Appendix A

River Ouse – Possible Installation Methods for Underground Cables

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Introduction

As set out throughout this Report in addition to an overhead line, an underground cable crossing could be considered for the River Ouse crossing within the emerging preferred corridor[43]. This would require the installation of long ducts or the construction of one or more tunnels to accommodate the eighteen transmission cables likely to be required, as these could not be laid securely on the riverbed.

NGET has not reached any final conclusion with regard to the acceptability of an overhead line crossing. This decision will need to be informed by engagement with stakeholders, in particular Natural England, the RSPB and other nature conservation organisations, as well as by the results of extensive site surveys. However, it was noted that underground cable would result in very significant increases in cost and potentially delay the completion date for the Project. At this stage, geological data is also limited for the crossing areas and so detailed studies would be required to confirm the technical viability of installing underground cables across the River Ouse within any of the four corridors considered.

This Appendix provides a description of infrastructure required to facilitate an underground cable crossing of the River Ouse, an indication of the potential installation techniques that could be used, any operation and maintenance requirements of each technique and potential environmental impacts.

Where a section of underground cable resurfaces to connect to an overhead line a SEC is required. These would be required regardless of the underground cable installation method used. **Section 2.3** provides a description of SECs and indicative dimensions.

Underground Cables

There are several cable installation methods which are summarised below:

- Open cut methods: These would typically be utilised in open agricultural land. This involves the excavation of a trench into which the cables could either be directly laid, or a duct could be laid through which cables could then be pulled. This is usually followed by land reinstatement.
- Trenchless methods: These would typically be utilised where features (watercourses, roads, railway lines, flood defences or other utilities) require to be crossed. This would involve the installation of ducts or a tunnel below the feature. The cables would then be pulled through the ducts or the tunnel.

A trenchless method would be required at the River Ouse should an underground cable crossing be required at this location. The following sections provide a description of the potential methods that could be used for a trenchless crossing of the River Ouse.

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[43] This is the case with any of the other corridors with crossings of the River Ouse.

In determining the most appropriate trenchless technique for installing underground cables for a 400kV cable system, NGET need to ensure the electrical performance of the cables are not compromised. Therefore, it is important that the physical environment of the cables enables:

- Heat dissipation, to prevent overheating and subsequent reduction in cable rating (capacity for carrying current);
- Physical protection, so that the cable does not become damaged or become a potential danger to third parties; and
- Proper access in order to ensure efficient inspection repairs or replacement.

The ability of the rock or soil that surrounds underground cables to dissipate the heat emitted by the cables could determine the number of cables required. This is because heat build-up reduces the current that the cables are able to carry, potentially requiring the installation of further cables to make up for any capacity shortfall.

To meet the double circuit rating required for this connection, based on our work to date and the preliminary rating studies, eighteen transmission cables are likely to be required for an underground crossing of the River Ouse.

Potential Installation Methods

There are a number of potential trenchless installation methods that could be considered for an underground cable crossing of the River Ouse. These are:

- Horizontal Directional Drilling (HDD);
- Tunnel Boring Machine (TBM) Tunnelling:
  - Microtunnelling/Pipejacking; and
  - Conventional Tunnelling Method (CTM).

These options are described in more detail in the sections below.

Horizontal Directional Drilling (HDD)

HDD is a multistep process which involves:

- Drilling a small diameter pilot bore along the proposed route from a launch location on one side of a crossing to a reception location on the other side of a crossing;
- The pilot bore is then enlarged by pulling a larger drilling tool (back reamer) from the reception pit to the launch pit connected to drill rods installed during pilot boring. The back reamer is rotated during the pull back, enlarging the pilot bore to later fit the permanent duct. If required, the reaming stage may be repeated to achieve larger bores at the diameter required for the duct; and
- The permanent duct is installed by pulling it back through the bore enlarged by the reaming process.

For the typical 400kV cable conductor, each installed duct would likely be of the order of 400mm in outer diameter, requiring an overall drilled bore diameter of 500mm to 600mm.

Construction

During construction, a construction compound is required at both the launch and reception locations. The required area depends on the length of the HDD crossing and the diameter of the duct but typically, a minimum of 30m wide by 120m long per drill would be required at the launch location. Adequate space is also required at the reception location to pull the duct as a continuous length.

At the River Ouse it is likely that a minimum working width of 240m would be required at both the launch and reception locations subject to the specific location of the drill, the length of the drill and more detailed geotechnical and environmental information.

