SCF17071L4 - Desktop Study & Line Design Assessment (CP0966)

EirGrid

Work Package 1: Desktop Study, Route Investigation & Survey - Final Report

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Executive Summary

As part of the voltage uprate project (SCF17071L4), EirGrid have requested ESBI to undertake a desktop study & line design assessment of two existing 220 kV overhead lines (OHL) which have been identified as potential candidates for uprating to 400 kV. This is required to create a new 400 kV link between Dunstown and Woodland stations using the existing OHL corridors under CP0966.

This report details the desktop study, route investigation and various surveys carried out as part of work package 1 (WP1) of SCF17071L4 under CP0966. The report considered two existing 220 kV OHLs namely Dunstown-Maynooth (2) (D-M) 220 kV and Gorman-Maynooth (G-M) 220 kV and the feasibility of voltage uprating these circuits to form the proposed Dunstown-Woodland (D-W) 400 kV circuit.

A review of all existing records and data relating to both OHLs was undertaken as part of the study. This data along with an as-built PLS-CADD model of the D-M route was used to develop a high level PLS-CADD model of the proposed D-W 400 kV circuit. The D-W 400 kV PLS-CADD design was developed to meet 400 kV design requirements e.g. 9m over ground at the specified MOT of 80°C and assuming a twin bundle 600mm^2 ACSR “Curlew” conductor configuration.

The proposed (D-W 400 kV circuit considered as part of this study includes 139 towers from Dunstown 400 kV station to Woodland 400 kV station. this proposed circuit does not include the loop-in section to Dunstown 400 kV station while the by-pass around Maynooth 220 kV station has assumed an indicative route based on the lidar imagery. The last tower on the proposed D-W 400 kV line has been assumed as structure 139 for the purposes of this study. This tower is located on the current G-M 220 kV line and is located approx. 5 km west of Woodland 400 kV station.

The study considered three potential options relating specifically to the tower locations for voltage uprating or ‘re-constructing’ the existing 220 kV OHLs to 400 kV. The three options considered were:-

- Option A – Construct 400 kV towers at existing 220 kV locations;
- Option B – Construct 400 kV angle mast (AM) towers at existing 220 kV locations but relocate intermediate (INT) towers by approx. 15-20 m into the ahead or back span;
- Option C – Laterally offset the 400 kV line (or sections) by approx. 50 m.

The desktop survey exercise utilised a wide range of datasets which encompassed a variety of real-world elements all of which were used to inform the decision making process. The use of all available data allowed for an effective assessment of the different design options as set out in the study. Option C was effectively ruled out based on the findings of the desktop survey, therefore no further consideration of this option was given. When considering Options A and B and the combination of both, the datasets and mapping utilised gave valuable insight into potential issues such as major crossings, restricted sites, and major developments all of which influence the final recommended option.

The geotechnical desktop carried out for both lines provides a summary of the geotechnical conditions at each structure site, makes recommendations on the extent and scope of site investigation works and identifies likely foundation types of tower structures. Table 9 and

Table 10 give a summary of the ground conditions at each structure location for the two lines. Table 11 and Table 12 give recommendations for intrusive investigations along the two lines.

As part of a follow up site walkover survey, ESBI visited 24 locations to assess their suitability for the recommended uprating option (Option A or Option B). Three locations could not be accessed due to locked gates/restricted access while the following issues were identified during the walkover surveys:-

- INT43, AM51, AM87 could not be accessed due to locked gates/restricted access.
- AM locations 4, 8, 10, 32 and 111 have restrictions in either the ahead or back span (See Figure 14). Due to the location of the tower in close proximity to a boundary, one temporary structure may have to be installed on a different landowner site.
- Seven INT locations would result in a change in landowner based on the proposed moves therefore Option A has been assumed for these locations.
- It is also important to note that 52 INT locations are located on/near a hedge/boundary. The proposal of moving these towers away from the hedge/boundary may prove difficult with landowner particularly in agricultural locations therefore the likelihood is that Option A will be required for a greater number of INT locations.

A summary table noting the recommended uprating option based on the desktop review and walkover survey is included in Appendix 3. Option A is recommended for all AM locations and 14 INT locations while Option B is recommended at all other INT locations as a starting basis for developing a final design. This table is a high level assessment at this stage and should be used as a guide only for locations where ESBI feel that option B may not be feasible. The importance of completing a landowner engagement process and outlining the proposed tower locations (Option B) is noted in the report. This is essential as a final design cannot be completed until all tower locations have been confirmed.

High level construction programmes were developed for both lines and for Options A and B separately. The programmes even at a high level clearly demonstrate that Option B will provide significant benefits in terms of a reduced overall construction programme.

The study notes that a non-earthwire design was developed. This assumes the use of the 400 kV voltage uprate INT (non-earthwire) design used in conjunction with a standard 400 kV AM (earthwire) design. If an earthwire design is required, this will involve revising the INT tower design along with additional type testing. Furthermore, a twin 600mm^2 ACSR “Curlew” conductor configuration with a specified MOT of 80°C was assumed in the design. If alternative non-conventional conductor options were to be considered (e.g. HTLS) this would also involve a review of the INT tower design.

Since the mid-1980’s it has been EirGrid policy to fully shield all new 220 kV (and 400 kV) lines due to the improvement in lightning performance. The next phase of the study should consider the planning, technical and cost implications of providing a fully shielded 400 kV circuit as against an unshielded option considering any lightning/grounding performance deficits, implications and mitigation measures that could be adopted.

As no insulator design has been confirmed at the time of writing this report, additional electrical studies required (Corona/RVI performance, insulation coordination) were not carried out. These studies will be required when a final insulator design has been agreed.

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2 Introduction & Background

As part of the voltage uprate project (SCF17071L4), EirGrid have requested ESBI to undertake a desktop study & line design assessment of two existing 220 kV overhead lines (OHL) which have been identified as potential candidates for uprating to 400 kV. This is required to create a new 400 kV link between Dunstown and Woodland stations using the existing OHL corridors under CP0966.

This report details the desktop study, route investigation and surveys as outlined in work package 1 (WP1) of SCF17071L4 under CP0966. WP1 covers the following areas only:-

- Review of existing data and records;
- Lidar survey of existing lines*;
- Conduct desktop studies (geotechnical, site access requirements, 3rd party services and earthing/OFT requirements);
- High level work sequencing with focus on minimising outages;
- Route investigation (including high-level review of stability/strain structure requirements);
- Issue report on WP1 findings of above activities.

*A Lidar survey was not possible due to Covid-19 restrictions. For WP1 ESBI were able to utilise previous lidar data, hand drawn profiles and imagery mapping to develop a high level design model of the line route. Lidar will be required at a later stage to complete a detailed (pre-planning) design, possibly as part of work package 2 (WP2).

In addition to the desktop study and line design assessment (WP1) as outlined in this report, previous and ongoing ESBI studies related to the 400 kV uprate project overall are summarised below:-

- **Concept Design Stage (2012-15):** The initial feasibility study completed by ESBI examined various concepts designs to uprate the existing 220 kV towers to be used at 400 kV. A concept design which utilises a composite crossarm solution was selected as the preferred design solution.
- **Tower Design & Testing (2015-17):** Two existing 220 kV single circuit (SC) and double circuit (DC) towers were designed and successfully type tested in Spain. This design and testing stage covered the lattice steel tower element only. The composite crossarm was not included in this project.
- **Suitability Assessment for Voltage Uprate Project (2018-Ongoing):** A 400 kV trial for construction and maintenance of the composite crossarm will be carried on the ESB Donard test line. The purpose of the trial is to give a better understanding of installation techniques such as stringing, terminating conductor and replacing hardware for maintenance purposes etc. Furthermore, the performance of the structures, notably the composite insulators can also be monitored for a period of time. An assessment was carried out to identify the tasks to be undertaken during the trial and procedures to perform these tasks were developed. The tasks identified during this suitability assessment study are now included in the CPP for the 400 kV

uprate trial. Refer to report “Suitability Assessment for 400 kV Uprate Trial (Pre CPP) (PE610-F0035-R00-004)” for more details.

- **Mechanical Testing of Composite Crossarm for Tower Voltage Upgrade Project (TBC):** The design and testing of the composite crossarm to be used in the trial has yet to begin and at the time of writing this report no contract has been awarded. A mechanical design and testing requirements report (PE610-F0035-R00-001) was produced previously. The suitability assessment and trial installation cannot be completed until a final design and testing of the composite crossarm is completed*.

*It is important to note that ‘Composite Crossarm’ encompasses the outer phase insulators (pivoted-vee x 2) and middle phase insulator (vee-string x 1) used together, all of which are composite designs. For the purposes of the PLS-CADD design and assessment detailed in this report, ESBI have assumed an indicative composite insulator design as detailed in Figure 1.

EirGrid are currently considering the voltage uprate option against other OHL and cabling options. If it is decided to proceed with the voltage uprating option, further studies are required as outlined in SCF17071L4:-

- Line Design & Electrical Assessment (Work Package 2)
- Due Diligence & Project Delivery (Work Package 3)

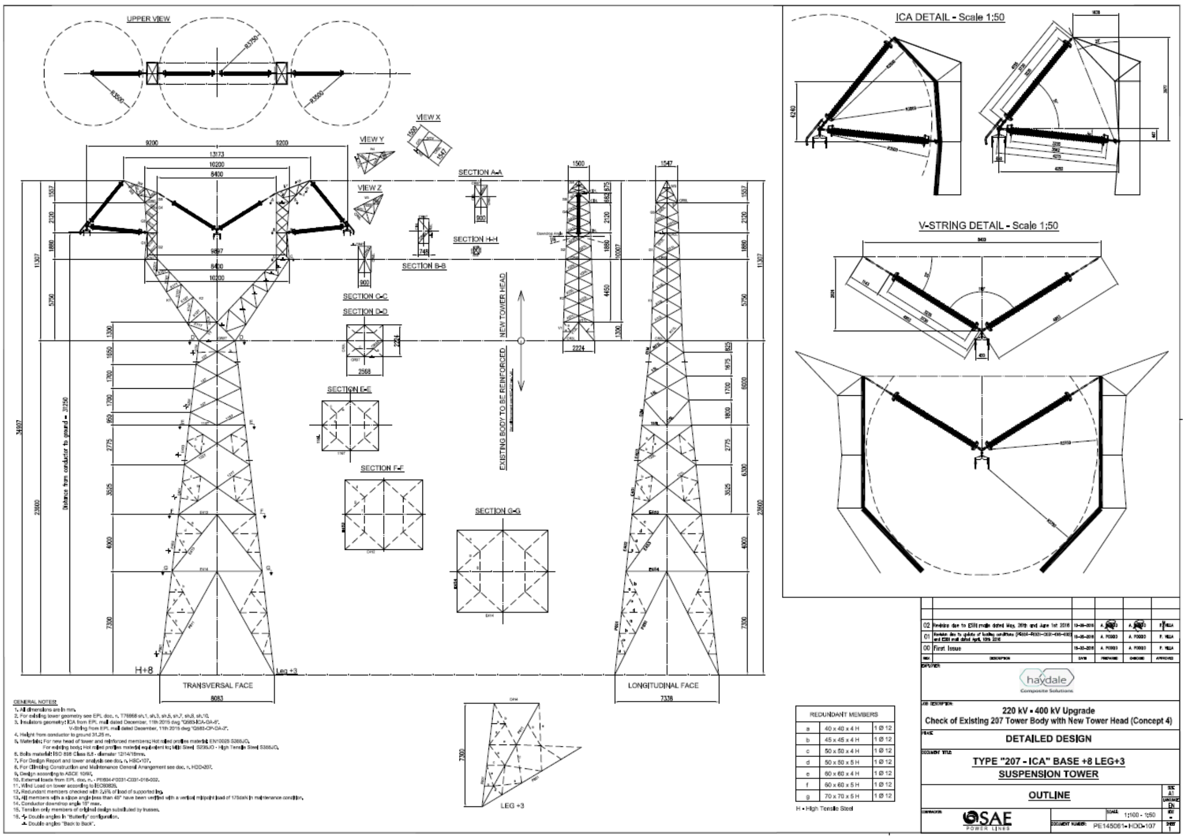

Figure 1 – Indicative Composite Insulator Geometry

3 Voltage Uprating existing 220 kV Lines to 400 kV

As part of the voltage uprate project, EirGrid are considering voltage uprating two existing 220 kV OHLs to 400 kV and connecting them to create a new 400 kV circuit between Dunstown and Woodland 400 kV stations. The 400 kV voltage uprate suspension/intermediate (INT) tower design (See Figure 2) utilises a composite insulator installed using a hinge-joint on the tower i.e. pivoted-vee design which enables the insulator to rotate longitudinally (outer phases only). A key feature of the voltage uprate design is that it allows the new 400 kV tower footprint to remain the same as the existing 220 kV tower and therefore permits a narrower than usual 400 kV corridor width (Approx. 18.4m as opposed to 21m) and less disruption to landowners. The middle phase is also a composite insulator and is a standard vee-string design – similar to the glass equivalents currently used on the 400 kV network.

To date, no strain/angle (AM) tower design specific to the voltage uprate project has been developed therefore for the purposes of the desktop study ESBI have assumed the North-South 400 kV design will be used.

(Note: for the purposes of this report and associated appendices, suspension/intermediate towers are referred to as INT while strain/angle towers are referred to as AM.)

Figure 2 – 220 kV to 400 kV Uprate INT Tower Design

The two existing 220 kV lines being considered as part of this study are:-

- Dunstown-Maynooth (2) 220 kV OHL
- Gorman-Maynooth 220 kV OHL

As noted previously, EirGrid are considering voltage uprating both lines as one of the potential options to create a new 400 kV circuit (See Figure 3). This option will also involve a by-pass around Maynooth 220 kV station and a loop-in design to Woodland 400 kV station. Both of these design elements are not included in the scope of this study therefore indicative high-level structure positions have been assumed at these locations in order to develop a single PLS-CADD model of the entire route.

Although not considered as part of this study, it is possible that the existing 220 kV line routes into Maynooth station could be also voltage uprated in order to provide a future connection to Maynooth at 400 kV.

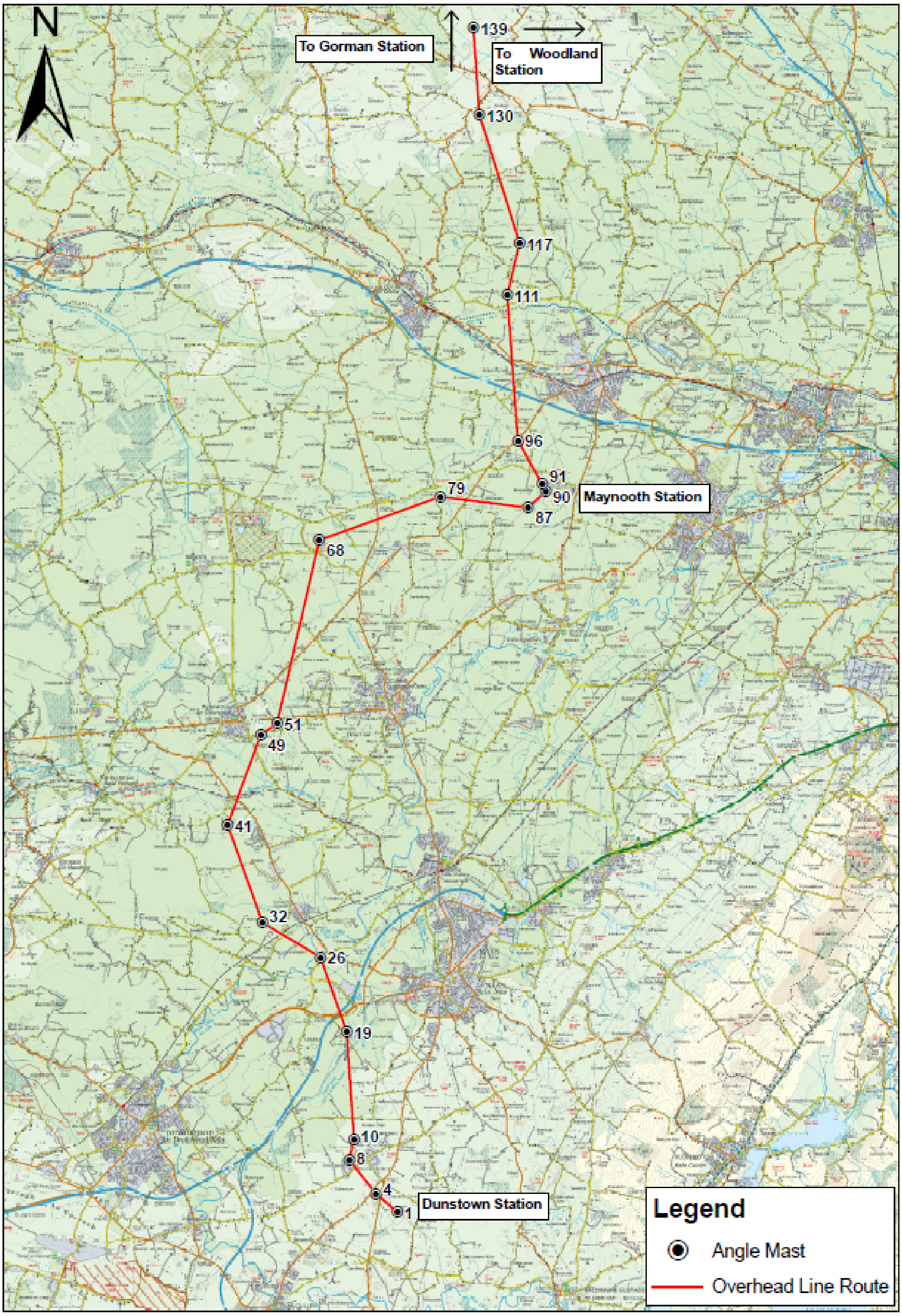

Figure 3 - Indicative line route &numbering for new 400 kV circuit

3.1 Dunstown-Maynooth (2) 220 kV Line

The Dunstown-Maynooth (2) (D-M) 220 kV line was commissioned in 1986 and is approximately 30.5 km in length. The line is composed of three sections built at different times as summarised below:-

- Section No. 1 : Structures EM1 to AM2:-
    - This section was built in 1986 looping the original Great Island–Maynooth–Turlough Hill into the new 400 kV station at Dunstown.
- Section No. 2 : Structures AM2 to AM86 (Part of the Great Island–Maynooth–Turlough Hill):-
    - This section was originally constructed as part of the Donard-Maynooth 220 kV line in 1974, which become part of the Great Island–Maynooth–Turlough Hill and later the Great Island-Dunstown 220 kV line when Dunstown 400kV station was constructed.
- Section No. 3 : Structures AM86 to EM92 (Part of the Maynooth – Turlough Hill):
    - This section was originally constructed in 1973 as part of the Maynooth–Turlough Hill 220 kV line. A new section of line was constructed to reroute the Maynooth–Turlough Hill line to a double circuit line common with Dunstown–Maynooth No. 1.

