From:	[redacted]
To:	East Anglia ONE North; East Anglia Two
Subject:	Preliminary Meeting issues - PINS Refs. 20023840 & 20023842
Date:	12 August 2020 12:39:42

Hello EA1N and EA2 Case Teams

Following submission of my Preliminary Meeting Involvement Form I have the following initial comments on the Rule 6 procedural arrangements to be discussed at the Preliminary Meetings for the EA1N and EA2 projects:

1. Given that BEIS announced an Offshore Transmission Network Review on 15th July 2020 with a key objective of addressing the impact on coastal communities of ongoing and future wind-farm projects, and that NGESO has already started activities in its workstreams within that review with an early completion date, it cannot be correct that the Examinations for EA1N and EA2 should proceed. They should be suspended until the outcome of the Review is clear, as both of these projects would have significant adverse environmental and community impact if allowed to proceed as currently planned, and alternative coordinated implementations with significantly lesser impact are believed to exist even with current technology.

2. It is essential that sufficient Issue Specific Hearings (ISHs) are held to cover all aspects of the onshore impacts of the both the Scottish Power Renewables and National Grid projects, including the allocation of Leiston/Sizewell as a Grid Connection point. It is important that National Grid representatives attend such hearings.

3. A number of issues may need to be raised with regard to the draft DCOs themselves and further ISHs may be needed to address these.

4. It is important that Site Visits take place at the most appropriate seasons and times, in particular to allow the tranquillity of the Grove Wood and surrounding locality to be properly appreciated, and to observe the lack of screening after leaf fall.

Kind regards

Chris Wheeler
[redacted]

From:	[redacted]
To:	East Anglia ONE North; East Anglia Two
Subject:	Written Representations - Email 1
Date:	01 November 2020 17:11:08
Attachments:	CW WR Introduction to Representations v7 Final.docx CW WR Cumulative Impact v11 Final.docx CW WR Downsizing Summary v4 Final.docx CW WR Flood Risk Sequential Test Detail v6 Final.docx CW WR Flood Risk Sequential Test Summary v4 Final.docx

Hello EA1N and EA2 Case Teams

Please find attached one or more documents and related References forming part of my Written Representation set for EA1N and EA2, Deadline 1. These are being sent in more than several emails, which are successively numbered.

My document 'Introduction to Representations' (file *CW WR Introduction to Representations v7 Final.docx*) should be read in conjunction with each WR, as it contains an **Important Note**.

Kind regards

Chris Wheeler
IP references 20023849 and 20023842

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

INTRODUCTION TO REPRESENTATIONS

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 1 November 2020 **Issue:** 7

1. INTRODUCTION

   This document provides a summary of the Written Representations I am making, as in total these considerably exceed 1500 words. These representations, which are provided as a number of separate *docx* files as listed below, supplement the information in my Relevant Representations, which continues to remain valid.

2. Grid Connection Documents *CW WR Grid Connection Summary v6 Final.docx* and *CW WR Grid Connection Detail v7 Final.docx* refer.

   In these documents the argument is made that for several reasons the selection by NGESO of Sizewell/Leiston as the Grid Connection point for the Applicant's projects is both incorrect and unacceptable and that the projects should therefore be **refused Consent**.

3. National Grid Substation Document *CW WR NGET Substation v6 Final.docx* refers.

   This includes key issues regarding the proposed National Grid substation, including questioning the need for a nine bay substation, why the proposed site is acceptable, why an AIS design is described as 'Worst case', and key concerns about the likelihood that NGET will use its Permitted Development Powers to extend its substation without further planning permission. An example of this occurring at Bramford is outlined. Without adequate answers to these questions the application should be **refused Consent.**

4. Flood Risk Documents *CW WR Flood Risk Sequential Test Summary v4 Final.docx* and *CW WR Flood Risk Sequential Test Detail v6 Final.docx* refer.

   Here the critical point is made that the Site Selection process for the National Grid substation site failed to follows the Sequential Test procedure mandated by the NPPF and that as a result a substation site with a Zone 3 Surface Water Flood risk is proposed. This cannot represent correct process and therefore the Application should be **refused Consent**.

5. Operational Noise Document *CW WR Noise Impact v7 Final.*docx refers.

   The applicants proposals for Operational Noise from their proposed substations are analysed in appropriate detail and found to be entirely unacceptable and that therefore the Application should be **refused Consent.**

6. Landscape And Visual Impact Document *CW WR Landscape & Visual Impact v6 Final.docx* refers.

   This document identifies several unsatisfactory aspects of the Applicant's assessment of the impact of their proposed substations on the Friston environment and notes that the proposed mitigation is inadequate. It therefore requests **refusal of Consent**.

7. Sizewell Evacuation Plan Document *CW WR Safety - Sizewell Evacuation Plan v2 Final.docx* refers.

   This document explains why the proposed projects are thought likely to have an unacceptable impact on emergency evacuation plans for the Sizewell nuclear site and argues for rejection of the current proposals and **refusal to grant Consent.**

8. Cumulative Impact Document *CW WR Cumulative Impact v11 Final.docx* refers.

   This document draws the Examiners attention to the large number of energy projects planned to connect at the proposed Friston NGET substation within the same time period, and the need to ensure a comprehensive Cumulative Impact Assessment is carried out before consideration is given to whether the projects can be consented. It is thought that such an assessment will conclude that the overall impact on the local area would be so great that these projects must be **refused Consent.**

9. Substation Design Document *CW WR Substation Design v11 Final.docx* refers.

   The argument is made that the Power Engineering aspects of any proposed SPR substation should be subject to independent assessment by a qualified body to ensure that a design with least visual impact is adopted. At present only the aesthetic aspects of substation design are addressed. This request therefore addresses **mitigation** in the event that Consent is granted.

10. Commitment to Power Output Document *CW WR Downsizing Summary v4 Final.docx* refers.

    This document explains that multiple recent wind farm projects have been downsized after DCO approval, to the detriment of their efficient implementation and environmental impact. It is requested that this should not be permitted should the current projects be approved so is a **mitigation** measure against unnecessary future development.

11. OFH3 Script Document *CW OFH3 Script v11 Final.docx* refers.

    This script identifies the lack of community consultation by National Grid ESO with regard to their assessment of a Grid Connection, and presents an alternative HVDC solution to the delivery of the EA1N and EA2 power in a way less environmentally damaging to the Leiston/Friston area.

Chris Wheeler
CEng MIET MIEEE

IMPORTANT NOTE

My representations are made as a Friston resident and member of the public, and not as an expert. They are provided in good faith but cannot be guaranteed to be correct. All web links worked at the date of submission, but alternative file versions are also available if required.

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

GRID CONNECTION SUMMARY

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 27 October 2020 **Issue:** 6

1. Introduction This document summarises in a timeline the many arguments as to why National Grid's choice of Leiston as the Grid Connection Point for EA1N and EA2 is both incorrect and unacceptable. The detail behind these arguments, together with documents referred to is in document *CW WR Grid Connection Detail v7.docx* provided as part of these Written Representations.

2. June 2014 SPR received DCO consent for EA1 including an obligation to construct **six** cable trenches on the 37km Bawdsey to Bramford cable route against an earlier CION agreement with National Grid to accept 3.6GW of power at Bramford substation using HVDC from EA1 (1.2GW) and two subsequent 1.2GW projects of SPR/Vattenfall. The detail of these trenches is shown in Figure 1 below. Possible sites for the additional converter stations required are shown in the ~*Detail* document and formed part of the EA1 submission.

   The approval of this arrangement was encouraging as it amounted to an obligation to construct a coordinated "Energy Motorway" from Bawdsey to Bramford which should have been of major long-lasting benefit to several off-shore electrical power projects and whose existence should have been steadfastly protected.

3. March 2016 However, when SPR failed to gain more than 714MW of CfD support for EA1 they argued that they should be allowed to change the transmission technology from HVDC to HVAC, resulting in a changed trench configuration and an entirely different design of onshore substation. Figure 1 shows the revised arrangement.

   SPR further argued that this was a Non-Material Change to the project and that therefore DCO consent did not need to be reapplied for. This interpretation of a Non-Material Change is not thought to be one generally recognised as correct by professional Project Managers (as it involved a wide range of technical and physical changes to the deliverable items and potentially their impact on the environment). It is noted that National Grid, the Local Authorities and BEIS did not object to the arguments offered by SPR's lawyers, the last on the basis that apparently there is no legal definition of what represents a Non-Material Change.

   The effect of this change was to both immediately reduce the capacity of the Bawdsey to Bramford "Energy Motorway", and to waste land area at Bramford by using the originally consented EA1 1.2GW HVDC Converter Station land area to construct only a 714MW HVAC substation.

4. January 2017 SPR further argued that since the overall programme for their subsequent projects had changed for commercial and other reasons since the provision of DCO consent for EA1 that they should be freed from the Regulation 29 obligation to build a

total of six trenches, and that only **three** trenches should be required. Again Figure 1 illustrates the effect of the change.

This is interesting as it discloses that in fact only one trench was now deemed necessary to carry the whole 1.2GW power from the EA3 project (recently increased to **1.4GW**), when previously two trenches had been specified. This would be appear to be because of a change in HVDC technology from Symmetric Monopole to Bipole, which has not obviously been highlighted or approved.

As Figure 1 shows, if all six trenches originally mandated by the EA1 DCO Consent had been fully utilised using Bipole HVDC at the same power level as EA3 as much as **8.4GW** (6 x 1.4GW) could have been routed to from Bawdsey to Bramford via the "Energy Motorway". Instead that has now been reduced to **2.1GW** with no objection from any party consulted. And even more bizarrely in 2016/17 SPR wished to <u>reopen the cable route</u> for the purposes of connecting their EA1N and EA2 projects, as evidenced by Minutes of meetings with PINS (see ~*Detail*).

5. <u>July 2017</u> National Grid, in a CION agreement with SPR, revised their agreement for SPR to connect at Bramford and instead required SPR to connect EA1N and EA2 to an unspecified site in the Leiston area. It is clear from the largely redacted CION assessment (see ~*Detail* Ref. 9) that this would require the construction of both a new National Grid substation and two SPR substations amounting to some 30 acres of equipment, yet NGESO appear to have only considered the environmental impact of their NGET substation, ignoring the effects of the SPR ones. This cannot be correct.

   Moreover, it is noted in the CION (Ref. 9 of *CW WR Grid Connection Detail v7.docx*, page 13, Conclusion) that on the basis of the "*non-quantifiable factors*", Option 1 (defined on Page 15 of Ref. 9 as Bramford) remained the "*most preferred option*", but that Least Worst Regret analysis suggested otherwise. This raises the key issue of why certain factors are excluded from the Cost Benefit Analyses and how this can be justified under National Grid's obligations to be "economic, coordinated and efficient" under the Electricity Act 1989.

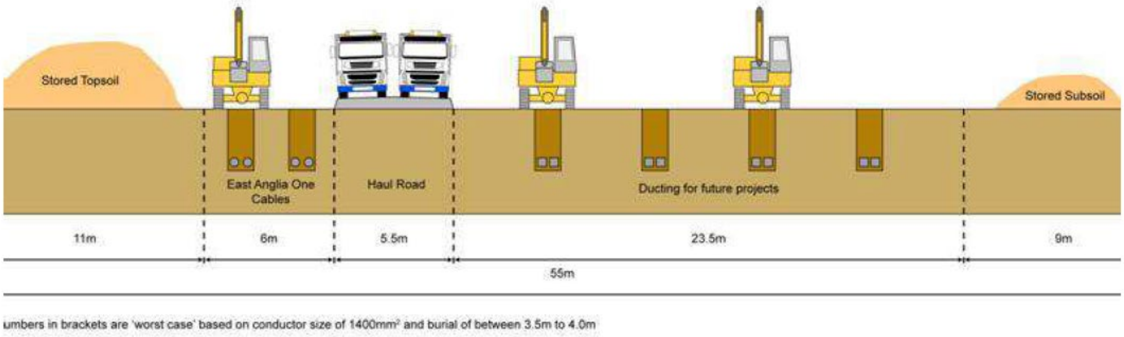
6. Socio-Economic assessment of project impacts is a well-established body of knowledge, and given the level of Adverse Impact of the proposed SPR projects, including substantial employment losses and damage to local businesses potentially requiring Government (and therefore taxpayer as proxy for electricity consumer) financial support, it is not acceptable that such costs are excluded. And clearly such Socio-Economic costs must include all aspects of the project such as all three substations, the cable route, and both coastal and cumulative impact with other projects.

   Had such costs been included the financial analysis by National Grid may well have indicated continued use of a connection to Bramford as being most economic. A further factor in all this is NGESO's use of a Least Worst Regrets approach to analysis. This by its nature supports an exceptionally short-term view of available options, when NGESO should be taking a <u>coordinated</u> and strategic approach as it is required and expected to do.

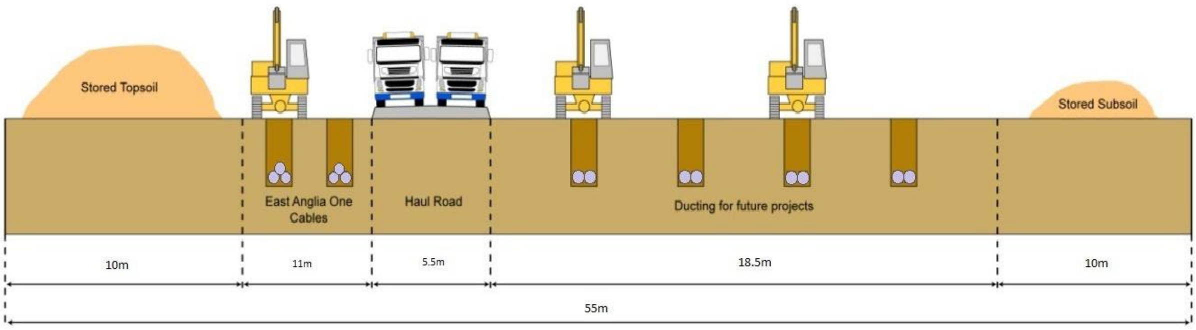
7. <u>Summary</u> It is clear from the above that the National Grid decision to change the grid connection from Bramford to Leiston is just the latest in a series of bad and inadequately justified decisions which will result in terrible damage to the local environment and economy of East Suffolk if the DCO application is approved.

BAWDSEY TO BRAMFORD CABLE ROUTE

1. What was originally approved in the East Anglia ONE DCO. Six cable trenches each planned to carry **600MW each** using HVDC.

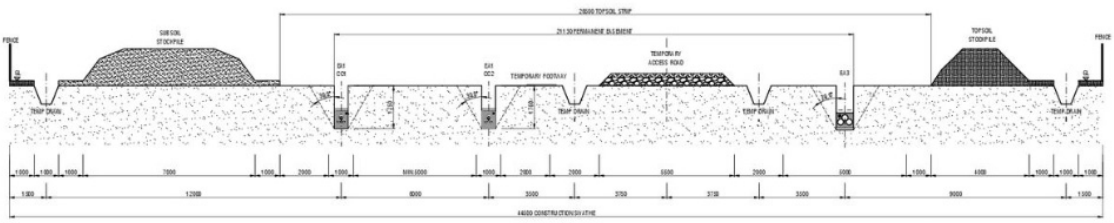


2. What this changed to after approval of the technology change of HVDC to HVAC after the CfD auction which allocated only 714MW to EA1 instead of the full 1.2GW. EA1 cable trenches 1 and 2 now carry only **357MW each**. Some dimensions also changed.



3. What was eventually agreed to and built after further correspondence with BEIS. Six trenches now reduced to three, but trench 3 now carrying the whole **1.4GW** from EA3. Had all six trenches been used in this way the cable route capacity might have been **8.4GW**.

VIEW FROM SHORE LANDING TOWARDS SUBSTATIONS OPTION 1



VIEW FROM SHORE LANDING TOWARDS SUBSTATIONS OPTION 2

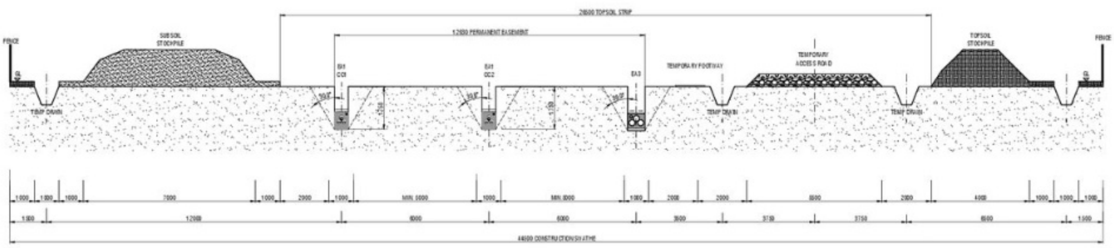


Figure 1

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

GRID CONNECTION DETAIL

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 27 October 2020 **Issue:** 7

1. The Examiners will be well aware that the Friston substation site is widely regarded as entirely unsuitable and unacceptable by communities along and at both ends of the Cable Route, most especially at Friston, and very significantly, by both East Suffolk District Council and Suffolk County Council. The many Environmental reasons for this are well documented elsewhere, especially by SASES, and will not be repeated. What are not so well documented are the underlying Engineering and Planning mistakes that have led to these entirely unacceptable projects which should unquestionably be rejected.

2. In particular it has emerged from the site search plans shown by National Grid Ventures (NGV) for their Nautilus Project is that it is <u>not</u> essential for Energy Company substations to be co-located with National Grid substations. Rather it is adequately practicable and economic for these two types of substation to be a number of kilometres apart. Had SPR accepted this for their projects then the area of search adopted for the SPR substations could have been very much wider and it is believed that other sites may exist which would be much more suitable than the Friston site. Indeed, one such site, about 5km from Friston, was suggested to NGV by the Local Authority and is being actively considered for the Nautilus project.

   However, SPR set criteria in their RAG assessments that sites which did not permit co-location of National Grid and SPR substations were to be marked Amber, and SPR substation sites not within 1km of overhead lines as Red, so effectively excluding them from consideration. The Examiners are requested to visit this issue in detail and reach their own conclusions. A copy of the NGV site selection area is shown at the end of this document as Fig.1 and in Ref 1 page 3. Sites 7 and 8 are of particular note.

3. Between 2008 and 2015 several well-resourced investigations (Refs. 2, 3, 4 and 5 amongst others) were carried out by both National Grid and the Crown Estate, together with the Energy Industry, into methods for delivering the forecast off-shore wind energy to the existing Electricity Grid, with its well established <u>inland</u> substations. These included several methods which could be regarded as embryo Off-Shore Ring Mains (ORMs). Fig.2 shows a relevant extract from Ref. 5 showing a possible coordinated off-shore arrangement.

   However in 2015 no business case support could be found for <u>any</u> innovative methods of Grid connection and all efforts to agree on an <u>Economic, Coordinated and Efficient</u> approach to the connection of power from the massive wind farm areas that the Crown Estate wished to develop were apparently shelved (Ref. 4 page iii last paragraph states:

"As a result the project team does not believe it would be economic and efficient to progress with the development of an integrated design philosophy or delivery of anticipatory assets at this time.").

Note the failure to use the word "coordinated". And for unaccountable reasons none of the investigations took proper note of the size of on-shore substations required at the end of the cable routes to process the raw electricity coming from the wind farms.

In retrospect this can be seen as having been a huge error, as the only remaining method of connection was to allow Radial connection of individual wind farms to existing National Grid substations via project specific cable routes across unspoilt countryside, and the construction of massive onshore substations on a per project basis, which approach must be hugely inefficient and uncoordinated.

4. Against this background, the apparent failure of National Grid and other statutory bodies to protect the carefully coordinated set of six cable trenches that were approved as part of the DCO for Scottish Power's East Anglia ONE and other projects seems inexcusable. (Ref. 6 para 6 documents that the Local Authorities raised no objection). And National Grid's failure is all the worse for apparently failing to consider the inefficiencies of allowing SPR to downsize its project and change technology for its EA1 project from HVDC to HVAC.

5. A more sensible approach might have been to agree to SPR constructing a reduced number of wind turbines for EA1, but required the unchanged installation of HVDC infrastructure to allow for potential expansion to full DCO-approved capacity. The incremental cost of this would have been small by comparison with off-shore costs of turbines etc., and as we now know, only a single cable trench would then have been needed to get up to 1.2GW of power from the EA1 wind farm to Bramford (the EA3 wind farm, now approved for expansion to 1.4GW, only requires one cable trench), not the two cable trenches required by the EA1 wind farm, now reduced to 714MW and using HVAC.

6. With regards to Grid Connection offers themselves, National Grid have argued that their entirely secretive CION process entitles them to reach conclusions on optimum means of allocating connections to the Grid. And they did so by reopening their CION agreements with SPR for EA1N and EA2 which approved reuse of the same EA1 cable route to Bramford which only a year before they had allowed to be downsized. But this time they concluded for reasons that have never been adequately explained that Leiston was now the preferred Grid connection point.

   As we now know, had National Grid not allowed SPR to be relieved of their obligation to build a six trench cable route this could have delivered in excess of 8.4GW to Bramford substation (6 x 1.4GW using HVDC). Surely this would have represented an efficient and coordinated solution.

7. It is clear from all this that National Grid's apparent belief that they can make short-term decisions on individual projects using Least Worst Regrets financial analysis, and no coordinated forward planning, is not a helpful interpretation of the Energy Act 1989 and the Examiners are asked to subject it to careful scrutiny.

   And investigation of the CION assessment (Ref. 9) for a Leiston connection raises the issue of where underlying costs have come from for the Cost Benefit Analyses.

Reference is made to a probably outdated (2012) IET/Parsons Brickenhoff report on cable costs (Ref. 7) but detailed investigation of this report (page vii, last paragraph) reveals that these are for 400kV HVAC and 320kV/400kV HVDC cables of long service life as part of the main National Grid network, not the circa 220kV specification cables required for wind farm connection. And no information has been made available as to what costs have <u>actually</u> been used by NGESO. So can the CION assessments be safely relied upon? The Examiners are asked to insist on full transparency of all the National Grid CION information relating to the Sizewell/Leiston connection before reaching any conclusions about its validity.

8. It is also appears that National Grid makes no adequate assessment of Environmental Impacts, and makes no <u>Quantification</u> of such impacts (socioeconomic and others), when making its CION decisions. In particular it is not clear that it takes adequate consideration of both the environmental impact of its <u>own</u> infrastructure and that of the Energy Company's infrastructure (wind farm substations are much larger than those constructed for other projects) which inevitably accompany it. Rather, the environmental implications of the decisions it makes are placed onto Energy Companies without consideration of the hurdles that may be faced when lightly made assumptions about the practicality of connections prove unrealistic.

   This is made clear from the first sentence of Ref. 9 page 20 which states that Option 3, connecting at Leiston (identified on page 17 of Ref 9 as an AONB site with the Sizewell Marshes SSSI less than 50m to the NE) was the preferred option for a new 400kV NGET substation, with a 860MW OFTO substation adjacent. But it must have been obvious that there was no capacity for accommodating the SPR substations at or near the same site without large scale use of and major adverse impact on AONB land and the conclusion must therefore be reached that National Grid's environmental assessment made no adequate allowance for the wind farm substations, despite the land area they require (20 acres plus surroundings).

   And in any case National Grid were obviously not fully confident in their choice of location because in the last sentence of Ref. 9 page 20 they were prepared for an alternative connection location (redacted but presumed to be Bramford) to be considered if the Leiston site was not possible. In addition Table 3 on Page 12 of Ref. 9 confirms that Option1 (identified on page 15 of Ref. 9 as Bramford) had the highest ranking on the basis of non-quantifiable factors, supporting this thesis.

9. Further, para 2 of page 5 of Ref. 9 fails to make clear that the principal reason that sufficient cable trenches are no longer available on the Bawdsey to Bramford cable route for EA1N and EA2 is that SPR requested approval to change its EA1 Technology from HVDC to HVAC (Ref. 8) and then later persuaded BEIS (Ref. 6) that they should no longer be held to Regulation 29 of the EA1 DCO which required six cable trenches to be laid. Without these two changes at least two cable trenches to Bramford would remain which could probably have been used for EA1N and EA2 if enough ducts had been installed and HVDC technology used.

   And in any case SPR made it clear to PINS (Ref. 11 page 1 para 3) that even after the technology change to EA1, and the Regulation 29 agreement to allow them to avoid installing the full six cable ducts, they still wished reopen the Bawdsey to Bramford cable route for further cable ducts for EA1N and EA2 (and of course this could have included additional ducts for other projects had those involved been minded to consider "coordination" with future projects, e.g. NGV).

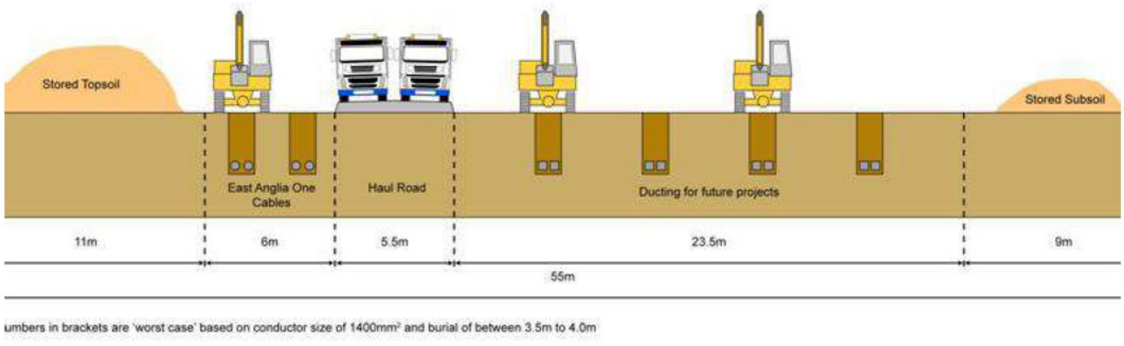
10. In consequence there must be considerable doubt as to whether that the Grid Connection assessments that have been provided for the projects under consideration can be relied on, and the Examiners are requested to look very closely indeed at the underlying Grid Connection recommendations made by National Grid and consider whether they should be reassessed, with a possible return to the Bawdsey to Bramford cable route as originally supported by SPR, or to an entirely different connection location such as Bradwell, both of which might avoid reconductoring of the Sizewell to Bramford overhead lines.

11. The next page of this document provides a summary of the history of the Bawdsey to Bramford cable route showing quite clearly the way that it was modified and then downsized, and the huge opportunity which seemed to have been overlooked of delivering up to 8.4GW to Bramford via a cable route from Bawdsey.

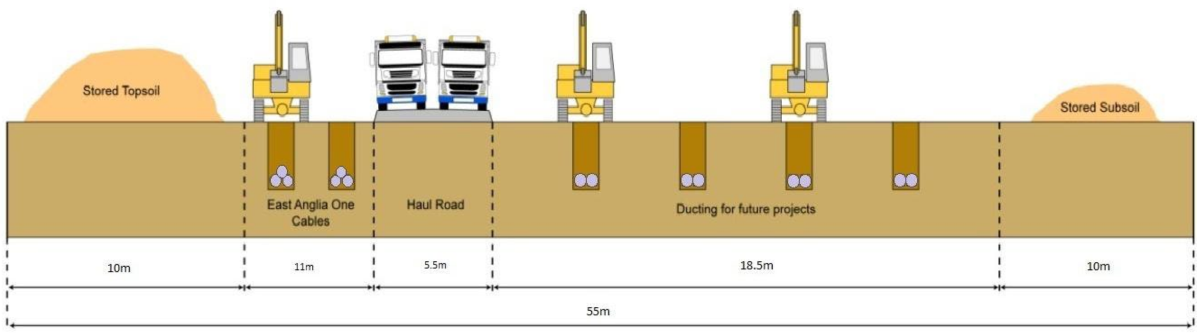
12. In case the argument should be offered that there is insufficient land area at Bramford for further wind farm substations or converter stations, and that this is an argument against reopening the Bawdsey to Bramford cable route, Ref. 12 (Figure 3) and Ref 13 (Figure 4) show possible additional substation sites at Bramford promoted by SPR in consultation documentation for EA1 and EA3, and even one site for an unnamed future project.

BAWDSEY TO BRAMFORD CABLE ROUTE

1. What was originally approved in the East Anglia ONE DCO. Six cable trenches each planned to carry **600MW each** using HVDC.

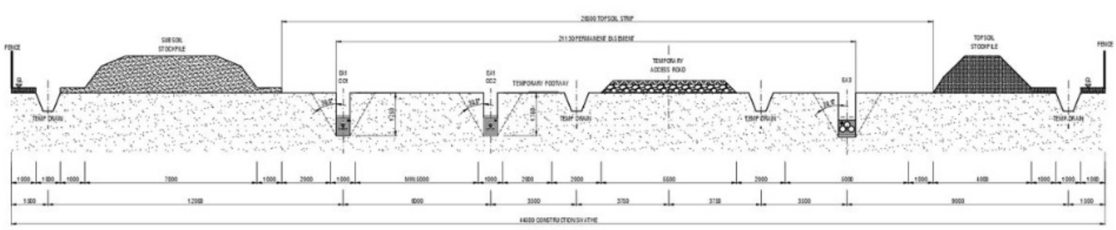


2. What this changed to after approval (Ref. 8) of the technology change of HVDC to HVAC after the CfD auction which allocated only 714MW to EA1 instead of the full 1.2GW. EA1 cable trenches 1 and 2 now carry only **357MW each**. Some dimensions also changed.



3. What was eventually agreed to and built after further correspondence with BEIS. Six trenches now reduced to three, but trench 3 now carrying the whole **1.4GW** from EA3. Had all six trenches been used in this way the cable route capacity might have been **8.4GW**.

VIEW FROM SHORE LANDING TOWARDS SUBSTATIONS OPTION 1



VIEW FROM SHORE LANDING TOWARDS SUBSTATIONS OPTION 2

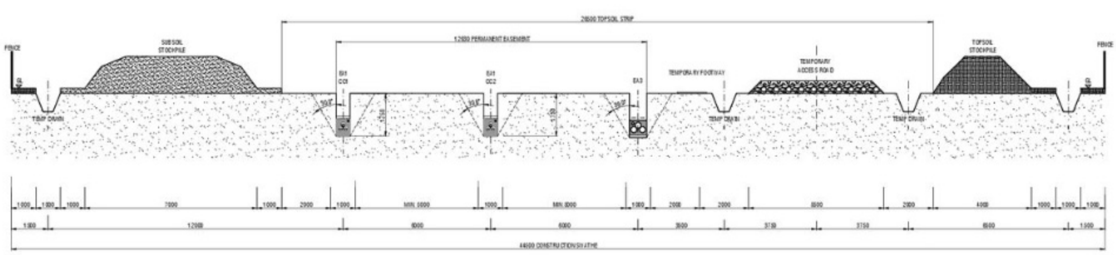
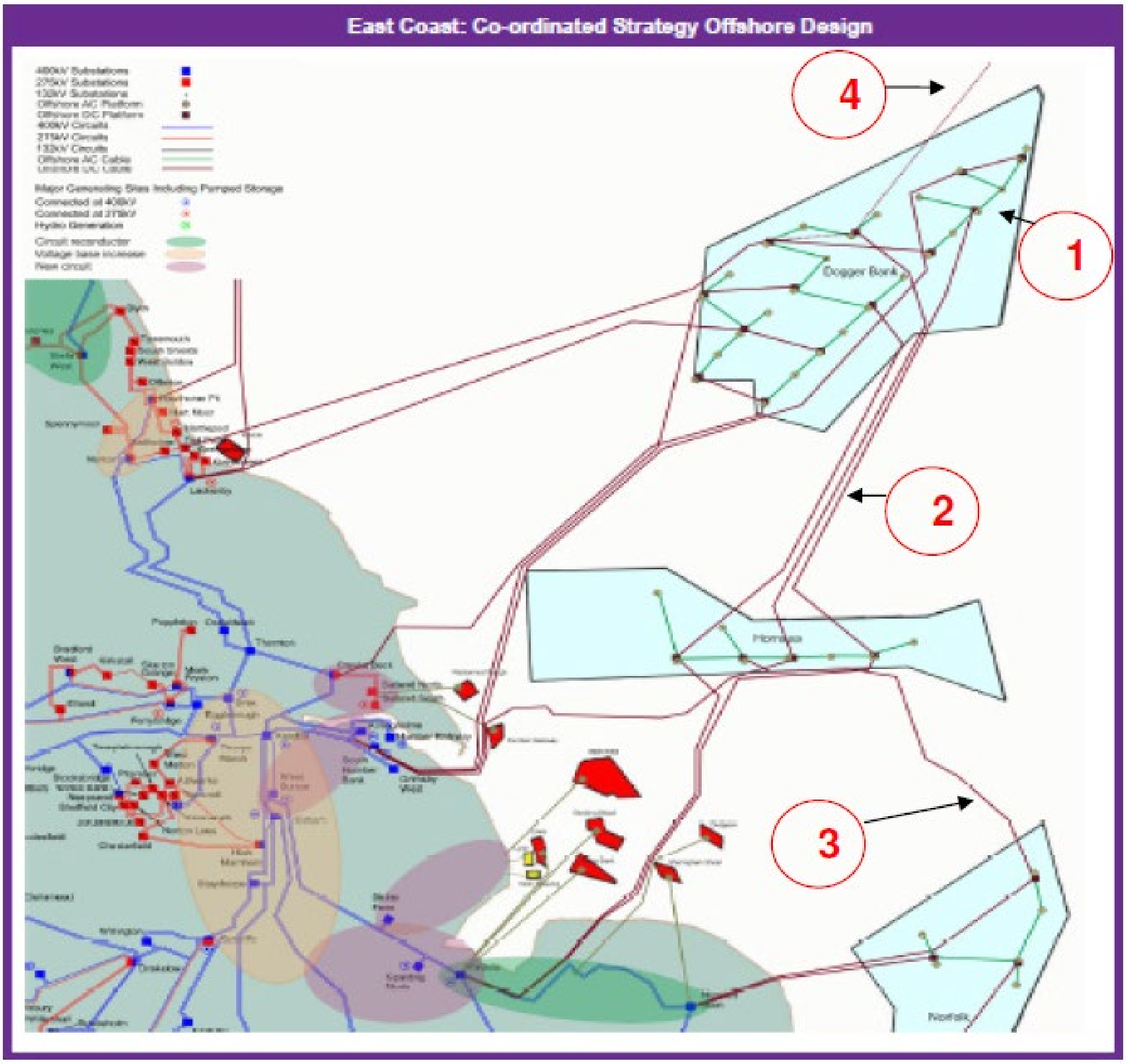


Fig. 1 National Grid Ventures Site Assessment Area



Key:

1. Intra-zonal coordination
2. Inter-zonal coordination
3. Onshore/offshore coordination
4. International coordination

Figure 2 Extract from Ofgem OTCP Report showing embryonic offshore coordination

References

Ref. 1 Nautilus Interconnector Briefing Pack.pdf July 2019
https://www.nationalgrid.com/document/125601/download

Ref. 2 Crown Estate Round 3 Offshore Wind Farm Connection Study
https://www.waveandtidalknowledgenetwork.com/wp-content/uploads/legacy-files/00883.pdf

Ref. 3 National Grid Input into UK Offshore Energy SEA
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/196493/OES_NatGrid_OnshoreETS.pdf

Ref. 4 Integrated Offshore Transmission Project (East) Final Report August 2015
https://www.nationalgrid.com/sites/default/files/documents/44400-IOTP_Summary_Report.pdf

Ref. 5 Ofgem Offshore Transmission Coordination Project 1 March 2012
https://www.ofgem.gov.uk/sites/default/files/docs/2012/03/20120103_otcp-conclusions-report.pdf

Ref 6 BEIS letter EN010025-002918-East Anglia ONE Requirement 29 Letter to Scottish Power of 30 January 2017.
https://webarchive.nationalarchives.gov.uk/20190814122457/https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010025/EN010025-002918-East%20Anglia%20ONE%20Requirement%2029%20Letter%20to%20Scottish%20Power%20of%2030%20January%2020.pdf

Ref. 7 Electricity Transmission Cost Study 31 January 2012
https://www.theiet.org/media/1651/transmission-report.pdf

Ref. 8 BEIS letter to Scottish Power of 24 March 2016 Approval of Non-Material Change
https://webarchive.nationalarchives.gov.uk/20190206154718/https://infrastructure.planninginspectorate.gov.uk/document/EN010025-000044

Ref. 9 Redacted CION Assessment Version 2.0 for East Anglia TWO windfarm dated 9 October 2017 (provided as email attachment due to size and lack of web link).

