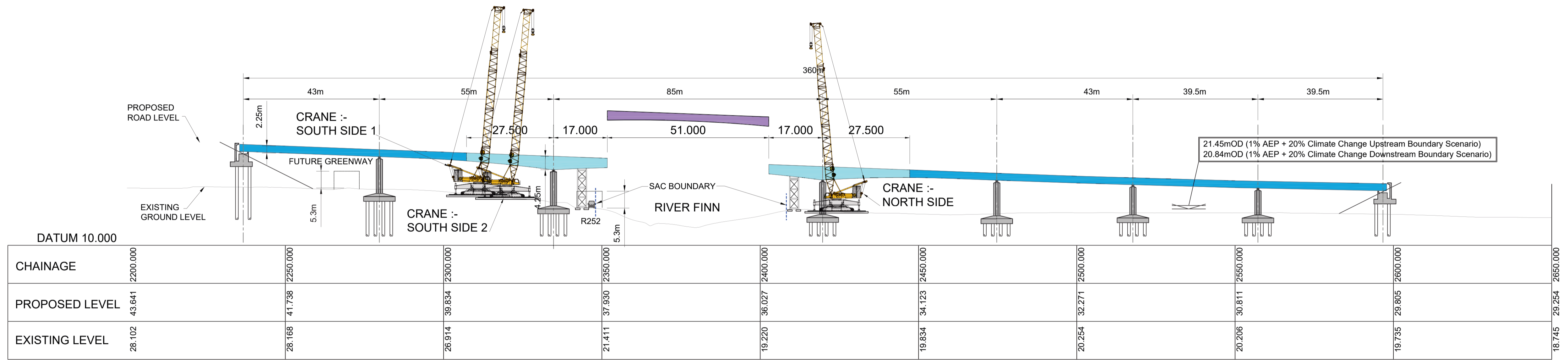
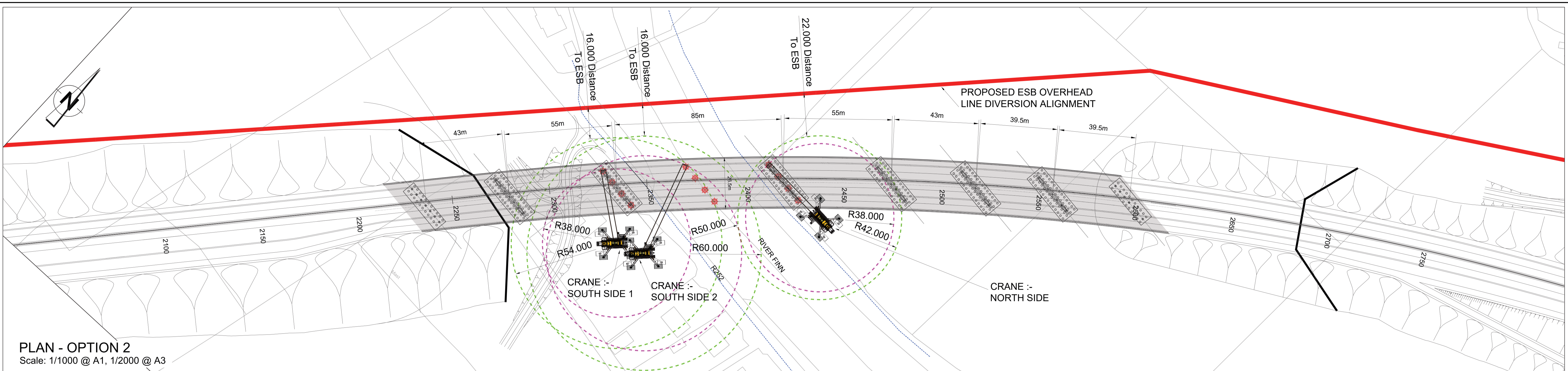
Table 4-1: Transport distance calculations