The line includes 92 towers and is strung with single 600mm^2 “Curlew” conductor with a specified maximum operating temperature (MOT) of 80°C. As part of previously planned refurbishment works, a line condition assessment (LCA) was completed along with a foundation QRA in 2019. A lidar survey of the line was completed in 2014 and a full 3D PLS-CADD line model produced which was utilised for this project.

It is important to note that the proposed D-W 400 kV circuit will utilise the majority of the existing D-M route however the by-pass around Maynooth 220 kV station will likely result in a small number of structure locations being retired, possibly 90-92. For the purposes of this study, ESBI have assumed AM90 will be relocated slightly and become the last tower from the D-M section as shown in Figure 4. However, as noted previously, EirGrid may wish to retain and/or voltage uprate these structures such that future connections to Maynooth station at either 220 kV or 400 kV can be accommodated.

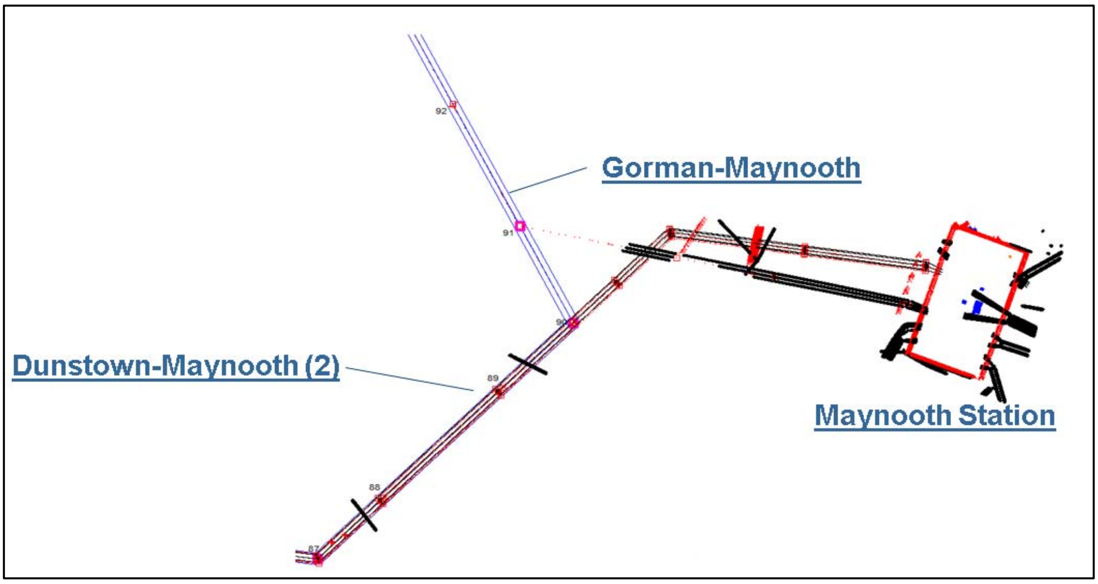

Figure 4 – Indicative Route around Maynooth 220 kV Station

3.2 Gorman-Maynooth 220 kV Line

The Gorman-Maynooth (G-M) 220 kV line was commissioned in 2002 and is approximately 42 km in length. The line is composed of two sections built at different times as summarised below:-

- Section No. 1 : Structures 1 to 141 (part of Maynooth-Louth)
  - This section of the line was constructed in 1969. The line was originally Maynooth-Tanderagee until 1973 when three new towers were built at Louth and the line was looped in.
- Section No. 2 : Structures 141-142 (Gorman loop)
  - The Gorman loop was constructed in 2002.

The line includes 141 towers and is strung with a single 600mm^2 “Curlew” conductor with a specified MOT of 80°C. It should be noted that the proposed 400 kV circuit will utilise a section of the existing G-M from approximately structure 90 to Maynooth station (EM141). It is envisaged that the remainder of the G-M line (1-89) will be looped into Woodland 400 kV station and continue to operate at 220 kV and would become Gorman-Dunstown 220 kV. As noted previously, based on the assumption that the voltage uprate option will be the preferred option, the final loop-in position has yet to be determined and will be examined in a separate study. ESBI have conservatively assumed structure 90 as this runs beyond the point where the line crosses under the existing Oldstreet-Woodland 400 kV line.

As no LCA or lidar survey of the line route has been completed to date, no PLS-CADD model was available. For the purposes of this study, ESBI have utilised the original hand-drawn profiles and digitised these in PLS-CADD to develop a high-level 3D model. This model was then further supplemented using data procured from Bluesky. Bluesky are a 3rd party supplier of raw ground datasets in Ireland. The data obtained included high resolution imagery which was required for numerous aspects of the desktop study and is described in more detail in section 4.

3.3 Dunstown-Woodland 400 kV Line (Proposed)

The proposed Dunstown-Woodland (D-W) 400 kV circuit considered as part of this study includes 139 towers from Dunstown 400 kV station to Woodland 400 kV station. As noted previously, this proposed circuit does not include the loop-in section to Woodland 400 kV station while the by-pass around Maynooth 220 kV station has assumed an indicative route based on the lidar imagery.

The last tower on the proposed D-W 400 kV line has been assumed as structure 139 for the purposes of this study. This tower is located on the current G-M 220 kV line and is located approx. 5 km west of Woodland 400 kV station.

For the purposes of all mapping and tables detailed in this report and associated appendices, the indicative proposed line numbering (Figure 3) has been assumed and not the actual line numbering for the as-built towers on site.

4 Desktop Surveys & Mapping

4.1 Introduction

A desktop survey of the existing 220 kV lines was carried out to assess the OHL route options for the new proposed 400 kV line and all aspects associated with it, including possible line realignments, structure (tower) relocations and other construction elements. Various elements were included in the desktop survey and assessed to determine the impact these would have on a new 400 kV line route i.e. site constraints, landowners, existing property's, natural features etc.

For the desktop survey to be carried out effectively it was necessary to gather as much data as possible. This involved analysing the large datasets acquired from various sources and the study on various aspects related to this project. Various recommendations were made based on the findings from the desktop survey. The following sections of this report describes all data acquired, methods of analysis and the conclusions.

Mapping has been created to supplement the desktop survey. The various maps were created to be visually informative and to present the various aspects and findings of the desktop survey.

As part of the desktop survey exercise the best possible route options for the link to Woodland Station were assessed and possible routes are presented along with recommendations for the preferred route option.

4.2 Survey Data

Data was both acquired from 3rd party sources and also created from the available sources prior to any analysis and assessments being carried out. The data determined the type of analysis that could be carried out and what information could be extracted from different datasets. The following is a list of all datasets that were used in the desktop survey:-

- Background Mapping and Aerial Imagery:
    - Ordnance Survey Ireland (OSI) Discovery Series Maps
    - OSI Aerial Imagery
    - ESRI Basemap (Aerial Imagery)
- National Parks and Wildlife:
    - Natural Heritage Areas (NHA)
    - Proposed Natural Heritage Areas (PNHA)
    - Special Areas of Conservation (SAC)
    - Special Protection Areas (SPA)
- Geological:
    - GSI Bedrock Boreholes
    - GSI Verified Borehole Logs
    - External Site Investigations
    - External Boreholes
    - Bedrock
    - Quaternary Sediments
    - Karst Data
- National Monuments:

- Buildings
- Forestry
- 3rd Party Utility Services
- Landowner Information:
  - PRAI Data
- Overhead Line Information:
  - Existing Line Route
  - Existing Structure Positions
  - Proposed Structure Move Positions
- Construction Related Information:
  - Access Routes
  - Stringing Platform Areas
  - ERS Working Areas
  - Intermediate Mast Working Areas

4.2.1 Background Mapping and Aerial Imagery

The primary background mapping and aerial imagery used extensively in this project were obtained from the Ordnance Survey of Ireland (OSI). These are available through their Web Mapping Service (WMS) and ESBI have access to these datasets.

The OSI offer a variety of background mapping including aerial imagery, Discovery 1:50k series, large and medium scale basemaps. The Discovery Series mapping was primarily used in the presentation of the line route maps and the geotechnical study mapping. The aerial imagery was used for larger scale mapping requirements, including parallel route option maps and desktop survey maps. The aerial imagery used is the OSI's DigitalGlobe Series. It should be noted that the aerial imagery from OSI can be up to 8 years old in places. More up to date background imagery is available as a basemap service from ESRI within the ArcGIS software package. However, there is a slight positional discrepancy associated with this imagery, therefore, this imagery was not used for the map presentation purposes. However, it can indicate more recent changes in infrastructure that may not be shown on the OSI aerial imagery, therefore it was useful for critical locations where the tower is located close to existing infrastructure.

Lidar data and aerial imagery was already available for the D-M 220 kV OHL section and this was used for design purposes. Aerial imagery was purchased from Bluesky Ireland for the G-M section along with a 1.0 metre digital surface model. This was used for high level design purposes only. The line route maps and the tower location maps were produced using the OSI imagery.

4.2.2 Environmental Constraints

The National Parks and Wildlife Service (NPWS) have designated nature conservation areas for the protection of habitats and species. The most up to date GIS data was obtained from the NPWS website and used in the desktop surveys. As stated above this included the NHA, PNHA, SAC and SPA datasets This allowed for such areas to be identified and assessed as to their impact on the overall desktop survey.

4.2.3 Geological Data

The Geological data was required to undertake a desktop geotechnical study as described in Section 5. Geotechnical and geological datasets are available from the Geological Survey of Ireland (GSI) and these were used in the desktop survey. Mapping was created to allow for further geotechnical studies. All the datasets are presented on the geotechnical study maps which were reviewed by the Geotechnical Engineer to use in the geotechnical study. The findings of the study can be seen in Section 5.

4.2.4 National Monuments

The National Monuments Services have designated locations as protected archaeological heritage sites. Data for these sites was downloaded from the National Monuments Service website in GIS formats and used in this desktop survey. This data was used primarily to identify sites which would have an impact on any planned works.

4.2.5 Buildings

It was necessary to assess the impact of the adjacent buildings on construction of the new line along the OHL route. Various data sources were used to identify buildings along the line routes. Aerial imagery was the primary source in identifying the location of buildings. The aerial imagery used was the OSI digital globe aerial imagery series and the ESRI Basemap. The exact date of the imagery used along the line was somewhat unknown but can be estimated to be between one and to eight years old. A Geodirectory dataset was also available and was used in the assessment of potential options. This data was obtained in 2019. This data was only used as a reference in the assessment process and is not presented on any maps due to copyright.

4.2.6 Forestry

It was essential to identify areas of forestry since they may have an impact on planning and construction works. These areas were identified using a combination of the OSI Aerial Imagery, ESRI Basemap Imagery and Coillte Data. The Coillte data provides locations of parcels of forestry so that further inspection could be carried out. This was used for both assessing structures relocations along the existing alignment and for the offsetting of the line route.

4.2.7 3rd Party Services

Existing utility service information was requested from various 3rd party services. Data was received from the following:-

- Irish Water
- Gas Networks Ireland
- Eir
- Meath County Council
- Kildare County Council

The 3rd party information was used only in the assessments. As the 3rd party utilities had zero impact at this stage of the survey it was decided not to include the data on the mapping. The data would be of more importance at the design and construction stages and it would be recommended that more up to date datasets be requested at those stages.

4.2.8 Landowner Information

The Property Registration Authority of Ireland (PRAI) hold data on registered lands in the Republic of Ireland. A request for all landowner data along the route corridor was made to the PRAI under the Public Sector Information license. The PRAI provided all the available landowner information in July 2020. The data included property boundary's in GIS format along with associated landowner information in spreadsheet formats. This data was processed and edited, and this created useable formats for project specific purposes.

4.2.9 Overhead Lines

All overhead line data was available and is used on most of the mapping created. The mapping includes:-

- Existing Line routes;
- Proposed new line route;
- Existing structure positions;
- Proposed new structure move positions.

4.2.10 Access Routes

Access Routes to each structure were created based on inspection of the aerial imagery. The access routes through the various land types are also identified, i.e. grass field, bog, track, lane etc. It should be noted that these routes may change after site surveys and the wayleave process are carried out.

4.2.11 Stringing Platforms

Stringing platform areas were created at angle mast and end mast locations and presented on the mapping. An area of 60m x 30m has been allocated for each stringing platform.

4.2.12 Intermediate Mast Working Areas

Working areas were created at intermediate mast locations and presented on the mapping. An area of 30m x 30m has been allocated for the working areas at each intermediate mast.

4.2.13 Emergency Restoration Structure (ERS) Working Areas

Working areas were created at locations that may require ERS's and presented on the mapping. A 40m radial area been allocated for the working areas.

4.3 Desktop Survey Assessments

The desktop survey was carried out in line with the route options described in Section 6.4. These were:

- **Option A** – the existing line route and all the existing tower locations would be utilised to construct the new 400 kV line;
- **Option B** – all existing AM tower locations would be utilised however; INT towers would be relocated by approx. 15-20m inline from the existing tower location for the new 400 kV line.
- **Option C** – the existing 220 kV line route/alignment would be adjusted by laterally offsetting the new 400 kV line approx. 50m.

Various elements of the project were examined in relation to each of the above options. The main criteria examined are:

- Parallel route options;
- Landowners;
- Structures relocation impacts;
- Access Routes to each structure;
- Construction working areas.

It was decided to undertake the option C, Parallel Route assessment first before assessing options A and B. This would determine if all or any of this option was a possibility before proceeding with any preliminary design work.

4.3.1 Option C Desktop Survey - Parallel Route Options

The possibility of constructing a new OHL at both sides of the existing D-M and G-M lines was examined. This option would have been the most optimal route from, an outage perceptive as it would have minimum impact on the existing 220 kV line and the outage requirements. This option was examined at an early stage of the study to determine if this route option was possible or should be discounted due to constraints.

In order to assess the possibility of this route option, some of the datasets listed above in Section 4.2 were used. The assessment was carried out in ArcGIS. The main datasets used in the assessment were:-

- Buildings;
- National Monuments;
- Forestry.

The available OSI aerial imagery and ESRI Basemap imagery were also used in the assessment process.

The existing D-M and G-M line routes were offset 50m to the left and right from the existing line alignment. A 30m corridor centred on the offset lines was setup, as this was the minimum clearance required for a potential 400 kV OHL. Each side's corridor was then examined for any potential obstructions, i.e. buildings, national monuments, forestry etc. that would impede a possible route. Please note that the existing structure numbering was used in this assessment and all numbering in the following tables in this section is based on the existing structure numbers.

4.3.1.1 Data Assessment

Buildings

When assessing the possibility of offsetting the overhead line laterally, the data was assessed to find out if the existing buildings would have a clearance infringement from any new line built using route option 'C'. Assessment on buildings that were present within the corridors, have been presented in Table 1, Buildings were found to be obstructions in all except four straights along the proposed route options.

Three straights alongside the G-M OHL are:-

- Straight 99-112 – Left
- Straight 118-133 – Left

- Straight 133-138 – Right

One straight along the D-M OHL is:-

- Straight 49-51 Left

Although there were also no buildings present along straights 86-90 and 90-92 on D-M line and along straight 138 – 141 on G-M line, these were deemed irrelevant as this may be the possible crossover point.

These findings would suggest that the option to offset the line would not be viable for most of the straights.