Ref. 10 National Grid assessment of grid connection for EA1 and EA2
https://www.scottishpowerrenewables.com/userfiles/file/National_Grid_COIN_Process_Connection_Assessment_Note.pdf

Ref. 11 PIN Minutes of Meeting with SPR 22 March 2017
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-Advice-00006-1-170322_EA1N_and_EA2_meeting_note.pdf

Ref. 12 Extract from Babergh Planning Application 0868/11 | IPC Consultation: Electricity cabling and converter station. See Figure 3 below showing possible converter locations.

Ref. 13 SPR EA3 DCO Environmental Statement Volume 2 Section 6.2.4, Page 5 and Figure 4 below
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000275-6.2.4%20Volume%202%20Chapter%204%20Site%20Selection%20and%20Alternatives%20Figures%20(Fig%204.1%20-%204.4).pdf

NOTE: Converter station 145x180m. The sites are chosen to avoid overhead HV cables, maximise existing tree screening, locate as far from residential property as possible and be contained, including mitigation screen within a single field parcel. On this basis the preferred location is site 2. Site 1 is visually well contained but within 600m of residents. Site 3 is outside the distance radius but like site 4 is visually exposed to the villages to the west and both are south of the existing sub-station and proposed cable route

Figure 130911

Figure 3

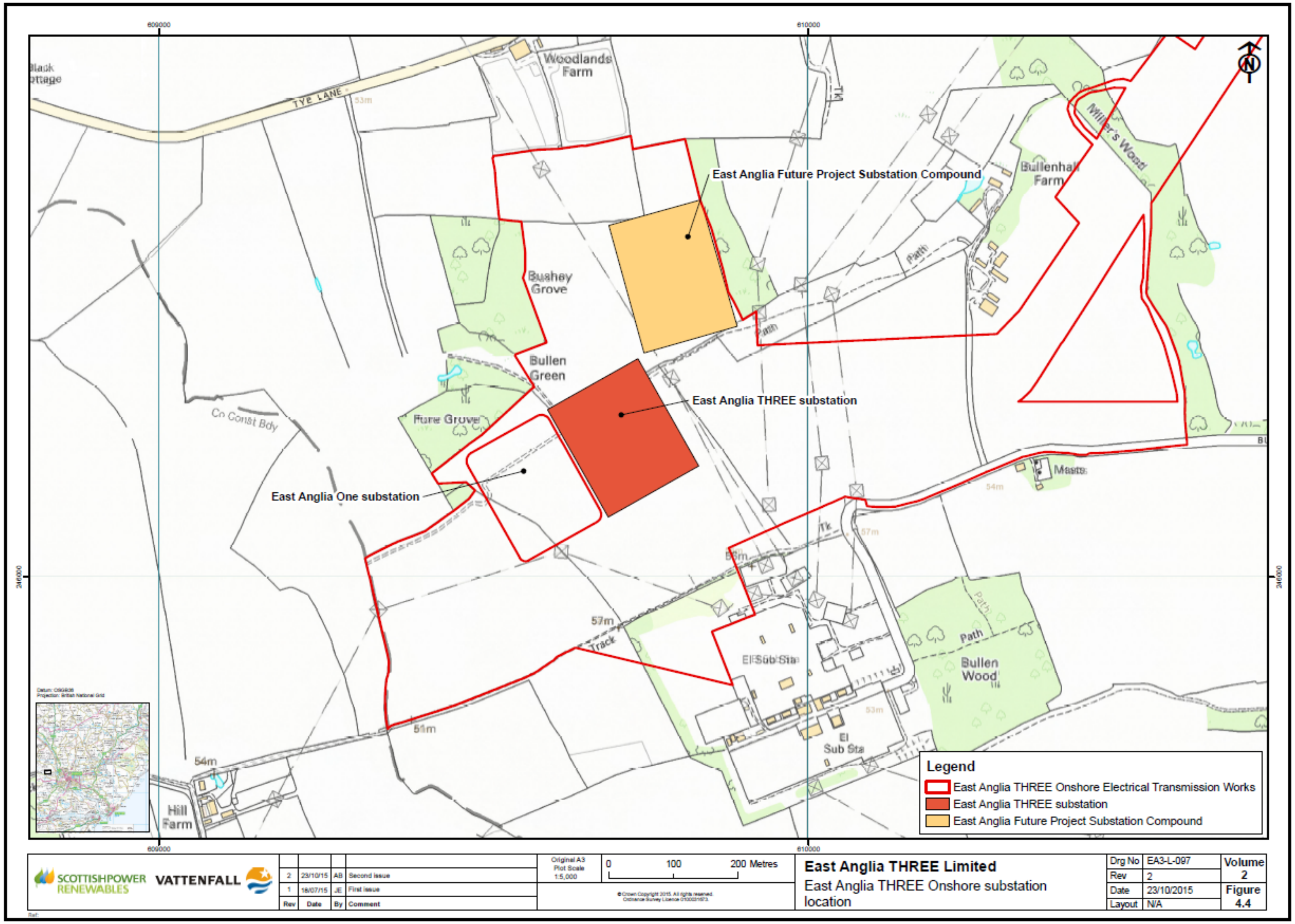

East Anglia Future Project Substation Compound
East Anglia THREE substation
East Anglia One substation
Woodlands Farm
Bushey Grove
Bullen Green
Bullenhall Farm
Miller's Wood
Bullen Wood
Hill Farm
TYE LANE
Legend
East Anglia THREE Onshore Electrical Transmission Works
East Anglia THREE substation
East Anglia Future Project Substation Compound
SCOTTISHPOWER RENEWABLES
VATTENFALL
2 23/10/15 AB Second issue
1 18/07/15 JE First issue
Rev Date By Comment
0 100 200 Metres
East Anglia THREE Limited
East Anglia THREE Onshore substation location
Drg No EA3-L-097
Rev 2
Date 23/10/2015
Layout N/A
Volume 2
Figure 4.4

Figure 4

WRITTEN REPRESENTATION FOR SPR EA1N and EA2 PROJECTS (DEADLINE 1)

NATIONAL GRID SUBSTATION

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 31 October 2020 **Issue:** 6

1. The SPR DCO Application includes an adjacent NGET substation, in one of two forms, either Air Insulated (AIS) or Gas Insulated (GIS), the connection of which to the adjacent overhead lines requires the construction of sealing ends with gantries on the adjoining land, and the relocation of some pylons. The need for associated Overhead Line Works necessities approval as an NSIP, but the Application fails to explain this clearly or where the legal boundary between the EA1N/EA2 NSIP and the NGET NSIP is. Does the latter include the NGET substation or not? This is unacceptable.

2. The proposal that the Grove Wood site be suitable for the NGET substation is incomprehensible given that it has a Zone 3 (1 in 30 year) Surface Water Flood Risk as explained in associated Written Representation Ref. 1, and the Grove Wood site should have been excluded at an early site selection stage after application of the Sequential Test. This is clearly contrary to planning guidance, and if nevertheless approved the site will present serious engineering challenges to avoid water damage to the electrical equipment and ensure adequate drainage. In Ref. 2, a National Grid publication, on page 21 it is noted that *"The risk with the greatest likelihood (20% -40% likely) with the most potential to impact the project are the ground conditions that will be encountered."*

   The possible need to <u>raise</u> the substations above expected flood levels to avoid flood risk has been suggested (Ref. 3) and if implemented would seriously undermine the accuracy of the visualisations in the application and the assumptions in it about landscape visual impact and noise emissions. All these issues indicate that the current application is unjustifiable.

3. No explanation is given in the Application of future development of the NGET substation, other than it has been established from National Grid Ventures that they would wish to extend it by around three acres for their Nautilus Interconnector (and presumably by a further three acres for their Eurolink Interconnector). Given the overall adverse impact of an extended National Grid substation, as well as two SPR substations, at the same site the Examiners are requested to consider this is as being unacceptable.

4. Ref. 2 presents the proposed Friston NGET substation as a 'case study' and notes on page 20, paragraph *"Connection at Leiston"* that a <u>nine</u> bay substation is the agreed preferred option. But with two identical projects, (EA1N and EA2), proposed to connect to it an even number of bays would be expected, presumably four input bays and four output. So what justification is there for a ninth bay? The allocation of bays needs to be explained and justified in some detail together with any Cumulative Impact implications of any further connection.

5. The Sealing End Compound for the most Northern overhead line is shown (Ref. 5) and described (Ref. 4) as having 'circuit breakers' incorporated in it (not a feature of the other sealing ends) as well as an adjacent non-standard pylon supporting this feature. Careful examination of the drawings provided shows that the purpose of the 'circuit breakers'

must be to allow the associated three wire circuit coming from Sizewell to be disconnected. The need for this feature is not described in the Application and is believed to be nothing to do with EA1N and EA2 projects but rather an additional item of NGET equipment that they would like to get approved together with the SPR projects. This is unsatisfactory.

6. Layer "*22_05 linework"* of the OLMP (Ref. 5) and Figure 1 below shows with a dashed blue line what appears to be the expected final size of the NGET substation complex. This appears to be consistent with the total area required for an AIS construction supporting the two SPR and two NGV projects, and possibly could also accommodate a 'ninth' bay' for purposes unknown. It is the completed development of this area which the Examiners are asked to consider as part of their evaluation.

7. But as well as an AIS version the Application retains the option of a GIS version of the NGET substation and claims that this GIS version is 'Not worst case' (Ref. 6), and by implication that the AIS version is. But it is not clear that AIS is Worst case, as although it covers a larger area for the purposes of the SPR projects, it is relatively lower profile (open format switchgear and gantries, buildings no higher than 6m, equipment no higher than 16m) whilst the GIS version has large buildings and equipment both with a height up to 16m and would therefore have greater adverse landscape impact from a distance and be much more difficult to screen. However the Application provides no detailed assessment of the GIS version to inform this.

   Notwithstanding the comments made by NGET in Ref. 2 referring to a nine-bay substation it is entirely possible that NGET might wish to develop the whole of the Figure 1 blue line area using GIS technology for future projects as yet undisclosed. The adverse visual impact of 13m height GIS buildings on the whole of the entire 'blue line' site would obviously be very significant and dramatically worse than either an AIS development or the currently proposed SPR-only GIS development.

8. Clearly this possibility brings with it further major concerns about Cumulative Impact from projects as yet not disclosed to the community, but likely to include:
   - SPR EA1N wind farm, cable route and substation, plus shared National Grid substation. DCO application accepted by PINS.
   - SPR EA2 wind farm cable route, and substations, plus shared National Grid substation. DCO application accepted by PINS.
   - National Grid plans for a <u>nine</u> bay NGET substation at Friston (so-called Leiston 400kV Substation). Part of Ea1N and EA2 applications.
   - Sizewell C twin reactor nuclear power station plus related infrastructure (road and rail). DCO application made.
   - Reconductoring of Sizewell to Bramford OHLs.
   - Sizewell B site relocation activities.
   - NGV Nautilus Interconnector and Converter Station. Recorded on PINS NSIP website with DCO application expected Q2 2022.
   - NGV Eurolink Interconnector connection summary.
   - Greater Gabbard/North Falls wind farm expansion, with cable route and substation.
   - Galloper/Five Estuaries wind farm expansion, with cable route and substation.

- National Grid SCD1 Interconnector referred to in NGESO Network Options Assessment 2020

- National Grid SCD2 Interconnector referred to in NGESO Network Options Assessment 2020
- Use of 'Sizewell' as Grid Connection for unspecified future wind farm and interconnector projects until 2030, and more up to 2050 unless an Integrated offshore design adopted

The Examiners are requested to fully investigate this issue and to ensure the possibility of a large scale GIS development, possibly as a result of the use of NGET 'Permitted Rights' to convert an approved AIS substation into a GIS version, and its related cumulative impact, is taken in to account when considering their recommendations. Approval of the current application would set a major precedent for future development in the area and is therefore strongly opposed.

9. It is further noted that at Bramford, NGET has in recent years received planning permission to extend its operational site there on the basis of requiring space for AIS substation equipment, but has subsequently changed tack to install GIS equipment (Ref. 7/Figure 2 and Ref. 8/Figure 3) as 'Permitted Development' with only minor additional approval and still have a large amount of unused space which could potentially be allocated to connection equipment for further wind farm and interconnector projects.

   Ref. 9 (Figure 4) and Ref. 10 (Figure 5) show previously suggested wind farm converter station sites at Bramford for which land is potentially available and in the case of Figure 4 already in the Applicant's ownership. This again raises the issue of why build a new NGET substation on a highly unsuitable and hugely unpopular greenfield site at Friston when capacity exists at Bramford? Claims about (redacted and therefore highly questionable) cable costs are totally inadequate given the possibility of expanding at Bramford in a straightforward and relatively benign way. Again, it is clear that the Application needs to be **rejected**.

10. A mentioned above there is great concern that NGET's use of its Permitted Rights could be used as at Bramford to allow any land allocated at Friston for a new AIS NGET substation to be repurposed as a GIS substation with potentially far greater connection capacity in the same land area. This could lead to cumulative impacts not previously anticipated or assessed.

    In any case it is considered unreasonable that after the passage of so much time NGET should be unclear as to whether they need an AIS or a GIS substation and the Examiners are requested to ensure that any DCO is prescriptive as to which type is permitted, and that if AIS then NGET's Permitted Rights to convert to GIS are removed.

REFERENCES

Ref. 1 CW WR Flood Risk Sequential Test Detail v6.docx (with CW Written Representation set)

Ref. 2 NGET_A8.02_Generation _redacted.pdf
https://www.nationalgrid.com/uk/electricity-transmission/document/132296/download

Ref. 3 East Anglia TWO Offshore WindfarmEnvironmentalStatement6.3.20.3 Appendix 20.3 Flood Risk Assessment page 30, para 181. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010078/EN010078-001515-6.3.20.3%20EA2%20ES%20Appendix%2020.3%20Flood%20Risk%20Assessment.pdf

Ref. 4 6.1.6 EA1N Environmental Statement Chapter 06 Project Description page 110 para 514. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001060-6.1.6%20EA1N%20Environmental%20Statement%20Chapter%2006%20Project%20Description.pdf

Ref. 5 6.2.29.11a Environmental Statement - Figure 29.11a - Outline Landscape Mitigation Plan (OLMP) General Arrangement. See Figure 1 below. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001493-6.2.29.11a%20EA1N%20ES%20Figure%2029.11%20Outline%20Landscape%20Mitigation%20Plan%20(OLMP)%20General%20Arrangement.pdf

Ref. 6 8.2 Development Consent and Planning Statement Page 40 Table 3.3 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001012-8.2%20EA1N%20Development%20Consent%20and%20Planning%20Statement.pdf

Ref. 7 Babergh District Council Planning Application 0076/07 Construction of extension to 400KV electricity substation and associated access road. Bramford Sub Station Bullen Lane Bramford. See Figure 2 below.

Ref. 8 Google Earth Image of Bramford substation viewed on 10 June 2020. See Figure 3 below.

Ref. 9 Ref. 13 SPR EA3 DCO Environmental Statement Volume 2 Section 6.2.4, Page 5 and Figure 4 below https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000275-6.2.4%20Volume%202%20Chapter%204%20Site%20Selection%20and%20Alternatives%20Figures%20(Fig%204.1%20-%204.4).pdf

Ref. 10 Babergh District Council Planning Application 0868/11 IPC Consultation. See Figure 5 below.

Figure 1 Outline Landscape Management Plan for EA1N and EA2

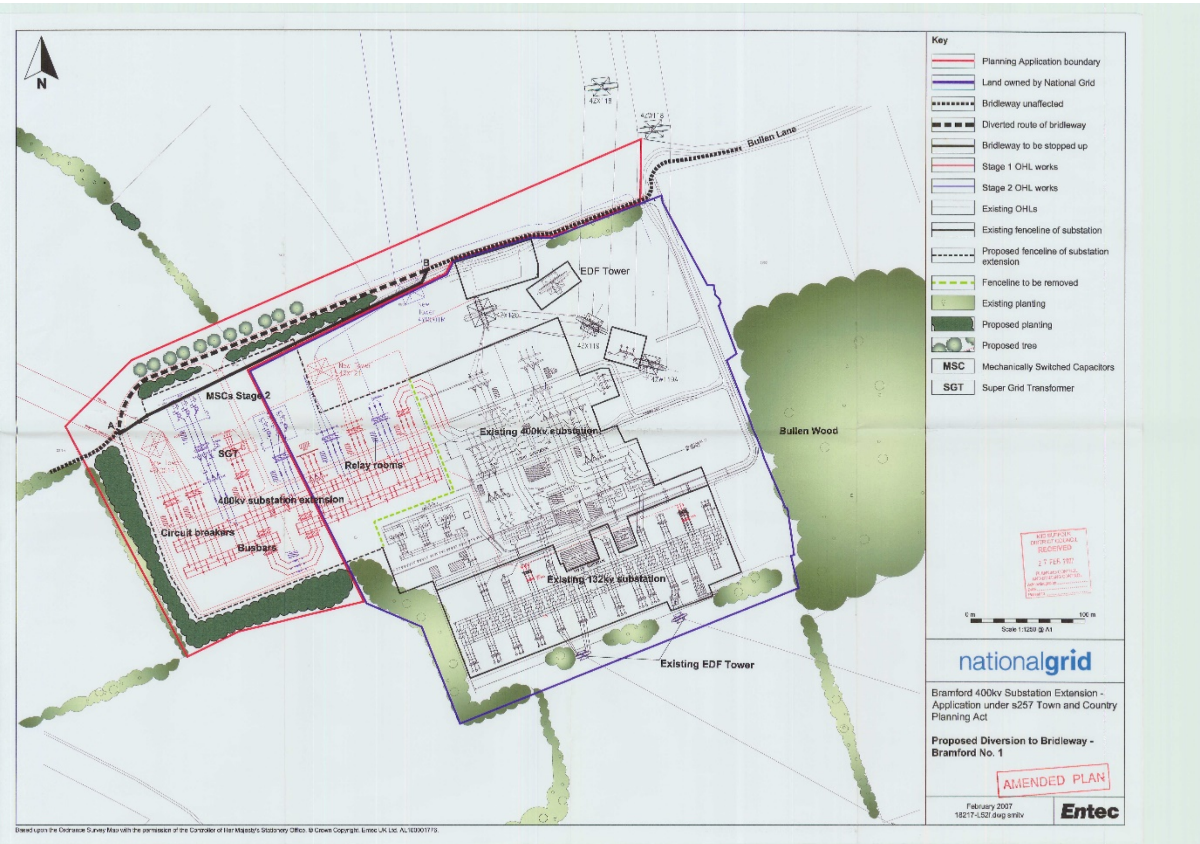


Figure 2 – As applied for AIS extension to NGET substation at Bramford

Figure 3 – As built GIS extension to NGET substation at Bramford

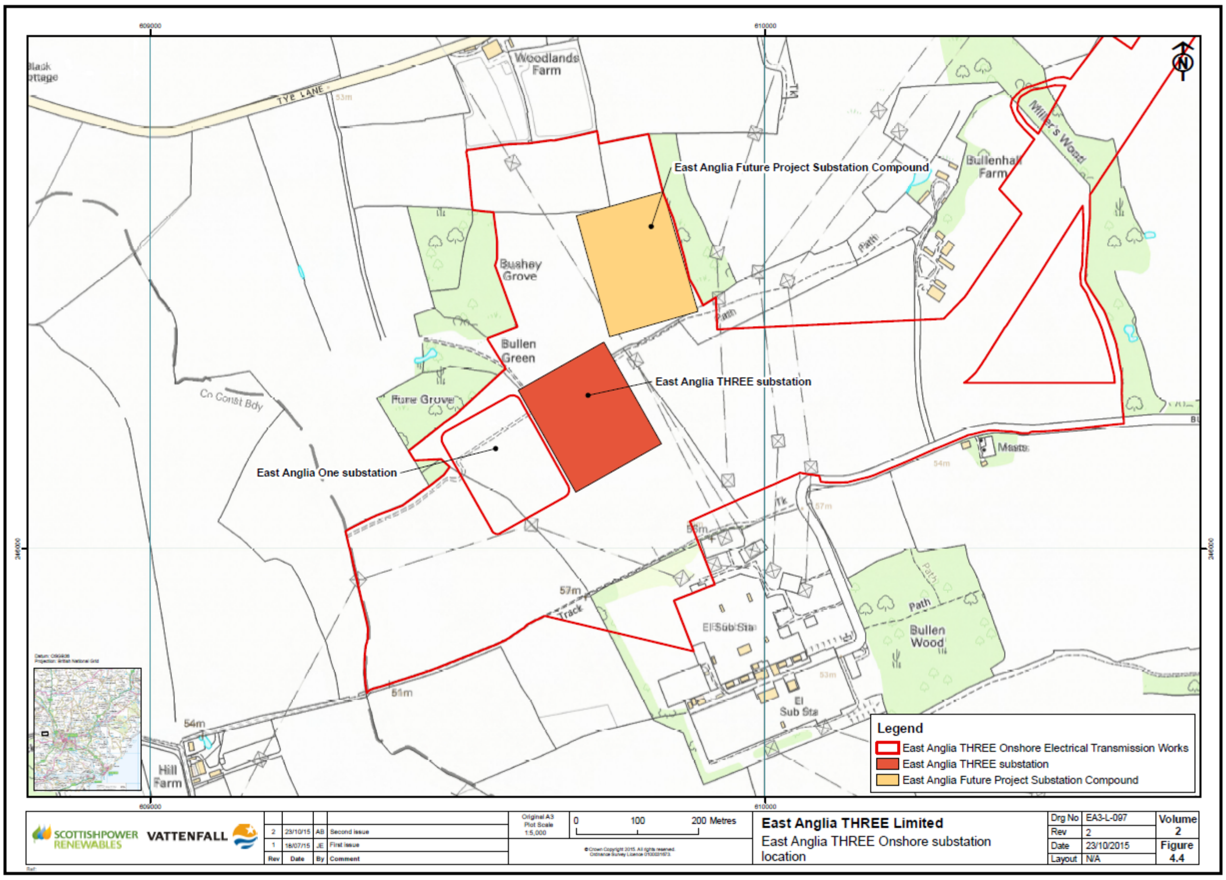


Figure 4 –Possible wind farm converter station sites at Bramford

NOTE: Converter station 145x180m. The sites are chosen to avoid overhead HV cables, maximise existing tree screening, locate as far from residential property as possible and be contained, including mitigation screen within a single field parcel. On this basis the preferred location is site 2. Site 1 is visually well contained but within 600m of residents. Site 3 is outside the distance radius but like site 4 is visually exposed to the villages to the west and both are south of the existing sub-station and proposed cable route

Figure 130911

Figure 5 – Further possible wind farm converter station sites at Bramford

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

SITE SELECT - FLOOD RISK SEQUENTIAL TEST SUMMARY

Interested Party: Chris Wheeler **PINS Refs:** 20023840 & 20023842

Date: 23 September 2020 **Issue:** 4

There is believed to be a key defect in the SPR Site Selection Process whereby the Sequential Test for Flood Risk has not been properly applied. This note summarises as a timeline the background to the situation. Document *CW WR Flood Risk Sequential Test Detail v6.docx* contains relevant detailed information and should be read in conjunction with this note.

TIMELINE

<u>July 2017</u>

1. SPR hold Expert Topic Group meetings with Statutory Consultees and discuss site selection amongst other issues. No formal Minutes available.

<u>May 2018</u>

2. SPR published Consultation Phase 3 results of the RAG assessments carried out for Site Selection across seven identified areas within Onshore Investigation Area, and advised a preference for the Grove Wood site.

3. These RAG assessments showed a criterion for Fluvial Flood Risk but <u>no criterion for Pluvial Flood Risk</u> (surface water flooding), even though runoff from the Grove Wood site is widely known to be a cause of flooding in Friston village, a fact which was communicated to SPR at preceding PID consultations in March 2018, at public meetings and otherwise.

4. Widespread criticism led to a Phase 3.5 assessment of the Broom Covert site near Sizewell nuclear facility as an alternative.

<u>December 2018</u>

5. SPR published the results of their Phase 3.5 Site Selection assessment (Ref. 2) and advised the community that the Broom Covert site was regarded as unsuitable.

<u>May 2019</u>

6. SPR published the results of their Phase 4 Site Selection RAG assessment as part of their PEIR documentation, confirming the choice of the Grove Wood site. This RAG assessment also failed to have a criterion for Pluvial Flood Risk (surface water flooding), only Fluvial (river etc.) flooding being considered.

7. The Flood Risk Assessment provided did not describe the risk of a 1 in 30 year Surface Water Flood Risk at the NGET substation site despite the Environment Agency Surface Water Flood Map provided showing a high risk of surface water flooding within the proposed NGET substation site and the adjacent land to the North within the NGET overhead line realignment area.

November 2019

8. PINS published the SPR DCO application documentation but this time disclosure is made of a 1 in 30 flood risk at the NGET substation site and associated NGET OHL realignment area.

9. It is indicated that the Sequential Test has been satisfied but no clear evidence trail is provided.

THE ISSUE

10. It is believed from EN-1 that the flood avoidance guidance within the NPPF and associated Government Planning Guidance is applicable to the SPR development, including the NGET substation component.

11. This guidance provides that a Sequential Test shall be applied to the sites available to the developer and that a site which is Flood Risk 1 rated (very low flood risk) (included ALL forms of flooding, river, rainfall etc.) is to selected in preference to all those which are not so rated. Only if no such sites are available are sites with a Flood Risk 2 or greater to be considered, with an Exception Test being applied.

12. Given that the NGET part of the Grove Wood site has a Surface Water Flood risk rating of Zone 3 (1 in 30 years) and that other sites from the original seven considered do not all have such a rating of flood risk (several are Zone 1) the Grove Wood site **should not pass the Sequential Test** and therefore should not have been selected by SPR.

13. Available Local Authority responses to the PEIR do not clarify whether or not they carried out a formal Sequential Test, although they do make many criticisms of the Flood Risk Assessment, including noting the high flood risk at the NGET site.

14. This leads to the conclusion that the Site Selection process followed by SPR may have a fundamental process defect, and therefore be invalid, in which case the current DCO application should be refused.

FURTHER READING

For evidence and references please refer to *CW WR Flood Risk Sequential Test Detail v6.docx.*

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

SITE SELECT - FLOOD RISK SEQUENTIAL TEST DETAIL

Interested Party: Chris Wheeler **PINS Refs:** 20023840 & 20023842

Date: 3 September 2020 **Issue:** 6

1. The process by which SPR have selected Grove Wood for the National Grid substation and their EA1N and EA2 substations is believed to be defective for a variety of reasons and this decision is strongly challenged. This document provides detail of what are believed to be defects with the Flood Risk Sequential Test. The quoted documents are for EA1N but the equivalent documents for EA2 also apply.

2. In May 2018 SPR published the results of their Phase 2 Site Selection RAG assessment (Ref. 1). Selection of the Grove Wood site was advised based on the scoring at that stage. However it was noted at the time that although there was a criterion for Fluvial Flood Risk, there was no criterion for Pluvial Flood Risk (surface water flooding), even though runoff from the Grove Wood site is widely known to be a cause of flooding in Friston village, a fact which was communicated to SPR at preceding PID consultations in March 2018, at public meetings and otherwise. The RAG matrix below was shown at public meetings and is taken from the copy slide set provided by SPR.

RAG assessment – SPR substation results

Criteria	Option E1 (Fig3.3)	Option E1a (Fig3.3)	Option E2 (Fig3.4)	Option E2a (Fig3.4)	Option E3 (Fig3.5)	Option E3a (Fig3.5)	Option E4 (Fig3.6)	Option E4a (Fig3.6)	Option W1 (Fig3.7)	Option W1a (Fig3.7)	Option W2 (Fig3.8)	Option W2a (Fig3.8)	Option W3 (Fig3.9)	Option W3a (Fig3.9)8)
Archaeology														
Proximity to National Designations – SMs, Grade 1 Listed Buildings	<500m but screened by woodland	<500m but screened by woodland							<500m but screened by woodland	<500m of Listed Building	<500m but screened by woodland	<500m but screened by woodland	<500m but screened by woodland	<500m but screened by woodland
Proximity to Regional Designations – Local Historic Environment Records, grade II Listed Buildings	<500m but screened by woodland	<500m but screened by woodland	<500m of HER monument	<500m of HER monument		<500m of HER monument		<500m but screened by woodland	<500m but screened by woodland	<500m of HER record	<500m of HER record	<500m of HER record	<500m of HER monument	<500m of HER monument
Ecology														
Proximity to National Designations – SSSI / SPA	<500m to SPA / SSSI	<500m to SPA / SSSI			<500m to SPA / SSSI	<500m to SPA / SSSI	<500m to SPA / SSSI	<500m to SPA / SSSI						
Proximity to Local Designations – Local Nature Reserves (LNR) / Suffolk County Wildlife Site														
Proximity to mature woodland	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland
Landscape – see Appendix C Table C.1 for explanation of RAG scoring														
Potential to affect the special qualities of the AONB														
Proximity to Special Landscape Areas (SLA)														
Landscape character and sensitivity to development														
Opportunity to utilise existing features for screening														
Visual sensitivity to development														
Hydrology / hydrogeology														
Proximity to licenced abstraction points				<50m to abstraction										
Presence of potentially contaminated land														
Source Protection Zone									Within SPZ2	Within SPZ2	Within SPZ2	Within SPZ2	Within SPZ2	Within SPZ2
Proximity to fluvial flood risk		<500m to FZ3									<500m to FZ3	<500m to FZ3	<500m to FZ3	<50m to FZ3
Engineering														
Site efficiency					Limited co-location potential	Limited co-location potential							Limited co-location potential	Limited co-location potential

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Criteria	Option E1 (Fig3.3)	Option E1a (Fig3.3)	Option E2 (Fig3.4)	Option E2a (Fig3.4)	Option E3 (Fig3.5)	Option E3a (Fig3.5)	Option E4 (Fig3.6)	Option E4a (Fig3.6)	Option W1 (Fig3.7)	Option W1a (Fig3.7)	Option W2 (Fig3.8)	Option W2a (Fig3.8)	Option W3 (Fig3.9)	Option W3a (Fig3.9)8)
Highway access (construction and operational)	Access via Aldringham	Access via Aldringham	Access via Aldringham	Access via Aldringham	Access via Aldringham	Access via Aldringham	Access via Sizewell Gap Road	Access via Sizewell Gap Road						
Proximity to high voltage electrical transmission infrastructure (overhead lines)	>500m to OHL				>1km to OHL	>1km to OHL	>500m to OHL				>500m to OHL		>500m to OHL	
Community														
Presence of residential properties	Properties <250m but screened by woodland		Properties within 50m	Properties within 50m	Properties <250m but screened by woodland		Properties within 250m	Properties within 50m	Properties <250m but screened by woodland			Properties <250m but screened by woodland		Properties within 250m
PRoW / National trails (NT)			Public bridleway <100m	Public bridleway <100m	Public footpath <100m			Public bridleway <100m		Crosses public footpath	Public footpath <100m	Public footpath <100m		
Agricultural Land Classification	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3		ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3
Sensitive land uses (schools and hospitals)				School <250m										
Property														
Number of landowners														
Planning														
Current planning applications or knowledge of other developments														
SCORE	1 red 9 yellow 13 green	1 red 9 yellow 13 green	1 red 10 yellow 12 green	2 red 11 yellow 10 green	4 red 6 yellow 13 green	4 red 6 yellow 13 green	4 red 5 yellow 14 green	5 red 5 yellow 13 green	1 red 2 yellow 20 green	1 red 5 yellow 17 green	1 red 8 yellow 14 green	1 red 7 yellow 15 green	1 red 8 yellow 14 green	2 red 8 yellow 13 green

This is the equivalent matrix for the proposed NGET substation:

East Anglia TWO and East Anglia ONE North September, 2017
Onshore substation Site Selection RAG Assessment

National Grid Substation Options (by relevant Zone)	NG4 (Fig4.2)	NG2 (Fig4.3)	NG1 (Fig 4.6)	NG7 (Fig4.4)	NG6 (Fig4.5)	NG5 (Fig 4.7)	NG8 (Fig4.8)
Archaeology							
Proximity to National Designations – SMs, Grade 1 Listed Buildings)		<500m to Heritage Coast		<500m to Listed Buildings	<500m but screened by woodland	<500m but screened by woodland	
Proximity to Regional Designations – Local Historic Environment Records, grade II Listed Buildings	<500m to HER monument	<500m to HER monument	<500m to HER monument	<500m to HER monument	<500m to HER monument	<500m to HER monument	<500m of HER monument
Ecology							
Proximity to National Designations – SSSI / SPA	>500m to SSSI / SPA	>500m to SSSI / SPA	>500m to SSSI / SPA				<500m to SPA / SSSI
Proximity to Local Designations – Local Nature Reserves (LNR) / Suffolk County Wildlife Site							<500m to Sizewell Belts Nature Reserve
Proximity to mature woodland / Environmental Stewardship scheme	<500m to mature woodland	<500m to mature woodland	<500m to mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland	Cable route requires removal of mature woodland	<500m to mature woodland
Landscape – see Appendix D for explanation of RAG scoring							
Potential to affect the special qualities of the AONB							
Proximity to Special Landscape Areas (SLA)							
Landscape character and sensitivity to development							
Opportunity to utilise existing features for screening							
Visual sensitivity to development							
Hydrology / hydrogeology							
Proximity to licenced abstraction points							
Presence of potentially contaminated land							
Source Protection Zone					Within SPZ2	Within SPZ2	
Proximity to fluvial flood risk					<500m to FZ3	<500m to FZ3	<500m to FZ3
Engineering							

Onshore Substations Site Selection RAG Page 17

East Anglia TWO and East Anglia ONE North September, 2017
Onshore substation Site Selection RAG Assessment

National Grid Substation Options (by relevant Zone)	NG4 (Fig4.2)	NG2 (Fig4.3)	NG1 (Fig 4.6)	NG7 (Fig4.4)	NG6 (Fig4.5)	NG5 (Fig 4.7)	NG8 (Fig4.8)
Highway access (construction and operational)	Access via Aldringham	Access via Sizewell Gap Road	Access via Aldringham				Access via Sizewell Gap Road
Proximity to high voltage electrical transmission infrastructure (overhead lines)			Requirement for sealing end compound + >1km cable			Requirement for sealing end compound + >500m cable	
Community							
Presence of residential properties		Properties within 250m		Properties within 250m	Properties within 250m	Properties within 250m	
PRoW / National trails (NT)	Public footpath <100m	Public bridleway <100m	Public footpath <100m	Crosses public footpath	Crosses public footpath		
Agricultural Land Classification	ALC Zone 2 or 3		ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3	ALC Zone 2 or 3
Sensitive land uses (schools and hospitals)							
Property							
Number of landowners				2 or more landowners		2 or more landowners	
Planning							
Current planning applications or knowledge of other developments							Proposed Sizewell C reptile mitigation land
SCORE	1 red 9 amber 12 green	4 red 7 amber 11 green	4 red 7 amber 11 green	1 red 9 amber 12 green	3 red 6 amber 13 green	1 red 9 amber 12 green	1 red 8 amber 13 green

Table 4.1: RAG assessment table of development considerations for the seven potential NG AIS substation locations

*Note: Consultation with Suffolk Wildlife Trust identified that Grove Wood woodland should be identified as a Local Wildlife Site. This would result in an additional Amber score for NG7 as this site would be within 500m. This would result in a zone score of 1 red, 10 amber and 11 green for Zone 7. This is not reflected in the table as this consultation response was received post-publication. This update does not alter the conclusions of this document or the site selection process.

Onshore Substations Site Selection RAG Page 18

3. In December 2018 SPR published the results of their Phase 3.5 Site Selection assessment (Ref. 2) and advised the community that the Broom Covert site was regarded as unsuitable.

4. In May 2019 SPR published the results of their Phase 4 Site Selection RAG assessment as part of their PEIR documentation for EA1N (Ref. 3). This RAG assessment also failed to have a criterion for Pluvial Flood Risk (surface water flooding) despite the Surface Water Flood Map (Ref. 4, last page) provided in the PEIR documentation clearly showing a high risk of surface water flooding within the proposed NGET site and the adjacent land to the North within the overhead line realignment area.

5. Moreover in para 113 of the EA1N PEIR Flood Risk Assessment (page 18 Ref 4) SPR state (author's emphasis):

   "113. The Environment Agency's Long Term Flood Risk Information map (Environment Agency undated) (Figure 20.1.2) shows the onshore substation and National Grid infrastructure to be in an area at primarily low risk of surface water flooding i.e. outside the extent of the 1 in 1,000 year surface water flooding event. However, there is ***an area along the western perimeter*** *which is at medium risk of surface water flooding i.e. there is a risk of flooding during the 1 in 100 year event. In addition, there are* ***small isolated locations*** *where there is a high risk of surface water flooding i.e. during the 1 in 30 year event. This is likely to be due to the presence of localised land drainage combined with areas of low-lying land."*

However, this wording does not seem consistent with the actual surface water flood risk shown in the Environment Agency map (see Fig. 1 below which has been assembled from Figure 20.1.2 of Ref. 4 and the OLMP plan from Ref. 5). The NGET substation is the structure on the North-West side. The required Pylon and Sealing End Compounds and structures are also shown, and also fall within the surface water flood area.