Option	Material Category	Material Name	Area (m2)	Depth (m)	Volume of material (m3)	Weight of material (t)	Transport distance (km)	Transport vehicle capacity (tonnes)	Density of material (tonnes per m3)	Transport vehicle capacity (m3)	Number of loads (no.)	Total distance (km)
Both	Series 800 - Road Pavements	Cement bound granular material	5580	0.15	837	-	50	20	2.1	9.5	88	4394
Both	Series 900 - Road Pavements	Dense asphalt concrete	5580	0.04	223.2	-	50	20	2.1	9.5	23	1172
Both	Series 900 - Road Pavements	Surface chippings, coated	5580	0.005	27.9	-	50	20	2.1	9.5	3	146
Option 1 - Steel Multigirder	Series 1700 - Structural Concrete	Concrete (50% GGBS)	-	-	6368	-	100	19.2	2.4	8	1054	79600
Option 2 - Concrete Box	Series 1700 - Structural Concrete	Concrete (50% GGBS)	-	-	11481	-	100	19.2	2.4	8	2001	143513
Option 1 - Steel Multigirder	Series 1800 - Structural Steelwork	Rebar	-	-	-	1601	240	40	7.85	5.1	45	9607
Option 2 - Concrete Box	Series 1800 - Structural Steelwork	Rebar	-	-	-	2253	240	40	7.85	5.1	87	13518
Option 1 - Steel Multigirder	Series 1800 - Structural Steelwork	Column	-	-	-	4800	240	40	7.85	5.1	148	28800
Option 2 - Concrete Box	Series 1800 - Structural Steelwork	Anchorage and holding down bolt assemblies	-	-	-	460	240	40	7.85	5.1	12	2760
Both	Series 1700 - Structural Concrete	Waterproofing (resin) for steel and concrete elements	-	-	-	25.67	240	9	-	-	3	685

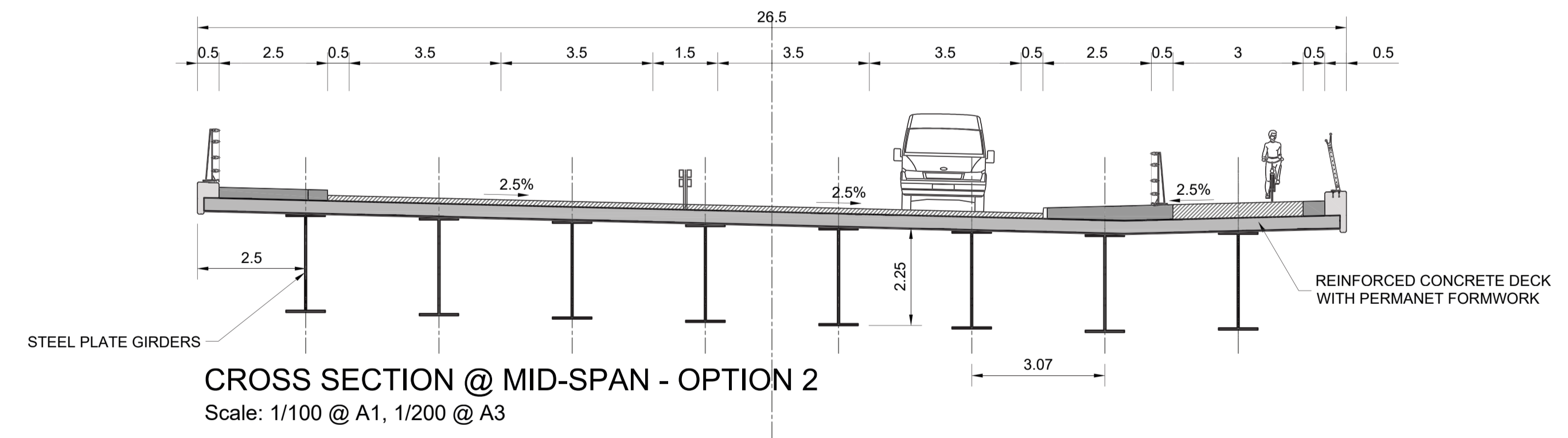
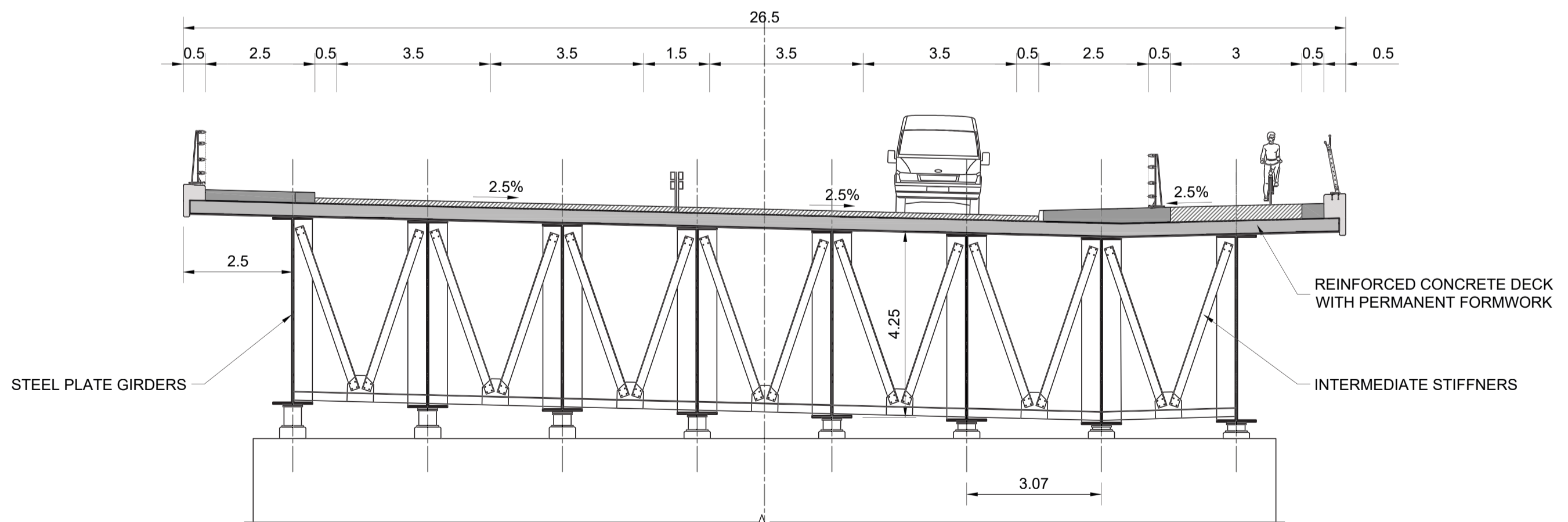
REPORT