Table 1 – Buildings along the line routes

Dunstown - Maynooth 2 220 kV Line		
Straight	**Side**	**Number of buildings**
1-4	Left	1
	Right	4
4-8	Left	6
	Right	6
8-10	Left	2
	Right	3
10-19	Left	10
	Right	1 (Driveway, house nearby)
19-26	Left	9
	Right	1
26-32	Left	5
	Right	2
32-41	Left	1
	Right	1
41-49	Left	5
	Right	3
49-51	Left	0
	Right	6
51-67	Left	11
	Right	6
67-78	Left	4
	Right	4

Dunstown - Maynooth 2 220 kV Line		
Straight	**Side**	**Number of buildings**
78-86	Left	1
	Right	1
86-90	Left	0
	Right	0
90-92	Left	1
	Right	0

Gorman-Maynooth 220 kV Line		
Straight	**Side**	**Number of buildings**
90-99	Left	6
	Right	2
99-112	Left	0
	Right	1
112-118	Left	3
	Right	3
118-133	Left	0
	Right	3
133-138	Left	3
	Right	0
138-141	Left	0
	Right	0

National Monuments

National monuments were also checked for obstruction on the possibility of offsetting the line alignment. Such sites would prove to be an obstruction for any type of construction works, therefore it was investigated if any of these sites would be located along the offset routes.

There were six sites that were identified as being located within the route corridors. These sites along with the straights are shown in Table 2.

Table 2 – National monuments along the line routes

Dunstown - Maynooth 2 220 kV Line		
Straight	**Side**	**Number of National Monuments**
1-4	Left	2
32-41	Left	2
51-67	Right	1
67-78	Right	1

Therefore, it can be concluded that offsetting line along these straights would not be a viable solution.

Forestry

Forested areas may also be considered as an obstruction for any potential line route. It was assessed if any forested areas were located along the offset line routes. A total of 13 forestry areas along the new line routes were identified and shown in Table 3.

Table 3 – Forestry along the line routes

Dunstown - Maynooth 2 220 kV Line		
Straight	**Side**	**Forestry Areas**
41-49	Left	1
	Right	2
51-67	Left	2
	Right	3
86-90	Left	1
	Right	0
Gorman-Maynooth 220 kV Line		
Straight	**Side**	**Forestry Areas**
99-112	Left	1
	Right	1
133-138	Left	1
	Right	1

These findings would need to be assessed further when any lateral movement of the line route is considered since it would require forestry clearing.

4.3.1.2 Conclusions

It is evident from the assessment that only two straights along any of the potential offset line routes would be possible. The details of the obstructions along each straight has been summarised in Table 5.

The two straights along the G-M section where the line ccould potentially be offset are:-

- Straight 99-112
- Straight 118-133

The main obstruction in lateral offsetting the line is the presence of buildings. However, a total of 142 obstructions were found along all possible line route corridors as listed in Table

4. These included some other obstructions other than those listed previously, i.e. graveyard, driveways, gardens, horse ring, overhead line crossings etc.

Table 4 – Obstructions along parallel routes

Obstruction Type	Number of
Buildings	114
Forestry	13
National Monument	6
Graveyard	1
Horse Ring	1
Private Driveway	2
Overhead Line	4
Overhead Line Tower	1

Table 5 – Total number of obstructions along each parallel straight

Dunstown - Maynooth (2) 220 kV Line		
Straight	**Side**	**Number of obstructions**
1-4	Left	3
	Right	4
4-8	Left	6
	Right	6
8-10	Left	2
	Right	3
10-19	Left	10
	Right	1
19-26	Left	9
	Right	1
26-32	Left	5
	Right	2
32-41	Left	3
	Right	1
41-49	Left	6
	Right	6
49-51	Left	1
	Right	6
51-67	Left	13
	Right	11
67-78	Left	4
	Right	5

Dunstown - Maynooth (2) 220 kV Line		
Straight	**Side**	**Number of obstructions**
78-86	Left	1
	Right	1
86-90	Left	2
	Right	1 (Common with 90-92)
90-92	Left	2
	Right	1

Gorman-Maynooth 220 kV Line		
Straight	**Side**	**Number of obstructions**
90-99	Left	6
	Right	2
99-112	Left	1 (Forestry)
	Right	2
112-118	Left	3
	Right	3
118-133	Left	0
	Right	3
133-138	Left	4
	Right	1
138-141	Left	1
	Right	1

Based on these results it is concluded that this option would not be possible for most of the straights (except two on G-M line). However, if Option C is considered as a route design option for some straights, the findings from the desktop survey would need to be further reviewed.

4.3.2 Options A & B Desktop Survey –

As the Option C to offset the Overhead line and construct a new one can be discounted it was then considered which of Options A or B would be preferable or perhaps a combination of both. The desktop survey contributed to the decision-making process for the preferred route option and a source of information for the line design. Based on the line design discussed in more detail in Section 6, it was concluded that a combination of Option A and B would be a preferable solution. The desktop survey examined and presented the various elements that would have impact on this route option. Most of the elements listed above in Section 4.2 were also included in this desktop survey. The main elements those were examined are-:-

- Overhead Line Information
  - Existing Line Route
  - Existing Structure Positions
  - Proposed Structure Move Positions
- Landowner information
- Construction Related Information
  - Access Routes
  - Stringing Platform Areas
  - ERS Working Areas
  - Intermediate Mast Working Areas
- National Parks and Wildlife

Please note that for this assessment the new updated proposed structure numbers are used, and any reference to structures, spans or straights in the following sections are based on the new structure numbers.

4.3.2.1 Existing Data Assessment

Overhead Line

Existing line data (OHL and Structures) was included in the desktop survey along with the new proposed design data. This data formed the basis of the desktop survey when assessing all major deciding factors related to the route options.

Landowners

A significant aspect in the construction of a new OHL is the land ownership. This may have potential impacts on the line route. It is essential that all land holdings and boundaries along with the owners associated with them are identified beforehand.

The owners of lands where the existing structures are located or where the conductor crosses the land could were identified as part of this assessment. This data is presented in the desktop survey maps along with a spreadsheet listing all land owners.

The data was also used to assess the impact of relocating any existing structure. Primarily it was examined if any structure relocated from the current location would change the land ownership. This situation was not preferable, so it was important to identify these structures at the desktop study stage.

From assessing the new structure positions for the new line route design, it was found that seven structures would change lands and ownership. These structures are:-

- 22, 48, 67, 74, 85, 90, 121

The landowner boundary data was also used to examine distances of the structures from land boundaries, so that the impact of structure relocation can be determined. This was also applicable for working out the available areas for erecting an ERS as discussed below. These results were fed into the line deign model to find the most appropriate locations for locating the structures.

Access Routes

Aerial imagery was used to determine the best routes for accessing the structures along the line routes. These access routes are shown on the maps. Each route is defined according to the topography and the land use e.g. grass, lane, track, bog, crops etc. Google maps street view was also used to determine the best access point to the structures.

This exercise allows advance planning to access each location. Also, any potential access issues may be identified at this stage. The length of the access route can also be measured for each access route type. This can be used for estimating quantities such as stone for access tracks, bog mats that may be required for laying over soft ground etc.

Stringing Platforms

The stringing platforms are shown on the maps at the proposed angle mast and end mast locations to assess the land requirements. An area of 60m x 30m has been considered for the stringing platforms. The structures listed below in Table 6 are located close to the boundary and any structure that was 60.0m or less from the nearest boundary are identified. These structures may need to be assessed before any design would commence as space may be restricted. All structures were assessed with respect to the distance to the boundaries of the landholdings in which they are located.

Table 6 – Structures 60m or less from nearest boundary

Structure	Distance to Boundary (m)	Structure	Distance to Boundary (m)
1	60.2	51	7.5
4	19.6	68	52.8
8	14.1	87	17.9
10	22.8	90	0.7
19	35.2	91	51.2
26	32.2	96	43.1
32	16.6	111	34.1
41	1.8	117	33.4
49	22.0	130	53.7

Intermediate Tower Working Areas

The working areas are shown on the maps at the proposed intermediate mast locations to assess the land requirements. An area of 30m x 30m has been allocated for the working area. The structures listed below in Table 7 are located close to the boundary and any structure that was 30.0m or less from the nearest boundary are identified. These structures may need to be assessed before any design would commence as space may be restricted. All structures were assessed with respect to the distance to the boundaries of the landholdings in which they are located.

Table 7 – Structures 30m or less from nearest boundary

Structure	Distance to Boundary (m)	Structure	Distance to Boundary (m)	Structure	Distance to Boundary (m)
7	22.6	57	0.4	94	12.3
17	26.6	58	26.5	100	28.1
20	23.8	59	1.2	101	21.0
21	9.5	61	25.6	104	17.5
22	11.5	64	25.2	105	22.4
23	21.3	66	5.1	110	23.9
24	7.8	67	7.1	114	24.9
29	14.2	70	21.7	118	8.2
30	23.1	73	18.5	121	1.7
39	18.2	74	9.3	122	7.2
40	4.6	76	20.9	124	24.7
43	0.3	77	22.0	127	28.6
46	24.7	80	28.4	128	16.6
48	1.4	83	0.1	129	18.4
53	22.7	84	14.0	136	19.4
54	11.1	85	2.9	137	26.6
56	16.5	92	18.2		

ERS Working Areas

The working areas are shown on the maps at the proposed mast locations where ERS's may be required to assess the land requirements. A 40.0m radial area has been allocated for the ERS working area. The structures listed in Table 8 are located close to the boundary and any structure that was 80.0m or less from the nearest boundary are identified. These structures may need to be assessed before any design commences as space may be restricted. All structures were assessed with respect to the distance to the boundaries of the landholdings in which they are located. Exceptions to this were AM1 and AM96. AM1 was included since it is located close to the Dunstown station perimeter fence. AM 96 was included as it just over 40.0m from a road.

Table 8 – Towers 40m or less from nearest boundary

Structure	Distance to Boundary (m)	Structure	Distance to Boundary (m)
1	60.2	49	22.0
4	19.6	51	7.5
8	14.1	87	17.9
10	22.8	90	0.7
19	35.2	96	43.1
26	32.2	111	34.1
32	16.6	117	33.4
41	1.8		

Environmental Constraints

The desktop survey identified three areas where the OHL route crosses a NPWS conservation area. The three areas are designated as Proposed National Heritage Areas (PHNA), which are as follows:-

- Span 17-18 crosses the Grand Canal (PNHA)
- Span 43-44 crosses the Grand Canal (PNHA)
- Span 103-104 crosses the Royal Canal (PNHA)

The existing structures are not found to be located in any of the designated areas, nor it is envisaged that any structure moves will be relocated into any of these areas. This means that the construction works will have minimal impact on the conservation areas. The areas above will only be relevant during the stringing stages along the above given spans.

Buildings

Buildings have minimum to zero impact on the existing line corridor; therefore, they are not relevant for any planned structure relocations along the alignment. Some buildings are visible in the aerial imagery background on the maps. The existing buildings point data were not shown on the maps as this was not required.

National Monuments

The existing National Monuments sites have relatively no impact on the existing OHLs. Any structure relocations along the proposed alignment will not be affected by these sites. National Monument data was therefore not shown on the desktop survey maps.

Forestry

No significant forestry parcels were identified that would cause an issue for the movement of structures. Structures already located in or close to forestry typically are within a forestry cut corridor and therefore would have scope for movement with little cutting requirements other than the routine maintenance. Forestry is visible in places on the aerial imagery background on the maps. No forestry data is shown on these maps as this is not required.

4.3.2.2 Conclusions

The desktop survey assessment has not identified any major issues from a construction or planning perspective for route Options A or B. Buildings, Environmental Constraints, National Monuments, Forestry and 3rd party services have minimum to zero impact on the proposed design structure moves.

Some constructability issues were identified which would need further investigation prior to any final design or planned works. These issues are mainly associated with relocating structures into a new land holding and the working areas which are required around few mast locations. Actual site surveys may be required to assess these issues described in this report and site-specific solutions may need to be developed. It is recognised that the replacement and/or relocation of a structure may have planning implications and this will have to be confirmed by the TSO EirGrid.

4.4 Mapping

Maps were created for different aspects of the desktop study to visually present the information gathered. The maps are created to show the following information:-

- Line Route Maps;
- Parallel Route Options;
- Desktop Survey;
- Geotechnical.

A brief description on the details shown on each map series is discussed below. The Line Route, Desktop Survey and Parallel Route Options maps are included in Appendix 1.

4.4.1 Line Route Maps

The Line Route Maps show the new proposed line route overlaid on the OSI Discovery Series background map. The new line route is shown up to intermediate mast 139, where the new link is proposed to connect the tower and Woodland Station.

The line route maps are included in Appendix 1.

4.4.2 Parallel Route Options Maps

The parallel route options maps present the possible options for offsetting the line either left or right to the existing D-M and G-M line routes as described in Section 4.4.1 for route Option C. Locations of the obstructions such as property's, forestry, national monuments are shown on these maps. The OSI Digital Globe aerial imagery was used for the background on these maps. Please note that the existing structures are numbered as per existing 220 kV lines on these maps.

The parallel route options maps are included in Appendix 1.

4.4.3 Desktop Survey Maps

The desktop survey maps were created to show different elements of the overall study. These maps were created focussing on a combination of Options A and B (as described in Section 4.4.2 above). The OSI Digital Globe aerial imagery was used for the background on these maps. The maps show the existing structures positions along with the new relocated positions.

The Line route is shown as one line where it is proposed that the D-M and G-M lines will be connected at a crossover point west of Maynooth station. The line is shown up to Intermediate Mast 139, where the new link is proposed to connect the tower and Woodland

Station. The structure numbers have been updated to reflect the new structure numbers and these are shown on these maps.

Land boundaries are shown on these maps along with an ID number for the landowner.

Access Routes to each of the structures are shown on the maps. The access route type is shown according to the topography and the land use i.e. grass field, track, lane, crops fields etc. These access routes shown were created by inspecting the aerial imagery available and using Google Maps Street View.

Construction related information is also shown on the maps. This included showing the ERS working area, the stringing platforms and the working area designated around the intermediate or angle masts.

The desktop survey maps are included in Appendix 1.

4.4.4 Geological maps

The geological maps were created to carry out the appropriate geotechnical study. The OSI Discovery Series Mapping was used for the background on these maps. Different maps were created to show different geological elements as listed in Section 4.2 above. The geological maps were created for:

- GSI Boreholes and Site Investigation Maps;
- Bedrock Maps;
- Quarternary Sediments Maps;
- Karst Map.

These maps are referred to in Section 5 and included in Appendix 2.

4.5 Desktop Survey – Woodland Link Line Route

As the proposed line is planned to connect to Woodland station, some examination of the best possible route into the station was required. It is assumed for this study that the new link will be OHL. The proposed new 400 kV line follows the same route as the D-M OHL (up to the crossover point west of Maynooth Station) and then along the G-M OHL (up to between structure 130-139) where it will be required to go east and link into Woodland station. The optimum route was examined, and a preferred route option was recommended based on the desktop survey.

An assessment process was carried out similar to the process for the offset route option in Section 4.3.1. There was more scope to placing a line route in this case as the route was not as strictly defined as the offset routes in Section 4.3.1 i.e. there was more flexibility for placement of the angle mast and the route of the line. This assessment was carried out using ArcGIS. A 30.0m wide corridor was centred along the potential route options and an assessment was carried out to examine factors that may affect the route corridors. Buildings, environmental constraints, national monuments and forestry were primary factors in this assessment. The requirement to avoid these was the main criteria. Consideration was also given to the existing Oldstreet–Woodland 400 kV line. This line crosses the existing G-M OHL between spans 135-136. Based on this it was proposed that the link into Woodland station could be south of this crossing point (south of tower 135).

With all the above factors considered and examined two routes were deemed to be possible that would satisfy the criteria.

- Routes start south of Mast 135 on G-M line;
- Route corridors avoid any buildings;
- Route corridors avoid any National Monuments;
- Route Corridors do not cross areas of Environmental significance;
- Route corridors avoid forested areas.

Figure 5. shows the two potential OHL link route options. The northern route option branches off at G-M intermediate Mast 135 while the southern route option branches off at G-M angle tower 130.

The southern line may be the preferred option as it is envisaged that the northern option would prove more difficult from a public acceptance point of view. The northern line would mean that two 400 kV lines would be running parallel relatively close to each other. This could cause some problems with the landowners in the area as it would mean some properties would be sandwiched between the two 400 kV lines. Although the southern option is a slightly longer line, it navigates through much more open terrain where there are less properties nearby. It is thought that this would be more favourable from the public acceptance perspective.