Figure 1. Surface Water Flood Risk to NGET Substation and OHL Works

6. Given this clear flood risk to the NGET substation area and adjoining land required for NGET realignment and other works as part of the linked NSIP, the applicant's obligations under the NPPF (as confirmed by NPS EN-1, EN-3 and EN-5) are understood to require the Sequential Test for flood risk to be undertaken, whereby the Grove Wood site is compared with other relevant sites also in Fluvial Flood Zone 1. <u>There is no evidence that this has been done.</u> Indeed it is not clear how the Grove Wood NGET site could pass such a test given that sites adjacent to the overhead lines in the other zones considered by SPR as part of their Site Selection process can be seen as not having a surface water flood risk (Figure 2 below). (Note that Zone 7 is also referred to as 'W1').

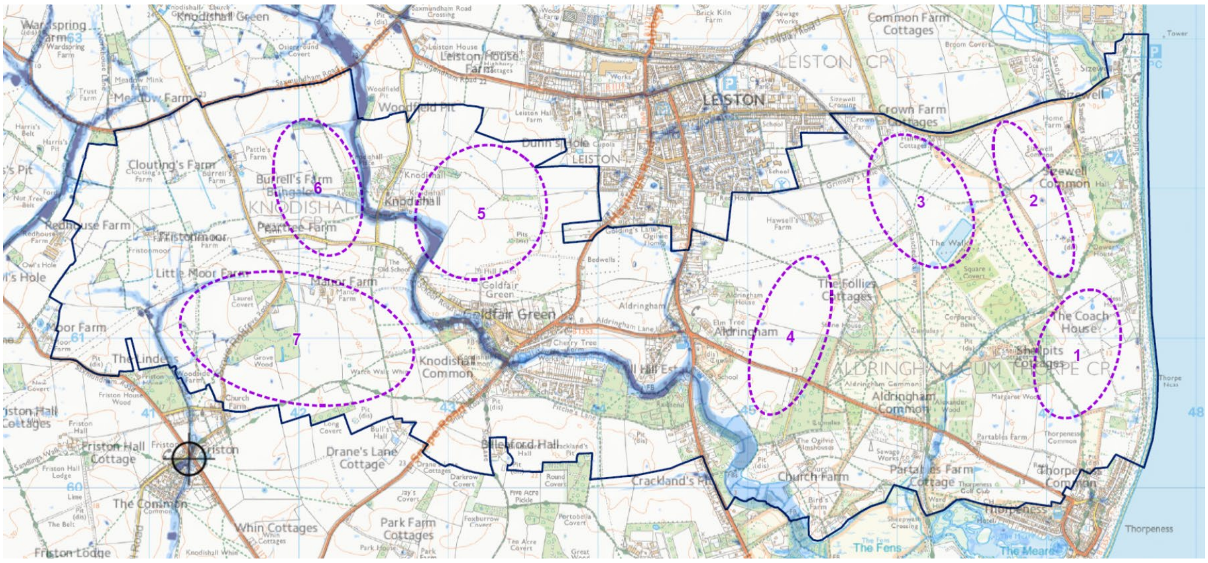


Figure 2. Surface Water Flood Risk to SPR selection zones (except Broom Covert)

7. Suffolk County Council and East Suffolk District Council issued a joint response to the SPR PEIR documentation (Ref 6). Page 40, para 136 states (author's emphasis):

   "The Flood Risk Assessment (FRA) briefly assesses surface water flood risk (paragraphs 113-116). SPR (113) ***incorrectly state*** *the substations are located outside the extent of the 1:1000 year surface water flooding event. The only surface water flood map provided by SPR is to a scale of 1:25,000. Upon further investigation, it is evident that* ***the National Grid substation is located directly on a 1:30, 1:100 & 1:1000 surface water flow path."***

8. In addition Ref. 6, page 107, documents the Council's response to the Flood Risk Assessment provided with the PEIR and finds many areas of this to be non-compliant with the required standard for such documents.

9. In November 2019 SPR published their Environmental Statement in which it is stated (Ref. 8) (author's emphasis) that:

   "From the outset, careful siting of the onshore substation and National Grid substation has set out to avoid key areas of sensitivity wherever possible. Embedded mitigation has included:

   - ~ (lines omitted as not relevant)
   - o ***Siting the East Anglia ONE North onshore substation and National Grid substation in an area of low flood risk (Flood Zone 1****)."*

   This statement appears inconsistent with the surface water flood risk referred to above and elsewhere.

10. In November 2019 SPR published the Environmental Specification Flood Risk Assessment (Ref. 7) as part of their DCO application for EA1N. This refers to a further copy of the Environment Agency Surface Water Flood Risk Map (Ref. 7, Fig. 20.3.3) and now states in para. 125 (author's emphasis):

*"125. However, the National Grid Substation, National Grid CCS, cable sealing end compounds and permanent access road are located in an area with **varying risk of surface water flooding**. The northern and western boundary around the National Grid substation, including the cable sealing end compounds, and part of the footprint of the National Grid substation, includes areas at both **high risk of surface water flooding** i.e. during the 1 in 30 year event and medium risk of surface water flooding i.e. there is a risk of flooding during the 1 in 100 year event. This flood risk is associated with the drainage of surface water from the north in proximity to Little Moor Farm."*

11. It is clear, therefore, that SPR now accept that the National Grid site area **is** subject a serious surface water flood risk and in that case a **Flood Risk Sequential Test** would have been expected as part of the overall Site Selection and DCO Application processes. But no documented evidence has been found that this test has been carried out across the various sites available (see Figure 2 and Broom Covert), or that the test has been approved by the relevant Local Authority (ESDC and/or SCC). The selection of Grove Wood as the site for EA1N, EA2 and NGET substations and associated overhead line works must therefore be unsound.

REFERENCES

Ref. 1 SPR Summary and Approach to Site Selection
https://www.scottishpowerrenewables.com/userfiles/file/summary_and_approach_to_site_selection.pdf?v=4

Ref. 2 SPR Phase 3.5 Decision Summary
https://www.scottishpowerrenewables.com/userfiles/file/EA1N_2_Phase_3_5_Decision_Summary.pdf

Ref. 3 Chapter 4 Site Selection – Assessment of Alternatives
https://www.scottishpowerrenewables.com/userfiles/file/EA1N_PEI_Chapter_04_Site_Selection_Assessment_of_Alternatives.pdf

and associated appendix:
https://www.scottishpowerrenewables.com/userfiles/file/EA1N_PEI_Chapter_4%20Appendix_4-1_East_Anglia_ONE_North_and_East_Anglia_TWO_Onshore_Substations_Site_Selection_RAG_Assessment.pdf

Ref. 4 EA1N PEI Chapter 20 Appendix Flood Risk Assessment
https://www.scottishpowerrenewables.com/userfiles/file/EA1N_PEI_Chapter_20_Appendix_20-1-FRA.pdf

Ref. 5 [APP-401] EA1N ES Outline Landscape Management Plan Figure 29.11a
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001493-6.2.29.11a%20EA1N%20ES%20Figure%2029.11%20Outline%20Landscape%20Mitigation%20Plan%20(OLMP)%20General%20Arrangement.pdf

Ref. 6 SCC and ESC Response
https://www.eastsuffolk.gov.uk/assets/Planning/Offshore-Windfarms/Phase-4-Consultation-Response-from-SCC-and-SCDC-26.03.19.pdf

Ref. 7 [APP-496] EA1N Environmental Specification – Appendix 20.3 Flood Risk Assessment
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001292-6.3.20.3%20EA1N%20ES%20Appendix%2020.3%20Flood%20Risk%20Assessment.pdf

Ref. 8 [APP-054] EA1N Environmental Specification – Chapter 6 Project Description Page 91 para 426
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001060-6.1.6%20EA1N%20Environmental%20Statement%20Chapter%2006%20Project%20Description.pdf

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

OPERATIONAL NOISE IMPACT

Interested Party: Chris Wheeler **PINS Refs:** 20023840 & 20023842

Date: 31 October 2020 **Issue:** 7

1. The project comprises 2 x 10 acre SPR substations, equipment up to 18m high + NGET substation (similar size) + multiple sealing end compounds and a new pylon all very close to a long-stablished village with a Grade 2* parish church and graveyard, and some residential property within 250m of the substations themselves (Figure 1 below).

2. All these will cause noise pollution in what is otherwise an exceptionally quiet rural location, and has been for hundreds of years, and this is a cause of huge concern to the locality. SASES has an Acoustics expert witness who will be representing them at the relevant ISH. The following comments, therefore, will be of a more general nature.

3. The substation design is understood (Ref. 6) to be a copy of the East Anglia One substation at Bramford (which I hope the Examiners will visit and listen to – it's on SASES requested visit list). But SPR are suggesting that less demanding Impact criteria should apply to the Friston site compared with the Bramford one. Why should Friston residents be treated differently?

4. Substations hum (we know that from day to day experience) – and SPR accepted at EA1 DCO submission that the EA1 substation would hum (Ref 1 page 19 para 40), and it does seem to. This is known as 'Tonality'. And SPR accepted that Residential property should be regarded as Highly Sensitive to noise from the substation (Ref 1 page 32). Quite understandable given the level of irritation and associated health damage that substation noise can cause to humans, and animals.

5. But the DCO documentation for EA1N and EA2 doesn't accept either of these criteria. SPR <u>deny</u> that their Friston substations will be 'Tonal' (Ref 2 paras 110 and 113) despite being an enlarged version of the EA1 Design, and they regard Friston residents as having only Medium Sensitivity (Ref 3) compared with those in the region of Bramford, despite the presence of many elderly residents, a number of whom are housebound.

6. The impact of these criteria downgrades appears to allow SPR to state that there will be Negligible Adverse Impact due to Noise from their EA1N and EA2 substations. But if the EA1 criteria are substituted then using the same approach the Impact level appears to no longer be Negligible in some locations.

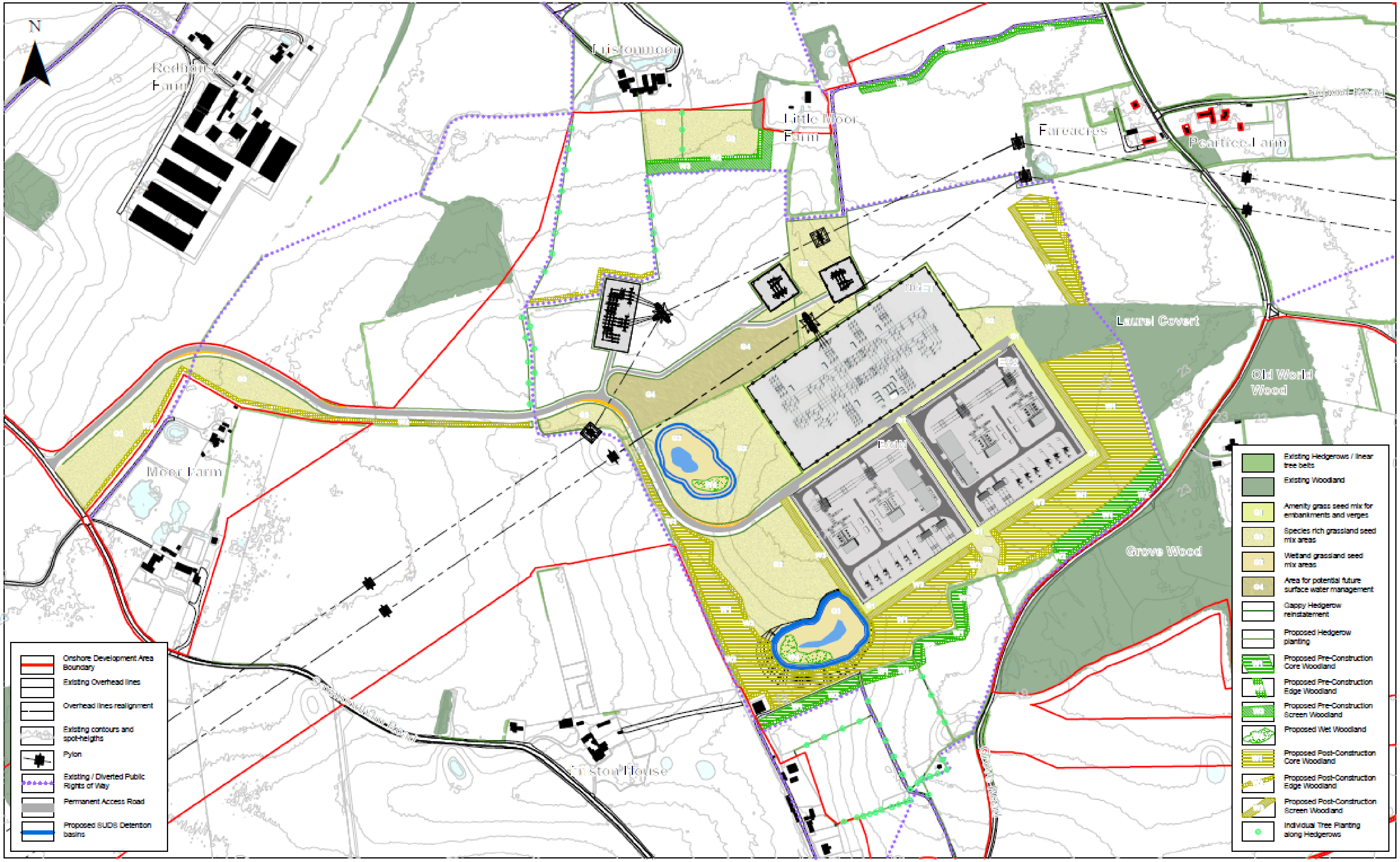
7. In addition it is noted that the Night-Time Background Noise levels shown in the DCO documentation (Ref 4) are <u>significantly higher</u> at several locations than those shown and commented on in the PEIR documentation (Ref. 5), with SSR2 being substantially higher. No justification has been found in the DCO documentation for these changes, and had they not been made then additional other locations would be likely to be rated as having Impacts greater than the Negligible Impact that SPR claim.

8. Also it is noted from other DCO applications that the noise levels of equipment may not be worst case, e.g. STATCOMS may only have been assessed at 50% load. It is essential that all equipment noise levels and assessments quoted are complete, worst case and properly authenticated, including the provision of "third octave" data which is understood to be required to reach conclusions about 'Tonality'. This does not currently seem to be the case and should be grounds for refusing the application as in this case the noise impacts cannot be relied on.

9. Therefore the Examiners are asked to closely scrutinise all the noise claims made by SPR, as it is clear that even modest changes to, or omissions from, criteria can have a disproportionate effect on any Adverse Impact results and therefore site acceptability. And in any case, surely a conservative approach should be adopted, especially to a community which is largely retired with many residents already in less than good health.

10. A further concern is the proposal in the DCO that a 34dBA rating level be used, despite the site being a tranquil location, and that only at two locations (SSR2 and SSR5 NEW), when ALL Friston residential properties should be entitled to the same protection, given that sound levels may be highly localised due to reflections and ground contours. And whatever criteria are chosen they must be fully tested before equipment is allowed to 'go live' We are aware of another site (in Scotland) where noise was shown to have a significant impact after commissioning but the transmission operator is understood to have refused to allow the equipment to be powered down for remediation. This would be unacceptable.

11. A final concern is that atmospheric effects, ground-borne noise, and equipment aging are all known to seriously affect perceived noise levels at receptors. These represent yet further concerns that the currently proposed noise emission levels are entirely unacceptable and that the site chosen is unsuitable for the proposed development and that Consent should therefore **be refused**.



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment		
8	21/08/2019	mb	Eighth Issue.		
7	13/08/2019	mb	Seventh Issue.	Prepared:	mb
6	24/07/2019	th	Sixth Issue.	Checked:	sm
				Approved:	lt

1:2,500 Scale @ A1 — 0 125 250 m

East Anglia ONE North

OLMP General Arrangement

Drg No	EA1N-DWF-ENV-REP-IBR-000388	
Rev	8	Coordinate System: BNG Datum: OSGB36
Date	21/08/19	
Figure	29.11a	

P:\2015\150687_EA1N&2\PRODUCTION\GRAPHICS\190404_OLMP Figures\Final Sheets

Figure 1

REFERENCES

Ref 1 Page 19 EA1 Accepted Tonality

40 BS 4142 provides a methodology for assessing industrial noise against ambient background noise levels. A 'rating penalty' of 5dB is added to the industrial noise if it contains characteristics that are likely to increase the potential for it to cause annoyance. Such characteristics could include impulses (e.g. bangs/crashes) or tonal components (e.g. hums/whistles etc). Noise from electricity infrastructure can contain tonal components (the "mains hum"). As such, a 5dB rating penalty has

Environmental Statement Volume 3 - Onshore Noise and Vibration Chapter 26, Page 19

been applied to predicted noise levels from the converter station when assessed to BS4142.

Ref 1 Page 32 EA1 Receptor Sensitivity

SCOTTISHPOWER RENEWABLES VATTENFALL

Sensitivity/Importance of Receptor			
Sensitivity of Receptor	**Description**		
	Construction Noise	**Operational Noise**	**Construction Vibration**
High	Education, healthcare facility	Residential area, education, healthcare facility	Listed buildings & non-earthwork Scheduled Ancient Monuments
Medium	Residential area	Area used primarily for leisure activities and not already exposed to significant levels of noise	Unreinforced or light framed structures
Low	Area used primarily for leisure activities	Area used primarily for leisure activities and already exposed to significant levels of noise	Residential or light commercial buildings
Negligible	All other areas such as those used primarily for industrial or agricultural purposes	All other areas such as those used primarily for industrial or agricultural purposes	Reinforced or framed structures Industrial, heavy commercial buildings and earthworks (Scheduled Ancient Monuments)

Table 26-11 Sensitivity/Importance of Receptor

Environmental Statement Volume 3 - Onshore Noise and Vibration Chapter 26, Page 32

109. When assessing the noise from a source, which is classified as the Rated Noise Level, it is necessary to have regard to the acoustic features that may be present in the noise. Section 9.1 of BS 4142:2014+A1:2019 states:

- *"Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, add a character correction to the specific sound level to obtain the rating level."*

110. An operational assessment in accordance with BS 4142:2014+A1:2019 has been undertaken for the onshore substation as it is the only noise source associated with the operational phase. Due to the separation distance, existing ambient soundscape and a detailed screening of the onshore substation plant and equipment, no penalty corrections for intermittency, tonality or impulsivity are required. Further detail is provided in ***Appendix 25.5.*** These acoustic features are added based on perceptibility at the receptor location.

111. In terms of intermittency, the onshore substation will typically operate for the full 24hrs each day, with no expected stops/starts to the fixed electrical plant. Therefore, no intermittency penalty correction is required. Where there may be air cooling fans that stop/start, this is not considered to be distinctively audible at the receptor, above baseline sound characteristics due to masking effects.

112. In terms of impulsivity, the onshore substation will typically operate for the full 24hrs each day, with no expected stops/starts to the fixed plant. There are no items of fixed electrical plant with impulsive characteristics under typical operating conditions.

113. Tonality screening was in accordance with Annex C of BS4142:2014+A1:2019. All fixed electrical plant items were assessed based on source levels detailed in (***Table 25.31***). Further screening was undertaken of the predicted noise levels at the receptor in accordance with BS4142:2014+A1:2019. No tonality was identified based on the current available information.

114. The determination of the specific sound level free from sounds influencing the ambient sound at the assessment location is obtained by measurement or a combination of measurement and calculation. This is to be measured in terms of the $L_{Aeq,T}$, where 'T' is a reference period of:

- 1 hour during daytime hours (07:00 to 23:00 hours); and
- 15 minutes during night-time hours (23:00 to 07:00 hours).

Table 25.21 Definitions of the Different Sensitivity Levels for a Noise Receptor

Sensitivity	Definition	Examples
High	Receptor has very limited tolerance of effect	Noise Receptors have been categorised as high sensitivity where noise may be detrimental to vulnerable receptors. Such receptors include certain hospital wards (e.g. operating theatres or high dependency units) or care homes at night. Vibration Receptors have been categorised as high sensitivity where the receptors are listed buildings or Scheduled Monuments.
Medium	Receptor has limited tolerance of effect	Noise Receptors have been categorised as medium sensitivity where noise may cause disturbance and a level of protection is required but a level of tolerance is expected. Such subgroups include residential accommodation, private gardens, hospital wards, care homes, schools, universities, research facilities, national parks, (during the day); and temporary holiday accommodation at all times. Vibration Receptors have been categorised as medium sensitivity where the structural integrity of the structure is limited but the receptor is not a listed building or Scheduled Monument.
Low	Receptor has some tolerance of effect	Noise Receptors have been categorised as low sensitivity where noise may cause short duration effects in a recreational setting although particularly high noise levels may cause a moderate effect. Such subgroups include offices, shops, outdoor amenity areas, long distance footpaths, doctor's surgeries, sports facilities and places of worship. Vibration Receptors have been categorised as low sensitivity where the structural integrity of the structure is expected to be high. The level of vibration required to cause damage is very high and such levels are not expected to be reached during the proposed East Anglia ONE North project.
Negligible	Receptor generally tolerant of effect.	Noise Receptors have been categorised as negligible sensitivity where noise is not expected to be detrimental. Such subgroups include warehouses, light industry, car parks, and agricultural land. Vibration Receptors have been categorised as negligible sensitivity where vibration is not expected to be detrimental.

25.4.3.6 Impact Significance

133. Following the identification of receptor value and sensitivity and magnitude of the effect, it is possible to determine the significance of the impact. A matrix as presented in ***Table 25.22*** will be used wherever relevant.

Ref 4 DCO background Noise Levels – Night time

Table A25.2.10 Predicted East Anglia ONE North and East Anglia TWO Substations Operational Noise Impact – Night time

Name	Receptor Sensitivity	Measured Baseline Background Noise Level L_{90} (dBA)	Predicted Rating Noise Level Night time (dBA)	Difference in Rating Level and Measured Background L_{90} (dBA)	Impact magnitude (BS4142)	Impact significance (BS4142)	Operational noise limit (dBA)	Difference in Operational noise limit and Background L_{90} (dBA)	Difference in Rating Level and 32dBA Operational Limit (dBA)	Residual Impact magnitude (Compliance with 32dBA Limit))	Residual Impact Significance (Compliance with 32dBA Limit)	PPG/NPSE Category (Compliance with 32dBA Limit)
SSR1	Medium	33	29.8	-3.2	No impact	Negligible	34	+1.0	-4.2	No Impact	Negligible	NOEL
SSR2	Medium	31.5	33.4	+1.9	Negligible	Minor	34	+2.5	-0.6	No Impact	Negligible	NOEL
SSR3	Medium	30	28.8	-1.2	No impact	Negligible	34	+4.0	-5.2	No Impact	Negligible	NOEL
SSR4*	Medium	29	28.4	-0.6	No impact	Negligible	34	+5.0	-5.6	No Impact	Negligible	NOEL
SSR5 NEW	Medium	29	30.1	+1.1	Negligible	Minor	34	+5.0	-3.9	No Impact	Negligible	NOEL
SSR6*	Medium	29	26.9	-2.1	No impact	Negligible	34	+5.0	-7.1	No Impact	Negligible	NOEL
SSR7	Medium	35	28.3	-6.7	No impact	Negligible	34	-1.0	-5.7	No Impact	Negligible	NOEL
SSR8*	Medium	29	22.0	-7.0	No impact	Negligible	34	+5.0	-12.0	No Impact	Negligible	NOEL
SSR9**	Medium	29	26.5	-2.5	No impact	Negligible	34	+5.0	-7.5	No Impact	Negligible	NOEL
SSR10	Medium	31	16.8	-14.2	No impact	Negligible	34	+3.0	-17.2	No Impact	Negligible	NOEL

Ref 5 PEIR Background Noise Levels – Night time

Table A25.13 Predicted East Anglia TWO and East Anglia ONE North Substations Operational Noise Impact – Night time

Name	Receptor Sensitivity	Measured Background Noise Level (dBA)	Predicted Rating Noise Level Night time	Difference (dBA)	BS4142 Impact magnitude	Impact Significance Without Additional Mitigation	35db criteria impact magnitude	35db criteria Impact Significance
SSR1	Medium	33	31.1	-1.9	No Impact	Negligible	No Impact	Negligible
SSR2	Medium	27	33.6	6.6	Moderate	Moderate	No Impact	Negligible
SSR3	Medium	30	29.9	-0.1	No Impact	Negligible	No Impact	Negligible
SSR4*	Medium	27	30.5	3.5	Minor	Minor	No Impact	Negligible
SSR5	Medium	27	35.4	8.4	Moderate	Moderate	Negligible	Minor
SSR6*	Medium	27	28.4	1.4	Negligible	Minor	No Impact	Negligible
SSR7	Medium	35	29.2	-5.8	No Impact	Negligible	No Impact	Negligible
SSR8*	Medium	27	23.7	-3.3	No Impact	Negligible	No Impact	Negligible
SSR9	Medium	27	27.6	0.6	Negligible	Minor	No Impact	Negligible
SSR10	Medium	31	19.8	-11.2	No Impact	Negligible	No Impact	Negligible
SSR11	Medium	30	22.7	-7.3	No Impact	Negligible	No Impact	Negligible

EA2-DEVWF-ENV-REP-IBR-000820_004 Appendix 25.4 CIA Page 24

Ref. 6 Statement made by Ian McKay of SPR at public meeting held at Thorpeness Country Club on 15th October 2018 at about 19:30.

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE x)

LANDSCAPE & VISUAL IMPACT

Interested Party: Chris Wheeler **PINS Refs:** 20023840 & 20023842

Date: 27 October 2020 **Issue:** 6

1. The proposed construction of the SPR EA1N and EA2 at the Grove Wood site on the rising ground overlooking Friston Village would have a serious irreversible adverse visual impact on the entire area, including the nearby Grade II* Parish Church and graveyard and many residential properties in the area, and should therefore be rejected.

2. There is no confidence that the tree planting mitigation proposed will be effective due to the unsuitable soil conditions and the assumptions as to growth rate which are believed to be highly overoptimistic based on direct experience at other local sites, e.g. the Galloper substation site at Broom Covert. In any case the mitigation proposals are recorded in the Application material as providing <u>no mitigation from Significant Impact</u> to properties in Aldeburgh Road and the Northern part of Friston (Ref. 1 page 39 and Ref. 2 Fig. 29.21e).

   It should also be noted that the tree screening visualisation images appear to presume summer leaf growth and the situation will be entirely different in the Winter. No attempt seems to have been made to model the latter situation.

3. The visualisations in the Application are highly confusing because they show the ‘To Be’ landscapes based on using a camera with a <u>53.5 degree</u> angle lens whereas the Baseline ‘As Is’ landscape images were taken with a <u>90 degree</u> angle lens (Ref. 4 as an example). As a result much relevant content is missing from the ‘To Be’ images including, but not limited to, the Parish Church (see Ref. 4 Fig. 29.18b), the realigned overhead lines and sealing end compound with circuit breakers, and the tops of the existing and new/moved pylons. The resultant overall impression is therefore <u>misleading</u> and considerably understates the likely visual impact.

   In addition the Examiners are asked to note that the ‘As Is’ and ‘To Be’ Visualisations shown during the <u>Phase 3</u> Consultation were <u>all</u> taken using a camera with a <u>90 degree</u> angle lens (Ref. 5), so the use of a <u>53.5 degree</u> angle lens for the DCO Application Visualisations is a further inconsistency and highly questionable. The Examiners are asked to investigate both these issues in detail before reaching any conclusions.

4. The Finished Ground Level of the SPR substations has not been finalised (see Ref. 7 para 11) and nowhere has the Finished Ground Level of the National Grid substation been found to be specified. Given that its proposed location is known as being in an area subject to severe risk of surface water flooding it may well be that it will have to be raised above surrounding ground level. Given these uncertainties the visualisations cannot be regarded as definitive or worst case and the application should therefore be rejected.

5. National Policies NPS-1, NPS-3 and NPS-5 all require the Applicant to have proper regard for the environment when proposing development, which requirement is not limited solely to Designated Areas. It is clear from the DOC Application that there will be Significant Adverse impact on multiple listed buildings, the extinction of important Public Rights of Way or their 'replacement' by totally unsuitable alternatives which will take users through areas of high substation noise (Ref. 6 for example).

6. The Grove Wood site has a heritage going back hundreds of years, including a well-documented Pilgrim's Trail going across the site, as well as field patterns unchanged for centuries. The impact of the SPR development on these would be to fragment them in such a way that no viable working field pattern was left. Expert advice received by SASES has confirmed this point and is documented elsewhere.

7. As stated in their CION (Ref. 8 page 20 last sentence) NGESO recognised that the Leiston option might not be possible and therefore an alternative connection location (redacted but presumed to be Bramford) would also be considered. Given this situation the Examiners are requested to reject the DCO Application.

REFERENCES

Ref. 1 [APP-569] Environmental Statement 6.3.29.5 Appendix 29.5
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001534-6.3.29.5%20EA1N%20ES%20Appendix%2029.5%20LVIA%20Cumulative%20Assessment.pdf

Ref. 2 [APP-412] Environmental Statement 6.2.29.21 Figure 29.21
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001504-6.2.29.21%20EA1N%20ES%20Figure%2029.21%20Viewpoint%209%20Saxmundham%20Road,%20south%20of%20Friston%20(with%20National%20Grid%20AIS%20Substation).pdf

Ref. 3 [APP-404] ES 6.2.29.13 Figure 29.13
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001496-6.2.29.13%20EA1N%20ES%20Figure%2029.13%20Viewpoint%201%20PRoW%20near%20Friston%20House%20(with%20National%20Grid%20AIS%20Substation).pdf

Ref. 4 [APP-409] ES 6.2.29.18 Figure 29.18b
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001501-6.2.29.18%20EA1N%20ES%20Figure%2029.18%20Viewpoint%206%20Friston,%20Village%20Green%20(with%20National%20Grid%20AIS%20Substation).pdf

Ref. 5 SPR Phase 3 Consultation Onshore substation photomontage booklet Viewpoints 5 to 9
https://www.scottishpowerrenewables.com/userfiles/file/EA1N2_onshore_substation_photomontage_booklet.pdf

Ref. 6 [APP-526] ES 6.3.25.5 Appendix 25.5 Operational Phase Assessment, Page 8 Plate A25.5.2 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001377-6.3.25.5%20EA1N%20ES%20Appendix%2025.5%20Operational%20Phase%20Assessment.pdf

Ref. 7 [APP-585] SPR Outline Onshore Substation Design Principles Statement, page 4, para 11:
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001018-8.8%20EA1N%20Outline%20Onshore%20Substation%20Design%20Principles%20Statement.pdf

Ref. 8 CION Assessment for East Anglia TWO windfarm dated 9 October 2017 (provided as email attachment due to size and lack of web link).

Offshore Connections and Infrastructure Options Note

<table>
<tr><td>User</td><td colspan="4">East Anglia Offshore Wind Limited</td></tr>
<tr><td>Site Name</td><td colspan="4">East Anglia Two</td></tr>
<tr><td>NETS Reference Number</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Application Steering Group Members
(Delete As Applicable)</td><td>NETSO</td><td>NGET</td><td>Lead details
Name:
Contact No:
Email:</td><td rowspan="3">[redacted]</td></tr>
<tr><td>Affected TO 1</td><td>NGET</td><td>Lead details
Name:
Contact No:
Email:</td></tr>
<tr><td>Other Affected TO</td><td>EAOW
(as OTSDUW User)</td><td>Lead details
Name:
Contact No:
Email:</td></tr>
<tr><td>Application Type</td><td colspan="4">Offshore Wind Generator Modification Application</td></tr>
<tr><td>Overview of the application (Short description of the application)</td><td colspan="4">East Anglia TWO Wind Farm was a 1200MW offshore wind farm connection. In [redacted], [redacted]. An East Anglia TWO Modification Application was submitted in [redacted] to relocate the offshore platforms. There was a subsequent Modification Application in [redacted] to change the connection date and also reallocate capacity between East Anglia TWO and ONE North.

The User has indicated it wishes to receive an SQSS compliant offer and standard ownership boundary connection as set out in CUSC for the East Anglia TWO project.</td></tr>
</table>

Revision Number	Date of Revision	Reason for Revision	Revised by
[redacted]			

Notes for Completion:

1. *Please complete the table above when the document is first used for a scheme and when any subsequent revisions are made to any of the information in the live document.*

2. *Please insert the scheme number into the header, and the revision number and date of revision into the footer.*

3. *This page should be retained throughout the life of the document and remain with the final version.*

East Anglia zone overview

Following the first Government announcement on subsidy levels through the Contract for Difference (CfD) in 2014, EAOW undertook a strategic review of the zonal development plan for the East Anglia zone; this included a review of project sizes and locations as well as connection technology with the aim of identifying projects within the zone which provide the lowest cost of energy, and of a suitable size to bring them in line with likely subsidies.

[redacted] East Anglia Offshore Wind Limited (EAOW) developing projects in the southern half of the zone. [redacted]

[redacted]

[redacted]

[redacted]

A new modification application was submitted to National Grid in [redacted]. This was for a reallocation of capacity between EA ONE North and EA TWO (to create an even split of 860MW for each project), and to modify the connection dates. The application was deemed competent on [redacted] and therefore also forms part of this ongoing CION assessment. The Agreement to Vary was received on [redacted] and became effective on [redacted].

The East Anglia Zone as it relates to EAOW/SPRUK is now be reflected as:

- EA ONE 680MW
- EA ONE North 860MW
- EA TWO 860MW
- EA THREE 1200MW

[redacted]

Figure 1: East Anglia zone platform locations

EA TWO

The EA TWO project is located in the west of the EA ONE. It is at a distance approximately 35km from shore. The project has a capacity of 860MW. The recent Agreement to Vary dated [redacted], has changed the Completion Date to 1st April 2026.

Currently, EA TWO is contracted to be connected to Bramford Substation. The development of the EA TWO wind farm and OTSDUW assets is in progress. The EA ONE cable route from the landfall at Bawdsey to Bramford substation will also be used by EA THREE and the Development Consent Order for EA ONE contains ducting for the cables required. Due to the change in design for EA ONE requiring addtional cables for AC, the consented cable route is now constrained and only ducts for EA THREE can be installed during the EA ONE construction works.

The EA TWO project is investigating routing alongside the EA ONE/EA THREE project, with possible extensions and/or diversions from this cable route to reach Bramford. It is anticipated that it is still possible to reach Bramford. However alternative route options including a [redacted] has begun to be assessed as part of the development work continuing in this area.

The Environmental Impact Assessment and associated surveys for EA TWO OTSDUW assets are underway The full scope of surveys cannot be determined until the connection point, substation locations and routing options are confirmed in [redacted]. A scoping opinion for EA TWO is planned to be sought in late [redacted] based on the decided routing option. The current programme is to submit Preliminary Environmental Information during [redacted] followed by the Development Consent Order submission in [redacted]. *NB. EA ONE North is being developed in conjunction with EA TWO and connection options for both projects will be considered in parallel.*

The CION process therefore considers the options in addition to the already contracted connection point at Bramford, which was previously deemed to be the most economic and efficient.

In the previous assessments HVDC technology was considered as an appropriate export technology when considering connection distance, 1200MW project capacities and readily available connection interface point (at Bramford). [redacted]. EA TWO is closer to shore with a potentially shorter connection distance and therefore an HVAC is being reconsidered in this CION.

Onshore Interface Points

Potential Onshore Interface Points included a number of existing NGET substations as well as those that would require new NGET 400kV substations, requiring an extension of the existing 400kV network.

The onshore Interface Points that have been considered in this CION (as shown in Figure 2) are described below:

- Bramford 400kV substation (current Onshore Interface Point)

[redacted]

[redacted]

Figure 2: East Anglia zone potential onshore Interface Points

Interface Points located north of [redacted] and south of [redacted] were discounted as they provide no benefit over closer Interface Points due to the technical issues and much higher cost involved with longer offshore routes.

Initial Options Appraisal

To comply with the statutory duties under Section 9 of the Electricity Act, the preferred connection design should be the most economic and efficient when considering both offshore and onshore works. Under the requirements of the Transmission Licence, the network design should be compliant with the minimum deterministic criteria of the NET SQSS.