A HDD rig and associated equipment would be set up at the launch location. This includes electricity supply (portable generator), drill mud filter, control unit and welfare facilities. Drilling utilises a drill bit, drill head and drilling fluid.

HDD requires a reliable, clean, and potable water source. If this is not available, on-site water treatment may be required.

Throughout all drilling stages of the process the drilling fluid is pumped down the bore to the drill head. The fluid pressure drives the rotation of a mud motor, facilitates the removal of cuttings, stabilises the borehole, cools the drill head and transmitter, and lubricates the passage of the duct. The constituents of the drilling fluid are selected to reflect the properties of the ground being drilled, typically they contain bentonite. Shallow launch and reception pits are dug at the launch and reception locations to collect the drilling fluid throughout the process. This fluid is recycling during drilling and removed from site for disposal upon completion.

The rate of drilling is largely dependent on ground conditions and the length of the drill. The construction period can however be shortened by employing multiple rigs for synchronous boring.

Once the ducts are installed a winch is used to draw the cables through ducts. Once the cables are installed the working areas would be removed and the land reinstated.

Operation and Maintenance

With the exception of the SECs and small kiosks either side of the ducted sections there is no requirement for any additional permanent above ground infrastructure.

For cables installed using HDD it is not possible to undertake direct inspections or maintenance, though in-situ testing is still possible. Should there be a fault on a cable this will require direct replacement via new HDD ducts. It is likely that spare ducts would be installed during construction to allow for ease of replacement should any faults be identified in future.

Underground cables have an assumed operational life of 40 years, but this may be extended dependent upon the actual operational conditions. Once the cables become life expired new ducts and cables would need to be installed as described above.

Environmental Considerations

The ducts and cables would be installed at a sufficient depth under the feature being crossed so as to remove the potential for any environmental impacts during operation.

During installation, in certain geology, there can be the potential for frack out (loss of drilling fluid to the environment and potential failure of the bore) and, where the rock formations are loosely bound, losing control of the drill path and collapse of the bore. Whilst frack out is unlikely, method statements would be in place during installation to manage any frack out with measures being proportionate to the amount and location of any frack out should it occur.

There is the potential for temporary impacts during installation at the launch and reception locations including noise associated with the drilling machinery and lighting at the compounds. HDD can also sometimes require 24-hour working during certain stages of the drilling process.

There would be temporary habitat removal at the launch and reception locations, this would be reinstated upon completion of the works.

The SEC sites would result in the permanent loss of land and related adverse landscape and visual impacts. In addition, adverse ecological and cultural heritage impacts could also result, dependent upon final siting.

Cost Considerations

The civil engineering operation to pre-install up to twenty long ducts beneath the River Ouse would add significantly to the capital cost associated with the use of underground cables to achieve any crossing. The use of underground cables installed in drilled ducts is likely to increase the overall capital cost of the reinforcement by in excess of £70m.

In addition, underground cables have an assumed operational life of 40 years. It would not be possible to remove the old cables from the ducts and refurbish the ducts themselves. Hence a complete set of new ducts would likely be needed and replacement costs likely to be in excess of £70m would again be incurred at this point.

Tunnelling - Tunnel Boring Machine (TBM)

TBM tunnelling is a term that can encompass the installation of tunnels by microtunnelling, pipejacking and conventional tunnelling as these forms of construction tend to share the common application of TBM to excavate tunnels.

Characteristically, microtunnelling/pipejacking methods are used for tunnel diameters of 0.3m to 2.4m and are typically limited to tunnel lengths of approximately 2km. Tunnels constructed using the CTM typically have minimum diameters of 4m and whilst possible for short tunnel lengths are most cost effective for tunnels greater than 5km.

The method of TBM tunnelling selected would also be based on the predicted geological conditions.

The main difference between microtunnelling/pipejacking and CTM is the method of lining the tunnel. Whilst pre-formed pipes are used as the structural lining in pipejacking/microtunnelling, in CTM, the lining is typically formed of precast concrete segments that are interlocked to line the tunnel bore as the TBM advances.

The following section describes the TBM tunnelling installation in general.

Construction

During construction, construction compounds are required at the launch and reception areas. Typically, a larger compound is required at the launch area as additional workspace is required for the siting of a slurry separation plant and tunnel pipes. A substantive power supply would also need to be established to power the TBM.

Once the construction compounds are established the first phase of tunnelling is to construct the launch and reception shafts. There are a range of methodologies for the sinking of shafts, typically these are either caisson or underpinning. The methodology would be determined based on the ground conditions. The depths of the shafts are dependent on the depth that the tunnel needs to be beneath the feature that is being crossed.