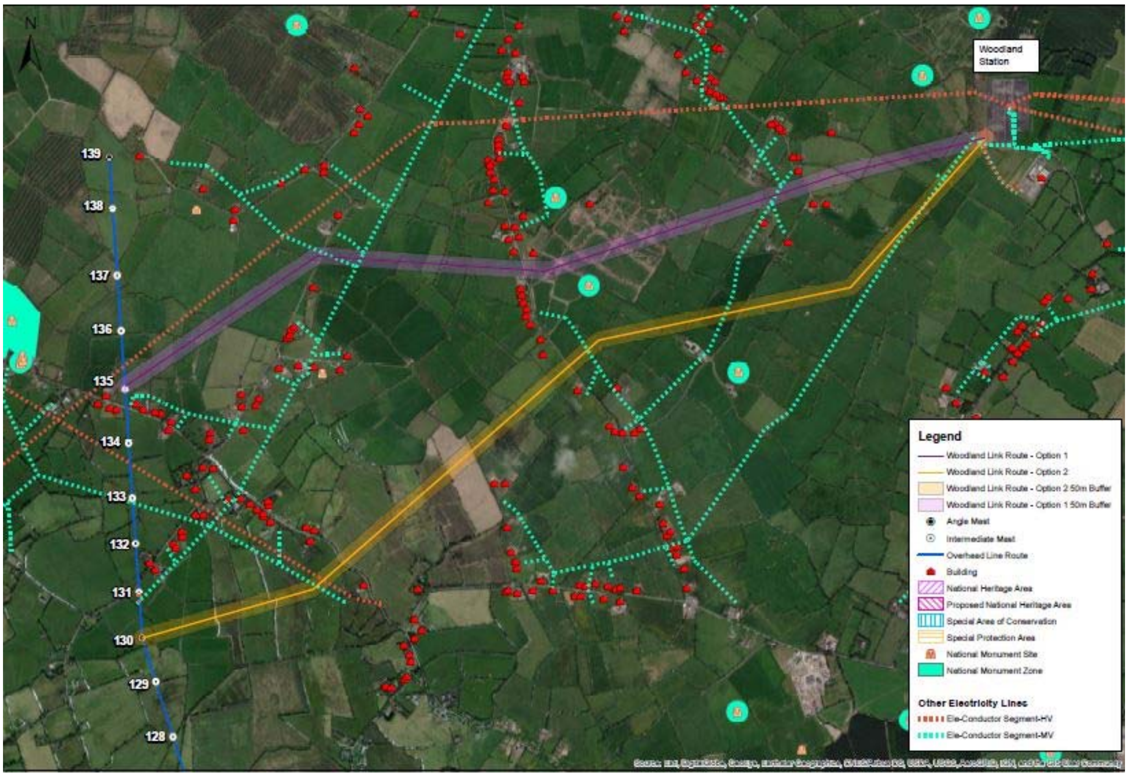

Figure 5 – Potential line routes to Woodland station

This high-level route assessment has identified the southern line option as potentially the most favourable from a landowner and public acceptance perspective. This assessment however does not consider the construction options i.e. potential double circuit along with G-M into Woodland. Furthermore, the use of an underground cable would also likely be considered as part of a wider route selection exercise.

5 Geotechnical Desktop Study

This geotechnical desktop study is a valuable source of information as it enables a better understanding of the nature of the ground conditions and types of challenges that will be encountered during the works.

The scope of the geotechnical desktop study includes:-

- To review existing sources of information outlined in Section 5.1;
- To assess the geotechnical conditions at each structure site;
- To make recommendations on the extent and scope of any ground investigation works and further studies;
- To identify assess likely foundation types of tower structures.

5.1 Sources of Information

The following sources of information were consulted for the geotechnical desktop study:-

- Aerial Photography of the Site (Provided by Ordnance Survey / & Bluesky)
- Teagasc Subsoils Map (Geological Survey of Ireland);
- Bedrock Geology Maps (Geological Survey of Ireland);
- Karst Database (Geological Survey of Ireland);
- Landslide Database (Geological Survey of Ireland);
- Geological Heritage Sites (Geological Survey of Ireland);
- Landfill Sites Maps (Geological Survey of Ireland);
- Site walkover survey carried out during the QRA (Qualitative Risk Assessment) for the Dunstown – Maynooth (2) Line;
- Historic site investigation records for projects in the vicinity of the 2 lines from the GSI.

5.2 Site Description

5.2.1 Major Infrastructure and Geology

The land use of the area where the two existing lines are located is predominantly agricultural with some built-up areas associated with towns and villages noted. The existing lines cross major roads including the M7 and M4 motorways, local roads and associated infrastructure e.g. existing bridges. A number of rivers (including the River Liffey) and streams are located in the vicinity of both existing lines. The Royal Canal and Grand Canal along with the Dublin to Mullingar and Dublin to Kildare railway lines cross the existing lines.

The bedrock geology mainly consists of limestones with some areas of shale, sandstones, calcareous greywacke siltstone located along the route of the two existing lines. Appendix 2.1 includes sketches of the bedrock geology with the two existing lines overlain.

Based on the GSI mapping, subsoils mainly consist of glacial till derived from sandstone and limestone. There are some localised areas of alluvium associated with rivers and streams. One localised area of cut over raised peat was noted in the vicinity of structure 35 on the D-M OHL quaternary geology map. An area of lake marl is noted in the vicinity of Structure 1 on the D-M OHL quaternary geology map. Appendix 2.2 includes sketches of the quaternary geology with the two existing lines overlain.

5.3 Ground Conditions & Preliminary Assessment

This section provides information on the ground conditions based on the desktop study from the sources indicated in Section 5.1 for each tower location on the D-M and the G-M lines.

The existing ground conditions for each tower location on the D-M line based on the desktop study have been summarised in Table 9. Table 10 provides information on the existing ground conditions for each tower location for the G-M line. Appendix 2.3 includes sketches of the borehole records and karst features with the routes of the two lines overlain. The structure numbers given in Table 9 and Table 10 below are the new structure numbers as shown on geological maps.

It should be noted that exploratory holes sourced from the GSI exploratory hole database within approximately 1.0km of structure locations provide information about the existing ground conditions and have been included in the table for information. This information should not be relied upon solely to assess the ground conditions or foundation requirements at structure sites.

The estimated foundation types are based on the bedrock and subsoils information, aerial photography combined with available exploratory hole records within the area. These estimated foundation types may change following review of further geotechnical information, intrusive ground investigation or on-site assessment by the ESBI HV Project Engineers.

5.3.1 Dunstown – Maynooth (2) Line

Table 9 provides information on ground conditions for each tower location for the D-M OHL:-

Table 9: Dunstown–Maynooth (2) Ground Conditions Summary

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
1 (EM), 2 (INT)	Calcareous greywacke siltstone & shale	Till derived from limestone, lake marl	5024 approximately 1km – Soft silt to 2m overlying firm silt and medium dense gravel. Groundwater 0.7m.	Pad foundations	Well drained farming land based on QRA walkover.
3 (INT)	Calcareous greywacke siltstone & shale	Till derived from limestone	5024 approximately 1km – Soft silt to 2m overlying firm silt and medium dense gravel. Groundwater 0.7m	Pad foundations	Well drained farming land based on QRA walkover
4 (AM)	Calcareous greywacke siltstone & shale	Till derived from limestone, alluvium	5024 approximately 1km – Soft silt to 2m overlying firm silt and medium dense gravel. Groundwater 0.7m	Pad foundations	Well drained farming land based on QRA walkover
5 (INT), 6 (INT), 7 (INT)	Calcareous greywacke siltstone & shale	Till derived from limestone	No records within 1km	Pad foundations	Well drained farming land based on QRA walkover

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
8 (AM), 9 (INT)	Calcareous greywacke siltstone & shale	Till derived from limestone, alluvium	No records within 1km	Pad foundations	Well drained farming land based on QRA walkover
10 (AM)	Lenticular mudstone & coarse siltstone / Calcareous greywacke siltstone & shale	Till derived from limestone	No records within 1km	Pad foundations	Well drained farming land based on QRA walkover
11 (INT)	Lenticular mudstone & coarse siltstone	Till derived from limestone	No records within 1km	Pad foundations	Identified as area at risk of flooding in QRA walkover
12 (INT), 13 (INT)	Skeletal, oolitic & micritic limestone	Till derived from limestone	No records within 1km	Pad foundations	Well drained farming land based on QRA walkover
14 (INT)	Skeletal, oolitic & micritic limestone	Till derived from limestone	No records within 1km	Pad foundations	Well drained farming land based on QRA walkover
15 (INT)	Skeletal, oolitic & micritic limestone	Till derived from limestone	2824-4 within 1km – Light brown till, sandy gravel	Pad foundations	Well drained farming land based on QRA walkover
16 (INT)	Skeletal, oolitic & micritic limestone	Till derived from limestone	2824-3 within 500m – Grey brown clay (Till), sandy gravel	Pad foundations	Well drained farming land based on QRA walkover
17 (INT)	Dark muddy limestone & shale	Till derived from limestone, alluvium	2824-2 within 200m - Grey brown clay (Till), sandy gravel, rock 6m.	Pad foundations	Well drained farming land based on QRA walkover
18 (INT)	Dark muddy limestone & shale	Till derived from limestone	2824-2 within 150m - Grey brown clay (Till), sandy gravel, rock 6m.	Pad foundations	Well drained farming land based on QRA walkover
19 (AM)	Dark muddy limestone & shale	Till derived from limestone	GSI Report 2824-1 within 100m – Grey brown clay (Till), rock 5m.	Pad foundations	Well drained farming land based on QRA walkover
20 (INT), 21 (INT)	Dark muddy limestone & shale	Till derived from limestone	2123 & 2136 within 500m (A51, A58, A59, A60, A61, A64 Soft clay in upper 1m, Firm to stiff Clay below, groundwater 1m approx.)	Pad foundations	Identified as Poorly drained farming land during QRA walkover
22 (INT)	Cherty often dolomitised limestone	Till derived from limestone	2123 & 2136 within 800m (A51, A58, A59, A60, A61, A64 Soft clay in upper 1m, Firm to stiff Clay below, groundwater 1m approx.)	Pad foundations	Well drained farming land based on QRA walkover
23 (INT)	Cherty often dolomitised limestone	Till derived from limestone	1458 within 300m, BH26 & 27 - Firm to stiff Clay overlying dense gravel – groundwater 3m approx.	Pad foundations	Watercourse within 10m

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
24 (INT)	Cherty often dolomitised limestone	Till derived from limestone / alluvium	1458 within 300m BH1, BH2 -Soft Clay overlying firm to stiff Clay, groundwater 3m approx.	Pad foundations	Watercourse within 10m
25 (INT)	Cherty often dolomitised limestone	Alluvium	1426, 1458 within 300m BH1, BH2 -Soft Clay overlying firm to stiff Clay, groundwater 3m approx.	Pad foundations	Well drained farming land based on QRA walkover
26 (AM), 27 (INT)	Cherty often dolomitised limestone	Alluvium	CN-053 within 400m – Dark brown Clay, rock 13m.	Pad foundations	Well drained farming land based on QRA walkover
28 (INT)	Massive unbedded lime mudstone	Till derived from limestone	2446 River Liffey Bridge within 500m – Firm to stiff Clay & dense Gravels, groundwater 4.5m.	Pad foundations	Well drained farming land based on QRA walkover
29 (INT)	Massive unbedded lime mudstone	Till derived from limestone	2446 River Liffey Bridge within 500m - Firm to stiff Clay & dense Gravels, groundwater 4.5m.	Pad foundations	Watercourse within 10m
30 (INT), 31 (INT)	Massive unbedded lime mudstone	Till derived from limestone	1608-1 within 800m approx. – Grey clayey gravel.	Pad foundations	Well drained farming land based on QRA walkover
32 (AM)	Massive unbedded lime mudstone	Till derived from limestone	5927, 5670 within 800m approx.. Soft to firm Clay / Silt medium dense sand & gravels overlying firm to stiff Clay.	Pad foundations	Watercourse within 10m
33 (INT)	Massive unbedded lime mudstone	Till derived from limestone	1608-2 within 800m approx. – Grey brown clayey gravel / brown till	Pad foundations	Watercourse within 10m
34 (INT)	Massive unbedded lime mudstone	Alluvium / eskers comprised of gravels	1608-3 within 800m approx. – Brown clay / grey brown clayey gravel	Pad foundations	Well drained farming land based on QRA walkover
35 (INT)	Massive unbedded lime mudstone	Cut over raised peat	1608-3 within 800m approx. - Brown clay / grey brown clayey gravel	Pad foundations or piled foundations depending on presence of peat	Well drained farming land based on QRA walkover
36 (INT), 37 (INT)	Massive unbedded lime mudstone	Till derived from limestone	1608-4 within 800m approx. – Brown till / grey gravel.	Pad foundations	Well drained farming land based on QRA walkover
38 (INT)	Nodular & muddy limestone and shale	Till derived from limestone / alluvium	3572, 1608-5 within 800m approx. -Brown clayey gravel / brown till.	Pad foundations	Well drained farming land based on QRA walkover
39 (INT), 40 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	3572, 1608-6 within 800m approx. – Grey brown sandy gravel.	Pad foundations	Watercourse within 10m

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
41 (AM)	Nodular & muddy limestone and shale	Till derived from limestone	1608-7, 1608-8 within 800m approx. – Brown clay / dark grey gravel.	Pad foundations	Watercourse within 10m
42 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	1608-7, 1608-8 within 500m approx. - Brown clay / dark grey gravel.	Pad foundations	Well drained farming land based on QRA walkover
43 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	1608-8 within 50m – Brown clay / dark grey gravel	Pad foundations	Watercourse within 10m
44 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	1608-8 within 600m approx. – Brown clay / dark grey gravel	Pad foundations	Poorly drained farming land based on QRA walkover
46 (INT)	Nodular & muddy limestone and shale	Alluvium / Till derived from limestone	4280 within 800m approx. – firm to stiff Clays, groundwater 1.8m.	Pad foundations	Watercourse within 10m
47 (INT), 48 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	4280 within 800m approx. indicating firm to stiff Clays, groundwater 1.8m.	Pad foundations	Well drained farming land based on QRA walkover
49 (AM)	Nodular & muddy limestone and shale	Till derived from limestone	4512 within 500m approx. – Firm to stiff Clay with groundwater at 1.5m	Pad foundations	Well drained farming land based on QRA walkover
50 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	4512 within 500m approx.– Firm to stiff Clay with groundwater at 1.5m. 5620 within 50m – stiff sandy gravelly Clay to 2.5m.	Pad foundations	Well drained farming land based on QRA walkover
51 (AM)	Nodular & muddy limestone and shale	Till / gravels derived from limestone	4512, 5620– Firm to stiff Clay with groundwater at 1.5m.	Pad foundations	Well drained farming land based on QRA walkover
52 (INT)	Nodular & muddy limestone and shale	Till derived from limestones	4512, 5620 within 200m – Firm to stiff Clay with groundwater at 1.5m.	Pad foundations	Well drained farming land based on QRA walkover
53 (INT)	Nodular & muddy limestone and shale	Till derived from limestones	4512, 5620 within 600m – Firm to stiff Clay with groundwater at 1.5m, CN-016 within 1km – firm to stiff Clay.	Pad foundations	Watercourse within 10m, groundwater at 1.8m in BHs
54 (INT)	Nodular & muddy limestone and shale	Till derived from limestones	4512, 5620 within 1km - Firm to stiff Clay with groundwater at 1.5m, CN-016 within 1km – bedrock borehole – rock 7m.	Pad foundations	Well drained farming land based on QRA walkover, groundwater at 1.8m

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
55 (INT)	Nodular & muddy limestone and shale	Till derived from limestones	CN-016 within 1km – bedrock borehole – rock 7m.	Pad foundations	Well drained farming land based on QRA walkover
56 (INT)	Nodular & muddy limestone and shale	Till derived from limestones	No records	Pad foundations	Well drained farming land based on QRA walkover
57 (INT), 58 (INT)	Nodular & muddy limestone and shale	Till derived from limestones	723-07, 723-09, 723-08, 723-02, 723-10, 723-03, BT-5, WBT-79-1, BT-4, 723-04 within 500m – glacial till overlying limestone.	Pad foundations	Well drained farming land based on QRA walkover
59 (INT)	Nodular & muddy limestone and shale	Alluvium / till derived from limestones	723-07, 723-09, 723-08, 723-02, 723-10, 723-03, BT-5, WBT-79-1, BT-4, 723-04 within 100m approx. – glacial till overlying limestone.	Pad foundations	Watercourse within 10m
60 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	BT-3, BT-3A, 723-06, 723-05 – within 100m approx.- Glacial till with rock at 3m approx.	Pad foundations	Well drained farming land based on QRA walkover
61 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	BT-3 within 200m – Bedrock borehole, rock 3.7m	Pad foundations	Well drained farming land based on QRA walkover
62 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	BT-3 CN-008 within 800m – Bedrock boreholes, rock 3 - 3.7m.	Pad foundations	Well drained farming land based on QRA walkover
63 (INT)	Nodular & muddy limestone and shale	Till derived from limestone	CN-009 within 700m – bedrock borehole – rock 8m	Pad foundations	Well drained farming land based on QRA walkover
64 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-009, CN058 within 800m – bedrock boreholes – rock 7 - 8m.	Pad foundations	Watercourse within 10m
65 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-009 within 600m – bedrock borehole – rock 8m.	Pad foundations	Identified as bog / marshland from QRA walkover
66 (INT), 67 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-004 within 700m – bedrock borehole – rock 4m.	Pad foundations	Well drained farming land based on QRA walkover
68 (AM), 69 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-061 within 300m – bedrock borehole – rock 14m	Pad foundations	Well drained farming land based on QRA walkover
70 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-002 within 100m – Fine to medium Sand, rock 9m	Pad foundations	Watercourse within 10m