Bramford was identified as the preferred IP for EA TWO (previously named EA FOUR) in the original grid connection offer in 2010 [redacted]. This was when EA TWO was considered as 1200MW capacity. As the project capacity has now been decreased to maximum of 860MW, the reduced project size could change some of the assumptions that were made in the original connection options, hence triggering the reopening of the CION.

The initial options appraisal considered all of the IPs identified based on a high level assessment of programme, construction complexity, land availability, environmental / consenting issues and cost. IPs that were identified to have no benefit over other IPs were parked. Table 1 provides a brief summary of the Initial Options Appraisal results.

Potential Interface Point (s)	Justification	Decision
Bramford	Current Interface Point for EA TWO.	Carried forward
[redacted]	The new OHL circuits and new substations required to establish the Interface Points at these locations would mean that the IP would not be available for the customer connection date.	Discounted
	The new OHL circuit and new substation needed to establish the Interface Point would require National Grid to seek a full consenting and consultation process as part of a Development Consent Order (DCO). Therefore the IP would not be available for the requested customer connection date.	Discounted
	These are a greater distance from the EA TWO project meaning that longer cables/technology would be required. They don't bring any benefits in terms of Network Infrastructure savings as described earlier, and will not be cost competitive in terms of OFTO investment. The alternative options that offer a shorter connection distance are considered in the document as being similar to [redacted], i.e. a connection at those points would require the same infrastructure investment as a connection at [redacted]. A further reason for parking them is that these closer Interface Point sites has no existing National Grid Substation, NGET works would be a new substation and minor OHL works.	Parked

[redacted]	If capacity can be ([redacted] made available at [redacted], this IP potentially becomes the most economic and efficient connection and therefore would be preferred. However, even if this capacity were not to become available, it may be possible to connect by extending the existing 400kV substation within the power station. The capacity of the existing overhead circuits from [redacted] could also be increased if required,therefore the IP may be available for the requested customer connection date. The existing [redacted] substation is surrounded by the Suffolk Coast and Heaths AONB, which present a land and environmental constraint to the extension of the existing substation but this may be acceptable in local planning terms. This potential Interface Point should be assessed as a possible option.	Carried forward
	In the immediate vicinity of [redacted]. Connection at [redacted] in terms of impact on the system is expected to be exactly the same as connecting at [redacted]. If capacity can be made available at this IP a connection could be made available at [redacted]. This is likely to involve redevelopment of the [redacted] substation to accommodate all proposed offshore wind projects and land/ environmental aspects will require to be considered in the local planning application process.	Carried forward

Table 1: Summary of Initial Options Appraisal

Therefore, the Onshore Interface Points shortlisted to be carried forward for further considerations are:

[redacted]

As the ModApp for EA TWO were submitted at the same time as EA ONE North, the two projects are interactive and the CION considers the different combinations of connecting the two projects at the substations listed above. Considering that the two projects are of the same size and similar connection date, it is assumed that there will be no difference which particular project are connected to which substation in the combination (i.e. the network impact of connecting EA TWO to Substation A and EA ONE North to Substation B is identical if the connection is swapped (EA TWO to Substation B and EA ONE North to Substation A). Therefore the Onshore Interface Connection Points combination options considered are as following:

- Both connecting to [redacted] Substation
- Both connecting to [redacted] Substation
- Both connecting to [redacted] Substation
- One each connecting to [redacted] Substation and [redacted] Substation
- One each connecting to [redacted] Substation and [redacted] Substation
- One each connecting to [redacted] Substation and [redacted] Substation

Note that as [redacted] Substation is radially connected to [redacted] Substation, it is assumed that connection to [redacted] Substation will have an identical network impact as connection to [redacted] Substation.

Technology Options

[redacted].

The power can be transmitted from the platforms to the onshore Interface Points using different transmission technologies, such as HVAC or HVDC, and the output from multiple wind farms strings can be collected for bulk transmission. Due to the number of Interface Points, the different transmission technologies available, the different options for interconnecting platforms offshore and the potential technological advances over the timescales of the projects, a number of assumptions have been made in order to limit the number of scenarios considered for this initial comparative assessment.

[redacted]

[redacted]. HVDC links should be considered when factors such as rated power, system design, Grid Code compliance, land availability, circuit corridor width, ground conditions lead to an HVAC connection being impractical or uneconomic. However none of the issues are problematic at this stage for EA TWO (and also EA ONE North) with an HVAC connection.

HVDC technology could only be considered if they prove to be more technically reliable, commercially viable and reduce costs over an HVAC connection. For the connection of EA TWO, via the possible interface points, the OTSDUW party has confirmed that utilisation of HVAC is the preferred technology for the connection of EA TWO (implied from EA ONE – being constructed).Therefore connection to an Interface Point with an existing HVAC substation maximising deployment of HVAC technology represents an economic and efficient method for the connection of EA TWO.

Detailed Options Appraisal

Four IP options for the connection of EA TWO (with all possible combination of connections in conjunction with EA ONE North) were assessed in greater detail by undertaking a desk-based constraint mapping exercise to identify potential substation locations and connection routes and assessing project specific costs. Figure 3 shows the location of all four shortlisted IPs.

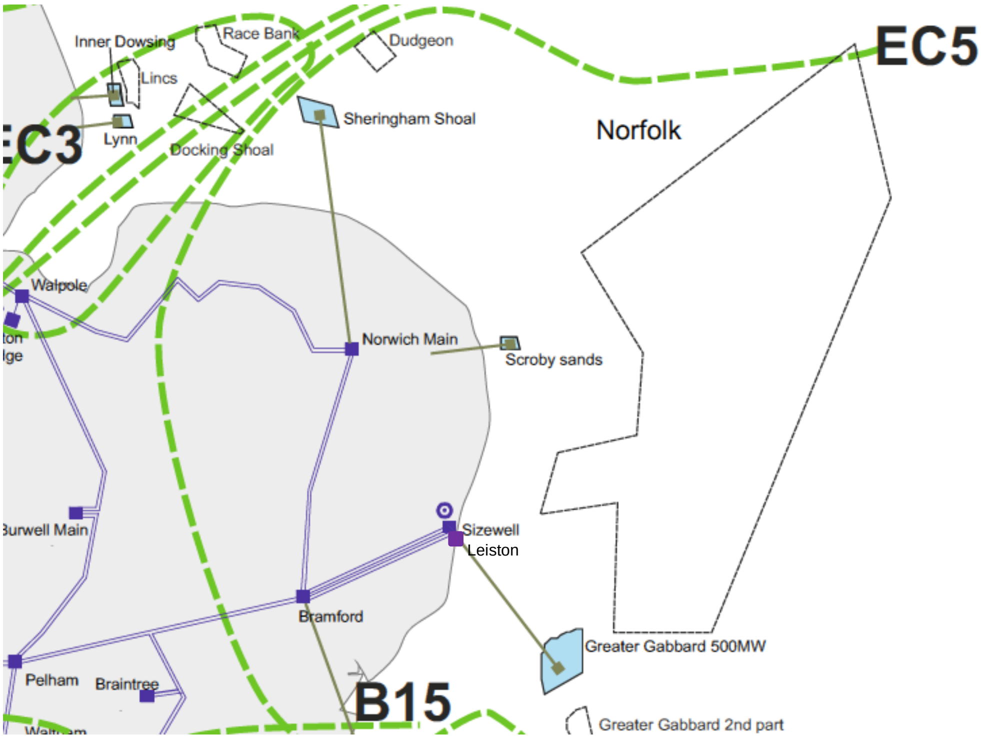


Figure 3: Onshore Interface Points shortlisted for Detailed Options Appraisal.

Sections 1 and 2 of this document provide detail of the cost comparison and technical assumptions.

Table 2 provides the route distance and OFTO cost summary of the Interface Points considered in the detailed assessment. In the Options Appraisal Matrix for completeness this is expanded to consider different combinations of connections for both projects (EA TWO and EA ONE North).

	Interface Point	Offshore Distance (km)	Onshore Distance (km)	Total (km)	OFTO Cost (£m)
1	[redacted]				
2					
3					

Note: Distances may vary compared to AC solution due to assumed locations of HVDC platforms

Table 2: Route distance for each shortlisted Interface Point and OFTO cost to connect EA TWO

Table 3 shows the summary of the appraisal of the non-quantifiable factors in the Detailed Options Appraisal:

Option No.	Interface Points Combination	Level of Onshore TO Works	Technical Risk	Consent Risk	Preliminary Ranking
1	[redacted]	Minimal	Low - Medium	Low - Medium	1
2		Extensive	Medium	Medium	3
3		Local	Low	Medium - High	2
4		Extensive	Low - Medium	High	7
5		Local / Extensive	Low - Medium	Medium – High	4
6		Moderate / Extensive	Low - Medium	High	6
7		Moderate / Extensive	Low-Medium	High	5

Table 3: Detailed Options Appraisal Summary

All the options listed in Table 3 are put into Boundary Capability Studies to identify the impact of each connection combination (including reinforcement works required) on the capability of Boundary EC5. The result is as shown in Table 4:

Capacity per year (MW)	NORM - NORM	NORM – SIZE NORM - BRFO	SIZE - SIZE LEIS-LEIS BRFO - BRFO
2024	[redacted]		
2025			
2026			
2027			
2028			
2029			
2030			
2031			
2032			

Table 4: Effect of the connection combinations on the EC5 Boundary Capability.

It can be seen that any connection combination is increasing the capability of Boundary EC5 hence all options are then carried forward for CBA. Table 5 shows the Least Worst Regret of all the shortlisted connections.

Regret (£m)	GG	SP	CP	NP	Worst Regret
Sizewell /Leiston (1720)	[redacted]				
Bramford (1720)					
Norwich (1720)					
Bramford (860) Sizewell (860)					
Norwich (860) Sizewell (860)					
Norwich (860) Bramford (860)					

Table 5: Least Worst Regret for Connection Combination Options for EA2 and EA1N.

The Least Worst Regret in Table 5 shows that in all Future Energy Scenarios, connection to either [redacted] has the Least Worst Regret. [redacted] share the same results as [redacted] is radially connected to [redacted].

The CBA concluded that Option 2 or 3 (Connecting both EA TWO and EA ONE North to Sizewell or Leiston Substation) is the most economic solution.

[redacted]

Conclusion

Eventhough the non-quantifiable factors identified Option 1 (Connecting both EA TWO and EA ONE North at [redacted] Substation) as the most preferred option, the substantial difference in the Least Worst Regret between Option 2/3 (Connecting both at [redacted]) and the other options means that Option 2/3 is the most economic and efficient connection option. The CION party discussed this over and agreed that the most preferred option is to connect EA TWO to a new substation near Leiston Substation using HVAC Technology.

SECTION 1 – Preferred Option Assessment

	Summary (Short overview description of each option)	**Major Risks**	**Onshore TO Cost £m**	**Offshore TO Cost £m**	**Overall Total Cost £m**
Option 1	Connecting to Bramford 400kV substation via HVAC link	**TO** Nil **OFTO** [redacted] [redacted] [redacted]	[redacted]	[redacted]	[redacted]

Option 2	Connecting to [redacted] 400kV substation via HVAC link	**<u>TO</u>** There are risks associated with finding a suitable location for substation infrastructure. [redacted] infrastructure is land locked within the perimeter of the nuclear site. **<u>OFTO (Comments apply to both [redacted] options)</u>** [redacted] [redacted] [redacted]	[redacted]	[redacted]

Option 3	Connecting to [redacted] 400kV substation via HVAC link	**TO** Proposed 400kV substation is situated within Suffolk Coast & Heaths AONB. Sizewell Marshes SSSI less than 50m to the NE. Leiston Aldeburgh SSSI and Sandlings SPA approx. 500m to the SW. New substation will require Planning Permission. Ecologically and politically sensitive area. Reconductoring should be covered under the exisiting S37 consent. **OFTO (Comments apply to both [redacted] options)** [redacted] [redacted] [redacted]	[redacted]	[redacted]

Option 4	Connecting to [redacted] 400kV substation via HVAC link.	**TO** [redacted] Few existing constraints to extending this substation. Dependant on size of extension there is a rail line to the east. Dunston Hall Hotel and golf course to east of subsation but site it already well screened by existing intervening woodlands. Small Local Nature Reserve to east part of of existing woodland surrounding the hotel. Gowthorpe Manor (Grade II* listed building) is to west of site although likely to be screened by existing woodland blocks depending on where extension would be located. Would need to review any local planning policies for any specific requirements relating to this location. **OFTO** [redacted]	[redacted]	[redacted]

			[redacted]	[redacted]

SECTION 2 - Preferred option

Option - The preferred option is **Option 3** where the 860MW of wind generation in EA TWO is connected to the onshore IP at Leiston. [redacted] An onshore substation of 860MW OFTO substation will be built adjacent to the Leiston substations. The offshore platform and onshore substation will be connected via two 220kV HVAC circuits. 400kV underground cables will connect the OFTO substation to the Leiston substation.

However it is recognised that this option may not be possible therefore HVAC connection to [redacted] will also be considered.

Details of Option 3 – Connecting to Leiston 400kV Substation via an HVAC link		
Offshore Works	**Description of Works** (Detailed description of the works)	[redacted]
	Cost	
	Completion Date	
	Issues, Risks & Comments	
	Outage Requirements	
Onshore Works	**Description of Works** (Detailed description of the works)	
	Cost	
	Completion Date	
	Issues, Risks & Comments	
	Outage Requirements	

Details of Option 3– Connecting to Leiston 400kV Substation an HVAC link
Single Line Diagram
[redacted]

Details of Option 1 – Connecting to [redacted] 400kV substation via an HVAC link		
Offshore Works	**Description of Works** (Detailed description of the works)	[redacted]
	Cost	
	Completion Date	
	Issues, Risks & Comments	
	Outage Requirements	
Onshore Works	**Description of Works** (Detailed description of the works)	
	Cost	
	Completion Date	
	Issues, Risks & Comments	
	Outage Requirements	

Details of Option 1 – Connecting to [redacted] 400kV substation via HVAC link
Single Line Diagram
[redacted]

SECTION 3 – Offshore Transmission Owner Cost Assumptions

[redacted]

SECTION 4 – Onshore Transmission Owner Cost Assumptions

An indicative capital cost estimate for the overall scope of works for each of the Onshore Interface Point has been prepared. All estimates were made based on high level project specific design information and based on assumptions about the scope of works required. National Grid's capital cost estimates include costs for the transmission equipment and also for the installation of that equipment and are based on generalised unit costs for the key elements of the option. The generalised unit cost information reflects recent contract values and/or budget estimates from equipment manufacturers/suppliers or specialist consultants and provides a consistent basis for preparing capital cost estimates. The IET, PB/CCI Report[1] presents cost information in size of transmission circuit capacity categories for each circuit design that was considered as part of the independent study.

[1] "Electricity Transmission Costing Study – An Independent Report Endorsed by the Institution of Engineering & Technology" by Parsons Brinckerhoff in association with Cable Consulting International. Page 10 refers to Double circuit capacities.
http://www.theiet.org/factfiles/transmission-report.cfm

APPENDIX A – Options Appraisal Matrix

[redacted]

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

SAFETY - SIZEWELL EMERGENCY EVACUATION

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 21 October 2020 **Issue:** 2

1. Introduction. The proposed projects cannot be Consented if they would place at risk the well-established public safety Evacuation Plans for the Nuclear Power Station complex at Sizewell. This is a very likely outcome of approval of the EA1N and EA2 projects for the reasons described below.

2. A serious equipment failure or other event (e.g. terrorism) at the Sizewell nuclear complex could lead to a likelihood of the release of radioactive contamination which would be threat to health. In these circumstances an evacuation of the population in the vicinity could be required and detailed Suffolk County Council plans exist for such a requirement.

3. The Outline Emergency Planning Zone (Fig. 1 taken from Ref.1) within which evacuation might be required in the event of serious radioactive release is in the process of being extended to 30km from Sizewell. Such an evacuation, especially from the Detailed Emergency Planning Zone (Fig. 1), would inevitably rely on the road infrastructure which has a number of bottlenecks in the Leiston Saxmundham area leading to the A12, including the congested signal controlled junctions in both towns.

4. Current Government policy supports the construction of a new dual reactor nuclear power station called Sizewell C, adjacent to the existing nuclear plants, and a DCO application has already been made for this. This project would be based mainly to the North of Sizewell/Leiston area and involve a very wide range of civil engineering activities, including multiple heavy lorry movements over as many as ten years.

5. It follows, therefore, that any required evacuation from the Sizewell/Leiston area would need to make most use of routes to the West and South, with the routes to the West being constrained by the congested traffic light controlled crossroads in Saxmundham centre, and the alternative narrow country roads leading to the A12. Routes to the South would inevitably pass through areas in the Leiston/Friston area proposed for use by the SPR and National Grid projects, as well as any other follow-on projects planning to connect at the Friston substation. These will therefore be highly constrained both by increased traffic movements and by cable route crossings with associated traffic lights. Fig. 2 taken from Ref. 2 refers and clearly shows the importance of the A1094 road as an evacuation route to the South, which road is also critical to the traffic movements in and out of the SPR projects..

6. There is already significant community concern (expressed publicly at meetings of the Sizewell Stakeholder Group) and elsewhere (Ref. 3) that the viability of the existing Evacuation Plan is unproven by fully representative testing, and the extension of the evacuation area to 30km is a yet further concern. It follows that consideration of approval of the EA1N and EA2 projects (and anticipated follow-on projects) must take into consideration the viability of the existing and any new Sizewell Evacuation Plan **on the presumption that the Sizewell C Project is to approved**. This is

obviously a Cumulative Impact issue which the Examiners are asked to carefully address.

7. Based on this information it is clear that in the interests of public safety the proposed EA1N and EA2 projects **cannot be consented** as there can be no confidence that their associated works will not block the Sizewell Emergency Evacuation Route.

Figure 1 Sizewell Emergency Planning Zones

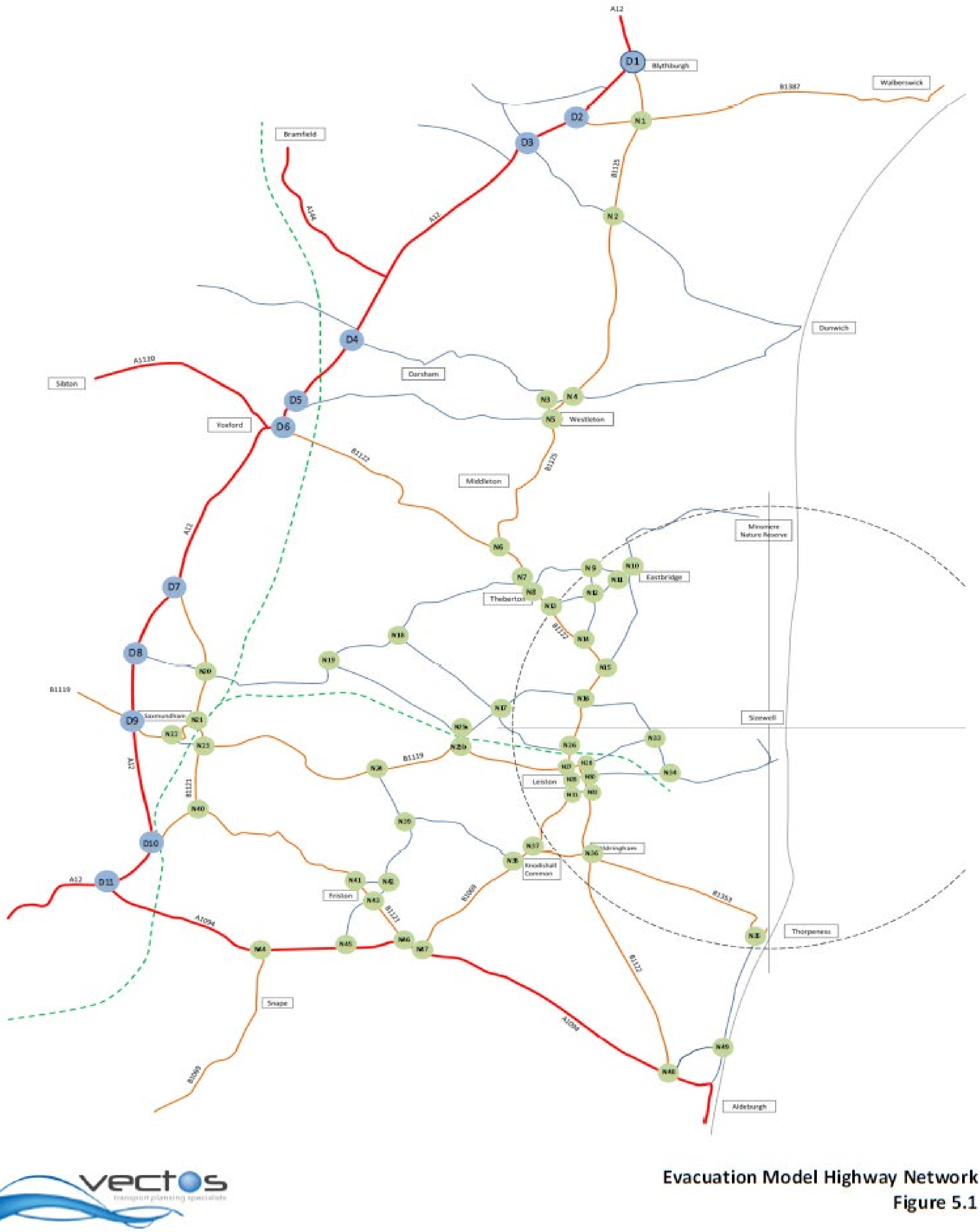


Figure 2 Road network for Emergency Evacuation from the DEPZ

References

Ref. 1 Sizewell Emergency Evacuation Leaflet September 2019
https://community.magnoxsocioeconomic.com/wp-content/uploads/2019/09/V3-A4-LEAFLET-SIZEWELL.pdf

Ref. 2 Vectos Transport Technical Report for Suffolk County Council August 2013.
Copy attached as separate file *VECTOS report from SCC.PDF*

Ref. 3 Public criticism of Sizewell evacuation plans
https://www.ipswichstar.co.uk/news/critics-claim-evacuation-measures-for-sizewell-b-meltdown-are-ridiculous-1-5099149

vectos
transport planning specialists

Suffolk County Council

Sizewell Evacuation

Transport Technical Report

August 2013

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Contents

Appendices

1 INTRODUCTION

1.1 Vectos is retained by Suffolk County Council (SCC) to provide technical transport support to assist SCC with their review of the evacuation arrangements of the population in the vicinity of the existing Sizewell nuclear power stations in the event of an incident at the power stations.

1.2 SCC is currently in the process of undertaking a formal review of their Sizewell Off-site Emergency Plan. The aim of the technical work is to examine the road network in the vicinity of the existing Sizewell nuclear power stations and produce an evacuation plan in order to evacuate the affected population to safety in the event of an emergency scenario at Sizewell.

1.3 In addition, the technical work considers the future growth in the area, based on growth forecasts up to 2027 provided by Suffolk Coastal District Council (SCDC). The technical work assesses the implications of future growth on an evacuation of the area and any potential constraints to growth.

1.4 This report describes the analysis undertaken and the results obtained in preparing the Evacuation Plan.

Project Outcomes

1.5 The project brief states that the technical support will provide the following output:

- An assessment of road network capacity to support evacuation of all permanent and transient population within 4km of the Sizewell B power station, including time to complete evacuation from initiation.
- The technical basis for the assessment, including models used or scientific research referenced.
- Options for evacuation assuming that a contaminated cloud may preclude the use of certain routes that are downwind within a 45 deg arc of the Sizewell B power station.
- Effect of self-evacuation on any deliberate activity if there is a time difference between the public announcement of an emergency and the advice to evacuate.
- Maps for each developed evacuation option showing routes, traffic management elements and any specific congestion pinch points.

- Validation of evacuation assumptions for population indicated in the Project Brief assumptions.
- Validation of evacuation decision timelines indicated in Project Brief assumptions.
- A methodology for use by the Suffolk Joint Emergency Planning Unit that allows it to consider the implications of any future population rises on the evacuation options provided by this work without recourse to the provided of the technical support.
- Indications of any areas within 4km that population limits might be advisable in the future to avoid scenarios where evacuation may not be safely conducted.

Report Structure

1.6 The remainder of this document is structured as follows:

- Section 2 – Concept of Evacuation;
- Section 3 – Approach;
- Section 4 – Assessment Variables and Scenarios;
- Section 5 – Highway Network Characteristics;
- Section 6 – Population Demand Estimates;
- Section 7 – Modelling;
- Section 8 – Evacuation Plan; and
- Section 9 – Conclusions.

2 CONCEPT OF EVACUATION

2.1 This section provides an overview of the evacuation process and any assumptions made about the process used to inform this study.

Evacuation Zone

2.2 The Detailed Emergency Planning Zone (DEPZ) is the area determined by the Office for Nuclear Regulation as being most likely to be affected by a reasonably foreseeable emergency and requiring detailed emergency plans. For the purposes of this report it has been assumed that the DEPZ is 4km from Sizewell B station. This area is illustrated in **Figure 2.1** and includes Leiston, Eastbridge, Aldringham and Thorpeness. At the time of publishing, the actual DEPZ is still being assessed by the Office for Nuclear Regulation.

2.3 The population within the DEPZ is considered to be evacuated at the point that it reaches the A12. From the A12 traffic can travel north and south away from the area.

Evacuation Timeline Assumptions

2.4 The Sizewell operator will make the initial declaration of an Off-site Nuclear Emergency, which will result in, or is likely to result in, the need to consider urgent countermeasures to protect the public outside of the Sizewell security fence from a radiological hazard.

2.5 On declaration of an off-site nuclear emergency, evacuation may be considered as a public countermeasure after understanding where any radiation hazard is; it will not be an automatic countermeasure. However, as soon as possible following the declaration of an Off-site Nuclear Emergency, the evacuation of people within the DEPZ who do not have substantial shelter will be undertaken as an automatic countermeasure. This will apply to the transient population (i.e. people camping/staying in the caravan parks) and pedestrians, cyclists, motorists within the DEPZ. For the purposes of this technical work the transient population and existing traffic on the network within the DEPZ has been assumed to be evacuated but no information is known about pedestrians and they have therefore not been included within the model.

2.6 A further automatic countermeasure is for the population within the DEPZ that do have substantial building for shelter to stay indoors, close doors and windows, and take pre-distributed Potassium Iodate tablets (Sizewell B incident only).

2.7 The Project Brief estimates that:

- 75% of people within the DEPZ will self-evacuate after public declaration of an Off-site Nuclear Emergency rather than adhere to the automatic countermeasure to shelter and potentially take Potassium Iodate tablets;
- 15% of people will require support by the emergency services to evacuate; and
- 10% will elect to remain in their homes.

2.8 The model has been set to assume that 10% of the population elect to remain at home. In order to validate the split between those who self-evacuate and those who will need support by the emergency services to evacuate (i.e. referred to as the vulnerable population within this report), the 'Vulnerabilities' estimates contained in the existing Off-site Evacuation Plan have been used. The remainder of the population has been assumed to self-evacuate.

2.9 The time to evacuate the self-evacuation population is measured from the point of public declaration of an Off-site Nuclear Emergency (Time 0) to when the last member of public has reached the A12. It has been assumed that the self-evacuation population will have finished evacuating before the emergency services begin to evacuate the vulnerable population.

3 APPROACH

3.1 This section summarises the approach used to develop the evacuation model, including the research that the approach is based on.

Background

3.2 Many disasters can lead to situations where people need to be evacuated from the affected area to safety. In such situations it is important to identify routes to enable the evacuation to be completed in the shortest possible time. Evacuation route planning therefore aims to find the optimised evacuation routes.

3.3 There has been a considerable amount of research undertaken on route planning for evacuation scenarios as a result of the risk of natural disasters such as hurricanes and earthquakes and more recently nuclear incidents and terrorist attacks. Research has focussed on methods to improve the planning of the evacuation process to maximise the efficiency of the existing road network.

3.4 Evacuation route planning falls into three categories:

- traffic simulation methods;
- network flow methods (Francis and Chalmet 1984, Kisko and Francis 1985, Ahuja *et al.* 1993, Kisko *et al.* 1998, Hamacher and Tjandra 2001);
- heuristic algorithms (Hoppe and Tardos 1994, Lu *et al.* 2003, 2005, 2007).

3.5 The traffic simulation approach uses traffic simulation models, such as VISSIM and Paramics, to simulate the behaviour of individual vehicles within a road network. However, it would take time to build and run a model and micro-simulation modelling is not normally suitable for testing a lot of scenarios, as required for this project. In addition, their assumption of repeated experience of drivers (e.g. commuting) leading to Wardrop equilibrium and perfect information does not hold for rare events such as emergency evacuations.

3.6 Network flow methods can be divided into two approaches: linear programming and dynamic minimum cost flow problem. However, these approaches require the user to provide an upper bound time of the evacuation which is not easy to do. An under estimate of the time will result in failure to find a solution and an over estimate of the time will lead to unnecessary run time. In addition, whilst these methods generate optimal solutions for moderate size networks such as building evacuation, they are not easily scaled to up a transport network due to the high computational time.

3.7 The third method uses heuristic algorithms (i.e. an algorithm designed to solve a problem quickly when classic methods are too slow). Research in heuristic algorithms has shown a 95% reduction in computational time with only a small degradation of solution quality when compared to network flow methods.

3.8 The initial heuristic approaches only calculated the shortest distance route from a source to the nearest destination without considering the route capacity constraints. More recent heuristic algorithms take account of capacity constraints. A well-known heuristic approach is Capacity Constrained Route Planner (CCRP). CCRP generates routes while constraining them to road capacities.

3.9 CCRP got its first major test in 2003 when it was used to create an alternative evacuation plan for Monticello, Minnesota, USA, a BWE type nuclear reactor. Using GIS, the researchers were able to model the transportation network surrounding the plant by incorporating population data for each part of the network. The resulting plan reduced the evacuation time from four to two and a half hours. Based on their test experience, CCRP was further refined. In 2005, the research team collaborated with many partners, including the Minnesota Department of Transportation, to develop evacuation plans for five locations in the Twin Cities area with up to 150,000 people in a one-mile radius.

3.10 It is important to note that SCC requested a tool that could be used to understand the road network under evacuation conditions without needing any further technical support from Vectos. As such, micro-simulation modelling is not considered appropriate. The CCRP algorithm is considered to be the most appropriate tool to prepare an evacuation plan for Sizewell and is described in more detail below.

Capacity Constrained Route Planner (CCRP)

3.11 The CCRP algorithm uses ‘nodes’ to represent junctions in the road network and ‘edges’ to represent road links between the junctions. Each road link (edge) has a travel time and a maximum capacity (i.e. vehicles per unit of time). In addition the junctions (nodes) have a maximum capacity which represents the maximum number of vehicles that can route through the junction per unit of time.

3.12 Nodes are split into the following three types:

- **Source node:** the area from which the population needs to be evacuated from is split into sub-areas and the centre of each sub-area is the ‘source node’;
- **Network node:** junctions within the road network between the source and destination nodes; and
- **Destination node:** the junctions that the evacuees need to reach in order to be considered evacuated/to have reached safety.

3.13 CCRP is based on an iterative approach for creating a complete evacuation plan. In each iteration of the model, the algorithm searches for a route *R* with the earliest arrival time to any destination node from any source node, taking previous reservations and possible wait times into consideration. Then, CCRP computes the actual number of evacuees that will travel through route *R*. The maximum number of evacuees to be sent on route *R* is then determined as the minimum of the available capacities on the links on route *R*. CCRP then reserves the node and link capacity on route *R* for these evacuees. The algorithm terminates when all the evacuees have been given an evacuation route and reached the destination nodes.

3.14 In order to develop the Sizewell Evacuation Plan, the CCRP example cited in the research papers has been reproduced and expanded for the Sizewell network. The research paper is included in **Appendix A** of this report as well as a bibliography of other research papers reviewed as part of this work.

4 ASSESSMENT VARIABLES AND SCENARIOS

4.1 This section summarises the assessment variables and the scenarios that have been included within the evacuation model.

Assessment Variables

4.2 **Figure 4.1** below illustrates the variables section of the model.

Figure 4.1 Variables within the Evacuation Model

Variables					
Scenario	**1**				
Time of Day	1	**Day**	**1**	Day	10:00
			2	Night	21:00
			1	North	
			2	East	
Wind Direction	1	**North**	**3**	South	
			4	West	
Flooding	0	**No Flooding**	**0**	No Flooding	
			1	Flooding	
Self Evacuate Population	1	Existing			
	1	Consented			
	0	Aldeburgh Rd			
	0	Valley Rd			
	0	Remaining SHLAA			
	0	Sizewell C			
Vulnerable Population	0	Existing			
Self Evacuate Vehicle Occupancy	**2**				
Vulnerable Vehicle Occupancy	**20**				
% Stay at Home	**10%**				
% of background traffic to evacuate	**50%**				

4.3 The 'Scenario' drop down menu allows the user to select the scenario they would like to test. The variables (e.g. time of day, wind direction, development quantum) then change according to the selected scenario. The vehicle occupancy, percentage of people who choose to stay at home and percentage of background traffic that is needed to evacuate can manually be adjusted. These variables are described in more detail below.

Assessment Years

4.4 The model assessment years have been taken to be 2013 as the base year and 2027 as the future year. 2027 has been selected as the future year to be assessed as the Suffolk Coastal Core Strategy considers the period up to 2027.

Time of Day

4.5 The evacuation plan needs to consider the time of day of the evacuation. For example, were the evacuation to take place during the day, the population to be evacuated from the DEPZ would consist of:

- traffic on the road network at the time of the evacuation;
- Daytime population (Census definition is people aged 16 to 74 who live and work in the area (or do not work) and people aged 16 to 74 who live outside the area and work inside the area);
- People aged over 74 (100% assumed to remain within the DEPZ during the day);
- School pupils;
- Children aged 0-4 not yet at school (100% assumed to remain within the DEPZ during the day); and
- Transient population staying in the camp sites/caravan parks (a worst case assumption that they remain within the DEPZ during the day).

4.6 However, were the evacuation to take place at night the population to be evacuated from the DEPZ would consist of:

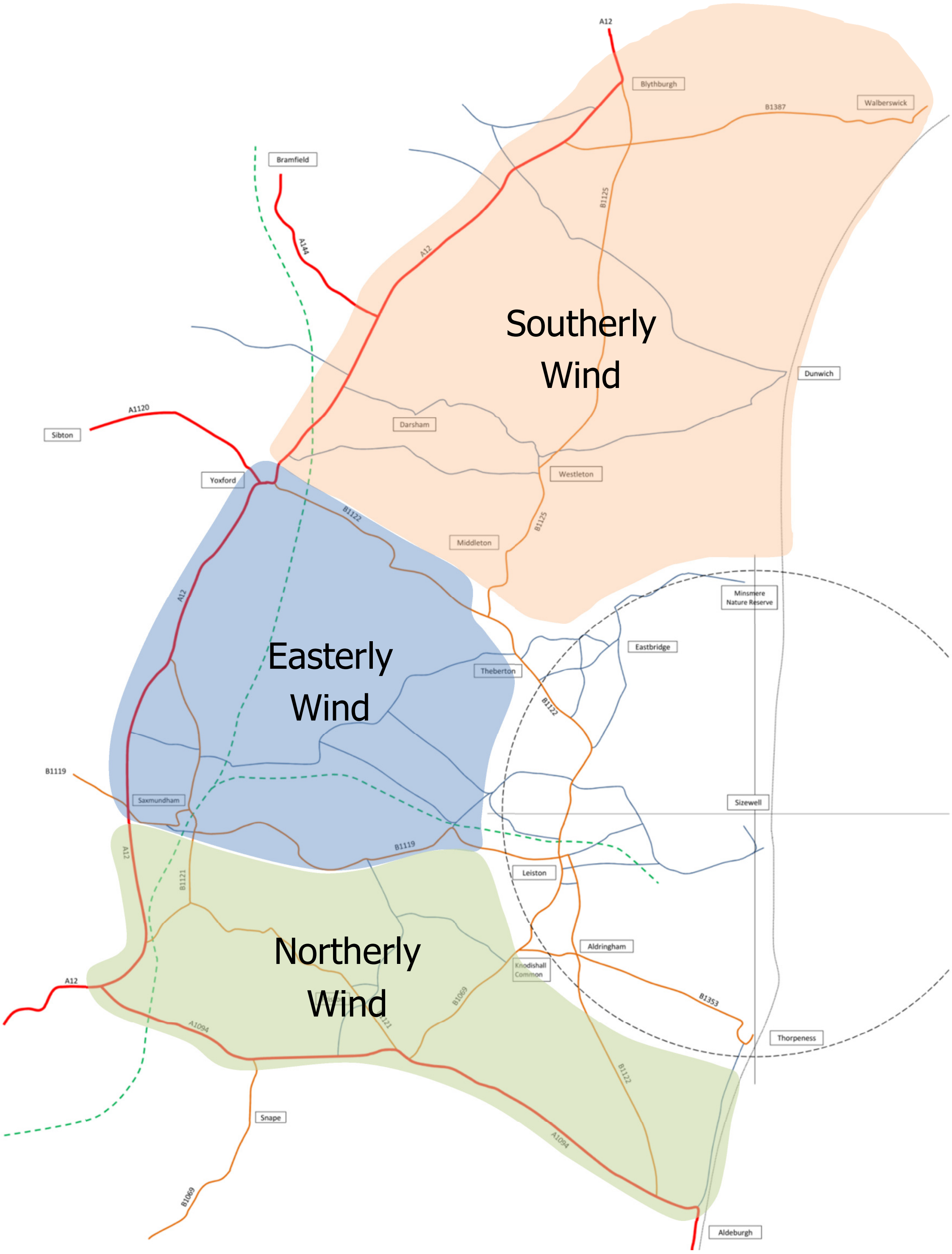
- traffic on the road network at the time of the evacuation;
- Resident population at their home (a worst case assumption of 100%);
- People working a night shift (i.e. at Sizewell nuclear power stations); and
- Transient population staying in the camp sites/caravan parks.