Option	Material Category	Material Name	Area (m2)	Depth (m)	Volume of material (m3)	Weight of material (t)	Transport distance (km)	Transport vehicle capacity (tonnes)	Density of material (tonnes per m3)	Transport vehicle capacity (m3)	Number of loads (no.)	Total distance (km)
Both	Other-Street Furniture and Electrical Equipment	Galvanised steel handrail	-	-	-	72	240	40	-	-	2	432
Both	Series 1100 - Kerbs, Footways and Paved Areas	Precast rubbing strips (no rebar)	-	-	-	1166	100	40	-	-	29	2915
Both	Series 1800 - Structural Steelwork	Rebar	-	-	-	20	100	40	-	-	1	100

APPENDIX 5: OPTION 2 CRANE DRAWING



LONG SECTION - OPTION 2
Scale: 1/750 @ A1, 1/1500 @ A3



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Bonneagar Iompair Éireann
Transport Infrastructure Ireland
Rialtas na hÉireann
Government of Ireland
Tionscadal Éireann
Project Ireland
2040

Donegal
NRO
Comhairle Contae
Dhún na nGall
Donegal County Council

RPS BARRY
TRANSPORTATION

NOTES
DO NOT SCALE, use figured dimensions only.
All levels are referred to Ordnance Survey Datum, Malin Head.
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Rev.	Date	Drawn	Description	Chk'd	Appr.
S3 P01	Feb.'22	DC	ISSUE FOR REVIEW & COMMENT	JM	EC

Project Title: TEN-T Priority Route Improvement Project, Donegal Section 1 - N15/N13		Model File Identifier: N/A	Status: S3
Drawing Title: RIVER FINN CROSSING CRANE LIFTING OPTION (STEEL MULTI-GIRDERS)		Rev: P01.02	
Designed: JM	Date: FEB 2022	Scale @ A1: AS	
Drawn: DC	@ A3: AS	File Identifier: TT_MGT0337-RPS-P3-S1-DR-C-RB N15R024 BR0099-01	
Approved: EC	Sheet: 01 of 1		
Checked: JM			