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
71 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-002 within 300m – Fine to medium Sand, rock 9m	Pad foundations	Well drained farming land based on QRA walkover
72 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-060 within 300m, – bedrock borehole, rock 5.3m	Pad foundations	Well drained farming land based on QRA walkover
73 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-060, 4889 – BH30, 6187 (unavailable) within 250m – firm to stiff Clay and dense gravels, rock 5.3m.	Pad foundations	Well drained farming land based on QRA walkover
74 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-060, 4889 – BH30, 6187 (unavailable) within 600m, firm to stiff Clay and dense gravels, rock 5.3m.	Pad foundations	Watercourse within 10m
75 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN-060, 4889 – BH30, 6187 (unavailable) within 1km, Firm to stiff Clay and dense gravel, rock 5.3m.	Pad foundations	Well drained farming land based on QRA walkover
76 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN006, 6790 within 700m – Made ground overlying medium dense gravels / firm to stiff sandy gravelly Clay.	Pad foundations	Watercourse within 10m
77 (INT)	Massive unbedded lime mudstone	Till derived from limestone	CN006, 6790 within 500m - Made ground overlying medium dense gravels / firm to stiff sandy gravelly Clay.	Pad foundations	Watercourse within 10m
78 (INT), 79 (AM)	Massive unbedded lime mudstone	Till derived from limestone	CN006, 6790 within 900m - Made ground overlying medium dense gravels / firm to stiff sandy gravelly Clay.	Pad foundations	Well drained farming land based on QRA walkover
80 (INT)	Nodular muddy limestone & shale	Alluvium	No records within 1km	Pad foundations	Watercourse within 10m
81 (INT)	Nodular muddy limestone & shale	Till derived from limestone	No records within 1km	Pad foundations	Well drained farming land based on QRA walkover
82 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-068, 5657 within 1km – Sandy gravelly Clay, rock 9.45m	Pad foundations	Watercourse within 10m
83 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-038 within 800m – bedrock borehole, sand & gravel, rock 4m	Pad foundations	Watercourse within 10m
84 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-038 within 600m – bedrock borehole, sand & gravel, rock 4m	Pad foundations	Well drained farming land based on QRA walkover
85 (INT), 86 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-038 within 800m – bedrock borehole, sand & gravel, rock 4m	Pad foundations	Watercourse within 10m

Structure No.	Bedrock Geology	Quaternary Geology	Exploratory Holes	Estimated Foundation Type	Other Remarks
87 (AM), 88 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-064 not available, CN-RL-4 within 700m - bedrock borehole – rock 6.1m.	Pad foundations	Watercourse within 10m
89 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-069, CN-RL-4 within 700m - bedrock boreholes, rock 5.45m – 6.1m, CN-064 not available.	Pad foundations	Area at risk of flooding based on QRA walkover survey
90 (INT)	Nodular muddy limestone & shale	Till derived from limestone	CN-069 – within 500m – bedrock borehole, rock 5.45m	Pad foundations	Well drained farming land based on QRA walkover

5.3.2 Gorman – Maynooth Line

Table 10 provides information on ground conditions for each tower location for the G-M OHL:-

Table 10: Gorman–Maynooth Ground Conditions Information

Structure No.	Bedrock Geology	Quaternary Geology	Boreholes	Estimated Foundation Type	Other Remarks
91 (AM), 92 (INT)	Nodular & muddy limestone & shale	Till derived from limestone	CN-069 within 250m - bedrock borehole, rock 5.85m.	Pad foundations	Watercourse in close proximity
93 (INT)	Nodular & muddy limestone & shale	Till derived from limestone	CN-069, CN-063 (not available) within 700m - bedrock boreholes, rock 5.85m.	Pad foundations	
94 (INT)	Massive unbedded lime-mudstone	Till derived from limestone	CN-063 within 500m – not available.	Pad foundations	
95 (INT)	Massive unbedded lime-mudstone	Till derived from limestone	CN-037, CN-063 (not available) within 800m – rock 4m.	Pad foundations	
96 (AM)	Massive unbedded lime-mudstone	Till derived from limestone	CN-037 within 800m - rock 4m. 2165 within 700m. Generally firm to stiff clay.	Pad foundations	
97 (INT), 98 (INT)	Massive unbedded lime-mudstone	Till derived from limestone	2165 within 600m. Generally firm to stiff Clay.	Pad foundations	
99 (INT), 100 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2165 Kilcock, within 300m. Generally firm to stiff Clay.	Pad foundations	
101 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2165 within 400m. Generally firm to stiff Clay.	Pad foundations	M4 Motorway in close proximity, Lyreen River in close proximity
102 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2165 within 300m. generally firm to stiff Clay.	Pad foundations	
103 (INT)	Dark limestone & shale (Calp)	Bedrock outcrop, alluvium, Till derived from limestone	2165 within 350m. Generally firm to stiff Clay.	Pad foundations	
104 (INT), 105 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2165 within 50m. Generally firm to stiff Clay	Pad foundations	Royal Canal crossing close by
106 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2165 within 600m. Generally firm to stiff Clay.	Pad foundations	
107 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2165 within 1km. Generally firm to stiff Clay.	Pad foundations	Watercourse in close proximity

Structure No.	Bedrock Geology	Quaternary Geology	Boreholes	Estimated Foundation Type	Other Remarks
108 (INT), 109 (INT), 110 (INT), 111(INT), 112 (INT), 113 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	No records within 1km	Pad foundations	
114 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	No records within 1km	Pad foundations	Watercourse within close proximity
115 (INT), 116 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2964 within 1km, firm to stiff Clay, groundwater 2.5m.	Pad foundations	
117 (AM), 118 (INT), 119 (INT), 120 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	2964 within 1km, firm to stiff Clay, groundwater 2.5m.	Pad foundations	Watercourse in close proximity
121 (INT), 122 (INT)	Dark limestone & shale (Calp)	Till derived from limestone	No records within 1km	Pad foundations	
123 (INT)	massive unbedded lime mudstone / Dark limestone & shale (Calp)	Till derived from sandstones	GSI report KC-07-AQU within 1km – bedrock BH – rock 17m.	Pad foundations	Boundary between 2 different rock types
124 (INT)	Dark muddy limestone, shale / massive unbedded lime mudstone	Till derived from sandstones	KC-07-AQU within 500m – bedrock BH – rock 17m.	Pad foundations	Boundary between 2 different rock types
125 (INT)	Dark muddy limestone, shale	Till derived from sandstones	KC-03-AQU within 50m – bedrock BH – rock 8m.	Pad foundations	
126 (INT)	Dark limestone & shale (Calp)	Till derived from sandstones, alluvium	KC-01-AQU, LH-80-2 within 500m, bedrock BHs, rock 13 -19m.	Pad foundations	Watercourse within close proximity
127 (INT)	Dark limestone & shale (Calp)	Till derived from sandstones	LH-80-1, WLH-1 within 500m, bedrock BHs, rock 4.3 -29m	Pad foundations	Watercourse within close proximity
128 (INT)	Dark limestone & shale (Calp)	Till derived from sandstones, alluvium	WLH-1 within 100m – bedrock BH, rock 4.3m.	Pad foundations	Watercourse within close proximity
129 (INT)	Shale & sandstone	Till derived from sandstones	WLH-3 not available, WLH-2, LH79-1 within 350m. bedrock BHs, rock 3 – 16.5m.	Pad foundations	
130 (AM)	Shale & sandstone	Till derived from sandstones	WLH-2, LH79-1 within 250m bedrock BHs, rock 3 – 16.5m.	Pad foundations	
131 (INT), 132 (INT)	Shale & sandstone	Till derived from sandstones	KC-05-AQU, WLH-2 within 800m, bedrock BHs, rock 3m.	Pad foundations	
133 (INT)	Shale & sandstone	Till derived from sandstones, alluvium	KC-05-AQU, WLH-2 within 1km – rock 3m.	Pad foundations	

Structure No.	Bedrock Geology	Quaternary Geology	Boreholes	Estimated Foundation Type	Other Remarks
134 (INT), 135 (INT), 136 (INT), 137 (INT), 138 (INT), 139 (INT)	Shale & sandstone	Till derived from sandstones	No records within 1km	Pad foundations	

5.3.3 Summary of Superficial Deposits

The following section provides a summary of the superficial deposits indicated to be present at the tower locations.

5.3.3.1 Glacial Till

Glacial till is identified at most structure sites and is recorded on the GSI mapping as till derived from limestones or till derived from sandstones. Glacial till is derived from the erosion and entrainment of moving ice from a glacier and is laid down by glacier action. Glacial till soils cover much of Ireland and are typically identified as firm to still sandy gravelly clays and medium dense to very dense gravels with a wide range of particle sizes including cobbles and boulders. Generally glacial tills are over-consolidated and possess adequate bearing resistance for shallow foundations.

5.3.3.2 Alluvium

Alluvium consists of material deposited by rivers. It normally consists of unconsolidated soil or sediment that has been eroded and re-shaped by water and deposited in a no-marine environment. Alluvium is typically made up of a variety of materials including fine particles of clay and silt and larger particles of sand and gravel. Alluvium consisting of clays and silts is likely to be highly compressible and may require excavation and replacement to ensure a suitable foundation bearing strata is provided. Where soft alluvium to depths greater than 4 m is identified an intrusive geotechnical investigation shall be carried out and a piled foundations utilising bearing resistance and skin friction from suitable materials below the soft alluvium should be proposed.

5.3.3.3 Peat

Peat forms as a result of the accumulation of organic matter and decayed vegetation. This normally occurs when dead vegetation is preserved below a high-water table such as swamps or wetlands. Peat is highly porous, highly compressible, has low shear strength and bearing capacity and is not a suitable material to found foundations on. Where peat extends to a depth of less than 4 m, peat should be excavated and replaced with a suitable material. However, if peat is present to a depth of greater than 4 m piled foundations utilising bearing resistance and skin friction from suitable materials below the peat should be proposed. The depth of bearing strata shall be confirmed from the intrusive ground investigation.

5.3.3.4 Marl

Marl is a lime rich mud / mudstone which contains variable amounts of clays and silt and poses concerns regarding settlement and stability. Marl consisting of clays and silts is likely to be highly compressible and may require excavation and replacement to ensure a suitable foundation bearing strata is provided. The foundation type for the marl shall be decided based on the depth of the bearing strata which shall be confirmed from intrusive ground investigation.

5.3.3.5 Groundwater

Groundwater was encountered at a range of depths across the structure sites in exploratory holes. For design purposes it is recommended that the groundwater level is considered between 1m and 2.5m below ground level

5.3.4 Summary of Bedrock Geology

Based on the desktop study of the 1:100,000 scale GSI map, the following are the bedrock formations that underly the D-M and G-M lines are as follows:

- Calcareous greywacke siltstone and shale;
- Calcareous shale, limestone conglomerate;
- Lenticular mudstone and coarse siltstone;
- Skeletal, oolitic and micritic limestone;
- Dark (muddy) limestone and shale;
- Nodular & muddy limestone and shale;
- Cherty often dolomitised limestone;
- Massive unbedded lime-mudstone;
- Shale and sandstone.

None of the bedrock types indicated above are likely to have an adverse impact on the foundations.

However, limestone can potentially be dissolved by rainwater over very long durations. It is often highly permeable and can result in eroded limestone (karst) areas. From the review of the GSI mapping it should be noted that there is no known risk of karst areas in the vicinity of the G-M and D-M lines.

From the bedrock information from the exploratory holes in the vicinity of the structure sites, depth to rock varies from approximately 3.0 m to approximately 20.0 m.

5.3.5 Other Items Assessed

The database of geological heritage sites and database of landslides from the GSI mapping was also consulted and it is noted that there are no geological heritage sites within 1.0 km approximately of the existing lines. There are also no records of landslides that occurred within 1.0 km of the existing lines. There are no towers located in Special Areas of Conservation (SACs).

5.4 Schedule of Intrusive Investigation

The geotechnical intrusive investigations proposed at each structure site are given in Table 11 and Table 12 below. At sites where no intrusive ground investigation is proposed, a site survey should be carried out in advance of foundation construction in addition to supervision of excavations and foundation construction to assess the required foundation types.

Table 11 – Dunstown – Maynooth (2) Intrusive Investigation Schedule

Structure No.	Intrusive Investigation Required	Details
1 (EM)	Dynamic probe	To 5m depth or refusal
2 (INT)	Dynamic probe	To 5m depth or refusal
4 (AM)	Dynamic probe	To 5m depth or refusal
6 (INT)	Dynamic probe	To 5m depth or refusal
8 (AM)	Dynamic probe	To 5m depth or refusal
10 (AM)	Dynamic probe	To 5m depth or refusal

Structure No.	Intrusive Investigation Required	Details
11 (INT)	Dynamic probe	To 5m depth or refusal
14 (INT)	Dynamic probe	To 5m depth or refusal
17 (INT)	Dynamic probe	To 5m depth or refusal
19 (AM)	Dynamic probe	To 5m depth or refusal
20 (INT)	Dynamic probe	To 5m depth or refusal
21 (INT)	Dynamic probe	To 5m depth or refusal
23 (INT)	Dynamic probe	To 5m depth or refusal
24 (INT)	Dynamic probe	To 5m depth or refusal
25 (INT)	Dynamic probe	To 5m depth or refusal
26 (AM)	Dynamic probe	To 5m depth or refusal
27 (INT)	Dynamic probe	To 5m depth or refusal
28 (INT)	Dynamic probe	To 5m depth or refusal
29 (INT)	Dynamic probe	To 5m depth or refusal
32 (AM)	Dynamic probe	To 5m depth or refusal
33 (INT)	Dynamic probe	To 5m depth or refusal
34 (INT)	Dynamic probe	To m depth or refusal
35 (INT)	Cable percussion borehole	To 8m depth or refusal, SPTs at 1.5m intervals, Undisturbed sampling in cohesive material with N<10.
38 (INT)	Dynamic probe	To 5m depth or refusal
39 (INT)	Dynamic probe	To 5m depth or refusal
40 (INT)	Dynamic probe	To 5m depth or refusal
41 (AM)	Dynamic probe	To 5m depth or refusal
43 (INT)	Dynamic probe	To 5m depth or refusal
44 (INT)	Dynamic probe	To 5m depth or refusal
45 (INT)	Dynamic probe	To 5m depth or refusal
46 (INT)	Dynamic probe	To 5m depth or refusal
49 (AM)	Dynamic probe	To 5m depth or refusal
51 (AM)	Dynamic probe	To 5m depth or refusal
53 (INT)	Dynamic probe	To 5m depth or refusal
56 (INT)	Dynamic probe	To 5m depth or refusal
59 (INT)	Dynamic probe	To 5m depth or refusal
64 (INT)	Dynamic probe	To 5m depth or refusal
65 (INT)	Cable percussion borehole	To 8m depth or refusal, SPTs at 1.5m intervals, Undisturbed sampling in cohesive material with N<10.
68 (AM)	Dynamic probe	To 5m depth or refusal
70 (INT)	Dynamic probe	To 5m depth or refusal
74 (INT)	Dynamic probe	To 5m depth or refusal
76 (INT)	Dynamic probe	To 5m depth or refusal

Structure No.	Intrusive Investigation Required	Details
77 (INT)	Dynamic probe	To 5m depth or refusal
79 (AM)	Dynamic probe	To 5m depth or refusal
80 (INT)	Dynamic probe	To 5m depth or refusal
82 (INT)	Dynamic probe	To 5m depth or refusal
83 (INT)	Dynamic probe	To 5m depth or refusal
85 (INT)	Dynamic probe	To 5m depth or refusal
86 (INT)	Dynamic probe	To 5m depth or refusal
87 (AM)	Dynamic probe	To 5m depth or refusal
88 (INT)	Dynamic probe	To 5m depth or refusal
89 (INT)	Dynamic probe	To 5m depth or refusal
90 (INT)	Dynamic probe	To 5m depth or refusal

Table 12 – Gorman – Maynooth Intrusive Investigation Schedule

Structure No.	Intrusive Investigation Required	Details
91 (AM)	Dynamic probe	To 5m depth or refusal
92 (INT)	Dynamic probe	To 5m depth or refusal
94 (INT)	Dynamic probe	To 5m depth or refusal
96 (AM)	Dynamic probe	To 5m depth or refusal
98 (INT)	Dynamic probe	To 5m depth or refusal
101 (INT)	Dynamic probe	To 5m depth or refusal
103 (INT)	Dynamic probe	To 5m depth or refusal
107 (INT)	Dynamic probe	To 5m depth or refusal
110 (INT)	Dynamic probe	To 5m depth or refusal
111 (AM)	Dynamic probe	To 5m depth or refusal
114 (INT)	Dynamic probe	To 5m depth or refusal
117 (AM)	Dynamic probe	To 5m depth or refusal
118 (INT)	Dynamic probe	To 5m depth or refusal
119 (INT)	Dynamic probe	To 5m depth or refusal
121 (AM)	Dynamic probe	To 5m depth or refusal
122 (INT)	Dynamic probe	To 5m depth or refusal
123 (INT)	Dynamic probe	To 5m depth or refusal
124 (INT)	Dynamic probe	To 5m depth or refusal
126 (INT)	Dynamic probe	To 5m depth or refusal
127 (INT)	Dynamic probe	To 5m depth or refusal
128 (INT)	Dynamic probe	To 5m depth or refusal
130 (AM)	Dynamic probe	To 5m depth or refusal
133 (INT)	Dynamic probe	To 5m depth or refusal
136 (INT)	Dynamic probe	To 5m depth or refusal

Structure No.	Intrusive Investigation Required	Details
139 (AM)	Dynamic probe	To 5m depth or refusal

5.5 Geotechnical Risks / Hazards

A list of the geotechnical hazards is provided below to outline the various risks associated with the foundation investigation and construction. The purpose is to highlight the hazards to be mitigated during the foundation investigation and foundation construction. The following are the hazards associated with the foundation investigation and construction:-

- Unexpected soft ground encountered;
- Greater extent of soft ground encountered compared to what was anticipated;
- Higher groundwater table encountered compared to what was anticipated;
- Collapse of excavation side slopes during construction if sheet piles not used;
- Flooding of excavation due to surface water inflow;
- Unexpected settlement of foundations following construction;
- Contaminated material that could be reactive with foundation construction materials;
- Unexpected hard obstructions making excavation difficult;
- Access difficulties for plant and equipment relating to foundation investigation / construction;
- Plant and equipment overturning or settling due to soft ground while accessing sites for foundation investigation / construction;
- Liaising with landowners to get access permission to site locations.