4.7 This report therefore considers the evacuation plan for a week day (09:00-10:00) and a week night (21:00-22:00).

Wind Direction

4.8 In the event of an incident at Sizewell, depending on wind direction, a contaminated cloud may preclude the use of certain routes. As such the wind direction has been included as a variable within the evacuation model. Wind direction is reported by the direction from which the wind originates. If the wind direction is westerly (i.e. blowing from the west towards the east) the contaminated cloud will head to sea and all routes will remain available for evacuation. If the wind is heading in any other direction then some routes would not be able to be used. In order to simulate this, the link and node capacities have been set to zero in the affected area. **Figure 4.2** below illustrates the wind direction areas that have been assumed for the model (i.e. the 'Southerly Wind' area illustrates the road network that has been assumed to be precluded from being used if there was a southerly wind heading north towards Lowestoft).

Figure 4.2: Wind Direction Assumptions



Population

4.9 The population to be evacuated from each 'source node' has been sub-divided into the following population sub groups:

- Existing Population within DEPZ (i.e. those people currently living, working or staying within the DEPZ prior to any future development considerations);
- Consented development;
- Aldeburgh Road development;
- Valley Road development; and
- Remaining Strategic Housing Land Availability Assessment (SHLAA) developments.

4.10 The existing population has been split into the following sub-categories:

- Non-vulnerable population: people who will not require support to evacuate; and
- Vulnerable population: people/institutions that will require support to evacuate (i.e. schools, campsites/caravan parks, nursing homes, care homes and sheltered housing).

4.11 The assumptions made to estimate the number of people in each of the above sub-groups are summarised in **Section 6** of this report.

Vehicle Occupancy

4.12 Data on the average car occupancy in an evacuation is not readily available and therefore an assumption has been made. The model has been set so that the car occupancy of the self-evacuated population is assumed to be an average of 2 people per car. This can be changed in the model if information becomes available. An assumption of 2 people per car has been used as it is higher than the national car occupancy average of 1.6 (National Travel Survey 2010) yet sufficiently low to provide a robust assessment.

4.13 The model has been set so that the average vehicle occupancy for the vulnerable population is 20 people per vehicle. This can also be changed in the model if evidence becomes available. A value of 20 has been used as it is considered that the vulnerable population will be evacuated from the DEPZ in larger vehicles such as buses/coaches.

Population Electing to Remain at Home

4.14 The project brief assumed that 10% of the population would elect to remain in their home even if they were advised to evacuate. The 'Variables' section of the model therefore includes a variable for the percentage of the population electing to remain at home. This has been set at 10% in the model to be consistent with the project brief but can be altered by the model user.

Proportion of Background Traffic to Evacuate

4.15 The traffic data provided by SCC has been analysed and the traffic on the road network within the DEPZ has been estimated for the assessment hours (i.e. 09:00-10:00 and 21:00-22:00). The traffic on the DEPZ road network in these hours is how much traffic flows on the road links over the entire hour. However, it is considered that at point an incident is declared, the 'background' traffic within the DEPZ and surrounding area will become aware of the incident and either avoid entering the DEPZ or evacuate the DEPZ. Therefore, the background traffic to be evacuated from the DEPZ will not be the whole hour of traffic provided in the traffic surveys.

4.16 The model includes a variable whereby the percentage of background traffic to be evacuated from the DEPZ can been altered. It has been set at 50% to provide a robust assessment.

Model Scenarios

4.17 **Figure 4.3** below provides an extract from the 'Variables' section of the Evacuation Model and summarises the scenarios that have been assessed.

4.18 The values within **Figure 4.3** correspond to the values in each variable in **Figure 4.1**. For example, Scenario 1 tests the following variables:

- 'Day time' as this is given a value of '1' in **Figure 4.1**;
- Wind direction 'North' as this is given a value of '1' in **Figure 4.1**;
- No flooding as this is given the value of '0' in **Figure 4.1**; and
- The existing vulnerable population, existing self-evacuation population and the consented development population.

Figure 4.3 Scenarios within the Evacuation Model

Modelling Scenarios												
Scenario Ref	Year	Time of Day	Wind Direction	Flooding	Population							
					Existing Vulnerable	Existing Self Evac	Consented	Aldeburgh Rd	Valley Rd	SHLAA	Sizewell C	
1	2013	1	1	0	0	1	1	0	0	0	0	
2	2013	1	1	0	0	1	1	1	1	0	0	
3	2013	2	1	0	0	1	1	0	0	0	0	
4	2013	2	1	0	0	1	1	1	1	0	0	
5	2013	1	2	0	0	1	1	0	0	0	0	
6	2013	1	2	0	0	1	1	1	1	0	0	
7	2013	2	2	0	0	1	1	0	0	0	0	
8	2013	2	2	0	0	1	1	1	1	0	0	
9	2013	1	3	0	0	1	1	0	0	0	0	
10	2013	1	3	0	0	1	1	1	1	0	0	
11	2013	2	3	0	0	1	1	0	0	0	0	
12	2013	2	3	0	0	1	1	1	1	0	0	
13	2013	1	4	0	0	1	1	0	0	0	0	
14	2013	1	4	0	0	1	1	1	1	0	0	
15	2013	2	4	0	0	1	1	0	0	0	0	
16	2013	2	4	0	0	1	1	1	1	0	0	
17	2027	1	1	0	0	1	1	1	1	1	0	
18	2027	1	1	0	0	1	1	1	1	1	1	
19	2027	2	1	0	0	1	1	1	1	1	0	
20	2027	2	1	0	0	1	1	1	1	1	1	
21	2027	1	2	0	0	1	1	1	1	1	0	
22	2027	1	2	0	0	1	1	1	1	1	1	
23	2027	2	2	0	0	1	1	1	1	1	0	
24	2027	2	2	0	0	1	1	1	1	1	1	
25	2027	1	3	0	0	1	1	1	1	1	0	
26	2027	1	3	0	0	1	1	1	1	1	1	
27	2027	2	3	0	0	1	1	1	1	1	0	
28	2027	2	3	0	0	1	1	1	1	1	1	
29	2027	1	4	0	0	1	1	1	1	1	0	
30	2027	1	4	0	0	1	1	1	1	1	1	
31	2027	2	4	0	0	1	1	1	1	1	0	
32	2027	2	4	0	0	1	1	1	1	1	1	
33	2013	1	1	0	1	0	0	0	0	0	0	
34	2013	1	2	0	1	0	0	0	0	0	0	
35	2013	1	3	0	1	0	0	0	0	0	0	
36	2013	1	4	0	1	0	0	0	0	0	0	
37	2013	2	1	0	1	0	0	0	0	0	0	
38	2013	2	2	0	1	0	0	0	0	0	0	
39	2013	2	3	0	1	0	0	0	0	0	0	
40	2013	2	4	0	1	0	0	0	0	0	0	

5 HIGHWAY NETWORK CHARACTERISTICS

5.1 The critical elements for determining the effectiveness of the road network to cope with an evacuation are the level of service/capacity of each of the road links and junctions (i.e. an estimate of the vehicular flow at which the link or junction would be 'congested') and the journey times through the study area. This section summarises how the highway network characteristics have been calculated for input into the Evacuation Model.

Highway Network

5.2 The DEPZ is 4km, as the crow flies, from the centre of the Sizewell B nuclear power station. The population within the DEPZ is considered to be evacuated at the point that it reaches the A12. From the A12 traffic can travel north and south away from the area. The highway network that is included within the evacuation model is illustrated in **Figure 5.1** and includes the DEPZ and the highway links between the DEPZ and the A12.

5.3 There are three types of nodes within the Sizewell modelled area:

- **Source node:** the population that is to be evacuated from the DEPZ has been split into Census output areas and the centre of each output area has been taken to be a 'source node' as shown on **Figure 2.1**;
- **Network node:** the 49 junctions (N1 to N49) within the road network between the source and destination nodes (i.e. junctions between Sizewell nuclear power station and the A12); and
- **Destination node:** the 11 junctions (D1 to D11) on the A12 that the evacuees need to reach in order to be considered evacuated/to have reached safety.

5.4 Within the model the source nodes are 'loaded' onto the nearest network node in order for the population within the source node to be evacuated.

Link Capacity

5.5 The 'level of service' or capacity of each road link within the study area for the 'day' and 'night' assessment hours has been estimated using guidance set out in the Design Manual for Roads and Bridges (DMRB). DMRB Volume 5, Section 1, Part 3 (TA 46/97) provides guidance on 'Traffic Flow Ranges for Use in the Assessment of New Rural Roads'.

5.6 Annex D of the guidance describes the Congestion Reference Flow (CRF), which is an estimate of the total Annual Average Daily Traffic (AADT) flow at which the carriageway is likely to be 'congested' in the peak periods. Part of the formula for CRF includes the calculation of capacity, which is taken to be the maximum sustainable hourly lane throughput.

Capacity = A – (B * Pk%H)

Where:

- PK%H is the percentage of 'Heavy Vehicles' in the peak hour (i.e. OGV1, OGV2 and PSVs); and
- A and B are parameters dependant on road standard. For single carriageway roads such as those within the study highway network A is 1380 and B is 15.

5.7 Within the guidance a single carriageway rural road is taken to be 7.3m wide. However, the roads within the study area are narrower than this and therefore the link capacity has been reduced based on the carriageway width of each road link in the network. For each link in the network the ratio of carriageway width to the standard 7.3m width has been calculated and multiplied by 1,380, the standard value of 'A' in the DMRB capacity formula.

5.8 For example, Lovers Lane between King George's Avenue and Valley Road is 6m wide and so in order to calculate the capacity of the northbound link (i.e. Link N34 to N33) the following calculation has been applied:

Link Capacity N34-N33 = (1380 * (6.0/7.3))- (15 *1.7%) = 1109 vehicles per hour

5.9 It has therefore been estimated that the capacity of the northbound Lovers Lane link is 1,109 vehicles per hour. This methodology has been applied to all links on the highway network and a summary of the link capacities is provided in **Appendix B**.

Node Capacity

5.10 In order to determine the maximum vehicular capacity of each of the nodes or junctions in the highway network individual junction models have been built using the industry standard assessment tools of PICADY for priority junctions and LINSIG for signalised junctions. Traffic has been loaded onto the junctions to determine when they reach their design capacity (i.e.

85% for priority junctions and 90% for signalised junctions). At this point the amount of traffic that has been loaded onto each arm is summed to provide the maximum capacity per hour of the junction. A summary of the maximum junction capacity (vehicles per hour) is provided in **Appendix B**.

Journey Times

5.11 The journey time for each road link has been estimated based on ITIS journey time data. ITIS has developed journey time data for the Great Britain road network using GPS technology in 'probe' vehicles. The data collection unit fitted in the probe vehicles supplies real time and historic information on each vehicle's speed and position at any given time. The data is aggregated to determine the average speed for a given stretch of road. A summary of the journey time for each road link is provided in **Appendix B**.

6 POPULATION DEMAND ESTIMATES

6.1 The DEPZ has been sub-divided into Census output areas as illustrated in **Figure 2.1**. This section provides a summary of the approach used and assumptions made to estimate the population to be evacuated from each of the Census output areas within the DEPZ. The Project Brief estimated that there would be 6,228 people within the DEPZ to be evacuated. The analysis in this section enables this to be validated or updated.

Population Sub-Groups

6.2 The population to be evacuated from each 'source node' within the DEPZ has been sub-divided into the following population sub groups:

- Existing Population within DEPZ (existing self-evacuation population and vulnerable population);
- Consented development;
- Aldeburgh Road development;
- Valley Road development;
- Remaining Strategic Housing Land Availability Assessment (SHLAA) developments; and
- Sizewell C peak construction.

6.3 The population for the above sub-groups has been calculated for both the 'day' and 'night' assessment scenarios.

6.4 **Table 6.1** summarises the development that has been included within each of the assessment years. It should be noted that the model can be varied to test each of the developments included in the table in isolation.

Table 6.1: Population included within each Assessment Year

Year	Population	Details
2013	Existing population living/working/staying within the DEPZ	Based on Census data
	Unimplemented consented development	25 dwellings as of 1st April 2013
	Resolution to grant permission	119 dwellings at Aldeburgh Road
		25 dwellings at Valley Road
2027	Strategic Housing Land Availability Assessment	70 units (potential) at St Margarets Crescent
		45 units (potential) Waterloo Avenue
		12-15 units on caravan park off King Georges Avenue
		3-4 units off Lovers Lane
	Sizewell C peak construction	See below

6.5 EDF Energy is proposing to develop a nuclear power station at Sizewell referred to as 'Sizewell C'. The peak construction year for the proposed Sizewell C nuclear power station is not yet known by EDF Energy but the Stage 1 Environmental Report (paragraph 2.4.5) states that it will take 7-9 years to construct, following the site preparation works. Figure 3.2.1 of the report shows that the construction peaks approximately 2 thirds through the main construction period (i.e. 4.5 – 6 years). Based on Figure 3.2.1 of the report it has been estimated that the site preparation works is approximately a third of the duration of the main construction period (i.e. 2-3 years). Therefore, as a worst case scenario, the peak construction will occur 9 years from commencement of the site preparation works. Providing a robust allowance for planning, it has been estimated that the peak construction would be around 2025. For the purposes of the evacuation model, the peak construction at Sizewell C has been assumed to occur in 2027, the period for the Suffolk Coastal Core Strategy.

6.6 The Project Brief does not require the analysis of the potential impact of Sizewell C on the evacuation plan but does require the Suffolk Joint Emergency Planning Unit to be able to use the assessment tool to consider the impact of the development on evacuation in the future. The model has been designed so that potential developments, such as Sizewell C, can be added.

2013 Day Population

6.7 This section summarises how the population to be evacuated from the DEPZ during a weekday (1000-1100) has been derived.

Existing Self-Evacuation Population

6.8 2001 Census data for the output areas has been used to derive the daytime population within the DEPZ. The definition of the daytime population is people aged 16 to 74 who live and work in the area (or do not work) and people aged 16 to 74 who live outside the area and work inside the area.

6.9 The percentage of each output area that falls within the DEPZ has been estimated and multiplied by the daytime population of the output area. The population of 0-4 year olds within each output area has then been added to the daytime population as it has been assumed, as a worst case, that 100% of these people will remain within the area and at home.

Existing Vulnerable Population

Schools

6.10 **Table 6.2** provides the details of the schools within the DEPZ. The staff will be evacuated alongside the pupils as part of the vulnerable population. The 143 staff have been included within the existing daytime population as well as the vulnerable population in order to provide a robust assessment.

Table 6.2 Schools within the DEPZ

Name	Address	Number of People to Evacuate		
		Pupils	Staff	Total
Leiston Primary School	King George’s Ave, Leiston, IP16 4JQ	350	23	373
Leiston Middle School	Waterloo Ave, Leiston, IP16 4HF	430	39	469
Alde Valley High School	Seaward Ave, Leiston, IP16 4BG	605	56	661
Summerhill School	Leiston, IP16 4HY	90	25	115
Total		**1,475**	**143**	**1,618**

Camping and Caravan Parks

6.11 Camp sites and caravan parks form part of the vulnerable population as people staying on them do not have the facility of a substantial building for shelter. They will need to be evacuated from the DEPZ as soon as possible after the incident happens. **Table 6.3** provides the details of the camp sites/caravan parks located within the DEPZ.

Table 6.3 Camp sites/Caravan parks within the DEPZ

Name	Address	Pitches	Number of People
Cakes and Ale Park	Abbey Lane, Theberton, IP16 4TE	75	150
Beach View Holiday Park	Sizewell Common, Leiston, IP16 4TU	60	120
Total			**270**

Care and Nursing Homes

6.12 **Table 6.4** provides details of the care homes within the DEPZ.

Table 6.4 Care and Nursing Homes within the DEPZ

Type	Name	Address	Number of People
Care Home	Leiston Old Abbey	Leiston, IP16 4RF	40
Care Home	Smyth House	106 High St, Leiston, IP16 4BZ	15
Care Home	Daneway House	Haylings Rd, Leiston, IP16 4DY	9
Nursing Home	Aldringham Court	Aldbeburgh Rd, Aldringham, IP16 4QF	34
Total			**98**

Sheltered Housing

6.13 **Table 6.5** provides details of the care homes within the DEPZ.

Table 6.5 Sheltered Houses within the DEPZ

Address	Number of Units	Number of People
Paxton Chadwick Close, Leiston, IP16	36 bungalows	72
Charles Adams Close, Leiston, IP16 4LP	42 bungalows	84
Total		**156**

Summary of Vulnerable Population

6.14 **Table 6.6** summarises the vulnerable population within the DEPZ. It makes worst case assumptions about the number of people to be evacuated during the day and night scenarios.

Table 6.6 Summary of Existing Vulnerable Population within the DEPZ

Type of Vulnerable Institution	Day time Number of People
Schools	1,618
Camping and Caravan Parks	270
Care Homes	64
Nursing Homes	34
Sheltered Housing	156
Total	**2,142**

Consented Development

As of 1st April 2013 there were 25 residential units of unimplemented consented development within the DEPZ. In order to estimate the population, the 25 units have been multiplied by the average household occupancy of the Leiston ward (Census 2011), which is 2.7 people per household. The percentage of Leiston ward residents that remain within the ward during the day has been calculated to be 73%, based on 2001 Census data (NB. this data had not been released for the 2011 Census at the time of undertaking the analysis). The resultant daytime population for the consented developments is 49 people (i.e. 25 houses x 2.7 people per house x 73%)

Aldburgh Road and Valley Road

6.15 There is a resolution to granted planning permission for two residential developments in Leiston; Aldburgh Road for 119 units and Valley Road for 25 units. In order to estimate the daytime population for these two developments the same approach has been used as for the consented development. The resultant daytime population for the consented developments is 284 people (i.e. 144 houses x 2.7 people per house x 73%).

Summary of 2013 Day Population

6.16 **Table 6.7** below summarises the population to be evacuated from the DEPZ in the day for the 2013 assessment year.

Table 6.7 2013 'Day' Population to be Evacuated from the DEPZ

Sub-Group	Daytime Population
Existing Self-Evacuation	4,428
Existing Vulnerable	2,142
Consented	49
Aldburgh Road and Valley Road	284
Total	**6,903**

6.17 A more detailed table showing the population estimates for each Census output area is provided in **Appendix C**.

2013 Night Population

6.18 This section summarises how the population to be evacuated from the DEPZ during a week night (2100-2200) has been derived.

Existing Self-Evacuation Population

6.19 2011 Census data for the output areas has been used to derive the resident population at night within the DEPZ. The percentage of each output area that falls within the DEPZ has been estimated and multiplied by the resident population of the output area. As a worst case it has been assumed that 100% of the resident population within the DEPZ will be at their home at the time of the Off-site Nuclear Emergency.

6.20 In addition to the resident population, the night shift workers at the existing Sizewell nuclear power station have been included (i.e. 25 people normal operation). It is recognised that the Operator will be responsible for the evacuation of these workers but they will evacuated using the same road network and therefore need to be considered.

Existing Vulnerable Population

6.21 **Table 6.8** summarises the vulnerable population within the DEPZ that has been considered for the night assessment. It makes a worst case assumption that 100% of the vulnerable population (except the schools) will be within the DEPZ at the time of the Off-site Nuclear Emergency.

Table 6.8 Summary of Existing Vulnerable Population within the DEPZ

Type of Vulnerable Institution	Night time Number of People
Schools	0
Camping and Caravan Parks	270
Care Homes	64
Nursing Homes	34
Sheltered Housing	156
Total	**524**

Consented Development

In order to estimate the night time population, the 25 consented residential units have been multiplied by the average household occupancy of the Leiston ward (Census 2011), which is 2.7 people per household. This assumes a worst case that 100% of the population would be at their home at the time of the Off-site Nuclear Emergency. The resultant night time population for the consented developments is 68 people.

Aldburgh Road and Valley Road

6.22 In order to estimate the night time population for the Aldburgh Road and Valley Road developments the same approach has been used as for the consented development. The resultant daytime population for the consented developments is 389 people (i.e. 144 houses x 2.7 people per house).

Summary of 2013 Night Population

6.23 **Table 6.9** below summarises the population to be evacuated from the DEPZ in the night for the 2013 assessment year.

Table 6.9 2013 'Night' Population to be Evacuated from the DEPZ

Sub-Group	Night time Population
Existing Self-Evacuation	5,847
Existing Vulnerable	524
Consented	68
Aldburgh Road and Valley Road	389
Total	**6,828**

6.24 A more detailed table showing the population estimates for each Census output area is provided in **Appendix C**.

2027 Day Population

Strategic Housing Land Availability Assessment

6.25 The following sites have been identified in the Suffolk Coastal District Council's Strategic Housing Land Availability Assessment (SHLAA) as having the potential to be developed in the period up to 2027:

- 70 residential units at St Margaret's Crescent;
- 45 units at Waterloo Avenue;
- Up to 15 residential units on the redundant caravan park off King George's Avenue; and
- Up to 4 residential units off Lovers Lane.

6.26 The Aldburgh Road and Valley Road developments are also included in the SHLAA but given that there is a resolution to grant planning permission they have been included in the 2013 assessment.

6.27 In order to estimate the daytime population for the remaining SHLAA developments the same approach has been used as for the 2013 consented development. The resultant daytime population for the SHLAA developments is 264 people (i.e. 134 houses x 2.7 people per house x 73%).

2027 Night Population

Strategic Housing Land Availability Assessment

6.28 In order to estimate the night time population for the 134 residential units set out above for the SHLAA the same approach has been used as for the 2013 consented development. The resultant night time population for the SHLAA developments is 362 people (i.e. 134 houses x 2.7 people per house).

Population Validation

6.29 The Project Brief makes the following population assumptions:

- 75% (4,671 people) will self-evacuate after public declaration of an Off-site Nuclear Emergency
- 15% (934 people) will require support by the emergency services to evacuate; and
- 10% (623 people) will elect to remain in their homes.

6.30 **Table 6.10** below provides a comparison of the 2013 Project Brief population estimates with the 2013 estimates derived in this section of the report.

Table 6.10 Comparison of 2013 Evacuation Populations

Sub-Group	Project Brief Population	2013 Day time Population	Night time Population
Self-Evacuate Population	4,671	4,071	5,621
Vulnerable Population	934	2,142	524
Remain at Home	634	690	683
Total	**6,228**	**6,903**	**6,828**

6.31 The day and night time estimates have been taken forward and used in the evacuation model in **Section 7**.

7 MODELLING

7.1 The evacuation model has been run for the various scenarios and this section provides a summary of the results. A model user guide is included in **Appendix D**.

Model Validation

7.2 Before the Sizewell model was built the example used within the research papers for CCRP was reproduced to ensure that the evacuation model provided the same answers.

7.3 In order to validate the model the total population within the source nodes was reduced to 40 vehicles to see how long it would take them to be evacuated. Under these conditions the vehicles should reach the destination nodes within a similar time as in normal conditions on the highway network. The model shows that with this low level of vehicles on the network they would all be evacuated in 13 minutes, which is similar to the travel time under non-evacuation conditions.

Model Results

7.4 This section summarises the model results for the various assessment scenarios.

2013 Existing + Consented Development

7.5 The 2013 existing self-evacuation population and consented development population have been tested for day and night time evacuation and the wind direction cutting off part of the highway network to determine the evacuation routes and timeline under varying conditions. **Table 7.1** below summarises the results.

Table7.1 2013 Existing + Consented Development Evacuation Time

Scenario Ref	Time of Day	Number of Vehicles	Wind Direction	Evacuation Time (minutes)
1	Day	5,179	North	93.0
5			East	93.0
9			South	137.0
13			West	154.0
3	Night	3,720	North	62.0
7			East	62.0
11			South	92.0
15			West	101.0

7.6 **Table 7.1** shows that if the Off-site Nuclear Emergency occurred during the day it would take approximately 50% longer to evacuate the DEPZ to safety than if the incident occurred at night.

7.7 In addition **Table 7.1** shows that if a contaminated cloud precluded the use of the roads to the north the evacuation time would not be increased as the routes to the north are not used in the optimum evacuation routing. If a contamination cloud precluded the use of the roads to the south then it would take approximately 50% longer to evacuate the DEPZ than if the road network were unaffected. Worst of all if a contamination cloud precluded the use of the roads to the west then it would take 60-70% longer than if the road network were unaffected.

2013 Existing + Consented + Resolution to Grant

7.8 The 2013 existing self-evacuation population and consented development population have been tested for day and night time evacuation and the wind direction cutting off part of the highway network to determine the evacuation routes and timeline under varying conditions. **Table 7.2** below summarises the results.

Table7.2 2013 Existing + Consented + Resolution to Grant Permission Evacuation Time

Scenario Ref	Time of Day	Number of Vehicles	Wind Direction	Evacuation Time (minutes)
2	Day	5,306	North	95.0
6			East	95.0
10			South	140.0
14			West	157.0
4	Night	3,895	North	65.0
8			East	65.0
12			South	96.0
16			West	105.0

7.9 **Table 7.2** shows that the two developments that have a resolution to grant planning permission (i.e. Aldburgh Road and Valley Road) would add 2-4 minutes to the evacuation time compared with the 2013 Base + Consented scenario, which equates to 2-4 % increase in evacuation time.

Future Year Growth Implications

7.10 The model has been designed to test any growth scenario. As an example of the potential impact future growth could have on the evacuation time the SHLAA developments (over and above the Aldburgh Road and Valley Road) have been added to the population within the DEPZ. This scenario has been tested for day and night time evacuation and the wind direction cutting off part of the highway network to determine the evacuation routes and timeline under varying conditions. **Table 7.3** below summarises the results.

Table7.3 2027 Base + SHLAA Evacuation Time

Scenario Ref	Time of Day	Number of Vehicles	Wind Direction	Evacuation Time (minutes)
17	Day	5,425	North	97.0
21			East	97.0
25			South	143.0
29			West	161.0
19	Night	4,058	North	68.0
23			East	68.0
27			South	100.0
31			West	109.0

7.11 **Table 7.3** shows that the SHLAA developments would add 2-4 minutes to the evacuation time over and above the 2013 Base + Consented + Resolution to Grant scenario. As with the other development scenarios, the greatest impact of a contamination cloud would be if it precluded the use of the roads to the south.

Vulnerable People Evacuation

7.12 It is assumed that vulnerable groups of people will be evacuated by the emergency services supported by local authorities. The transient population (i.e. camping /caravan parks) has been included within the self-evacuation population as they will be evacuated at the same time, albeit they may require some direction/support from the emergency services (assumed 2 people per vehicle and no account made for emergency service vehicles entering the DEPZ).

7.13 It has been assumed that the remaining vulnerable population (i.e. schools, care homes, nursing homes and sheltered housing) would be evacuated separately by the emergency services in vehicles with an average occupancy of 20 people and that by the time the vulnerable population is evacuated, no background traffic will be on the highway network (set at 0% in the model).

7.14 The 2013 vulnerable population (less transient population) have been tested for day and night time evacuation and the wind direction cutting off part of the highway network to determine the evacuation routes and timeline under varying conditions. The 'remain at home' variable in the model for each of the scenarios is set to 0 as well as the background traffic. **Table 7.4** below summarises the results.

Table7.4 2013 Vulnerable Population Evacuation Time

Scenario Ref	Time of Day	Number of Vehicles	Wind Direction	Evacuation Time (minutes)
33	Day	94	North	12.0
34			East	12.0
35			South	12.0
36			West	15.0
37	Night	13	North	11.0
38			East	11.0
39			South	11.0
40			West	12.0

7.15 **Table 7.4** shows that the vulnerable population could be evacuated in 11-15 minutes at any time of the day if they are evacuated after the self-evacuation population. This does not take into the account the time it takes for the vehicles to be despatched, travel to the vulnerable population and load the vehicles.

7.16 The analysis shows that the wind direction does not impact on the evacuation time, with the exception of a westerly wind. This would increase the evacuation time of the vulnerable population by 1-3 minutes, depending on the time of day.

7.17 In addition, assuming 20 people per vehicle, it would need 13 vehicles to evacuate the vulnerable population in the night and 94 vehicles to evacuate the population in the day.

8 EVACUATION PLAN

8.1 This section summarises the evacuation routes for the worst case scenarios for 2013. The difference between 2013 base + consented development and 2013 base + consented + resolution to grant is minimal and therefore the evacuation plan focusses on the 'with resolution to grant' scenarios. In addition, given that the day time evacuation is the worst case this is focussed on in this section. Therefore this section provides the evacuation routes for the following scenarios:

- 2013 Day Time with Westerly Wind (Scenario 6);
- 2013 Day Time with Southerly Wind (Scenario 2);
- 2013 Day Time with Easterly Wind (Scenario 14); and
- 2013 Day Time with Northerly Wind (Scenario 10).

Evacuation Maps

8.2 The output from the evacuation model is a series of maps for each scenario in time increments. The nodes (junctions) and links are coloured from green being low to red being high as follows:

- Junctions: demand as a percentage of maximum capacity per unit time;
- Links: flow along the link as a percentage of maximum capacity per unit time.

8.3 The thickness of the links also indicates the capacity of the link (i.e. the thicker the links the more traffic it can carry).

2013 Day Time with Westerly Wind (Scenario 6)

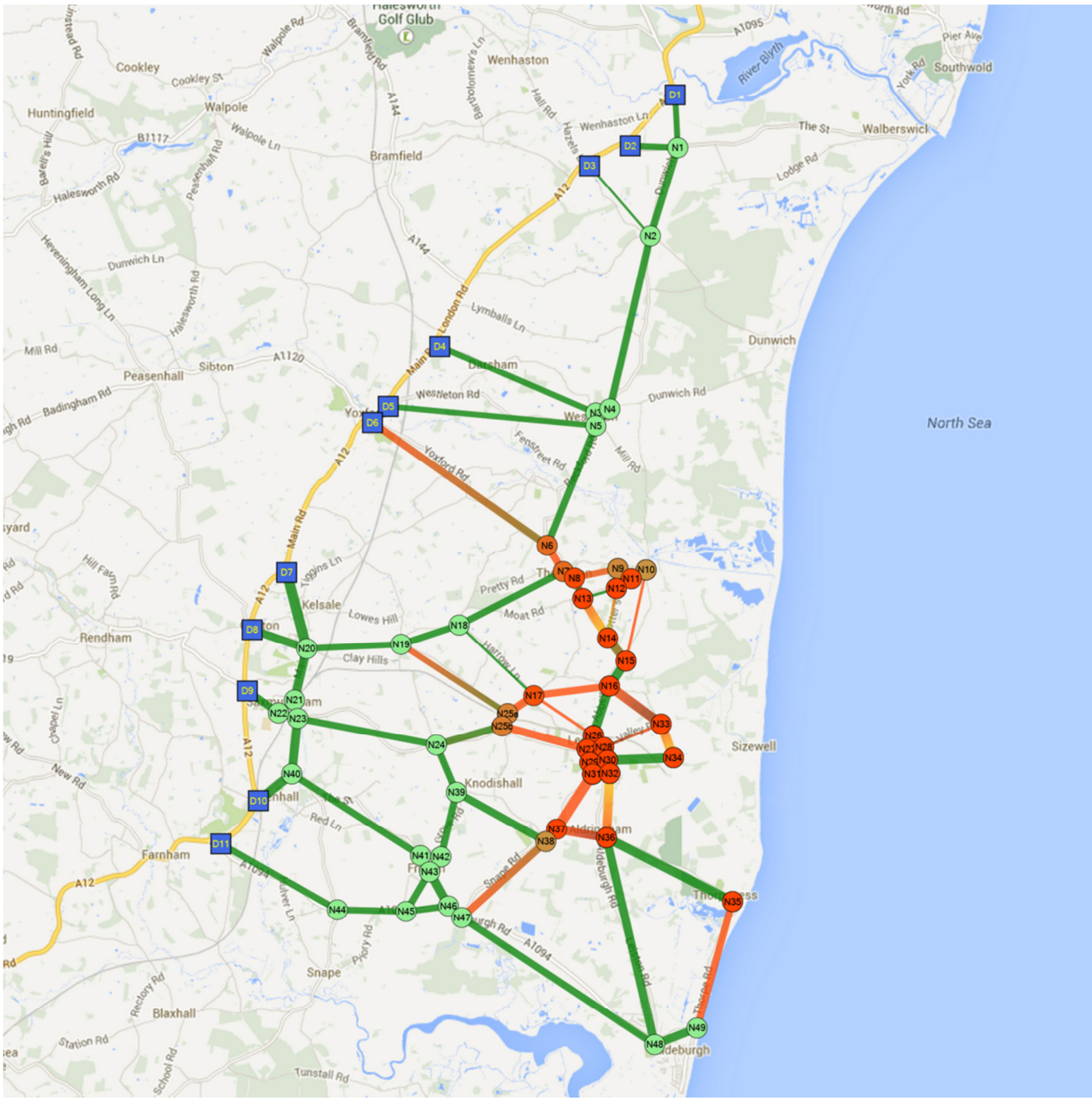
8.4 If the evacuation occurred during the day and when the wind is westerly (i.e. wind blowing from the west towards the east or sea), and therefore all routes are available for use, the optimum evacuation routes are via the following junctions onto the A12:

- D6: A12/B1122 (Yoxford Road);
- D7: A12/B1121 (Main Road), Dorleys Corner;
- D9: A12/Rendham Road;
- D10: A12/B1121 (Main Road), Benhall; and
- D11: A12/A1094

8.5 Node D6 evacuates the greatest amount of traffic (1,302 vehicles) followed by D9 (1,119 vehicles) and D7 and D11 (1,061 and 1,056 respectively). Node D10 evacuates the least amount of traffic (769 vehicles).