Following construction of the shafts, a base slab and tunnel headwall structure would be cast at the bottom of each shaft and a thrust wall installed within the launch shaft to allow the TBM to advance.

The TBM would be lowered into the launch shaft and tunnelling commenced between the launch and reception shafts. Depending on the method used either product pipes or concrete segmental rings are inserted behind the TBM as it processes. Water or mud mix is utilised to fluidise excavated material which is pumped to the slurry separation plant within the launch area construction compound. At the slurry separation plant, water is separated from the mix and treated with flocculants to facilitate reuse of clean water in the system.

Excavated material would typically be removed from site in HGVs for disposal or reuse where appropriate, although opportunities to move this material by boat would also be explored.

The amount of material and associated vehicle movements would depend on the length and diameter of the tunnel, the depths of the shafts and the type of material that is excavated.

Once the tunnel has been constructed and the cables installed the shafts would either be capped using prefabricated beams/slabs with the ground above the slab being backfilled and reinstated or a tunnel head house constructed. The requirement for a tunnel headhouse would be determined depending on whether the required cable ratings could be achieved without mechanical ventilation within the tunnel. If mechanical ventilation was required (which would be likely) a tunnel head house structure to house that equipment would be constructed above each shaft. These are likely to be approximately 15m by 15m with an approximate height of 10m and would require a permanent vehicle access.

Operation and Maintenance

Should there be a requirement for tunnel ventilation and therefore tunnel head houses these would be unmanned during normal operation.

The tunnel ventilation fans would operate according to the tunnel cooling demand and the tunnel would also be cleared as required of excess water using sump pumps.

The cables within the tunnel would be subject to maintenance inspections over the length of the tunnel comprising at least one annual inspection. The inspection would report on any defects or changes, identifying any additional requirements such as repairs/replacements. It is also anticipated that ventilation fans would be tested on a monthly basis.

Any replacement of cables within the tunnel or larger equipment within the tunnel head houses would require a temporary construction compound in proximity to the tunnel head house or cap and new cables installed as described above.

Environmental Considerations

The tunnel would be installed at a sufficient depth under the feature being crossed so as to remove the potential for any environmental impacts during operation.

During tunnelling there is the potential for ground borne noise/vibration due to the action of the TBM drilling head.

Similar to HDD in certain geology there is also the potential for the accidental release of drilling fluids via fissures in the geology at the drilling face. Whilst this is unlikely, method statements would be in place during installation to manage any risk, with measures being proportionate to the amount and location of any release should it occur.

There is the potential for temporary impacts during installation at the launch and reception locations including noise associated with the tunnelling machinery and lighting at the compounds. Tunnelling tends to require 24-hour working below ground when driving the main tunnel bore, but above ground vehicle movements can be restricted or avoided during night-time periods.

There would be traffic movements during construction associated with both the removal of material from site and bringing tunnelling materials such as precast concrete segments to site. The amount of vehicle movements would be dependent on the length of the tunnel and depth of the shafts as well and the type of material excavated. As an example, constructing a 40m deep, 5m diameter tunnel over two kilometres would generate approximately 60,000 cubic metres of spoil that would need to be disposed of, resulting in a significant number of vehicle movements. Opportunities to move this material by boat would be explored as an alternative to vehicle movements.

Permanent ventilation of any tunnel would likely be required, housed within one or more tunnel head houses. These may be co-located with the SEC or located separately.

Permanent sites would result in the loss of land and related adverse landscape and visual impacts. In addition, adverse ecological and cultural heritage impacts could also result, dependent upon final siting.

Tunnel head houses would need to include an appropriate acoustic design and mitigation to meet appropriate noise levels in order to mitigate any noise associated with the ventilation equipment being housed.

Given the geography of the River Ouse basin it is also likely that any head houses would be located within the flood zone and therefore any associated flood risk would also require appropriate mitigation which could include increasing the height of the head houses and providing compensation flood storage.

Cost Considerations

The civil engineering operation to install a bored tunnel beneath the River Ouse would add significantly to the capital cost associated with the use of underground cables to achieve any crossing. The use of underground cables installed in a tunnel is likely to increase the overall capital cost of the reinforcement by in excess of £100m.

In addition, insulated cables have an operational life of 40 years. Hence a minimum replacement cost of approximately £35m would need to be incurred at this point in time.

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