6 Voltage Uprate Design & Construction Options

6.1 Indicative PLS-CADD Model

The proposed D-W 400 kV circuit will be required to meet 400 kV OHL design requirements which includes additional clearance to external obstacles as summarised in Table 13. Furthermore, the 400 kV design (Non-Earthwire) will include a twin bundle 600mm^2 ACSR “Curlew” conductor with a specified MOT of 80°C.

It is worth noting that the span limits for 220 kV and 400 kV ESB lines strung with 600mm^2 ACSR “Curlew” are the same. This is advantageous when considering voltage uprating as no additional intermediate structures would be required hence the total number of structures overall remains the same.

Table 13 – 400 kV External Clearance Requirements

Obstacles		Clearance	Weather Case	Cable Condition
Over Normal Ground		9.0m	80°C	Max Sag RS
Over Roads, Railways		10.0m	80°C	Max Sag RS
Over Canals, Navigable Waterways		14.7m	80°C	Max Sag RS
Over Roads		5.5m	4 cm ice	Max Sag RS
Railways	Rail Level	7.5m	0°C, 1.2 x sag with 2.5 cm ice	Max Sag RS
	Traction Conductors	3.5m	0°C, 1.2 x sag with 2.5 cm ice	Max Sag RS
Over LT/10kV/38kV lines		3.5m	0°C, 1.2 x sag with 2.5 cm ice	Max Sag RS
		1.75m	0°C, 1.2 x sag with 4 cm ice	Max Sag RS
Over 110kV Lines		3.75m	0°C, 1.2 x sag with 2.5 cm ice	Max Sag RS
		2.0m	0°C, 1.2 x sag with 4 cm ice	Max Sag RS
Over 220kV Lines		4.25m	0°C, 1.2 x sag with 2.5 cm ice	Max Sag RS
		2.25m	0°C, 1.2 x sag with 4 cm ice	Max Sag RS

Note: All Ice Load Conditions using Specific Gravity = 0.9

A PLS-CADD model of the proposed D-W 400 kV line was created by combing the two existing PLS-CADD models of D-M and G-M. As noted previously, no lidar data is available for G-M therefore the PLS-CADD model for this section was developed by digitising the existing hand-drawn profiles and is by nature less accurate. The G-M section was supplemented by data procured from a 3rd party supplier which included high resolution imagery. This high-level PLS-CADD model will be used for the tasks required as part of this study however for the purposes of detailed final design a lidar survey of the entire line route is required.

6.2 Stability Analysis

A major design constraint of the composite insulator (pivoted-vee design) which will be used on the new 400 KV circuit is stability. As the insulator is installed on a hinge joint and is free to rotate, the longitudinal stability can be an issue. As shown in Figure 6, a failure scenario can arise under high wind loading conditions. In order to overcome this, it is necessary to use stability or stop type structures which ensure longitudinal stability of each INT structure in the affected tension straight. An important consideration of this study is to determine the number and location of stability structures required on the proposed D-W 400 kV line.

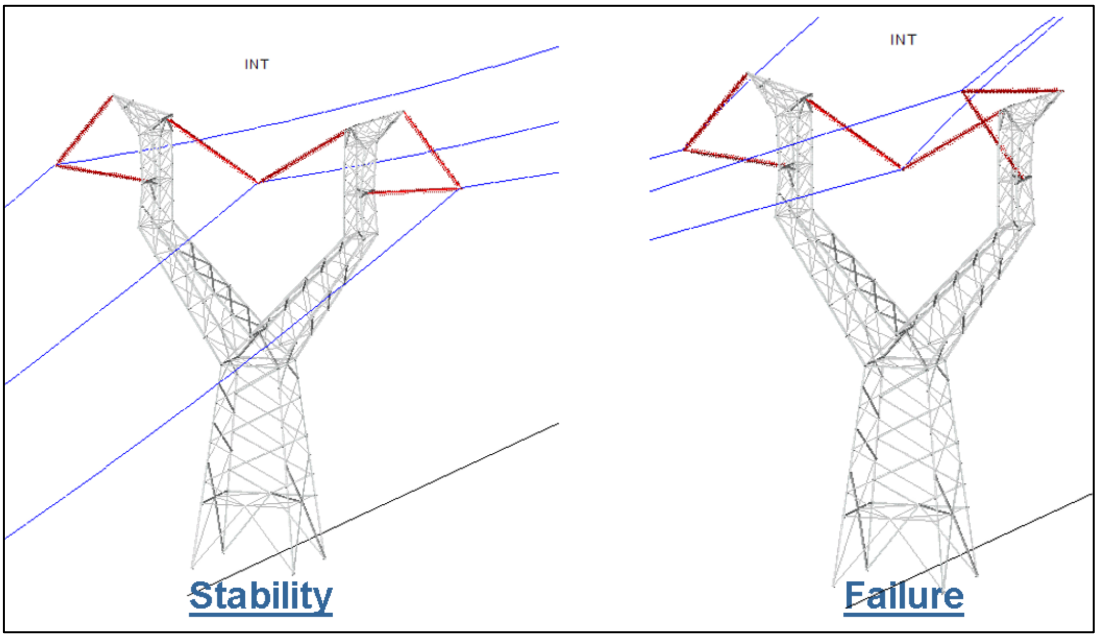

Figure 6 – Stability Concerns of Pivoted-Vee Insulator

As part of the concept design, no strain or stability type structure was designed and tested therefore for the purposes of this study ESBI have assumed that all stability structures will utilise the existing 400 kV strain tower (AM) designs completed for the North-South (N-S) 400 kV interconnector project. As the N-S towers are the most recent 400 kV designs available, in the event that a conventional 400 kV tower was required, it is envisaged these most recent designs would be used. It is possible however that a stability structure could be designed at a later stage of the project. The purpose of the stability structure is purely to provide longitudinal stability and not to act as a traditional AM which is required take the full conductor tension load at angle positions hence a more efficient structure design could be developed. The decision as to whether an existing 400 kV tower design or a completely new tower design is required for strain structures will be required before a detailed design can be completed.

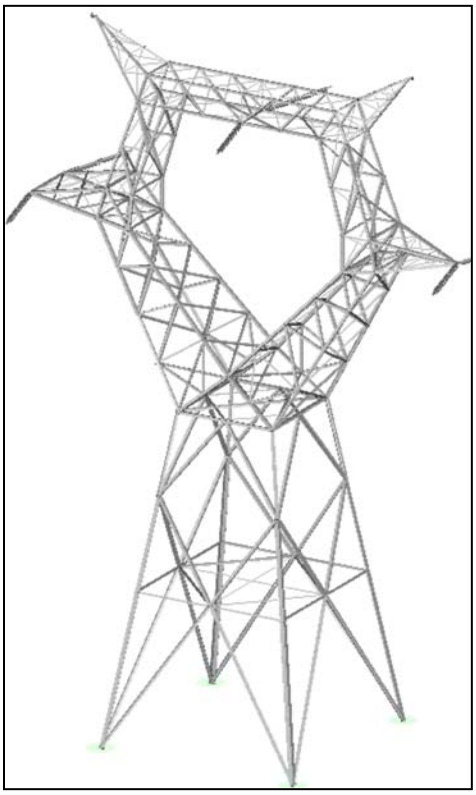

Figure 7 – North-South 400 kV Strain Tower (AM) Design

The stability analysis considered each INT location where the composite insulator structure is proposed under high wind loading. Where stability issues were identified, the straight in question was assessed to determine the optimum location for a stability structure. In total the stability analysis identified the need for seven stability structures which is relatively low (~5%) when considering a minimum of 139 structures on the proposed new 400 kV circuit. Considering the results of the stability analysis and the small number of stability type structures likely to be required, the feasibility of designing a structure specifically for this purpose may prove impracticable. However, it is worth noting that the most recent 400 kV strain tower design will have a larger footprint than the proposed INT voltage uprate design therefore the use of a standard 400 kV AM design may be unfavourable to the affected landowners.

6.3 Temporary Structures

A key feature of the voltage uprate project is that the existing line corridor and structure locations are utilised for the new 400 kV line. While advantageous from a planning and environmental perspective, this presents challenges specifically relating to construction and outages. EirGrid have indicated that an emergency return to service (ERS) is likely to be required during any construction works hence careful consideration must be given to the type and number of temporary structures likely to be required.

Figure 8 – Lindsey Structure in use on a 220 kV Line

An example of a temporary structure used previously for replacing 220 kV towers on ESB lines is the Lindsey structure as shown in Figure 8. In this instance, an intermediate (INT) suspension tower was being replaced and required the use of one Lindsey structure only. For the purposes of replacing AMs, it is envisaged that a minimum of two Lindsey structures would be required at one time. An indicative sketch outlining the replacement of an AM is shown in Figure 9. The inclusion of a 40 m working area (from the existing tower) in both the ahead and back spans has been assumed where each of the Lindsey structures would be installed. This would allow the line to be temporary terminated at both sides while conductor with dead-ends attached would be readily available on site if the ERS was activated.

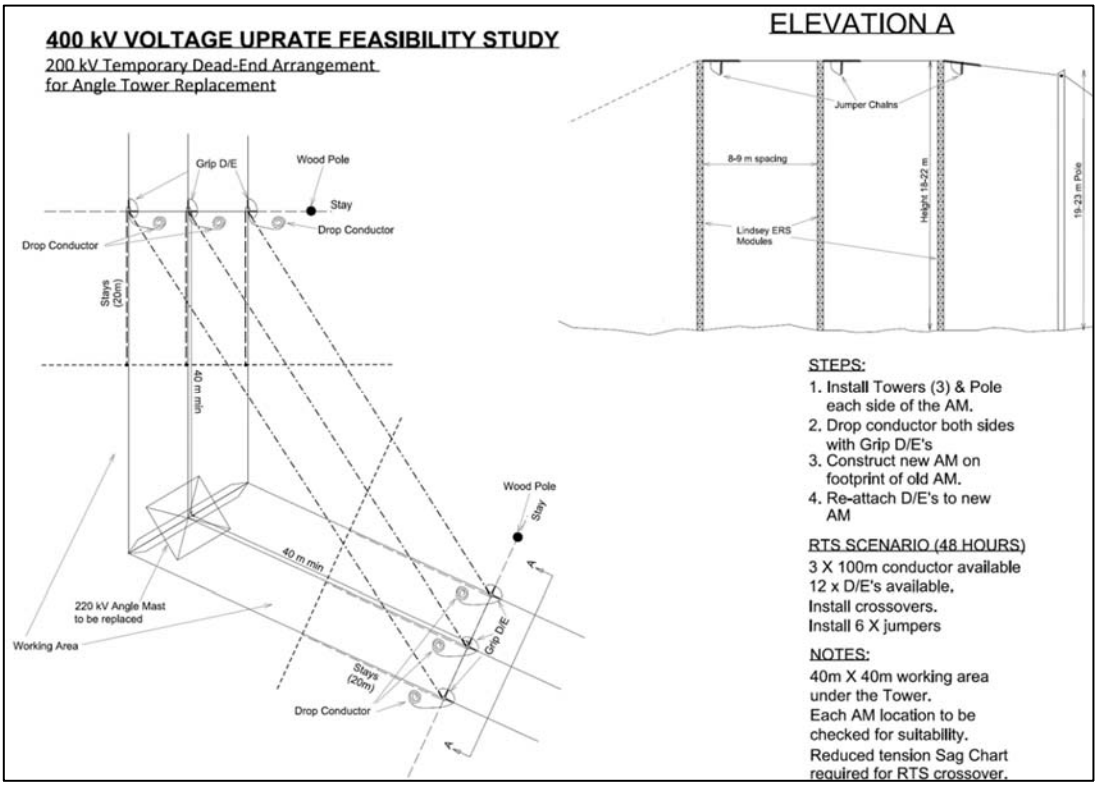

Figure 9 – Indicative Sketch showing AM Replacement

It is recognised that the replacement of INT structures may not require the use of Lindsey-type structures at all locations. Depending on the structure height, the use of wood poles in the form of a temporary 4 pole structure may be possible. Furthermore, the use of composite poles in portal construction as temporary structures for replacing INTs may also be possible however composite poles have only been tested for 110 kV loading to date. As the structures would be used on a temporary basis only there may be scope to reduce the loading accordingly. The use of wood and composite poles is limited to a height of 23m to 26m respectively. In the event that a Lindsey structure is required for replacing an INT tower, only one structure as opposed to two (for AM) would be required.

It is important to note that use of temporary structures for replacing INTs would only be required in the event that the structure is replaced in the existing location (Option A). Relocating the structure (Option B), a marginal distance would remove the need for a temporary structure for INTs. This is covered in more detail in section 6.4.

Figure 10 – 4 Pole Structure

6.4 Construction Options

As noted in the invitation to tender document issued by EirGrid: *"The TSO are seeking to increase the number of transmission uprate options which have reduced environmental and social impact while maintaining deliverability and cost."* A key feature of the voltage uprate project is that the existing line(s) corridor and the structure locations would be utilised with a relatively small increase in the overall corridor (right of way) width thus ensuring reduced environmental and social impact when compared to a new build 400 kV line.

From a constructability perspective and also considering ERS requirements, the voltage uprate project will provide significant challenges. While it is recognised that all AM locations may have to be retained in order to maintain the existing line route it is also recognised that INT locations could be relocated a maximum distance of approx. 15-20 m. Relocating INT towers by a marginal amount could potentially provide significant time benefits and cost savings to the project while the impact on landowners and the public remains largely the same. Even greater time benefits and cost savings could be achieved by laterally offsetting the new 400 kV line or sections of the line parallel to the existing 220 kV line route by approx. 50 m. As this option however essentially utilises a green field site it would have a greater environmental and social impact and is therefore less in line with the ethos of the project scope.

For the purposes of the desktop study and developing an outage estimate, three construction options for the new towers as outlined below have been considered:-

- Option A – Construct 400 kV towers at existing 220 kV locations
- Option B – Construct 400 kV AM towers at existing 220 kV locations but relocate INT towers in line by approx. 15-20 m into the ahead or back span
- Option C – Laterally offset the 400 kV line (or sections) by approx. 50 m

6.4.1 Option A

Option A assumes the existing line route and all tower locations would be utilised to construct the new 400 kV line (Figure 11). While likely to be advantageous from a landowner and planning perspective and overall acceptance of the project, this option will be the worst case in terms of outage requirements during construction and will incur a longer construction programme overall due to the nature of temporary works and outage dependent activities associated with this option.