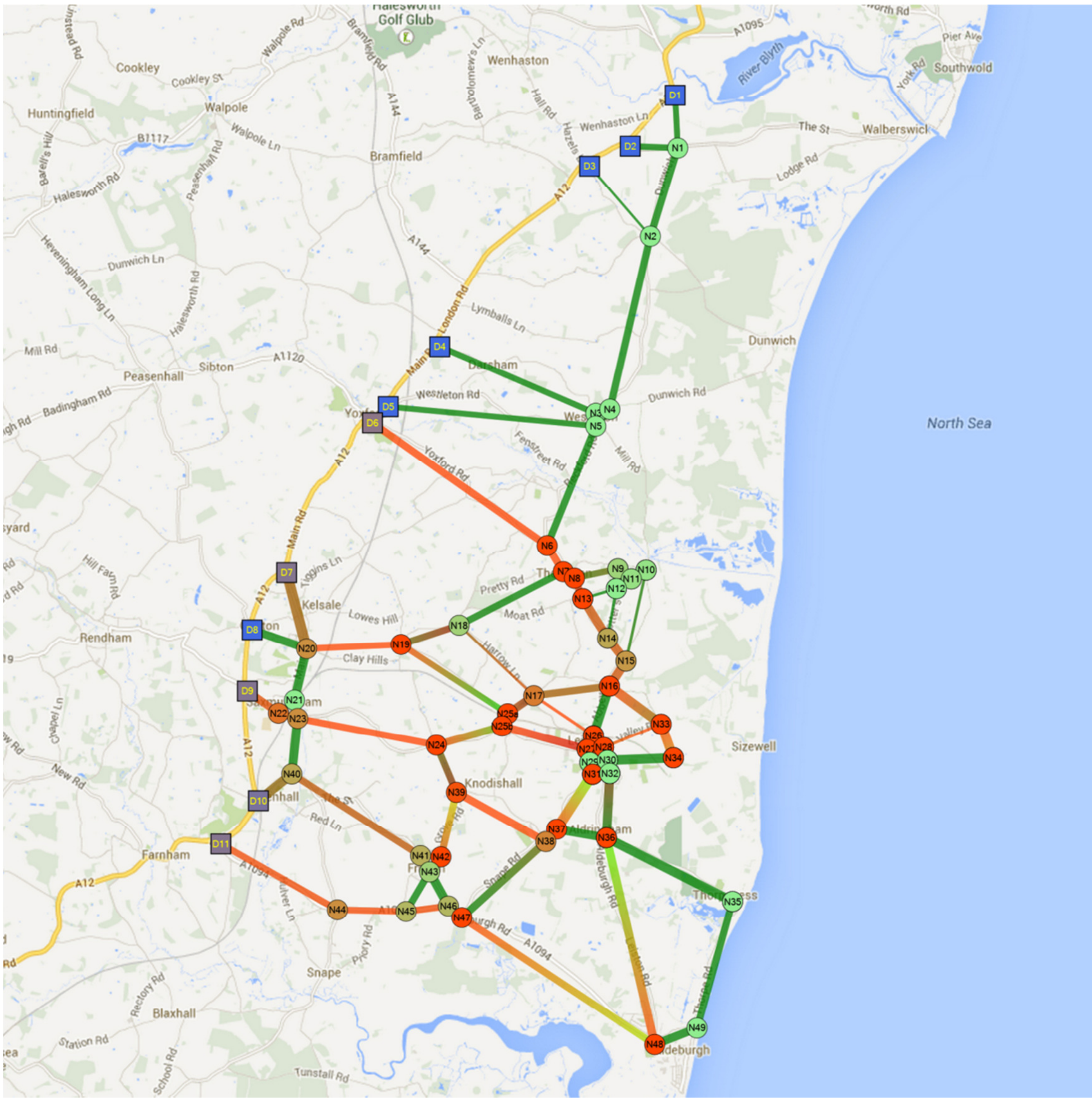
8.6 The first destination junction to be utilised is D6 (A12/B1122 (Yoxford Road)) as illustrated in **Figure 8.1** below for the early phase of the evacuation.

Figure 8.1 2013 Day Time with Westerly Wind (Scenario 6) Early Evacuation Phase



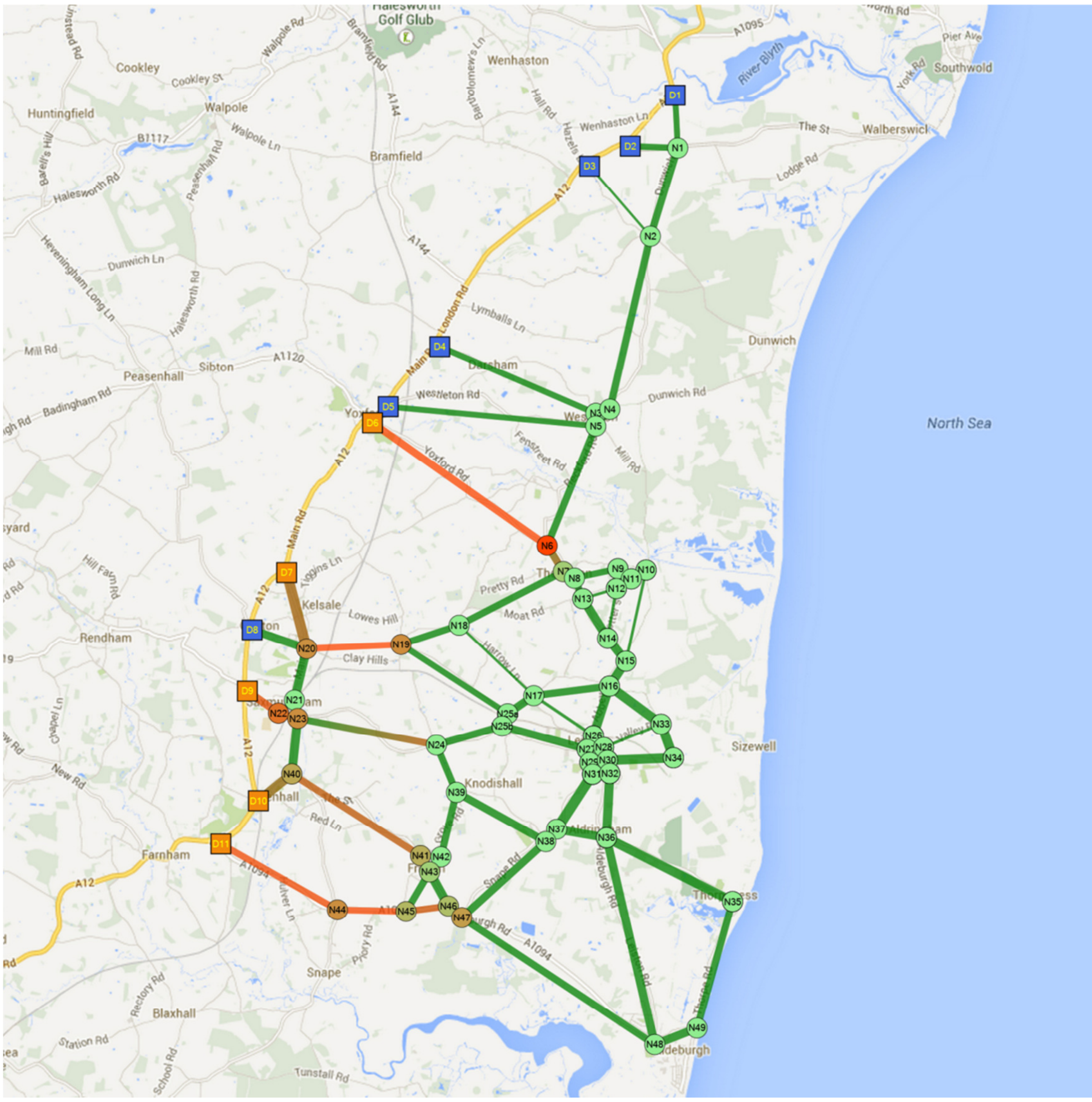
8.7 The next preferred destination node is D11 (A12/A094) followed by D7 (A12/B1121 (Main Road), Dorleys Corner), D9 (A12/Rendham Road) and D10 (A12/B1121 (Main Road), Benhall) as illustrated in **Figure 8.2** below for the mid evacuation phase.

Figure 8.2 2013 Day Time with Westerly Wind (Scenario 6) Mid Evacuation Phase



8.8 **Figure 8.3** below illustrates the final phase of the evacuation for Scenario 6. The last destination nodes to continue to be used are the junctions around Saxmundham (i.e. D7, D9 and D10).

Figure 8.3 2013 Day Time with Westerly Wind (Scenario 6) Final Evacuation Phase



2013 Day Time with Southerly Wind (Scenario 2)

8.9 If the evacuation occurred during the day and when the wind is southerly (i.e. wind is blowing from the south towards the north or Lowestoft), and therefore all routes to the north would not be able to be used, the optimum evacuation routes would remain the same as for the westerly wind scenario set out above. Closing the routes to the north does not impact on either the evacuation time or the route choice.

8.10 **Figures 8.4** to **8.6** below illustrate the early, mid and final phases of the evacuation of the DEPZ if the routes to the north are not able to be used.

Figure 8.4 2013 Day Time with Southerly Wind (Scenario 2) Early Evacuation Phase

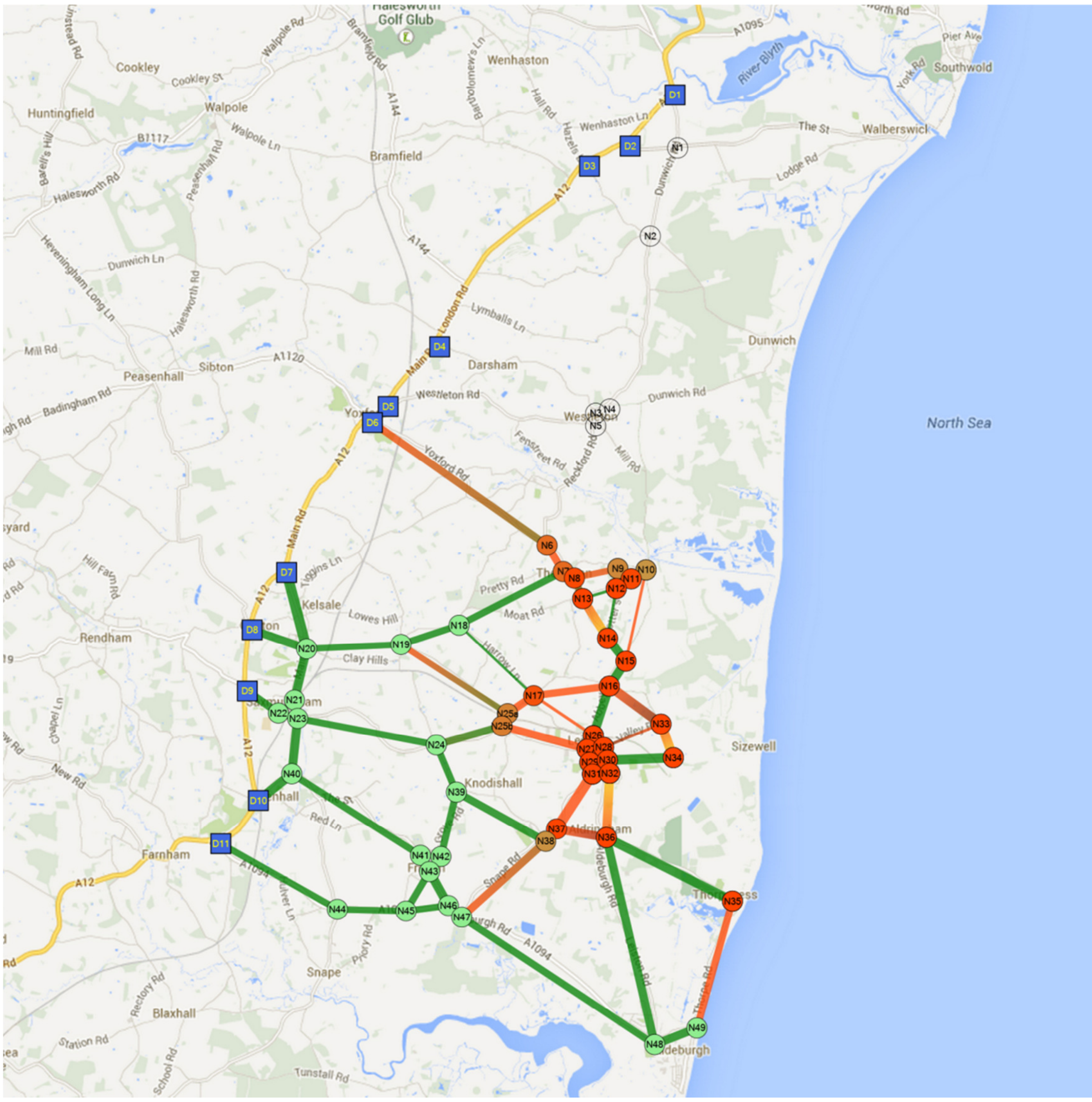


Figure 8.5 2013 Day Time with Southerly Wind (Scenario 2) Mid Evacuation Phase

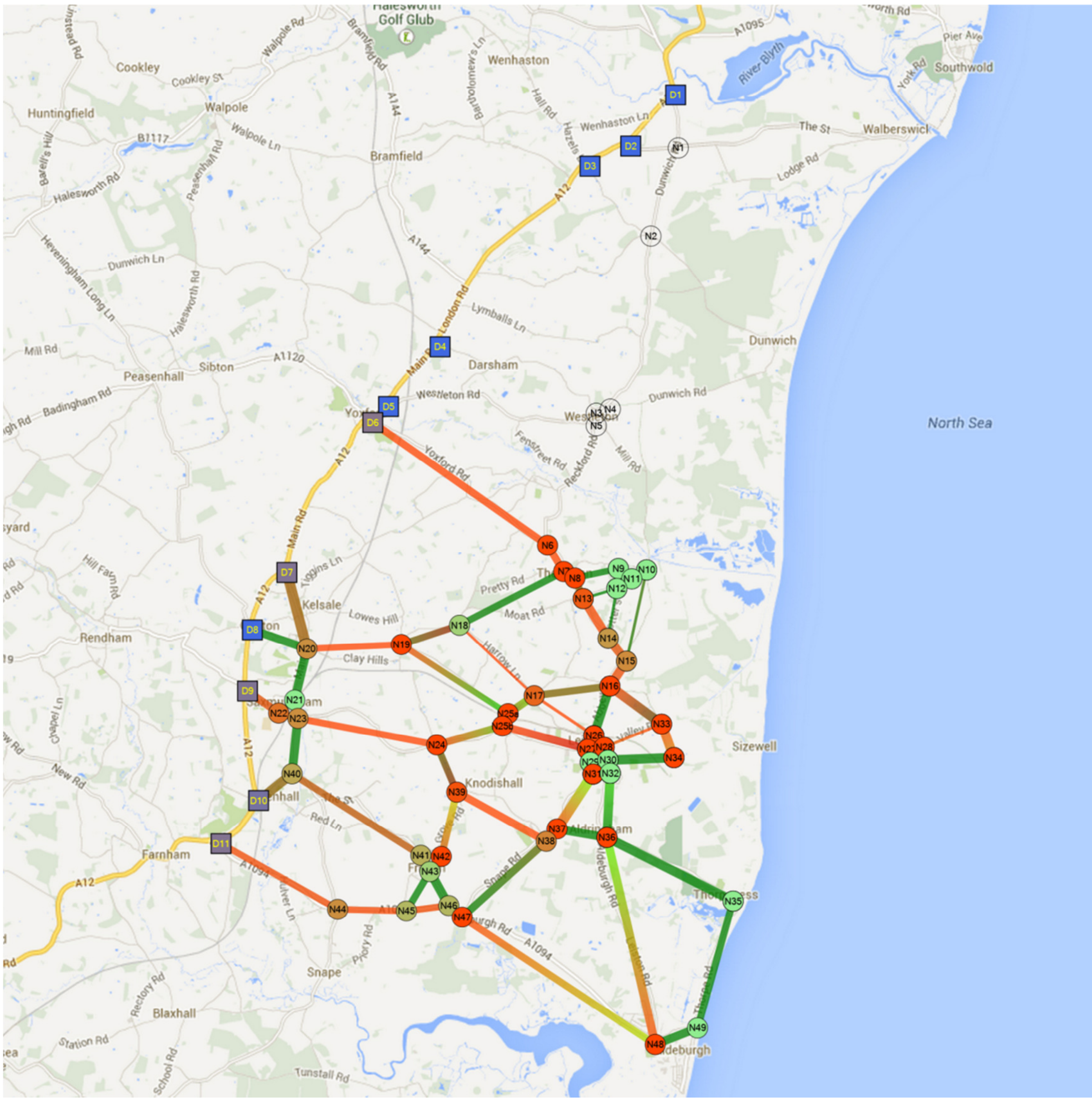
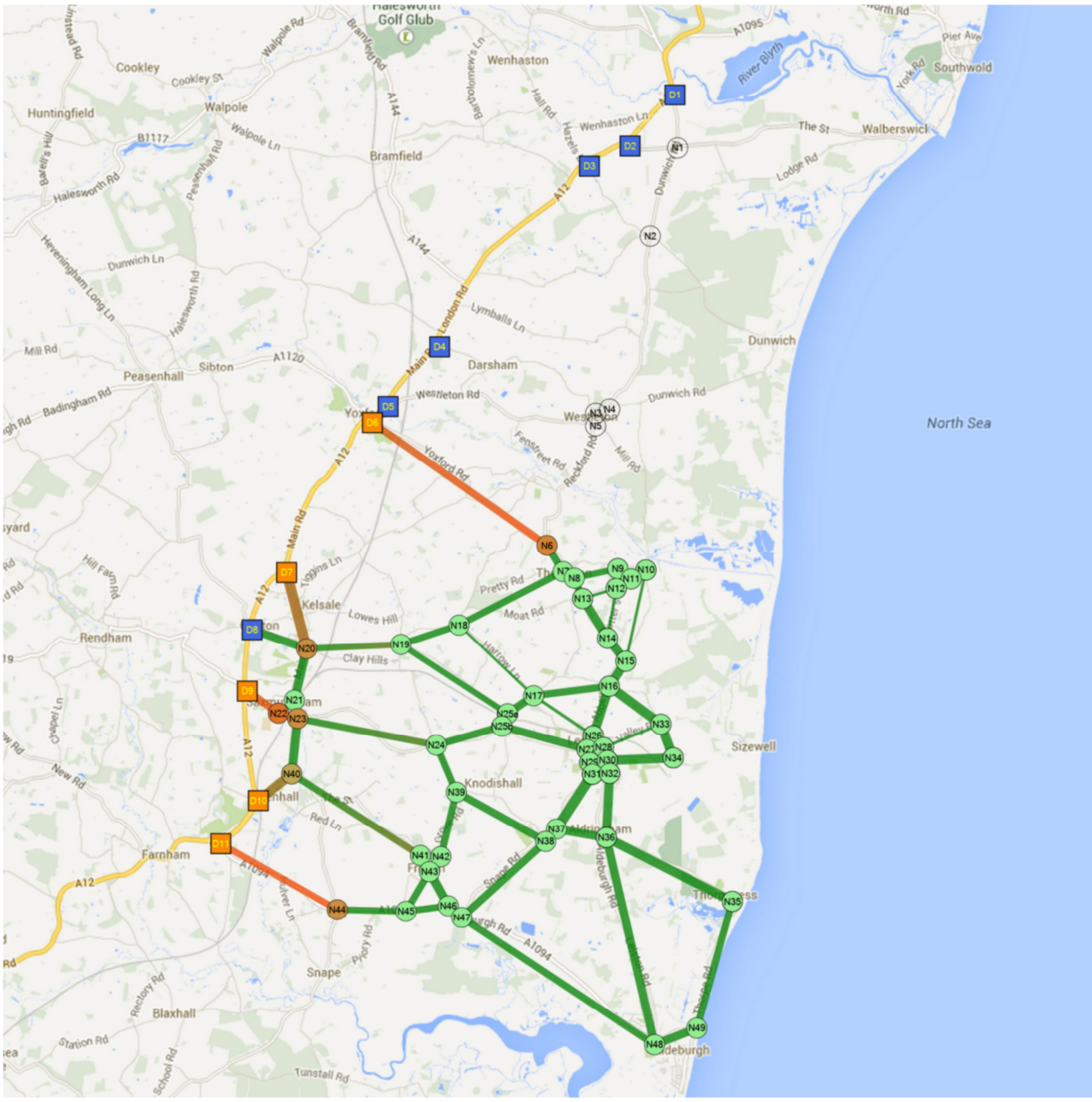


Figure 8.6 2013 Day Time with Southerly Wind (Scenario 2) Final Evacuation Phase



2013 Day Time with Easterly Wind (Scenario 14)

8.14 If the evacuation occurred during the day and when the wind is easterly (i.e. wind blowing from the east towards the west or Saxmundham), and therefore all routes to the west would not be able to be used, the optimum evacuation routes are via the following junctions onto the A12:

- D4: A12/The St;
- D5: A12/Westleton Road;
- D10: A12/B1121 (Main Road), Benhall; and
- D11: A12/A1094.

8.15 **Figures 8.7** to **8.9** below illustrate the early, mid and final phases of the evacuation of the DEPZ if the routes to the west are not able to be used.

Figure 8.7 2013 Day Time with Easterly Wind (Scenario 14) Early Evacuation Phase

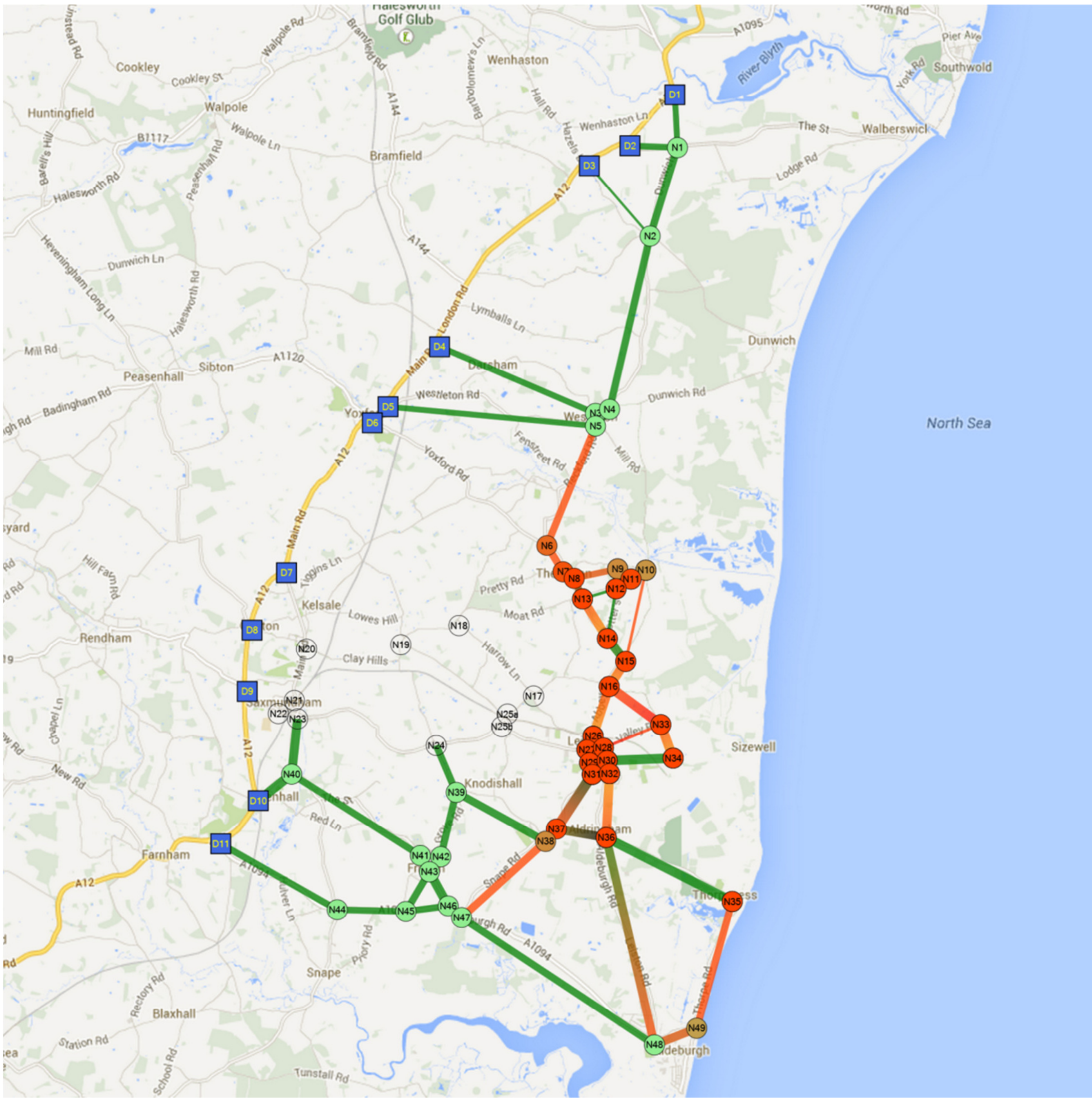


Figure 8.8 2013 Day Time with Easterly Wind (Scenario 14) Mid Evacuation Phase

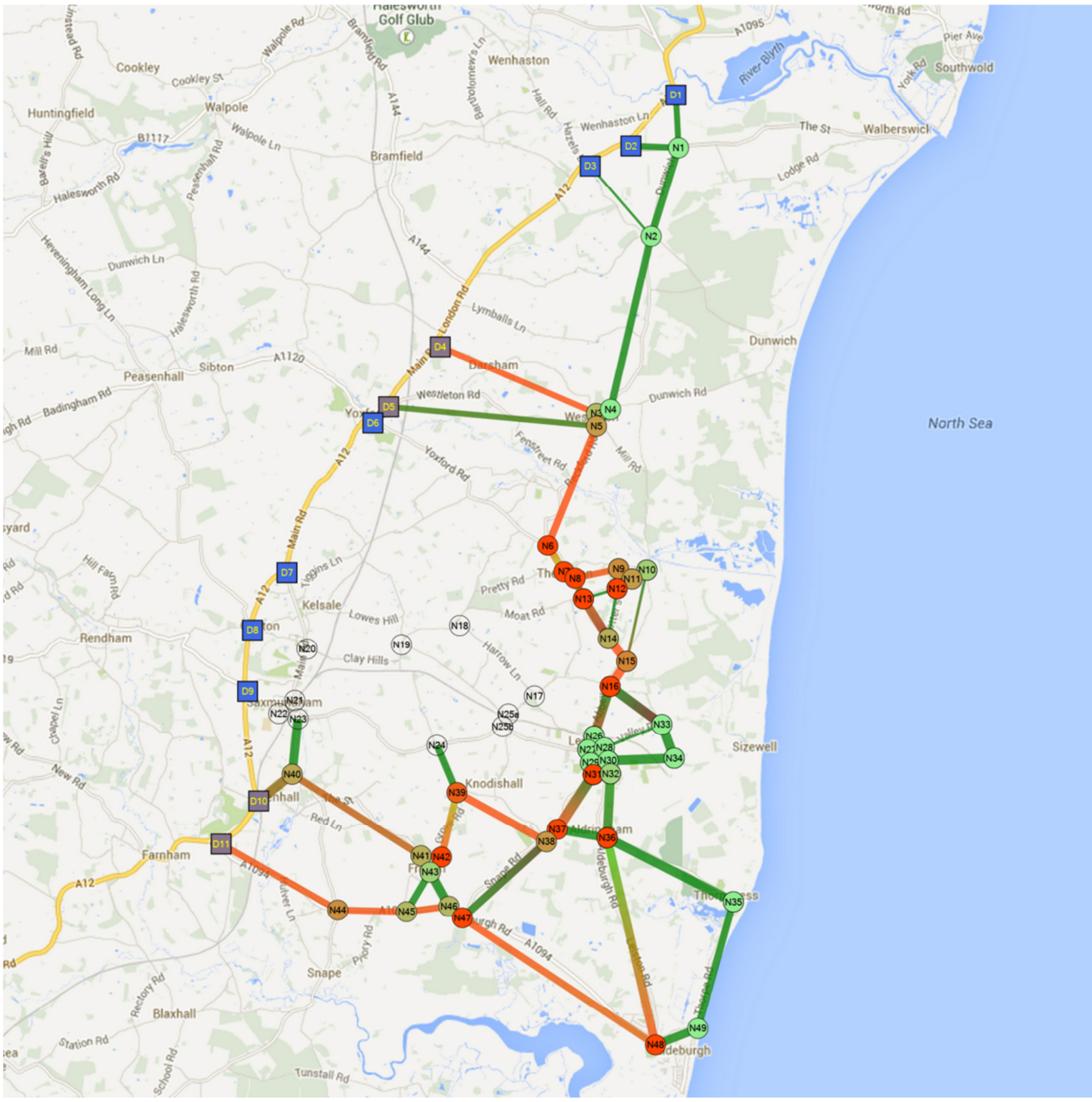
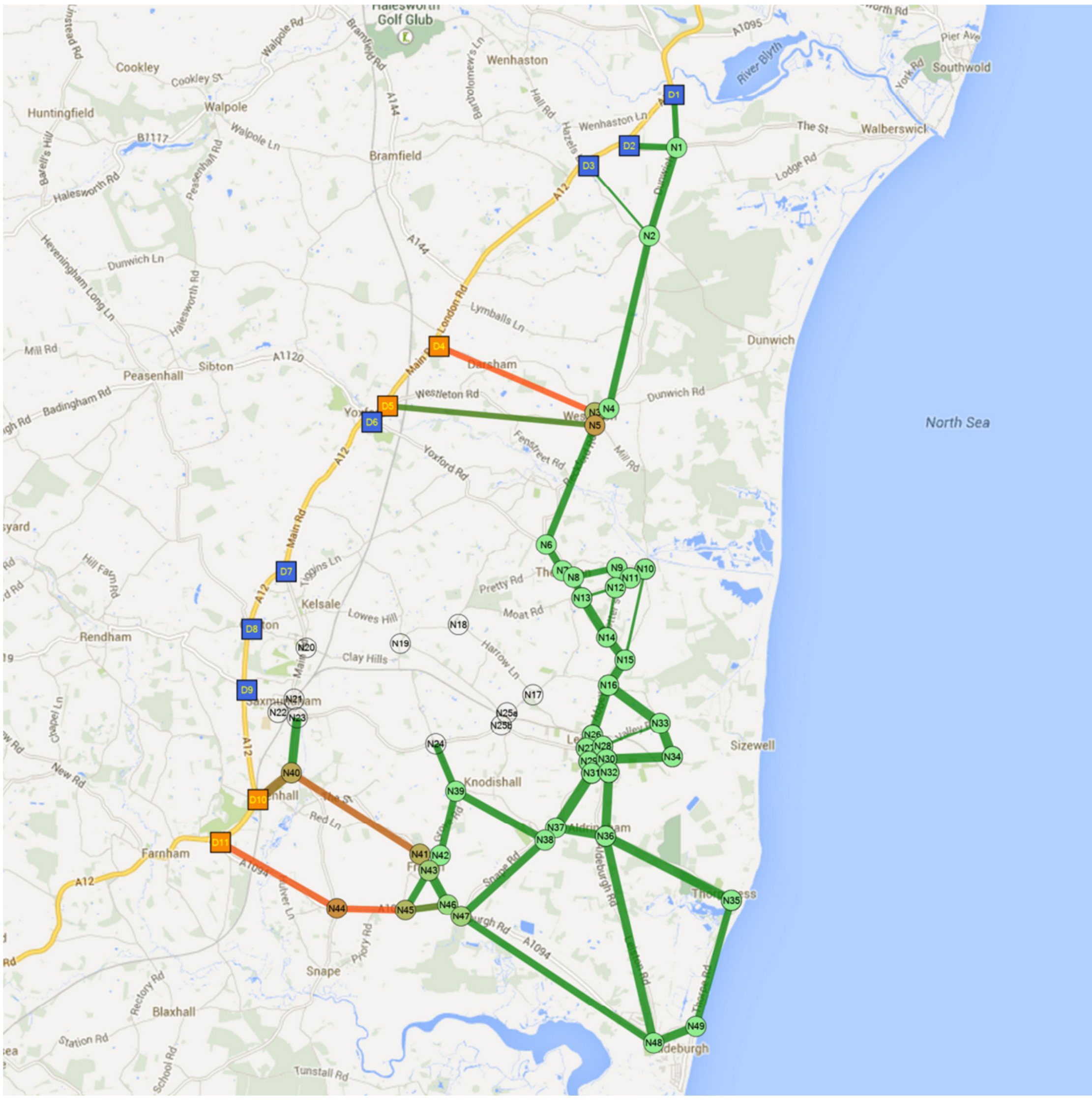


Figure 8.9 2013 Day Time with Easterly Wind (Scenario 14) Final Evacuation Phase



2013 Day Time with Northerly Wind (Scenario 10)

8.16 If the evacuation occurred during the day and when the wind is northerly (i.e. the wind is blowing from the north towards the south or Felixstowe), and therefore all routes to the south would not be able to be used, the optimum evacuation routes are via the following junctions onto the A12:

- D6: A12/B1122 (Yoxford Road);
- D7: A12/B1121 (Main Road), Dorleys Corner;
- D9: A12/Rendham Road;

8.17 Node D6 evacuates the greatest amount of traffic (1,949 vehicles) followed by D9 (1,721 vehicles) and D7 (1,636).

8.18 **Figures 8.10** to **8.12** below illustrate the early, mid and final phases of the evacuation of the DEPZ if the routes to the south are not able to be used.