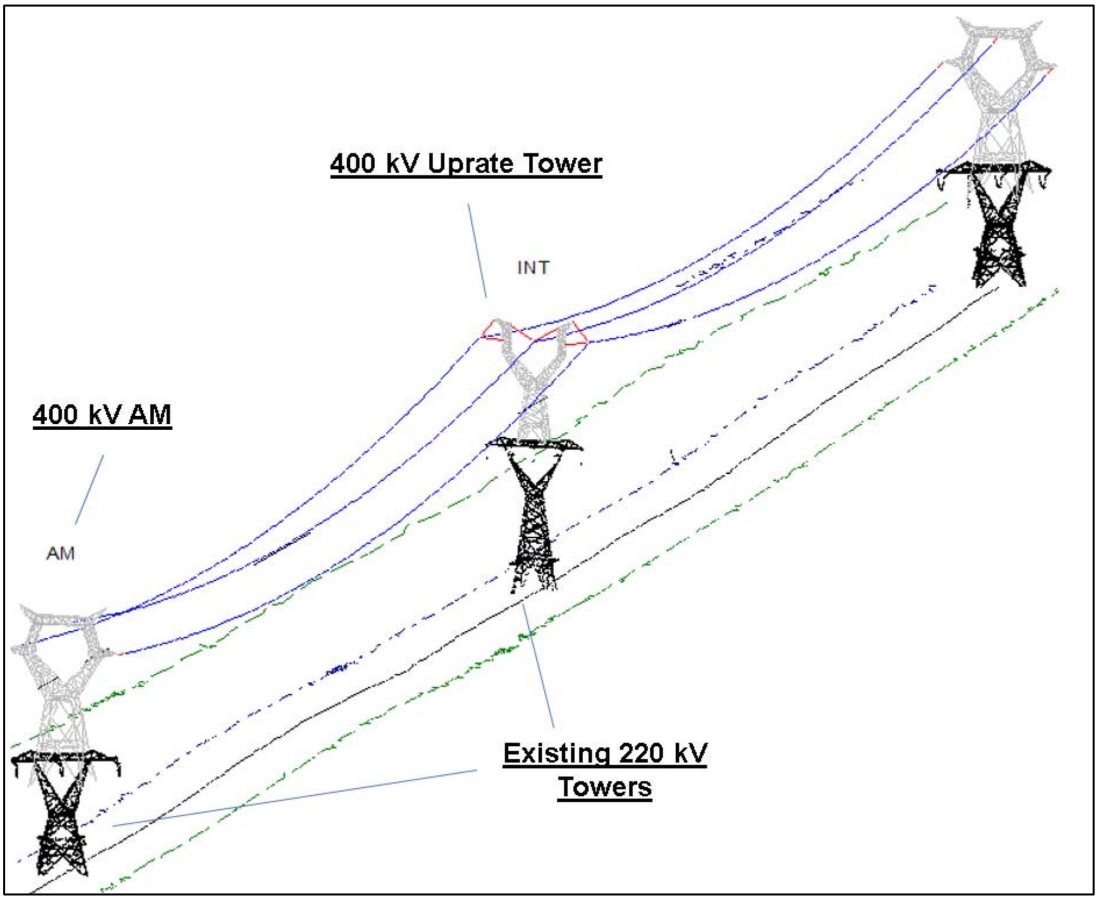

Figure 11 – Construction Option A

A summary of the work activities associated with replacing an AM tower and the timeline considered for this study is as follows:-

- Installation/removal of ERS = 1 week (O)*
- Removal of existing tower & foundations = 1 week (O)
- Concreting new foundations = 1 week (O)
- Curing concrete = 2 weeks (O)
- Tower erection = 0.5 week (O)

  Total = 5.5 Weeks

  *(O) denotes the activity is outage dependent

It should be noted that all work activities associated with replacing AMs under option A are outage dependent (O) i.e. 5.5 weeks total.

A summary of the work activities associated with replacing an INT tower and the timeline considered for this study is as follows:-

- Installation/removal of ERS 0.5 weeks (O)
- Removal of existing tower/foundations = 1 week
- Construction of new foundations = 0.5 weeks
- Curing of concrete = 2 weeks
- Erection of tower 0.5 week (O)

Total = 4.5 Weeks / 1 Week Outage

The total work activities associated with replacing an INT tower is 4.5 weeks while 1 week of this is outage dependent.

It is important to note that the timelines given are a high level estimation only and may change depending on a range of factors such as construction resources, site constraints and landowner issues etc.

6.4.2 Option B

Option B assumes all existing AM tower locations would be utilised however INT towers would be relocated by approx. 15-20m in the ahead or back span for the 400 kV towers (Figure 12). A minimum distance of 15-20m has been assumed as this will provide the required working area and clearance to construct the new 400 kV tower foundations while the existing 220 kV tower remains in-situ and mostly in-service during construction.

Option B may be less favourable from a landowner and planning perspective however it will be better than Option A in terms of outage requirements. As Option B has a lower outage dependency this will result in a shorter construction programme overall when compared to Option A. While ensuring reduced costs a shorter programme may also be favourable with landowners as it will result in less disruption in the form of construction activities overall.

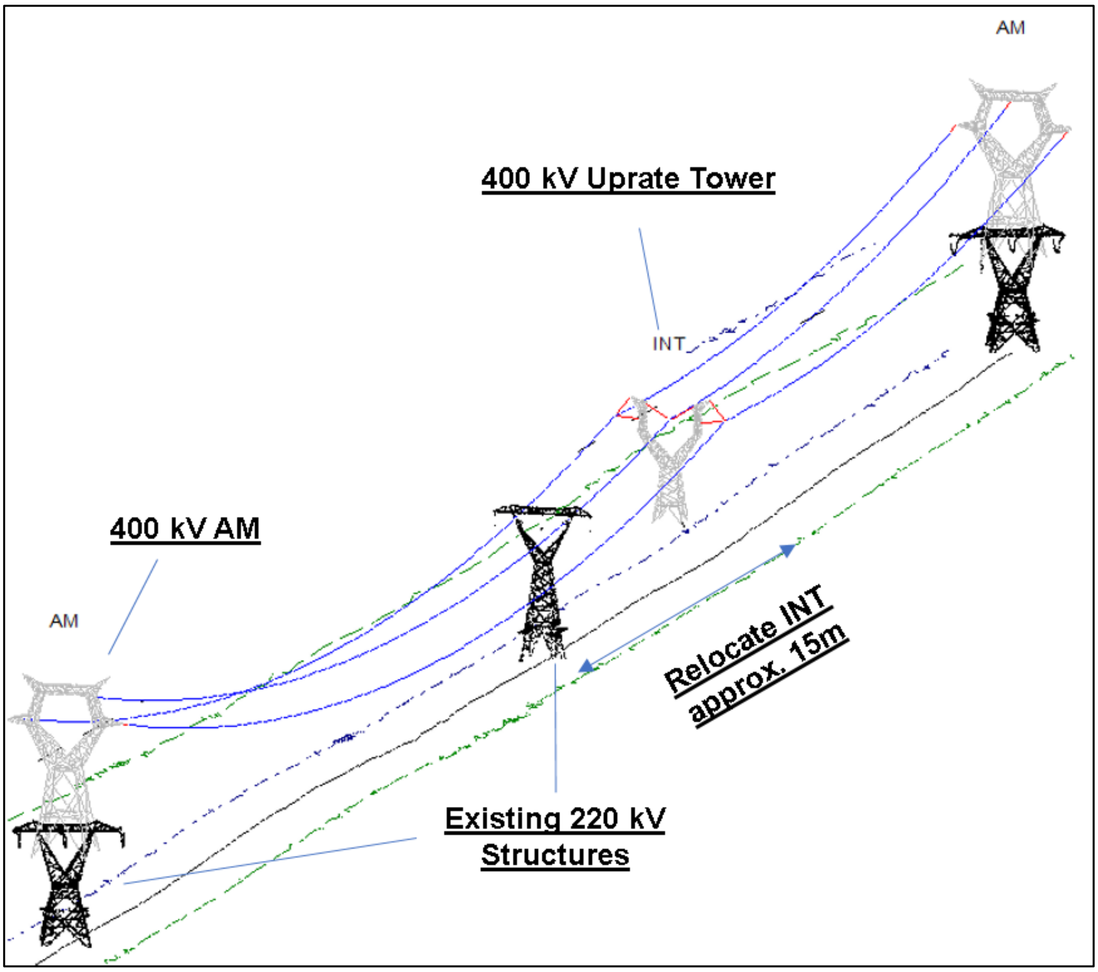

Figure 12 – Construction Option B

Similar to Option A the total work activities associated with replacing AMs under Option B are outage dependent (O) i.e. 5.5 weeks total.

A summary of the work activities associated with replacing an INT tower under Option B is as follows:-

- Construction of new foundations = 0.5 weeks
- Curing of concrete = 2 weeks
- Erection of tower 0.5 week (O)
- Removal of existing tower/foundations = 1 week

Total = 4 Weeks / 0.5 Week Outage

As noted above, the total work activities associated with replacing an INT tower is 4 weeks while 0.5 week of this is outage dependent.

6.4.3 Option C

Option C assumes the existing 220 kV line route/alignment would be adjusted by laterally offsetting the new 400 kV line approx. 50 m (Figure 13). A minimum value of 50m would be required to construct a new 400 kV line parallel to an existing in-situ 220 kV line. Option C is not outage dependent as the 400 kV works could be carried out while the 220 kV line remains in-service and would also have the shortest construction programme of all three options, it would be the least favourable option from a landowner and planning perspective.

Furthermore, as Option C effectively utilises a green-field site it is likely to have the greatest environmental impact of all three options.

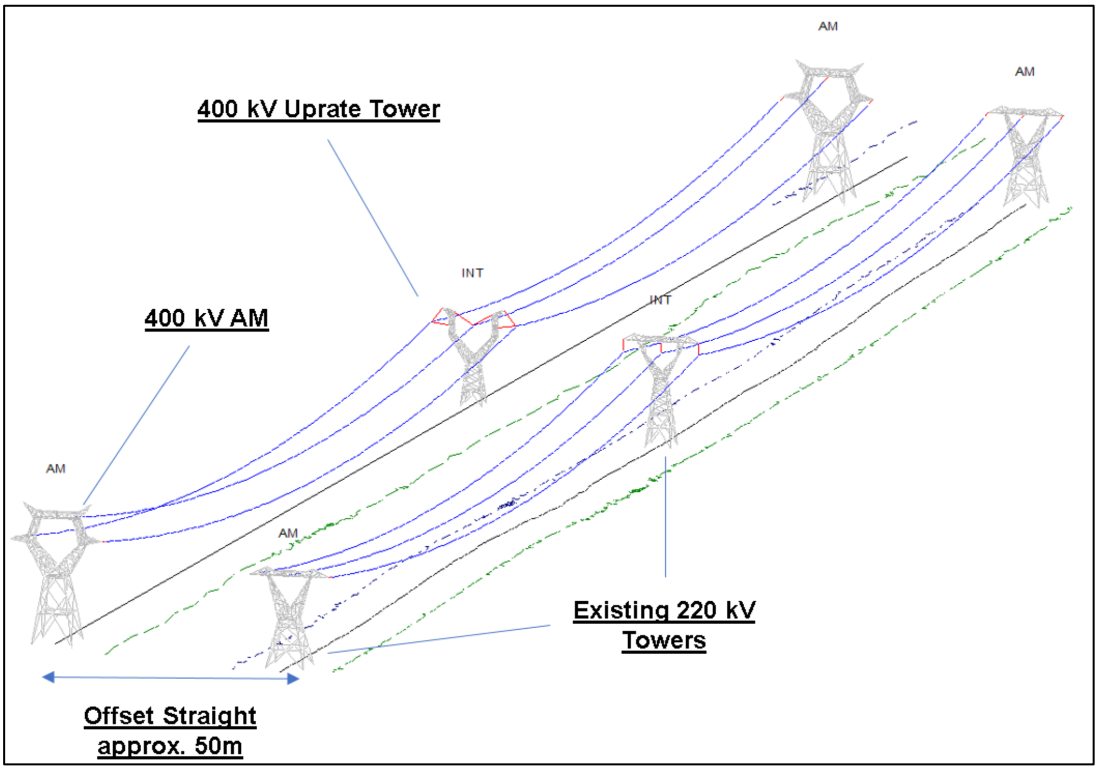

Figure 13 – Construction Option C

It is recognised that Option C would not feasible on numerous sections of both 220 kV lines due to the nature of the land use along their respective routes. However, adopting Option C even on an isolated straight(s) would still provide some benefit in terms of construction programmes and costs. Offsetting a single isolated straight would require a tie-in arrangement at the end of each straight. Following an initial desktop review of the land uses along the existing 220 kV line routes, it was found that Option C is likely to be feasible on two straights of the G-M line only (refer to section 4.3.1).

A summary of the work activities associated with constructing a new 400 kV AM tower under Option C is as follows:-

- Construction of new foundations = 0.5 week
- Curing of concrete = 2 weeks
- Tower erection = 0.5 week

A summary of the work activities associated with constructing a new 400 kV AM tower under Option C is as follows:-

- Construction of new foundations = 0.5 weeks
- Curing of concrete = 2 weeks
- Tower erection = 0.5 week

As noted previously, all work activities under Option C are non-outage dependent. However, a short outage is required to tie in the new line to the existing corridor.

6.4.4 Stringing Activities

In addition to constructing the new 400 kV towers and foundations, a significant portion of the construction activities will involve the stringing of a new twin bundle 600mm^2 ACSR conductor and installation of insulators and hardware. For stringing works to take place, an entire tension section (full straight) of towers must be installed i.e. AM to AM.

The work activities associated with stringing a twin bundle conductor assumed for this study are as follows:-

- Pulling Conductor = 2-4 days
- Sagging = 1.5 days
- Termination = 2 days
- Clamping = 2-4 days
- Jumpers = 1.5 days
- Spacers = 1-2 days

For Options A and B stringing is an entirely outage dependent activity while Option C is non-outage dependent. Based on the work activities listed, an Outage estimate for Options A and B based on the number of spans contained within a tension section is given below:-

- 1 - No of Spans ≤ 4; Length ≈ 1.4 km – 2 Weeks
- 2 - No of Spans 4≤ 6; Length ≈ 2.1 km – 2.5 Weeks
- 3 - No of Spans ≥ 6; Length ≈ 2.8 km – 3 Weeks

Also associated with stringing activities is the catenary support system (CSS) used for stringing over major obstacles such as Motorways, Railways etc.

6.4.5 Outage Estimate

A high level outage estimate for both 220 kV lines was developed based on the outage dependent activities described for Options A, B, C and stringing.

The outage estimate for D-M is given in Table 14 where it can be seen that there is a significant reduction in overall outage required between Option A and B for Stability and INT tower construction. As noted in the table however the stringing activities dominate the outage requirements as this activity is entirely outage dependent.

Table 14 – Outage Estimate for Dunstown-Maynooth (2) 220 kV

Dunstown-Maynooth (2) 220 kV

Tower	Qty	Crews	Option A (Weeks)	Option B (Weeks)	Option C (Weeks)
AM =	14	2	39	39	N/A
Stability (AM) =	5	2	38.5	19.25	
INT =	72				
Stringing =	19	1	53	53	
CSS =	9	1	9	9	
Max. Outage Required:			53	53	

The outage estimate for G-M is given in Table 15 which includes Option C where it has been deemed potentially feasible in two straights only. Again, stringing activities dominate the outage duration however Option C would see a reduction in the overall outage required.

Table 15 – Outage Estimate for Gorman-Maynooth

Gorman-Maynooth 220 kV

Tower	Qty	Crews	Option A (Weeks)	Option B (Weeks)	Option C (Weeks)
AM =	5	2	14	14	14
Stability (AM) =	2	2	21.5	10.75	4.25
INT =	41				
Stringing =	7	1	28	28	17.5
CSS =	7	1	9	9	9
Max. Outage Required:			28	28	18

6.5 Recommended Uprating Option

At a review meeting between EirGrid and ESBI on 07/07/20 where the construction options and high level outages were presented, it was noted by EirGrid that Option C was unlikely to be a runner largely due to landowner and planning concerns. As a starting basis for preparing an indicative design of the proposed 400 kV OHL route, ESBI have assumed Option A for all AMs and Option B for all INT's.

When reviewing the aerial imagery and mapping of the line route, a number of locations were identified for a follow up site survey to ascertain their suitability for the recommended uprating option, primarily from a construction perspective. The main items considered as part of the desktop review when deciding what towers required a follow up site survey were as follows:-

- AMs – is the tower located at or near boundary/crossings which may not permit the use of two Lindsey ERS structures as shown in Figure 9;
- AMs – will the larger tower footprint or working area for AMs create issues such as a change in landowner? Is the tower located on/near a restricted site where relocating may not be feasible?
- INTs – will moving the INT as outlined under Option B create issues such as a change in landowner? Is the tower located on/near a restricted site where relocating may not be feasible?

As part of a follow up site walkover survey, ESBI visited 24 locations to assess their suitability for the recommended uprating option. Three locations as noted below could not be accessed due to locked gates/restricted access. The following issues were identified during the walkover surveys:-

- INT43, AM51, AM87 could not be accessed due to locked gates/restricted access.
- AM locations 4, 8, 10, 32 and 111 have restrictions in either the ahead or back span (See Figure 14). Due to the location of the tower in close proximity to a boundary, one ERS may have to be installed on a different landowner site.

- Seven INT locations (INT22, INT48, INT54, INT67, INT74, INT85, INT121) would result in a change in landowner based on the proposed moves therefore Option A has been assumed for these locations.
- It is also important to note that 52 INT locations are located on/near hedge/boundary. The proposal of moving these towers away from the hedge/boundary may prove difficult with landowner particularly in agricultural locations therefore the likelihood is that Option A will be required for a greater number of INT locations (See Appendix 3).

A summary table noting the recommended uprating option based on the desktop review and walkover survey is included in Appendix 3. This table is a high level assessment at this stage and should be used as a guide only for locations where ESBI feel that Option B may not be feasible.

Before a final design can be completed (WP2) it is essential that the recommended uprating option for each tower is discussed with the relevant landowners. As noted previously, 52 INT locations are located at or near a boundary there relocating the tower may not be favourable/acceptable to the landowner. The position of the 400 kV tower will impact on the final design and the height of tower required to ensure adequate clearance therefore this needs to be confirmed through a landowner engagement process.

Figure 14 – AM in close proximity to boundary

6.6 Indicative Construction Programmes & Resources

While the outage estimates (section 6.4.5) give the TSO an idea of the outage period likely to be required on the existing 220 kV lines, they do not include the non-outage dependent activities which are included in the overall construction programme. A summary of the indicative construction programmes for options A and B and for each line separately is given in Figure 15. In terms of outage ESBI have assumed that outage dependent activities can only take place from March to October inclusive however, as shown in Figure 15 there have been some exceptions to this notable for Option B on both lines were it is assumed a longer outage season (approx. 4-5 weeks) would be required such that a second full mobilisation would not be required. This will reduce the construction timeline and costs. It is evident that option A for both lines will incur a much longer construction programme and as a result greater resources and costs. the indicative programmes can be summarised as follows:-

- **D-M (2) – Option A:**
  - Two outage seasons would be required assuming Mar-Nov inclusive for year 1 and Mar-Oct inclusive for year 2.
- **D-M (2) – Option B:**
  - Majority of work could be completed in 1 calendar year with an extended outage season. 1 month would also be required in year 2 to complete the works.
- **G-M – Option A:**
  - Majority of work could be completed in 1 calendar year with an extended outage season of Mar-Dec inclusive. Some final works may be required in the first month only of the second calendar year.
- **G-M – Option B:**
  - All work could be completed in one calendar year assuming an outage season of Mar-Sep inclusive.

When developing the indicative programmes, ESBI made the following assumptions with respect to resources:-

- Assumes 8 crews in total;
- Crews split across AM replacement, INT replacement, foundations, stringing. It is assumed that crews will intersperse with each other based on work demands on site);
- Although Figure 15 shows works starting for both lines simultaneously – this may not be the case in reality due to outage constraints and the sequence of uprating both lines.

The purpose of the programmes at this stage is to inform a discussion around the preferred uprating option and also to give an idea of the resources likely to be required to complete a project of this scope. It is also worth noting that the N-S 400 kV project is at the detailed design stage. If this project moves to construction in the next number of years, it will involve a lengthy construction programme with significant resource demands. It is recommended that early consultation with ESBN should be carried out to ascertain how feasible the indicative construction programmes are.

A copy of the full programmes is included in Appendix 4 while the original MPP files are available upon request.

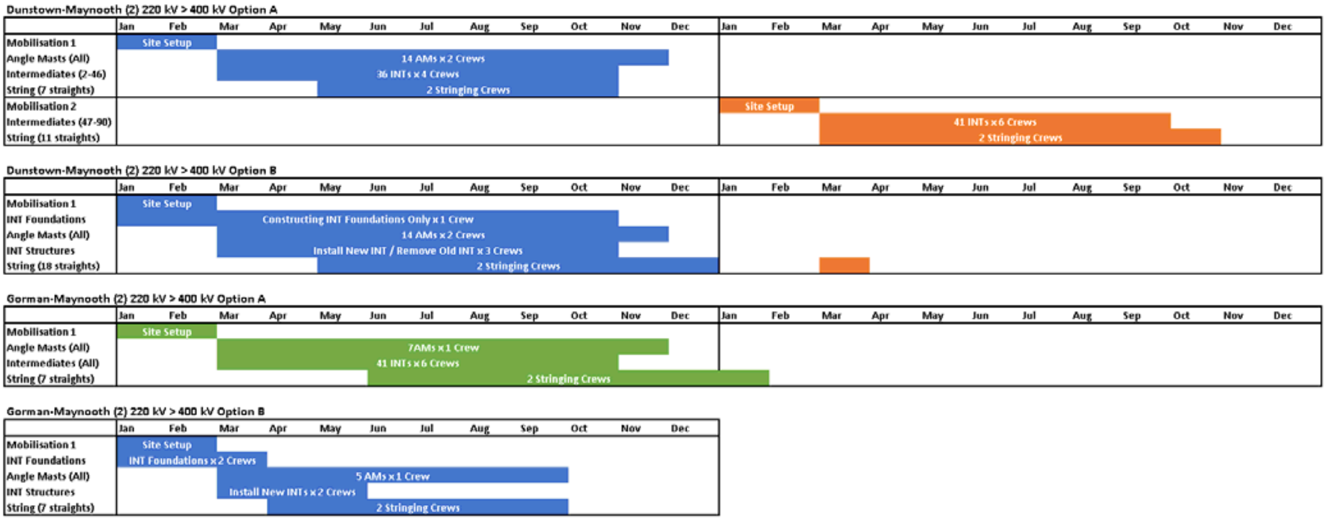

Figure 15 – Indicative Construction programme Summary

6.7 Other Design Considerations

In addition to the construction options discussed previously, other design considerations which will inform the final design overall and which may impact construction of the new 400 kV OHL are listed below and discussed in this section:-

- Strain towers
- Earthwire considerations
- High temperature low sag conductors (HTLS)
- Crossings & 3rd Party Services
- Often frequented towers (OFTs)
- Further Considerations

Other design considerations/studies which are primarily electrical based and were not considered as part of this study are corona/RIV performance and an insulation coordination study. These studies will have to be completed when an insulator design has been finalised.

6.7.1 Strain Towers

As discussed in section 6.2, the indicative PLS-CAD design developed for D-W has assumed the use of the N-S 400 kV AM tower design for all strain and stability locations. The N-S AM reduced visual impact design does include a twin earthwire on the peak of the tower as shown in Figure 7. As shown in Figure 2, the voltage uprate INT tower does not include an earthwire design and the proposed 400 kV design is therefore non-earthwire (similar to existing 220 kV lines).

ESBI have proposed to EirGrid to review the earthwire requirement for the new proposed 400 kV line. If an earthwire is deemed necessary, this would involve revising the design loading of the INT tower accordingly along with additional type testing to validate the structural integrity of the tower.

It is also worth noting that the stability type structures required at a number of existing INT locations do not require a full strain tower design. As the purpose of the stability structure is to ensure longitudinal stability of the pivoted-vee insulator only and not required to take full conductor tension for a series of line angles, a more efficient tower design could be developed. For the purposes of this study ESBI have assumed the use of s standard 400 kV AM tower solely for the purposes of developing a high-level PLS-CADD design. Furthermore, the N-S towers have been designed for a reduced maximum over-voltage value, this would have to be taken into consideration when undertaking an insulation coordination study for any new towers proposed.

6.7.2 Earthwire / Shielding Considerations

Since the mid-1980's it has been EirGrid policy (Section 3.2.1 of 1986 policy) to fully shield all new 220 kV (and 400 kV) lines due to the improvement in lightning performance. The voltage uprate proposal concerns the use of an existing unshielded 220 kV circuit where there was felt to be significant risk to the proposal were a fully shielded uprate to be considered. A 2002 CIGRE paper published by ESBI and UCD on the 220 kV network suggested that it may be possible to improve the lightning performance of unshielded 220 kV lines through the use of suitably placed line surge arresters combined with lower tower footing resistances at locations prone to lightning could improve the lightning performance of lines so equipped. The next phase of the study should therefore consider the planning, technical and cost implications of providing a fully shielded 400 kV circuit as against an unshielded option considering any lightning/grounding performance deficits, implications and mitigation measures that could be adopted.

6.7.3 High Temperature Low Sag (HTLS) Conductors

A twin bundle 600mm^2 ACSR (Curlew) conductor has been assumed for the indicative PLS-CADD design which is the standard conductor arrangement at 400 kV for ESB lines. No non-conventional conductors were considered e.g. HTLS however it is possible such conductors could be used in the eventuality that a greater line rating was required. The current standard uprating option for 600mm^2 ACSR is GZTACSR 586mm^2 (Traonach) however this conductor has never before been used on ESB lines at 400 kV in a twin bundle configuration. There are a wide range of non-conventional conductor options on the market which could be explored if such an option was deemed necessary.

6.7.4 Crossings & 3rd Party Services

The proposed line route was reviewed using aerial imagery, lidar and GIS software to identify all crossings under and above the line. Furthermore, information on 3rd party services such as gas and water infrastructure in the vicinity of the line was requested from the relevant statutory authorities. As part of the desktop review, the need for a catenary stringing system (CSS) has been identified for all major crossings. It would however be recommended that more up to date requests be made again from these 3rd party services if at a time construction is planned to proceed.

No data in relation to 3rd party services is shown on the desktop survey maps.

A summary of all crossings on the line along with information on any relevant 3rd party services is included in Appendix 5.

6.7.5 Often Frequented Towers

OFTs were assessed for the G-M section based on the revised ESB approach. This work had already been completed for the D-M section as part of the foundation QRA walkovers. The OFT assessment for the entire line route identified 5 towers as level 1 OFT, all of which are on the D-M section. A copy of the OFT status for each tower is given in Appendix 6.

6.7.6 Further Considerations

The line design model produced in this study is solely for the purposes of desktop route investigation. The single circuit intermediate tower (INT) used in the line model is the 400 kV uprated tower 207 which utilises the pivoted insulator (PVI) type composite crossarm as described in Section 2. The strain tower or angle mast (AM) used in the line model is the North South Interconnector 400 kV strain tower design.

The line model produced in this study is a basic model, where the 400 kV uprated tower type 207 is placed at or adjacent to the tower positions on the existing 220kV line. However, if the voltage uprate of the existing 220 kV lines is a preferred solution for the new D-W 400 kV line then a detailed line design model would be required and some key points (as described below) may need further consideration in the next phase of the project.

- The innovative new 400 kV intermediate tower (Tower type 207) was initially designed & tested for Reliability Level 1 (RL1) loadings (IEC 60826) in order to utilise as much of the existing 220 kV tower steelwork in the new 400 kV uprated tower. However, the feasibility study has found that the majority of the original 220kV tower steelwork would need to be replaced and that a completely new 400 kV uprated tower with the same footprint would be the most viable solution.
- The North South Interconnector towers were designed to Reliability Level 2 (RL2) (IEC 60826). It is understood that the decision to use RL2 was made by EirGrid due to the line being an interconnector. On the other hand, the existing Dunstown-Moneypoint, Moneypoint-Oldstreet and Oldstreet-Woodland 400 kV lines were designed to RL1. A new 400 kV tower design will provide an opportunity to examine a higher Reliability Level (RL) for the new D- W 400 kV line, if decided by EirGrid.
- The innovative new 400 kV INT tower was initially designed as non- earthwire to increase the chances of retaining the existing 220kV tower steelwork below the waist. As stated above, it was determined that the majority of the original 220 kV tower steelwork would need to be replaced and that a completely new 400 kV uprated tower would be the most viable solution. This will provide an opportunity to add an earthwire in the new 400 kV tower design, if decided by EirGrid.

As summarised above, the initial design approach sought to evaluate the feasibility of re-using the existing 220 kV tower steelwork by considering certain trade-offs or compromises e.g. the omission of the earthwire. The design and testing of the innovative 400 kV INT tower has nevertheless demonstrated that this unique tower design with reduced visual impact is a feasible solution for further design evaluation and testing once the decision on the RL and earthwire is made by EirGrid.

The potential impacts of changing the RL of the proposed line upgrade and/or adding earthwire to the line are noted below for consideration.

- The adoption of a higher RL than previously considered in the feasibility study while maintaining the same spans would increase the loading on towers which may change the tower outline profile and the footprint.
- The inclusion of earthwire would change the current 400kV uprated tower outline shape and dimensions depending on the earthwire arrangement. The new earthwire tower would be higher and the phase spacings may also change to provide adequate horizontal clearances between the earthwire and the phase conductors.
- The footprint of the new 400 kV tower may change to cater for the additional transverse loadings due to an earthwire conductor. The centre of action of the transverse loads would be higher than non-earthwire tower, which may change the slope of the tower legs for effective load transfer to the foundations.
- The route options are deemed to be independent of the tower type, however positioning of the tower may be affected by the change in tower footprint and overall dimensions.

Other items to consider as the project progresses are:-

- As stated in Section 6.7.3, the route investigation considers twin curlew conductors which corresponds to existing conductor used on existing 400kV lines. However, an evaluation of alternative conductors for achieving the higher line rating with similar impact as Curlew on the tower design can be included in the next phase of study.
- The electrical performance e.g. Corona, Audible noise (AN), Radio Interference (RI) and EMF impact will also impact the corridor selections, therefore it would be preferable if these studies are completed before finalising the D-W 400kV line route.
- The detailed design and testing may change the PVI dimensions currently being used. Therefore, the tower outline dimensions cannot be finalised until the PVI is fully designed and type tested.

7 Conclusion

This report considered two existing 220 kV OHLs namely D-M and G-M and the feasibility of voltage uprating these circuits to form the proposed D-W 400 kV circuit.

A review of all existing records and data relating to both OHLs was undertaken as part of the study. This data along with an as-built PLS-CADD model of the D-M route was used to develop a high level PLS-CADD model of the proposed D-W 400 kV circuit. The D-W 400 kV PLS-CADD design was developed to meet 400 kV design requirements e.g. 9m over ground at the specified MOT of 80°C.

The study considered three potential options relating specifically to the tower locations for voltage uprating or 're-constructing' the existing 220 kV OHLs to 400 kV. The three options considered were:-

- Option A – Construct 400 kV towers at existing 220 kV locations;
- Option B – Construct 400 kV AM towers at existing 220 kV locations but relocate INT towers by approx. 15-20m into the ahead or back span;
- Option C – Laterally offset the 400 kV line (or sections) by approx. 50m.

The desktop survey exercise utilised a wide range of datasets which encompassed a variety of real-world elements all of which were used to inform the decision making process. The use of all available data allowed for an effective assessment of the different design options as set out in the study. Option C was effectively ruled out based on the findings of the desktop survey, therefore no further consideration of this option was given. When considering Options A and B and the combination of both, the datasets and mapping utilised gave valuable insight into potential issues such as major crossings, restricted sites, and major developments all of which influence the final recommended option.

The desktop survey also considered possible OHL route options in to Woodland 400 kV station. The possible route options were found from carrying out this exercise using the datasets available. A preferable route option was put forward based on all the criteria that was assessed.

The geotechnical desktop carried out for both lines provides a summary of the geotechnical conditions at each structure site, makes recommendations on the extent and scope of site investigation works and identifies likely foundation types of tower structures. Table 9 and Table 10 give a summary of the ground conditions at each structure location for the two lines. Table 11 and Table 12 give recommendations for intrusive investigations along the two lines.

As part of a follow up site walkover survey, ESBI visited 24 locations to assess their suitability for the recommended uprating option. Three locations could not be accessed due to locked gates/restricted access. The following issues were identified during the walkover surveys:-

- INT43, AM51, AM87 could not be accessed due to locked gates/restricted access.
- AM locations 4, 8, 10, 32 and 111 have restrictions in either the ahead or back span (See Figure 14). Due to the location of the tower in close proximity to a boundary, one ERS may have to be installed on a different landowner site.

- Seven INT locations would result in a change in landowner based on the proposed moves therefore Option A has been assumed for these locations.
- It is also important to note that 52 INT locations are located on/near a hedge/boundary. The proposal of moving these towers away from the hedge/boundary may prove difficult with landowner particularly in agricultural locations therefore the likelihood is that Option A will be required for a greater number of INT locations.

A summary table noting the recommended uprating option based on the desktop review and walkover survey is included in Appendix 3. Option A is recommended for all AM locations and 14 INT locations while Option B is recommended at all other INT locations as a starting basis for developing a final design. This table is a high level assessment at this stage and should be used as a guide only for locations where ESBI feel that option B may not be feasible. The importance of completing a landowner engagement process and outlining the proposed tower locations (Option B) is noted in the report. This is essential as a final design cannot be completed until all tower locations have been confirmed.

High level construction programmes were developed for both lines and for Options A and B separately. The programmes even at a high level clearly demonstrate that Option B will provide significant benefits in terms of a reduced overall construction programme.

The study notes that a non-earthwire design was developed. This assumes the use of the 400 kV voltage uprate INT (non-earthwire) design used in conjunction with a standard 400 kV AM (earthwire) design. If an earthwire design is required, this will involve revising the INT tower design along with additional type testing. Furthermore, a twin 600mm^2 ACSR “Curlew” conductor configuration with a specified MOT of 80°C was assumed in the design. If alternative non-conventional conductor options were to be considered (e.g. HTLS) this would also involve a review of the INT tower design.

Since the mid-1980’s it has been EirGrid policy (Section 3.2.1 of 1986 policy) to fully shield all new 220 kV (and 400 kV) lines due to the improvement in lightning performance. The next phase of the study should consider the planning, technical and cost implications of providing a fully shielded 400 kV circuit as against an unshielded option considering any lightning/grounding performance deficits, implications and mitigation measures that could be adopted.

As no insulator design has been confirmed at the time of writing this report, additional electrical studies required (Corona/RVI performance, insulation coordination) were not carried out. These studies will be required when a final insulator design has been agreed.

Appendix 1

Line Route, Parallel Route Options and Desktop Survey Maps

Appendix 2

Geotechnical Maps

Appendix 3

Recommended Uprating Option Summary Table

Appendix 4

Indicative Construction Programmes

Appendix 5

Summary of Crossings & 3rd Party Services

Appendix 6

Summary of OFT Status