Figure 8.10 2013 Day Time with Northerly Wind (Scenario 10) Early Evacuation Phase

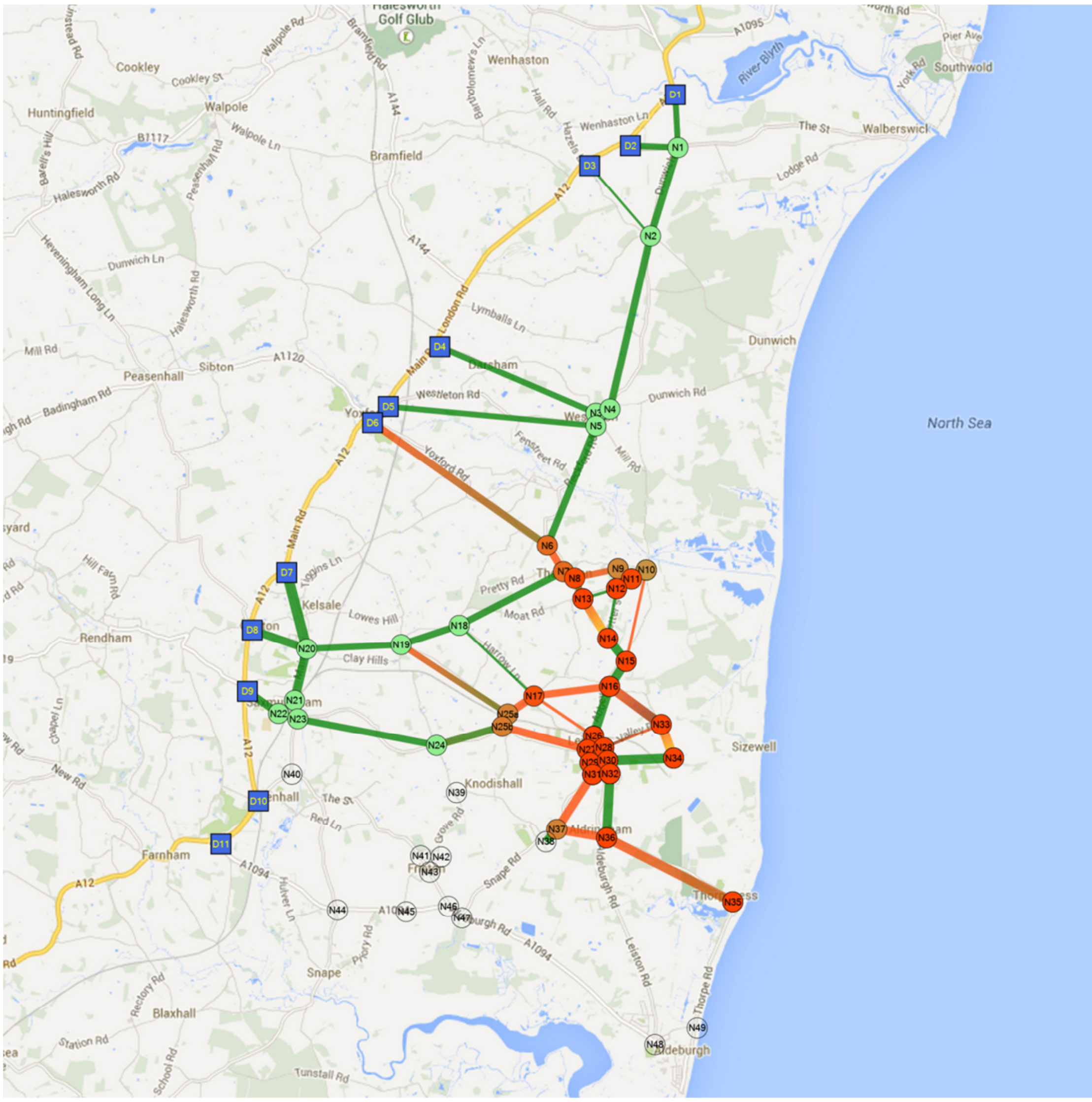


Figure 8.11 2013 Day Time with Northerly Wind (Scenario 10) Mid Evacuation Phase

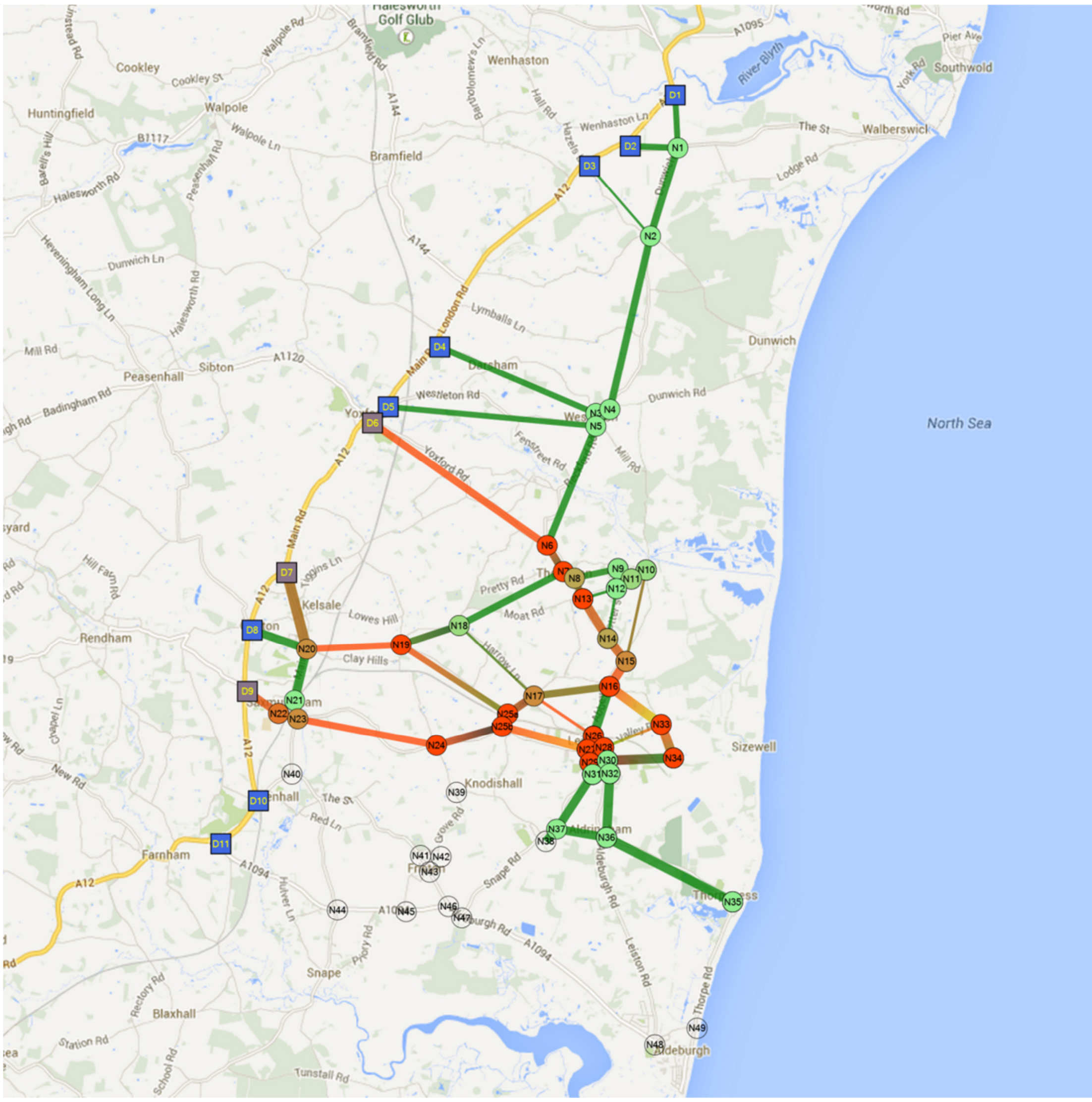
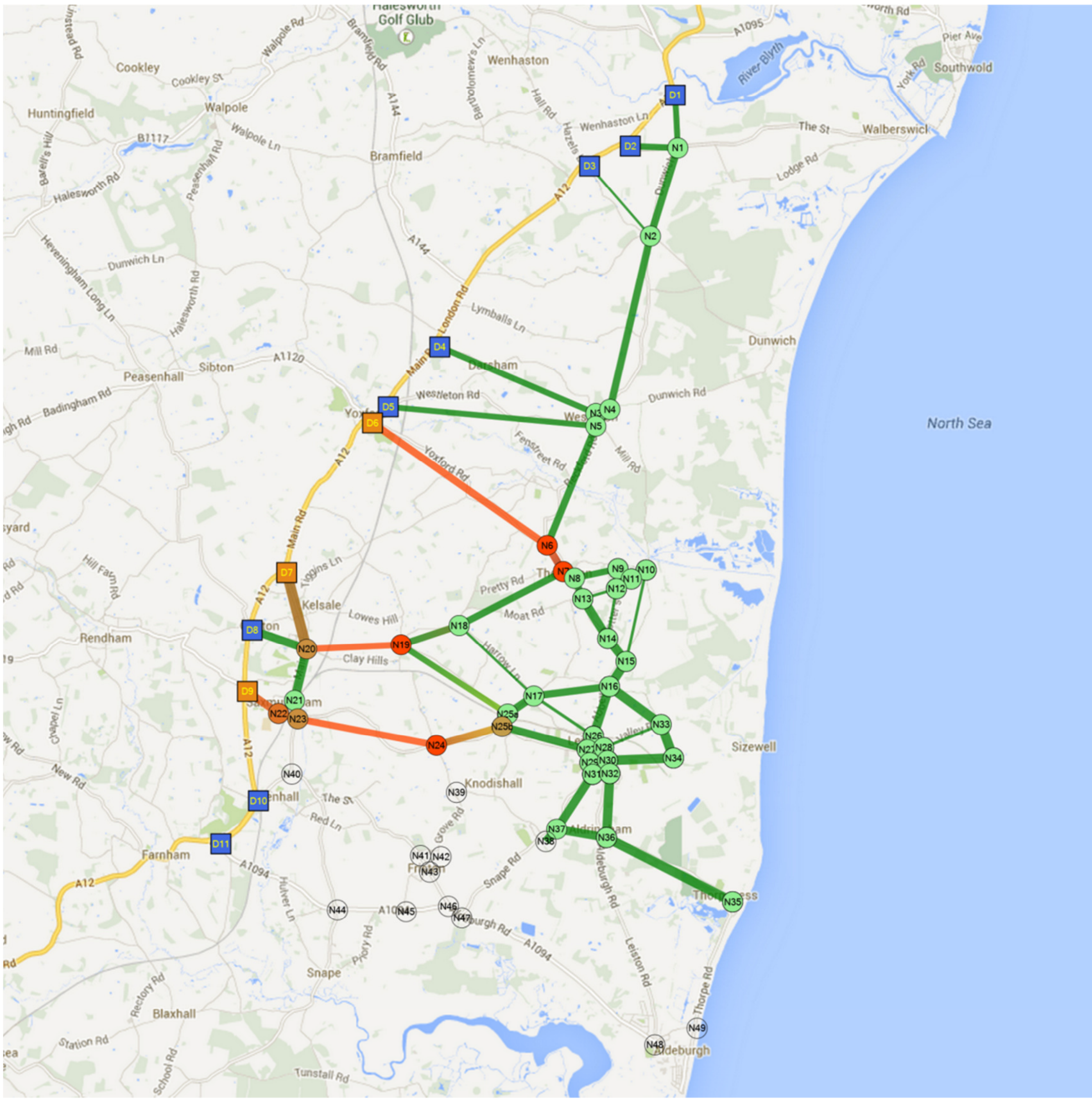


Figure 8.12 2013 Day Time with Northerly Wind (Scenario 10) Final Evacuation Phase



2013 Vulnerable Evacuation

8.19 The model shows that the optimum evacuation routes for the vulnerable population are via the following junctions onto the A12:

- D6: A12/B1122 (Yoxford Road);
- D7: A12/B1121 (Main Road), Dorleys Corner;
- D9: A12/Rendham Road; and
- D11: A12/A1094.

8.20 Node D6 evacuates the greatest amount of the vulnerable population (55 vehicles) followed by D7 (25 vehicles) and D11 and D9 (12 and 1 vehicle respectively).

9 SUMMARY AND CONCLUSIONS

9.1 The aim of the technical work is to examine the road network in the vicinity of the existing Sizewell nuclear power stations and produce an evacuation plan in order to evacuate the affected population to safety in the event of an emergency scenario at Sizewell. In addition, the technical work considers the future growth in the area, based on growth forecasts up to 2027 provided by Suffolk Coastal District Council (SCDC). The technical work assesses the implications of future growth on an evacuation of the area and any potential constraints to growth.

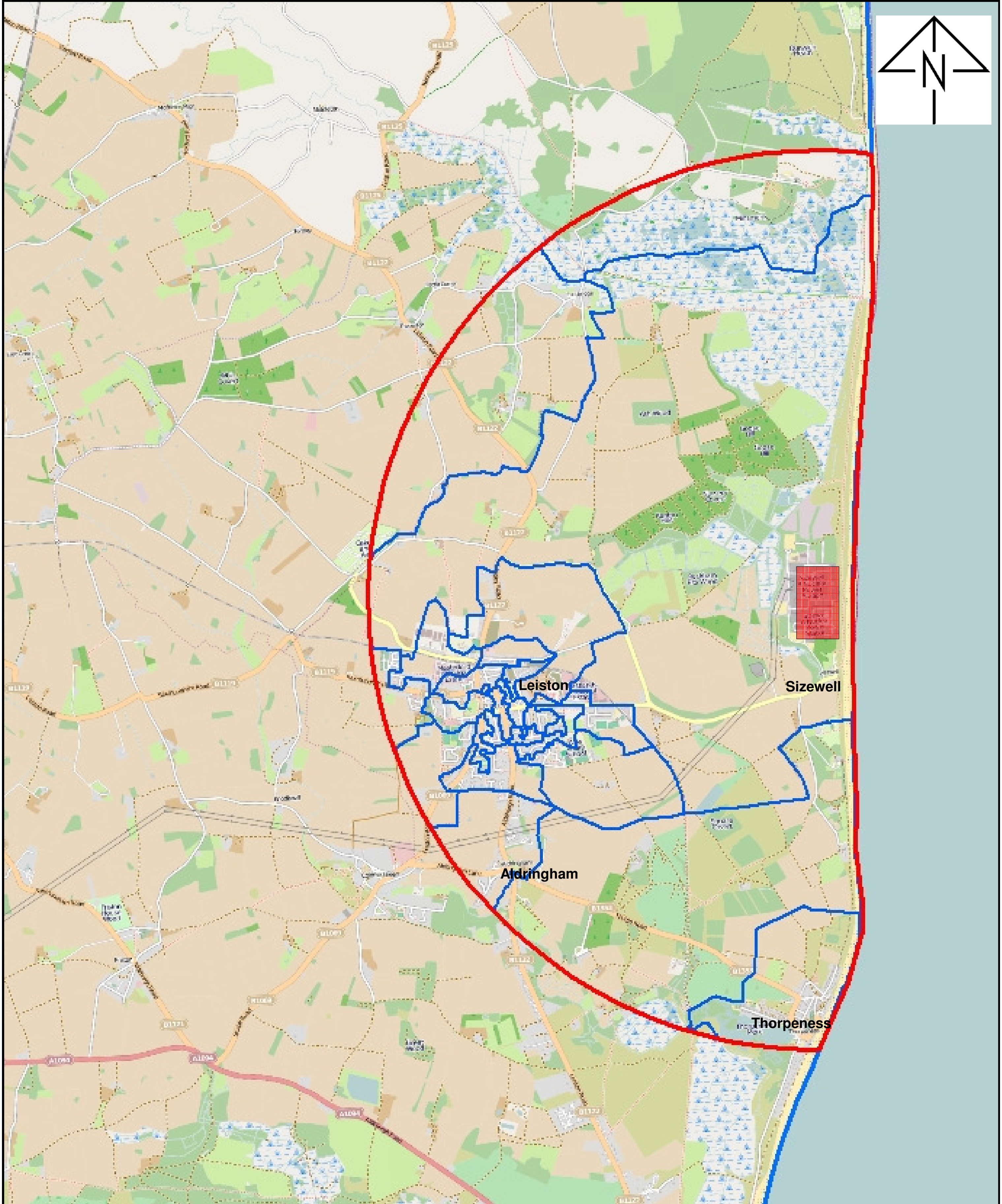
9.2 This technical work uses the heuristic algorithm 'Capacity Constrained Route Planner' (CCRP), to generate optimum evacuation routes while constraining them to road capacities. The CCRP algorithm has previously been used to create and evacuation plan for Monticello, Minnesota, USA, a BWE type nuclear reactor.

9.3 The evacuation model has been used to test a number of different variables to determine the optimum evacuation routes for each scenario and the evacuation time. The following conclusions can be made:

- If all of the roads were available to use under the 2013 Base +Consented Development scenario it would take around 93 minutes to evacuate the DEPZ in the day and around 62 minutes in the night (assuming that everyone evacuates on Time 0). Therefore it would take approximately 50% longer to evacuate the DEPZ to safety in the daytime than in the night.
- If a contaminated cloud precluded the use of the roads to the north the evacuation time would not be increased as the routes to the north are not used in the optimum evacuation routing. If a contamination cloud precluded the use of the roads to the south then it would take approximately 50% longer to evacuate the DEPZ than if the road network were unaffected. Worst of all if a contamination cloud precluded the use of the roads to the west then it would take 60-70% longer than if the road network were unaffected.
- The two developments with a resolution to grant permission (i.e. Valley Road and Aldburgh Road) would add 2-4 minutes to the evacuation time.
- The addition of the SHLAA developments, over and above Valley Road and Aldburgh Road, would add a further 2-4 minutes to the evacuation time.

- The vulnerable population could be evacuated in around 11-15 minutes at any time of the day, regardless of wind direction.
- The evacuation of the vulnerable population would require around 94 vehicles to evacuate the population in the day and 13 vehicles to evacuate the population at night, assuming a vehicle occupancy of 20 people per vehicle.

FIGURES



Census 2011 Output Areas

4Km Evacuation Zone

Census 2011 Output Area Boundary

Sizewell A & B Site

vectos
transport planning specialists

Network Building, 97 Tottenham Court Road, London W1T 4TP
Tel: 020 7580 7373 Email: london@vectos.co.uk www.vectos.co.uk

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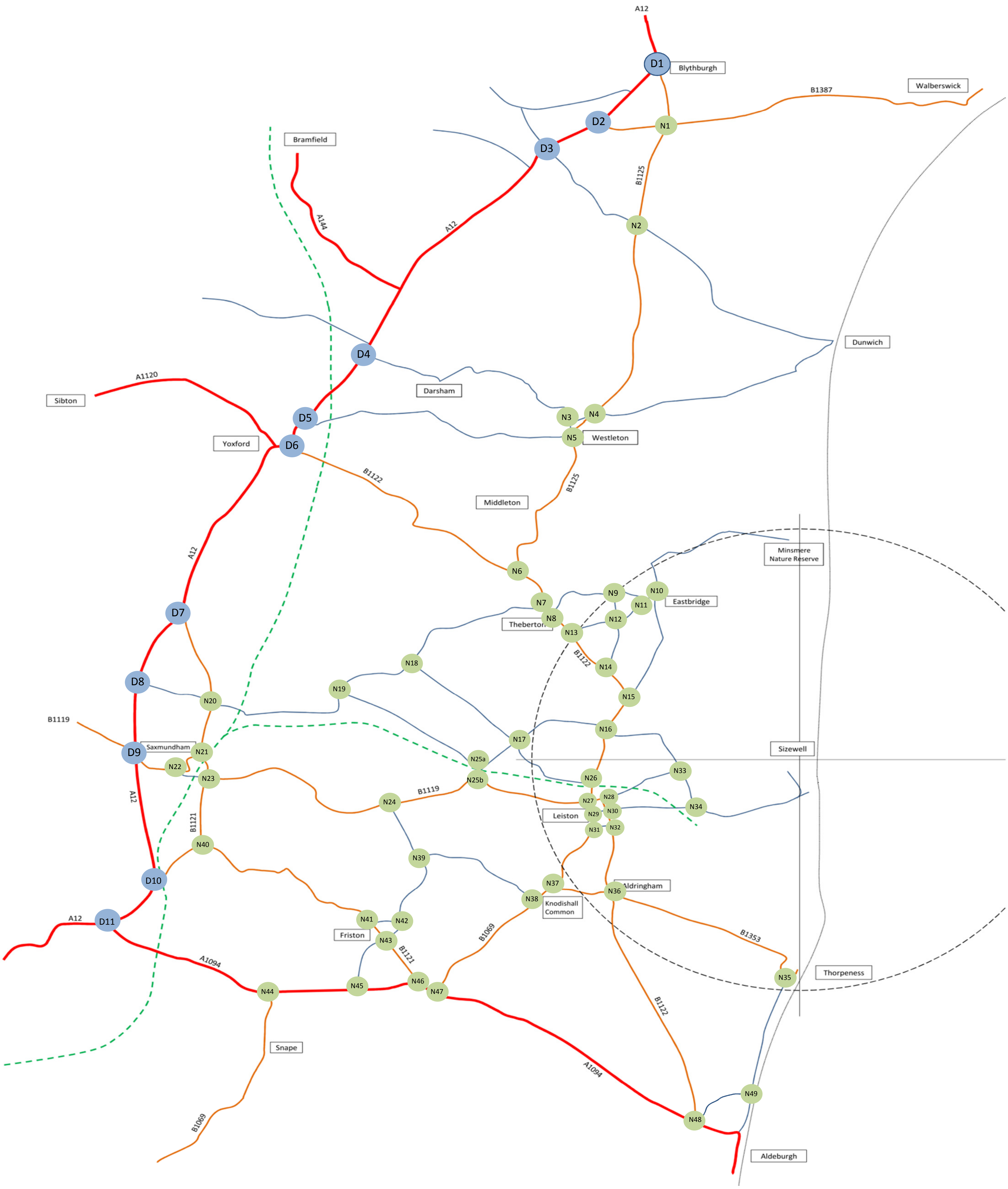

Evacuation Model Highway Network
Figure 5.1

Reference	Node Type	Location
D1	Destination Node	A12/Dunwich Rd
D2	Destination Node	A12/B1387 (The St)
D3	Destination Node	A12/Hazels Lane
D4	Destination Node	A12/The St
D5	Destination Node	A12/Westleton Rd
D6	Destination Node	A12/B1122 (Yoxford Rd)
D7	Destination Node	A12/B1121 (Main Rd), Dorleys Corner
D8	Destination Node	A12/Carlton Rd
D9	Destination Node	A12/Rendham Rd
D10	Destination Node	A12/B1121 (Main Rd), Benhall
D11	Destination Node	A12/A1094
S1	Source Node	
S2	Source Node	
S3	Source Node	
S4	Source Node	
S5	Source Node	
S6	Source Node	
S7	Source Node	
S8	Source Node	
S9	Source Node	
S10	Source Node	
S11	Source Node	
S12	Source Node	
S13	Source Node	
S14	Source Node	
S15	Source Node	
S16	Source Node	
S17	Source Node	
S18	Source Node	
S19	Source Node	
S20	Source Node	
S21	Source Node	
S22	Source Node	
S23	Source Node	
S24	Source Node	
N1	Network Node	B1387 The St/B1125 Dunwich Rd
N2	Network Node	B1125/Westleton Rd
N3	Network Node	Darsham Rd/The Hill
N4	Network Node	B1125/The Hill/Dunwich Rd
N5	Network Node	B1125/Yoxford Rd
N6	Network Node	B1125/B1122 Leiston Rd
N7	Network Node	B1122 Leiston Rd/Pretty Rd
N8	Network Node	B1122 Leiston Rd/Church Rd
N9	Network Node	Church Rd/Chapel Rd
N10	Network Node	Baker's Hill/Minsmere Nature Reserve Access
N11	Network Node	Chapel Rd/Baker's Hill
N12	Network Node	Baker's Hill/Onners Lane/Potter's St
N13	Network Node	B1122/Moat Rd
N14	Network Node	B1122/Potter's St
N15	Network Node	B1122/Minsmere Nature Reserve Access
N16	Network Node	B1122/Lover's Lane
N17	Network Node	Abbey Lane/Harrow Lane
N18	Network Node	Harrow Lane/Hawthorn Rd
N19	Network Node	Hawthorn Rd/Unnamed Rd (RAF Leiston)
N20	Network Node	B1121 Main Rd/Clay Hills
N21	Network Node	B1121 Main Rd/Fairfield Rd
N22	Network Node	B1119 Rendham Rd/Chantry Rd
N23	Network Node	B1121 High St/B1119 Mill Rd
N24	Network Node	B1119 Saxmundham Rd/Grove Rd
N25a	Network Node	B1119 Saxmundham Rd/Abbey Lane (north of railway)
N25b	Network Node	B1119 Saxmundham Rd/Abbey Lane (south of railway)
N26	Network Node	B1122 Abbey Rd/Westward Ho
N27	Network Node	B1069 Park Hill/B1119 Waterloo Ave
N28	Network Node	Main St/B1122 High St/Valley Rd
N29	Network Node	Park Hill/Victory Rd/Cross St
N30	Network Node	High St/Cross St/Sizewell Rd
N31	Network Node	Haylings Rd/Kings Rd
N32	Network Node	High St/Kings Rd
N33	Network Node	Lover's Lane/Valley Rd/Sandy Lane
N34	Network Node	Lover's Lane/King George's Ave
N35	Network Node	B1353 The Haven/Aldeburgh Rd
N36	Network Node	B1122 Aldeburgh Rd/B1353 Aldingham Lane
N37	Network Node	B1069 Leiston Rd/B1353 Aldringham Lane
N38	Network Node	B1069 Leiston Rd/School Rd (Mill Rd)
N39	Network Node	School Rd/Grove Rd
N40	Network Node	B1121 Main Rd/B1121 Church Hill
N41	Network Node	B1121 Saxmundham Rd/Church Rd
N42	Network Node	Church Rd/Grove Rd
N43	Network Node	B1121 Aldeburgh Rd/Grove Rd
N44	Network Node	A1094/B1069 Church Rd
N45	Network Node	A1094/Mill Rd
N46	Network Node	A1094/B1121 Aldeburgh Rd
N47	Network Node	A1094/B1069 Snape Rd
N48	Network Node	A1094/B1122 Leiston Rd
N49	Network Node	Church Farm Road/Thorpe Rd

APPENDIX A

Bibliography and Research Paper

Bibliography

Capacity Constrained Routing Algorithms for Evacuation Planning: A Summary of Results, Qingsong Lu, Betsey George and Shashi Shekhar

Evacuation Route Planning: A Case Study in Semantic Computing, Qingsong Lu, Betsey George and Shashi Shekhar

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Capacity Constrained Routing Algorithms for Evacuation Planning: A Summary of Results*

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Abstract. Evacuation planning is critical for numerous important applications, e.g. disaster emergency management and homeland defense preparation. Efficient tools are needed to produce evacuation plans that identify routes and schedules to evacuate affected populations to safety in the event of natural disasters or terrorist attacks. The existing linear programming approach uses time-expanded networks to compute the optimal evacuation plan and requires a user-provided upper bound on evacuation time. It suffers from high computational cost and may not scale up to large transportation networks in urban scenarios. In this paper we present a heuristic algorithm, namely Capacity Constrained Route Planner(CCRP), which produces sub-optimal solution for the evacuation planning problem. CCRP models capacity as a time series and uses a capacity constrained routing approach to incorporate route capacity constraints. It addresses the limitations of linear programming approach by using only the original evacuation network and it does not require prior knowledge of evacuation time. Performance evaluation on various network configurations shows that the CCRP algorithm produces high quality solutions, and significantly reduces the computational cost compared to linear programming approach that produces optimal solutions. CCRP is also scalable to the number of evacuees and the size of the network.

Keywords: evacuation planning, routing and scheduling, transportation network.

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** Corresponding author.

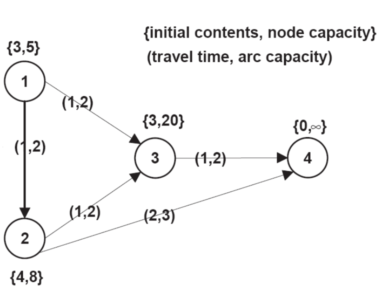
C. Bauzer Medeiros et al. (Eds.): SSTD 2005, LNCS 3633, pp. 291–307, 2005.

1 Introduction

Evacuation planning is critical for numerous important applications, e.g. disaster emergency management and homeland defense preparation. Traditional evacuation warning systems simply convey the threat descriptions and the need for evacuation to the affected population via mass media communication. Such systems do not consider capacity constraints of the transportation network and thus may lead to unanticipated effects on the evacuation process. For example, when Hurricane Andrew was approaching Florida in 1992, the lack of effective planning caused tremendous traffic congestions, general confusion and chaos [1]. Therefore, efficient tools are needed to produce evacuation plans that identify routes and schedules to evacuate affected populations to safety in the event of natural disasters or terrorist attacks [12,14,7,8].

The current methods of evacuation planning can be divided into two categories, namely traffic assignment-simulation approach and route-schedule planning approach. The traffic assignment-simulation approach uses traffic simulation tools, such as DYNASMART [27] and DynaMIT [5], to conduct stochastic simulation of traffic movements based on origin-destination traffic demands and uses queuing methods to account for road capacity constraints. However, it may take a long time to complete the simulation process for a large transportation network. The route-schedule planning approaches use network flow and routing algorithms to produce origin-destination routes and schedules of evacuees on each route. Many research works have been done to model the evacuation problem as a network flow problem [15,4] and to find the optimal solution using linear programming methods. Hamacher and Tjandra [17] gave an extensive literature review of the models and algorithms used in these linear programming methods. Based on the triple-optimization results by Jarvis and Ratliff [20], linear programming method for evacuation route planning works as follows. First, it models the evacuation network into a network graph, as shown by network G in Figure 1, and it requires the user to provide an estimated upper bound T of the evacuation egress time. Second, it converts evacuation network G to a time-expanded network, as shown by G_T in Figure 2, by duplicating the original evacuation network G for each discrete time unit $t = 0, 1, \ldots, T$. Then, it defines the evacuation problem as a minimum cost network flow problem [15,4] on the time-expanded network G_T. Finally, it feeds the expanded network G_T to minimum cost network flow solvers, such as NETFLO [21], to find the optimal solution. For example, EVACNET [9,16,22,23] is a computer program based on this approach which computes egress time for building evacuations. It uses NETFLO code to obtain the optimal solution. Hoppe and Tardos [18,19] gave a polynomial time bounded algorithm by using ellipsoid method of linear programming to find the optimal solution for the minimum cost flow problem. Theoretically, ellipsoid method has a polynomial bounded running time. However, it performs poorly in practice and has little value for real application [6].

Linear programming approach can produce optimal solutions for evacuation planning. It is useful for evacuation scenarios with moderate size networks, such as building evacuation. However, this approach has the following limita-



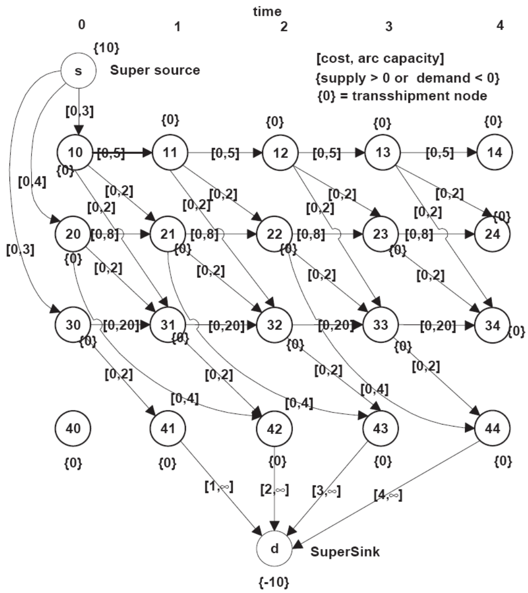


Fig. 1. Evacuation Network G, (source: [17])

Fig. 2. Time-expanded Network G_T, with T=4, (source: [17])

tions. First, it significantly increases the problem size because it requires time-expanded network G_T to produce a solution. As can been seen in Figures 1 and 2, if the original evacuation network G has n nodes and the time upper bound is T, the time-expanded network G_T will have at least $(T+1)n$ nodes. This approach may not be able to scale up to large size transportation networks in urban evacuation scenarios due to high computational run-time caused by the tremendously increased size of the time-expanded network. Second, linear programming approach requires the user to provide an upper bound T of the evacuation time in order to generate the time-expanded network. It is almost impossible to precisely estimate the evacuation time for an urban scenario where the number of evacuees is large and the transportation network is complex. An under-estimated time bound T will result in failure of finding a solution. In this case, the user will have to increase the value of T and re-run the algorithm until a solution can be reached. On the other hand, an over-estimated T will result in an over-expanded network G_T and hence lead to unnecessary storage and run-time.

Heuristic routing and scheduling algorithms can be used to find sub-optimal evacuation plan with reduced computational cost. It is useful for evacuation scenarios with large size networks and scenarios that do not require an optimal plan, but need to produce an efficient plan within a limited amount of time. However, old heuristic approaches only compute the shortest distance route from a source to the nearest destination without considering route capacity constraints. It cannot produce efficient plans when the number of evacuees is large and the evacuation network is complex. New heuristic approaches are needed to account for capacity constraints of the evacuation network. Lu, Huang and Shekhar [26] proposed prototypes of two heuristic capacity constrained routing algorithms, namely SRCCP and MRCCP, and tested its performance using small size building networks. SRCCP assigns only one route to each source node. It has very fast run-time but the solution quality is very poor and hence has little value for real application. MRCCP assigns multiple routes to each source node and produces high quality solution with much less run-time compared to that of linear programming approach. However, its scalability to large size networks is unsatisfactory because it has a computational cost of $O(p \cdot n^2 logn)$ (where n the is number of nodes and p is the number of evacuees). In this paper, we present an improved algorithm called Capacity Constrained Route Planner (CCRP). CCRP can reduce the run-time to $O(p \cdot nlogn)$ by conducting only one shortest path search in each iteration instead of the multiple searches used in MRCCP. We also present the analysis of its algebraic cost model and provide the results of performance evaluation using large size transportation networks.

In the CCRP algorithm, we model capacity as a time series because available capacity of each node and edge may vary during the evacuation. We use a generalized shortest path search algorithm to account for route capacity constraints. This algorithm can divide evacuees from each source into multiple groups and assign a route and time schedule to each group of evacuees based on an order that is prioritized by each group's destination arrival time. It then reserves route capacities for each group subject to the route capacity constraints. The quickest route available for one group is re-calculated in each iteration based on the available capacity of the network. Performance evaluation on various network configurations shows that the CCRP algorithm produces high quality solutions, and significantly reduces the computational cost compared to linear programming approach. CCRP is also scalable to the number of evacuees and the size of the network. A case study using a nuclear power plant evacuation scenario shows that this algorithm can be used to improve existing evacuation plans by reducing evacuation time.

We also explored the possibility of formulation of a new optimal algorithm using A* search[28,29]. It addresses the limitations of linear programming approach by using only the original evacuation network to find the optimal solution and it does not require the user to provide an upper bound of the evacuation time. Details of the A* search formulation and the proof of monotonicity and admissibility of this A* search algorithm are available in [25]. It is not included in this paper due to space constraints.

Outline: The rest of the paper is organized as follows. In Section 2, the problem formulation is provided and related concepts are illustrated by an example evacuation network. Section 3 describes the Capacity Constrained Route Planner (CCRP) algorithm and the algebraic cost model. In Section 4, we present the experimental design and performance evaluation. We summarize our work and discuss future directions in Section 5.

2 Problem Formulation

We formulate the evacuation planning problem as follows:

Given: A transportation network with non-negative integer capacity constraints on nodes and edges, non-negative integer travel time on edges, the total number of evacuees and their initial locations, and locations of evacuation destinations.

Output: An evacuation plan consisting of a set of origin-destination routes and a scheduling of evacuees on each route. The scheduling of evacuees on each route should observe the capacity constraints of the nodes and edges on this route.

Objective: (1) Minimize the evacuation egress time, which is the time elapsed from the start of the evacuation until the last evacuee reaches the evacuation destination. (2) Minimize the computational cost of producing the evacuation plan.

Constraint: (1) Edge travel time preserves FIFO (First-In First-Out) property. (2) Edge travel time reflects delays at intersections. (3) Limited amount of computer memory.

We illustrate the problem formulation and a solution with an example evacuation network, as shown in Figure 3. In this evacuation network, each node is shown by an ellipsis. Each node has two attributes: maximum node capacity and initial node occupancy. For example, at node N1, the maximum capacity is 50, which means this node can hold at most 50 evacuees at each time point, while the initial occupancy is 10, which means there are initially 10 evacuees at this node. In Figure 3, each edge, shown as an arrow, represents a link between two nodes. Each edge also has two attributes: maximum edge capacity and travel time. For example, at edge N4-N6, the maximum edge capacity is 5, which means at each time point, at most 5 evacuees can start to travel from node N4 to N6 through this link. The travel time of this edge is 4, which means it takes 4 time units to travel from node N4 to N6. This approach of modelling a evacuation scenario to a capacitated node-edge graph is similar to those presented in Hamacher [17], Kisko [23] and Chalmet [9].

As shown in Figure 3, suppose we initially have 10 evacuees at node N1, 5 at node N2, and 15 at node N8. The task is to compute an evacuation plan that evacuates the 30 evacuees to the two destinations (node N13 and N14) using the least amount of time.

Example 1 (An Evacuation Plan). Table 1 shows an example evacuation plan for the evacuation network in Figure 3. In this table, each row shows one group of evacuees moving together during the evacuation with a group ID, source node, number of evacuees in this group, the evacuation route with time schedule, and the destination time. The route is shown by a series of node number and the time schedule is shown by a start time associated with each node on the route. Take source node N8 for example; initially there are 15 evacuees at N8. They are divided into 3 groups: Group A with 6 people, Group B with 6 people and

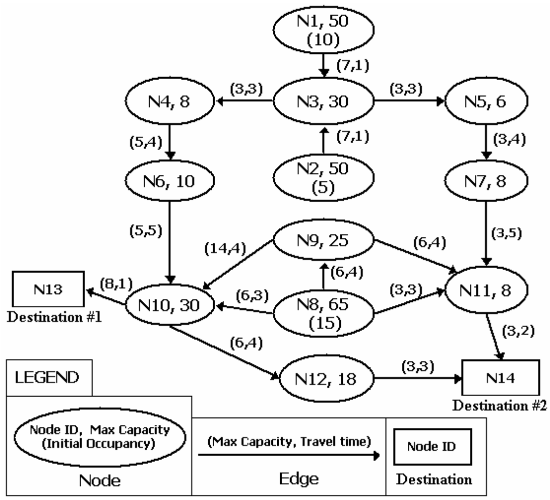


Fig. 3. Node-Edge Graph Model of Example Evacuation Network

Group C with 3 people. Group A starts from node N8 at time 0 to node N10, then starts from node N10 at time 3 to node N13, and reaches destination N13 at time 4. Group B follows the same route of group A, but has a different schedule due to capacity constraints of this route. This group starts from N8 at time 1 to N10, then starts from N10 at time 4 to N13, and reaches destination N13 at time 5. Group C takes a different route. It starts from N8 at time 0 to N11, then starts from N11 at time 3 to N14, and reaches destination N14 at time 5. The procedure is similar for other groups of evacuees from source node N1 and N2. The whole evacuation egress time is 16 time units since the last groups of people (Group H and I) reach destination at time 16. This evacuation plan is an optimal plan for the evacuation scenario shown in Figure 3.

In our problem formulation, we allow time dependent node capacity and edge capacity, but we assume that edge capacity does not depend on the actual flow amount in the edge. We also allow time dependent edge travel time, but we require that the network preserve the FIFO (First-In First-Out) property.

Alternate problem formulations of the evacuation problem are available by changing the objective of the problem. The main objective of our problem formulation is to minimize the evacuation egress time. Two alternate objectives are: (1) Maximize the number of evacuees that reach destination for each time unit; (2) Minimize the average evacuation time for all evacuees. Jarvis and Ratliff presented and proved the *triple optimization theorem* [20], which illustrated the properties of the solutions that optimize the above objectives of the evacuation problem. A review of linear programming approaches to solve these problem formulations was given by Hamacher and Tjandra [17].

Table 1. Example Evacuation Plan

Group of Evacuees			Route with Schedule	Dest.Time
ID	**Source**	**Number**		
A	N8	6	N8(T0)-N10(T3)-N13	4
B	N8	6	N8(T1)-N10(T4)-N13	5
C	N8	3	N8(T0)-N11(T3)-N14	5
D	N1	3	N1(T0)-N3(T1)-N4(T4)-N6(T8)-N10(T13)-N13	14
E	N1	3	N1(T0)-N3(T2)-N4(T5)-N6(T9)-N10(T14)-N13	15
F	N1	1	N1(T0)-N3(T1)-N5(T4)-N7(T8)-N11(T13)-N14	15
G	N2	2	N2(T0)-N3(T1)-N5(T4)-N7(T8)-N11(T13)-N14	15
H	N2	3	N2(T0)-N3(T3)-N4(T6)-N6(T10)-N10(T15)-N13	16
I	N1	3	N1(T1)-N3(T2)-N5(T5)-N7(T9)-N11(T14)-N14	16

3 Proposed Approach

Linear programming approach can produce optimal solutions for evacuation planning. It is useful for evacuation scenarios with moderate size networks, such as building evacuation. However, it may not be able to scale up to large size transportation networks in urban evacuation scenarios due to high computational cost caused by the tremendously increased size of the time-expanded network. Heuristic routing and scheduling algorithms can be used to find sub-optimal evacuation plan with reduced computational cost. It is useful for evacuation scenarios with large size networks and scenarios that do not require an optimal plan, but need to produce an efficient plan within a limited amount of time.

In this section, we present a heuristic algorithm, namely Capacity Constrained Route Planner (CCRP), that produces sub-optimal solutions for evacuation planning. We model edge capacity and node capacity as a time series instead of fixed numbers. A time series represents the available capacity at each time instant for a given edge or node. We propose a heuristic approach based on an extension of shortest path algorithms [13,11] to account for capacity constraints of the network.

3.1 Capacity Constrained Route Planner (CCRP)

The Capacity Constrained Route Planner (CCRP) uses an iterative approach. In each iteration, the algorithm first searches for route R with the earliest destination arrival time from any source node to any destination node, taking previous reservations and possible waiting time into consideration. Next, it computes the actual amount of evacuees that will travel through route R. This amount is affected by the available capacity of route R and the remaining number of evacuees. Then, it reserves the node and edge capacity on route R for those evacuees. The algorithm continues to iterate until all evacuees reach destination. The detailed pseudo-code and algorithm description are shown in Algorithm 1..

The CCRP algorithm keeps iterating as long as there are still evacuees left at any source node (line 1). Each iteration starts with finding the route R with the

Algorithm 1. Capacity Constrained Route Planner (CCRP)

Input:
1) $G(N, E)$: a graph G with a set of nodes N and a set of edges E;
   Each node $n \in N$ has two properties:
      $Maximum\_Node\_Capacity(n)$: non-negative integer
      $Initial\_Node\_Occupancy(n)$: non-negative integer
   Each edge $e \in E$ has two properties:
      $Maximum\_Edge\_Capacity(e)$: non-negative integer
      $Travel\_time(e)$: non-negative integer
2) S: set of source nodes, $S \subseteq N$;
3) D: set of destination nodes, $D \subseteq N$;

Output: Evacuation plan:Routes with schedules of evacuees on each route

Method:
Pre-process network: add super source node s_0 to network,
   link s_0 to each source nodes with an edge which
   $Maximum\_Edge\_Capacity() = \infty$ and $Travel\_time() = 0$; (0)
while any source node $s \in S$ has evacuee do { (1)
   find route $R < n_0, n_1, \ldots, n_k >$ with time schedule $< t_0, t_1, \ldots, t_{k-1} >$
      using one generalized shortest path search from super source s_0
         to all destinations, (where $s \in S$, $d \in D$, $n_0 = s$, $n_k = d$)
      such that R has the earliest destination arrival time among
         routes between all (s,d) pairs,
         and $Available\_Edge\_Capacity(e_{n_i n_{i+1}}, t_i) > 0, \quad \forall i \in \{0, 1, \ldots, k-1\}$,
         and $Available\_Node\_Capacity(n_{i+1}, t_i + Travel\_time(e_{n_i n_{i+1}})) > 0,$
            $\forall i \in \{0, 1, \ldots, k-1\}$; (2)
   $flow = \min($ number of evacuees still at source node s,
         $Available\_Edge\_Capacity(e_{n_i n_{i+1}}, t_i), \quad \forall i \in \{0, 1, \ldots, k-1\}$,
         $Available\_Node\_Capacity(n_{i+1}, t_i + Travel\_time(e_{n_i n_{i+1}}))$,
            $\forall i \in \{0, 1, \ldots, k-1\}$;
      ); (3)
   for $i = 0$ to $k - 1$ do { (4)
      $Available\_Edge\_Capacity(e_{n_i n_{i+1}}, t_i)$ reduced by $flow$; (5)
      $Available\_Node\_Capacity(n_{i+1}, t_i + Travel\_time(e_{n_i n_{i+1}}))$ reduced by $flow$;
         (6)
   } (7)
} (8)
Output evacuation plan; (9)

earliest destination arrival time from any sources node to any destination node based on the current available capacities (line 2). This is done by generalizing Dijkstra's shortest path algorithm [13,11] to work with the time series node and edge capacities and edge travel time. Route R is the route that starts from a source node and gets to a destination node in the least amount of time and available capacity of the route allows at least one person to travel through route R to a destination node.

Compared with the earlier MRCCP algorithm [26], major improvements in CCRP lie in line 0 and line 2. In MRCCP, finding route R (line 2) is done by running generalized shortest path searches from each source node. Each search is terminated when any destination node is reached. In CCRP, this step is improved by adding a super source node s_0 to the network and connecting s_0 to all source nodes(line 0). This allows us to complete the search for route R by using only one single generalized shortest path search, which takes the super source s_0 as the start node. This search terminates when any destination node is reached. Since the super source s_0 is connected to each source nodes by an edge with infinite capacity and zero travel time, it can be easily proved that the shortest route found by this search is the route R we need in line 2. This improvement significantly reduces the computational cost of the algorithm by one degree of magnitude compared with MRCCP. We give a detailed analysis of the cost model of CCRP algorithm in the next section.

3.2 Algebraic Cost Model of CCRP

We now provide the algebraic cost model for the computational cost of the proposed CCRP algorithm. We assume that n is the number of nodes in the evacuation network, m is the number of edges, and p is the number of evacuees.

The CCRP algorithm is an iterative approach. In each iteration, the route for one group of people is chosen and the capacities along the route are reserved. The total number of iterations equals the number of groups generated. In the worst case, each individual evacuee forms one group. Therefore, the upper bound of the number of groups is p, i.e. the number of iterations is $O(p)$. In each iteration, the computation of the route R with earliest destination arrival time is done by running one generalized Dijkstra's shortest path search. The worst case computational complexity of Dijkstra's algorithm is $O(n^2)$ for dense graphs [11]. Various implementations of Dijkstra's algorithm have been developed and evaluated extensively [4,10,32]. Many of these implementations can reduce the computational cost by taking advantage of the sparsity of the graph. Transportation road networks are very sparse graphs with a typical edge/node ratio around 3. In CCRP, we implement Dijkstra's algorithm using heap structures, which runs in $O(m + nlogn)$ time [4,10]. For sparse graphs, $nlogn$ is the dominant term. The generalization of Dijkstra's algorithm to account for capacity constraints affects only how the shortest distance to each node is defined. It does not affect the computational complexity of the algorithm. Therefore, we can complete the search for route R with $O(nlogn)$ run-time. The reservation step is done by updating the node and edge capacities along route R, which has a cost of $O(n)$. Therefore, each iteration of the CCRP algorithm is done in $O(nlogn)$ time. As we have seen, it takes $O(p)$ iterations to complete the algorithm. The cost model of the CCRP algorithm is $O(p \cdot nlogn)$. CCRP is an improved algorithm based on the same heuristic method of MRCCP [26] which has a run-time of $O(p \cdot n^2 logn)$. CCRP reduces the computational cost of MRCCP by one degree of magnitude.

The computational cost of linear programming approach depends on the method used to solve the minimum cost flow problem. Hoppe and Tardos [18] showed that this problem can be solved using ellipsoid method which is theoretically polynomial time bounded. However, the computational complexity of

Table 2. Comparison of Computational Costs (n: number of nodes, p: number of evacuees, T: user-provided upper-bound on evacuation time)

Algorithm	Computational Cost	Solution Quality
CCRP	$O(p \cdot nlogn)$	Sub-optimal
MRCCP	$O(p \cdot n^2 logn)$	Sub-optimal
Linear Programming Approach	at least $O((T \cdot n)^6)$	Optimal

ellipsoid method is at least $O(N^6)$[6](where N is the number of nodes in the network). Since linear programming approach requires a time-expanded network, N equals to $(T+1)n$ (where n is the number of nodes in the original evacuation network, T is the user-provided evacuation time upper bound).

Table 2 provides a comparison of CCRP, MRCCP, and the linear programming approach. As can be seen, linear programming approach produces optimal solutions but suffers from high computational cost. Both CCRP and MRCCP reduce the computation cost by producing sub-optimal solution, while CCRP gives better computational cost than MRCCP.

Lemma 1: CCRP is strictly faster than MRCCP.

The computational costs of CCRP and MRCCP are $O(p \cdot nlogn)$ and $O(p \cdot n^2 logn)$ respectively, as shown in Table 2.

4 Experiment Design and Performance Evaluation

Performance evaluation of the CCRP algorithm was done by conducting experiments using various evacuation network configurations. In this section, we present the experiment design and an analysis of the experiment results.

4.1 Experiment Design

Figure 4 describes the experiment design to evaluate the performance of the CCRP algorithm. The purpose is to compare the algorithm run-time and solution quality of the proposed CCRP algorithms with that of MRCCP [26] and NETFLO [21] which is a popular linear programming package used to solve minimum cost flow problems.

First, we used NETGEN [24] to generate evacuation networks with evacuees. NETGEN is a program that generates transportation networks with capacity constraints and initial supplies based on input parameters. In our experiments, the following three were selected as independent parameters to test their impacts on the the performance of the algorithms: number of evacuees initially in the network, number of source nodes, and network size represented by number of nodes. Number of edges is treated as a dependent parameter as we set the number of edges to be equal to 3 times the number of nodes because 3 is the typical edge/node ratio for real transportation road networks. Next, the same evacuation network generated by NETGEN was fed to the CCRP and MRCCP algorithms. Before feeding the network to NETFLO, we used a network transformation tool to transform the evacuation network into a time-expanded network, which is required by minimum cost flow solvers as NETFLO to solve evacuation problems [17,9]. This process requires an input parameter T which is the estimated upper-bound on evacuation egress time. If the evacuation cannot be completed by time T, NETFLO will return no solution. In this case, we must increase T to create a new time-expanded network and try to run NETFLO again until a solution can be reached. Finally, after CCRP, MRCCP and NETFLO produced a solution for each test case, the evacuation egress time, which represents the solution quality, and the algorithm run-time were collected and analyzed in the data analysis module.

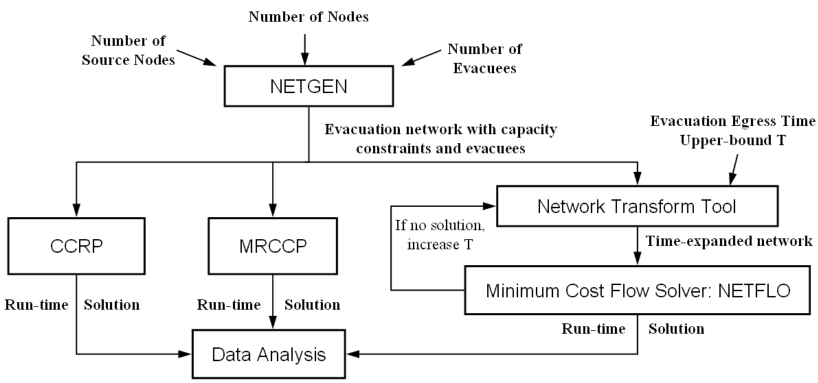


Fig. 4. Experiment Design

The experiments were conducted on a workstation with Intel Pentium IV 2GHz CPU, 2GB RAM and Debian Linux operating system.

4.2 Experiment Results and Analysis

We want to answer three questions: (1) How does the number of evacuees affect the performance of the algorithms? (2) How does the number of source nodes affect the performance of the algorithms? (3) Are the algorithms scalable to the size of the network, particularly will they handle large size transportation networks as in urban evacuation scenarios?

Experiment 1: How does the number of evacuees affect the performance of the algorithms?

The purpose of the first experiment is to evaluate how the number of evacuees affects the performance of the algorithms. We fixed the number of nodes and the number of source nodes of the network, and varied the number of evacuees to observe the quality of the solution and the run-time of CCRP, MRCCP and NETFLO algorithms.

The experiment was done with four test groups. Each group had a fixed network size of 5000 nodes and fixed number of source nodes at 1000, 2000, 3000, and 4000 respectively. We varied the number of evacuees from 5000 to 50000. Here we present the experiment results of the test group with number of source nodes fixed at 2000. We omit the results from the other three groups since this group shows a typical result of all test groups. Figure 5 shows the solution quality represented by evacuation egress time and Figure 6 shows the run-times of the three algorithms.

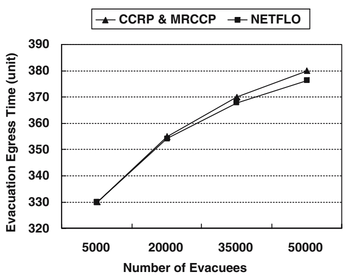


Fig. 5. Quality of Solution With Respect to Number of Evacuees

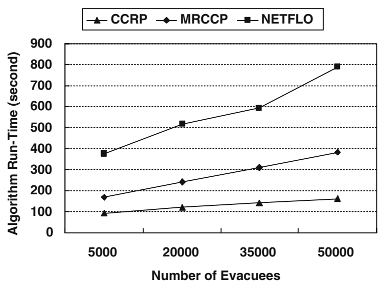


Fig. 6. Run-time With Respect to Number of Evacuees

Since CCRP and MRCCP use the same heuristic method to find solution, it is expected that CCRP and MRCCP produced solutions with the same evacuation egress time for each test case. As seen in Figure 5, CCRP and MRCCP produced very high quality solution compared with the optimal solution produced by NETFLO. The solution quality of CCRP and MRCCP drops slightly as the the number of evacuees grows. In Figure 6, we can see that, in each case, the run-time of CCRP remains half that of MRCCP and less than 1/3 that of NETFLO. In addition, the CCRP run-time is scalable to the number of evacuees while the run-time of NETFLO grows much faster.

This experiment shows: (1) CCRP produces high quality solutions with much less run-time than that of NETFLO. (2) The run-time of CCRP is scalable to the number of evacuees.

Experiment 2: How does the number of source nodes affect the performance of the algorithms?

In the second experiment, we evaluate how the number of source nodes affects the performance of the algorithms. We fixed the number of nodes and the number of evacuees in the network, and varied the number of source nodes to observe the quality of the solution and the run-time. In this experiment, by varying the number of source nodes, we actually create different evacuee distributions in the network. A higher number of source nodes means that the evacuees are more scattered in the network.

Again, the experiment was done with four test groups. Each group had a fixed network size of 5000 nodes and fixed number of evacuees at 5000, 20000, 35000, and 50000 respectively. We varied the number of source nodes from 1000 to 4000. Here we present the experiment results of the test group with number of evacuees fixed at 5000. It shows a typical result of all test groups. Figure 7 shows the solution quality represented by evacuation egress time and Figure 8 shows the run-times of the three algorithms.

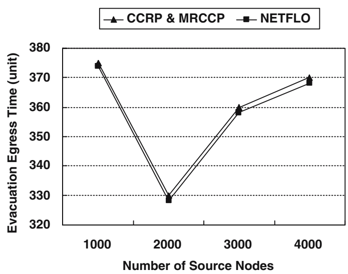


Fig. 7. Quality of Solution With Respect to Number of Source Nodes

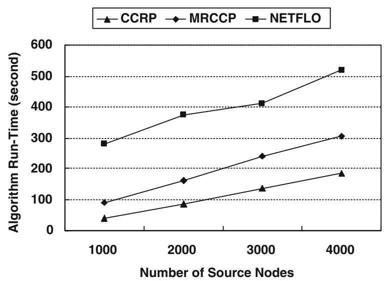


Fig. 8. Run-time With Respect to Number of Source Nodes

As seen in Figure 7, in each test case, CCRP and MRCCP produced high quality solution (within 5 percent longer evacuation time) and the number of source nodes has little effect on the solution quality. It is also noted that the evacuation time is non-monotonic with respect to the number of source nodes and we plan to explore the potential reasons in future works.

Figure 8 shows that the run-time of all three algorithms are scalable to the number of source nodes. However, the run-time of CCRP remains less than half that of NETFLO.

This experiment shows: (1)The solution quality of CCRP is not affected by the number of source nodes. (2) The run-time of CCRP is scalable to the number of source nodes.

Experiment 3: Are the algorithms scalable to the size of the network?
In the third experiment, we evaluate how the network size affects the performance of the algorithms. We fixed the number of evacuees and the number of source nodes in the network, and varied the network size to observe the quality of solution and the run-time of the algorithms.

The experiment was done with a fixed number of evacuees at 5000 and the number of source nodes at 10. We varied the number of nodes from 50 to 50000. Figure 9 shows the solution quality represented by evacuation egress time and Figure 10 shows the run-times.

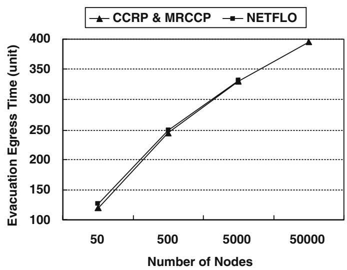
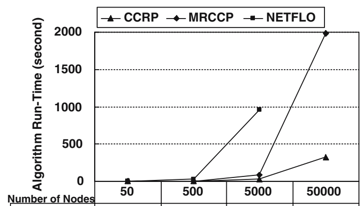


Fig. 9. Quality of Solution With Respect to Network Size



Number of Nodes	50	500	5000	50000
CCRP	0.1	1.5	23.1	316.4
MRCCP	0.1	2.8	78.5	1980.1
NETFLO	0.3	25.6	962.1	

Fig. 10. Run-time With Respect to Network Size

Note: x-axis(number of nodes) in Figure 9 and 10 is on a logarithmic scale rather than linear. Run-time of CCRP and MRCCP in Figure 10 grow in small polynomial.

There is no data point for NETFLO at network size of 50000 nodes. We were unable to run NETFLO for this setup because the size of the time-expanded network became too large (more than 20 million nodes and 80 million edges)that NETFLO could not produce solution.

As seen in Figure 9, in each of the first three test case, CCRP and MRCCP produced high quality solution (within 5 percent longer evacuation time) and the solution quality becomes closer to optimal solution as the network size increases. Figure 10 is shown with a data table of each run-time. The x-axis(number of nodes) of Figure 10 is on a logarithmic scale rather than linear and the run-time of CCRP and MRCCP grow in small polynomial. It can be seen that the run-time of CCRP is scalable to the network size while the NETFLO run-time grows exponentially.

This experiment shows: (1) Given a fixed number of evacuees and source nodes, the solution quality of CCRP increases as the network size increases. (2) The run-time of CCRP is scalable to the size of the network.

We also conducted experiments using a real evacuation scenario. The Monticello nuclear power plant is about 40 miles to the northwest of the Twin Cities. Evacuation plans need to be in place in case of accidents or terrorist attacks. The evacuation zone is a 10-mile radius around the nuclear power plant as defined by Minnesota Homeland Security and Emergency Management [3].

The experiment was done using the road network around the evacuation zone provided by the Minnesota Department of Transportation [2], and the Census 2000 population data for each affected city. The total number of evacuees is about 42,000. The old hand-crafted evacuation plan has an evacuation egress time of 268 minutes. CCRP algorithm produced a much better plan with evacuation time of only 162 minutes. This experiment shows that our algorithm is effective in real evacuation scenarios to reduce evacuation time and improve existing plans.

Our approach was presented in the UCGIS Congressional Breakfast Program on homeland security[30], and the Minnesota Homeland Security and Emergency Management newsletter[31]. It was also selected by the Minnesota Department of Transportation to be used in the evacuation planning project for the Twin Cities Metro Area, which involves a road network of about 250,000 nodes and a population of over 2 million people.

5 Conclusions and Discussions

In this paper, we proposed a new capacity constrained routing algorithm for evacuation planning problem. Existing linear programming approach uses time-expanded network and requires user provided upper bound on evacuation time. To address these limitations, we presented a heuristic algorithm, namely Capacity Constrained Route Planner(CCRP), which produces sub-optimal solution for evacuation planning problem without using time-expanded networks. We provided the algebraic cost model and the performance evaluations using various network configurations. Experiments show that CCRP algorithm produces high quality solution and significantly reduces the computational cost compared to linear programming approach which produces optimal solution. It is also shown that the CCRP algorithm is scalable to the number of evacuees and the size of the transportation network. A case study using real evacuation scenario shows that CCRP algorithm can be used to improve existing evacuation plans by reducing total evacuation time.

The limitation of CCRP algorithm remains the follows. First, we assume that maximum capacity of an edge does not depend on traffic flow amount on the edge. We understand that it is a challenging task to accurately model the capacity of each road segment in a real evacuation scenario as the actual traffic flow rate may depend on vehicle speed as well as road occupancy. Second, the generalized shortest path algorithm we used in CCRP requires that the edge travel time reflects traffic delays at intersections. For future work, we plan to incorporate existing research results, such as Ziliaskopoulos and Mahmassani [33], to better address this problem.

To address the sub-optimality issue of the CCRP algorithm, we also explored the possibility of formulating the evacuation problem as a search problem using A* algorithm. Our A* search formulation addresses the limitations of linear programming approach by only using the original evacuation network to find optimal solution. Thus, it does not require prior knowledge of evacuation time. We proved that the heuristic function used in our A* formulation is monotone and admissible thus guaranteeing the optimality of the solution. Details of the A* search formulation can be found in [25]. It is not included in this paper due to space constraints.

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APPENDIX B

Link and Node Capacities and Journey Times

Node Capacity

Node Reference	Node Type	Node Location (Junction or ONS Output Area)	X Co-ordinate	Y Co-ordinate	Total Node Capacity (veh/hr)
D1	Destination Node	A12/Dunwich Rd	645290	275315	1715
D2	Destination Node	A12/B1387 (The St)	644427	274335	2371
D3	Destination Node	A12/Hazels Lane	643644	273900	2238
D4	Destination Node	A12/The St	640964	270324	2419
D5	Destination Node	A12/Westleton Rd	640124	269171	2508
D6	Destination Node	A12/B1122 (Yoxford Rd)	639871	268713	2550
D7	Destination Node	A12/B1121 (Main Rd), Dorleys Corner	638271	265828	2020
D8	Destination Node	A12/Carlton Rd	637658	264680	2382
D9	Destination Node	A12/Rendham Rd	637615	263350	2291
D10	Destination Node	A12/B1121 (Main Rd), Benhall	637927	261245	3579
D11	Destination Node	A12/A1094	637169	260482	2488
S1	Source Node	N10	645232	266177	
S2	Source Node	N12	644659	265722	
S3	Source Node	N34	645857	262516	
S4	Source Node	N35	647194	259558	
S5	Source Node	N26	644319	262891	
S6	Source Node	N36	644619	261033	
S7	Source Node	N31	644353	262227	
S8	Source Node	N27	644324	262628	
S9	Source Node	N26	644319	262891	
S10	Source Node	N26	644319	262891	
S11	Source Node	N34	645857	262516	
S12	Source Node	N32	644583	262217	
S13	Source Node	N31	644353	262227	
S14	Source Node	N31	644353	262227	
S15	Source Node	N31	644353	262227	
S16	Source Node	N30	644538	262467	
S17	Source Node	N32	644583	262217	
S18	Source Node	N32	644583	262217	
S19	Source Node	N30	644538	262467	
S20	Source Node	N30	644538	262467	
S21	Source Node	N29	644351	262427	
S22	Source Node	N27	644324	262628	
S23	Source Node	N26	644319	262891	
S24	Source Node	N26	644319	262891	
N1	Network Node	B1387 The St/B1125 Dunwich Rd	645415	274300	1684
N2	Network Node	B1125/Westleton Rd	645014	272602	1246
N3	Network Node	Darsham Rd/The Hill	644039	269192	2279
N4	Network Node	B1125/The Hill/Dunwich Rd	644309	269272	1519
N5	Network Node	B1125/Yoxford Rd	644014	268952	1756
N6	Network Node	B1125/B1122 Leiston Rd	643229	266554	1129
N7	Network Node	B1122 Leiston Rd/Pretty Rd	643639	265972	1785
N8	Network Node	B1122 Leiston Rd/Church Rd	643754	265872	2083
N9	Network Node	Church Rd/Chapel Rd	644639	266202	1136
N10	Network Node	Baker's Hill/Minsmere Nature Reserve Access	645232	266177	1855
N11	Network Node	Chapel Rd/Baker's Hill	645097	266107	1339
N12	Network Node	Baker's Hill/Onners Lane/Potter's St	644659	265722	644
N13	Network Node	B1122/Moat Rd	644014	265529	2061
N14	Network Node	B1122/Potter's St	644492	265117	2027
N15	Network Node	B1122/Minsmere Nature Reserve Access	644845	264425	1748
N16	Network Node	B1122/Lover's Lane	644527	263845	1402
N17	Network Node	Abbey Lane/Harrow Lane	643222	263662	1314
N18	Network Node	Harrow Lane/Hawthorn Rd	641562	264869	1756
N19	Network Node	Hawthorn Rd/Unnamed Rd (RAF Leiston)	640569	264498	1325
N20	Network Node	B1121 Main Rd/Clay Hills	638706	264265	1375
N21	Network Node	B1121 Main Rd/Fairfield Rd	638571	263377	1847
N22	Network Node	B1119 Rendham Rd/Chantry Rd	638213	263127	1109
N23	Network Node	B1121 High St/B1119 Mill Rd	638633	263024	1445
N24	Network Node	B1119 Saxmundham Rd/Grove Rd	641350	262561	1736
N25a	Network Node	B1119 Saxmundham Rd/Abbey Lane (north of railway)	642670	263166	1109
N25b	Network Node	B1119 Saxmundham Rd/Abbey Lane (south of railway)	642662	263126	1365
N26	Network Node	B1122 Abbey Rd/Westward Ho	644319	262891	1954
N27	Network Node	B1069 Park Hill/B1119 Waterloo Ave	644324	262628	1705
N28	Network Node	Main St/B1122 High St/Valley Rd	644466	262665	1363
N29	Network Node	Park Hill/Victory Rd/Cross St	644351	262427	1508
N30	Network Node	High St/Cross St/Sizewell Rd	644538	262467	1375
N31	Network Node	Haylings Rd/Kings Rd	644353	262227	1341
N32	Network Node	High St/Kings Rd	644583	262217	1071
N33	Network Node	Lover's Lane/Valley Rd/Sandy Lane	645620	263164	1757
N34	Network Node	Lover's Lane/King George's Ave	645857	262516	1704
N35	Network Node	B1353 The Haven/Aldeburgh Rd	647194	259558	1736
N36	Network Node	B1122 Aldeburgh Rd/B1353 Aldingham Lane	644619	261033	1476
N37	Network Node	B1069 Leiston Rd/B1353 Aldringham Lane	643711	261098	1601
N38	Network Node	B1069 Leiston Rd/School Rd (Mill Rd)	643478	260958	1970
N39	Network Node	School Rd/Grove Rd	641735	261655	1075
N40	Network Node	B1121 Main Rd/B1121 Church Hill	638570	261907	1455
N41	Network Node	B1121 Saxmundham Rd/Church Rd	641095	260489	1584
N42	Network Node	Church Rd/Grove Rd	641487	260516	1829
N43	Network Node	B1121 Aldeburgh Rd/Grove Rd	641269	260226	1645
N44	Network Node	A1094/B1069 Church Rd	639546	259298	1328
N45	Network Node	A1094/Mill Rd	640866	259365	2308
N46	Network Node	A1094/B1121 Aldeburgh Rd	641781	259445	2291
N47	Network Node	A1094/B1069 Snape Rd	641963	259297	1320
N48	Network Node	A1094/B1122 Leiston Rd	645873	257052	2095
N49	Network Node	Church Farm Road/Thorpe Rd	646610	257369	1792

Link Capacity and Travel Time

Link Reference		Travel Time (sec)	Link Capacity (Node A to Node B) veh per hr	Link Capacity (Node B to Node A) veh per hr
Node A	Node B			
N34	N33	55	1109	1038
N34	N30	101	1107	1112
N33	N16	117	1112	1101
N33	N28	117	331	331
N28	N30	18	1028	975
N28	N27	15	1088	1110
N30	N29	24	1103	1088
N30	N32	25	1004	965
N32	N31	21	1087	1003
N32	N36	85	1064	1094
N27	N26	24	1302	1289
N27	N25b	135	902	897
N27	N29	17	965	990
N29	N31	16	1022	990
N31	N37	101	1211	1179
N37	N38	19	1206	1173
N36	N37	65	1005	969
N35	N36	230	1100	1064
N36	N48	273	1119	1119
N49	N35	180	930	930
N49	N48	66	1004	1019
N48	N47	262	1001	1025
N47	N38	166	1119	1119
N38	N39	156	929	914
N47	N46	13	1056	1068
N46	N43	61	1118	1103
N46	N45	54	1081	1081
N45	N43	78	830	834
N45	N44	74	1071	1080
N44	D11	154	1014	1023
N43	N41	23	1119	1119
N43	N42	31	276	276
N42	N41	31	323	323
N42	N39	101	836	836
N41	N40	218	905	917
N40	D10	72	1188	1200
N40	N23	79	1211	1197
N23	N22	56	936	933
N22	D9	47	1029	999
N22	N21	57	323	323
N21	N23	29	990	1022
N23	N24	233	1005	1025
N24	N39	86	836	836
N24	N25b	113	911	930
N25a	N19	195	741	741
N25a	N17	59	945	945
N25a	N25b	5	945	945
N17	N26	117	347	347
N17	N16	117	851	851

N17	N18	164	323	323
N18	N7	187	836	836
N18	N19	101	836	836
N19	N20	172	836	836
N20	N21	65	1212	1239
N20	D8	94	1025	1025
N20	D7	115	1296	1269
N26	N16	55	1056	1043
N16	N15	36	1064	1045
N15	N14	33	1036	1016
N15	N10	148	323	323
N14	N13	44	1036	1016
N14	N12	70	323	323
N12	N11	47	323	323
N11	N10	12	323	323
N11	N9	39	323	323
N9	N12	39	323	323
N12	N13	55	323	323
N9	N8	86	741	741
N13	N8	25	989	972
N8	N7	8	1272	1256
N7	N6	47	1027	1010
N6	N5	177	923	917
N6	D6	231	966	947
N5	D5	300	741	741
N5	N3	15	741	741
N5	N4	25	923	917
N4	N3	31	741	741
N3	D4	270	741	741
N4	N2	227	908	945
N2	D3	150	323	323
N2	N1	113	908	945
N1	D2	63	789	765
N1	D1	63	758	787

Key

(shaded) due to narrow road width (i.e. less than 4m) the single lane capacity has been assumed to be the 2-way capacity.

APPENDIX C

Population Estimates

Daytime Population to be Evacuated

Node Ref	OA Census Reference	Existing Non-Vulnerable (People)	Existing Transient (People)	Existing Vulnerable (People)	Consented (People)	Aldeburgh Road (People)	Valley Road (People)	Remaining SHLAA (People)
D1								
D2								
D3								
D4								
D5								
D6								
D7								
D8								
D9								
D10								
D11								
S1	E00154133	25	0	0				
S2	E00154059	42	150	0				
S3	E00153923	1144	0	40				8
S4	E00153735	153	0	0				
S5	E00153736	131	120	34				
S6	E00153737	111	0	0				
S7	E00153928	97	0	0				
S8	E00153937	66	0	0				89
S9	E00153934	313	0	0				138
S10	E00153921	95	0	199	8			30
S11	E00153925	259	0	0				
S12	E00153932	163	0	0	6			
S13	E00153933	170	0	9		235		
S14	E00153920	132	0	0	6			
S15	E00153931	134	0	0				
S16	E00153927	280	0	15				
S17	E00153929	136	0	0				
S18	E00153930	148	0	1034				
S19	E00153926	90	0	72				
S20	E00153924	249	0	0	24			
S21	E00153922	94	0	0				
S22	E00153919	190	0	469	4			
S23	E00153936	85	0	0			49	
S24	E00153935	122	0	0	2			
S25	N9							
S26	N10							
S27	N11							
S28	N12							
S29	N13							
S30	N14							
S31	N15							
S32	N16							
S35	N26							
S36	N27							
S37	N28							
S38	N29							
S39	N30							
S40	N31							
S41	N32							
S42	N33							
S43	N34							
S44	N35							
S45	N36							
Source Total (People)		4428	270	1872	49	235	49	264

Night time Population to be Evacuated

Node Ref	OA Census Reference	Existing Non-Vulnerable (People)	Existing Transient (People)	Existing Vulnerable (People)	Consented (People)	Aldeburgh Road (People)	Valley Road (People)	Remaining SHLAA (People)
D1								
D2								
D3								
D4								
D5								
D6								
D7								
D8								
D9								
D10								
D11								
S1	E00154133	18	0	0				
S2	E00154059	56	150	0				
S3	E00153923	163	0	40				11
S4	E00153735	185	0	0				
S5	E00153736	192	120	34				
S6	E00153737	230	0	0				
S7	E00153928	256	0	0				
S8	E00153937	122	0	0				122
S9	E00153934	356	0	0				189
S10	E00153921	261	0	84	11			41
S11	E00153925	325	0	0				
S12	E00153932	255	0	0	8			
S13	E00153933	313	0	9		321		
S14	E00153920	328	0	0	8			
S15	E00153931	300	0	0				
S16	E00153927	197	0	15				
S17	E00153929	260	0	0				
S18	E00153930	305	0	0				
S19	E00153926	245	0	72				
S20	E00153924	275	0	0	32			
S21	E00153922	251	0	0				
S22	E00153919	387	0	0	5			
S23	E00153936	288	0	0			68	
S24	E00153935	280	0	0	3			
S25	N9							
S26	N10							
S27	N11							
S28	N12							
S29	N13							
S30	N14							
S31	N15							
S32	N16							
S35	N26							
S36	N27							
S37	N28							
S38	N29							
S39	N30							
S40	N31							
S41	N32							
S42	N33							
S43	N34							
S44	N35							
S45	N36							
Source Total (People)		5847	270	254	68	321	68	362

APPENDIX D

Model User Guide

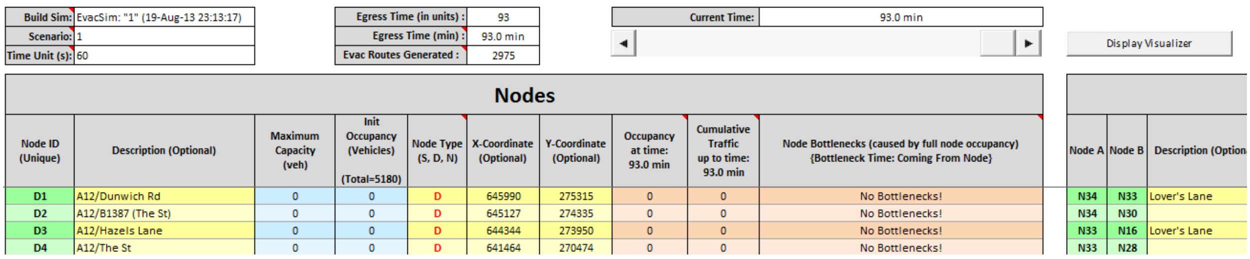
Evacuation Model User Guide

1. In order to run the model the model ‘EvacSim 190813 Final’ must be saved in the same folder as the Excel Add-In file ‘EvacSim.Addin’.

2. When making changes to the model ‘EvacSim 190813 Final’ it is best to save it to a folder that does not have the Add-In file within it as otherwise the model will run each time a change is made and will slow the editing process down. Only have the Add-In file located in the same folder as the model when the model needs to be run.

3. The only section of the model that the user should change is in the ‘Variables’ worksheet. The user should choose which scenario they would like to run. The scenarios are referenced 1 to 40 and each scenario is described in the table on the right hand side of the Variables worksheet. In addition the user can vary the following parameters within the Variables worksheet:
   - Self-Evacuate Vehicle Occupancy (default is 2)
   - Vulnerable Vehicle Occupancy (default is 20)
   - % Stay at Home (default is 10%)
   - % of background traffic to evacuate (default is 50%)

4. Once the scenario and other Variable parameters are chosen the model will run for a few moments. The inputs and results of the run can be seen in the ‘Evac Simulation’ worksheet. The image below provides a screenshot of part of the ‘Evac Simulation’ worksheet.



Build Sim:	EvacSim: "1" (19-Aug-13 23:13:17)
Scenario:	1
Time Unit (s):	60

Egress Time (in units) :	93
Egress Time (min) :	93.0 min
Evac Routes Generated :	2975

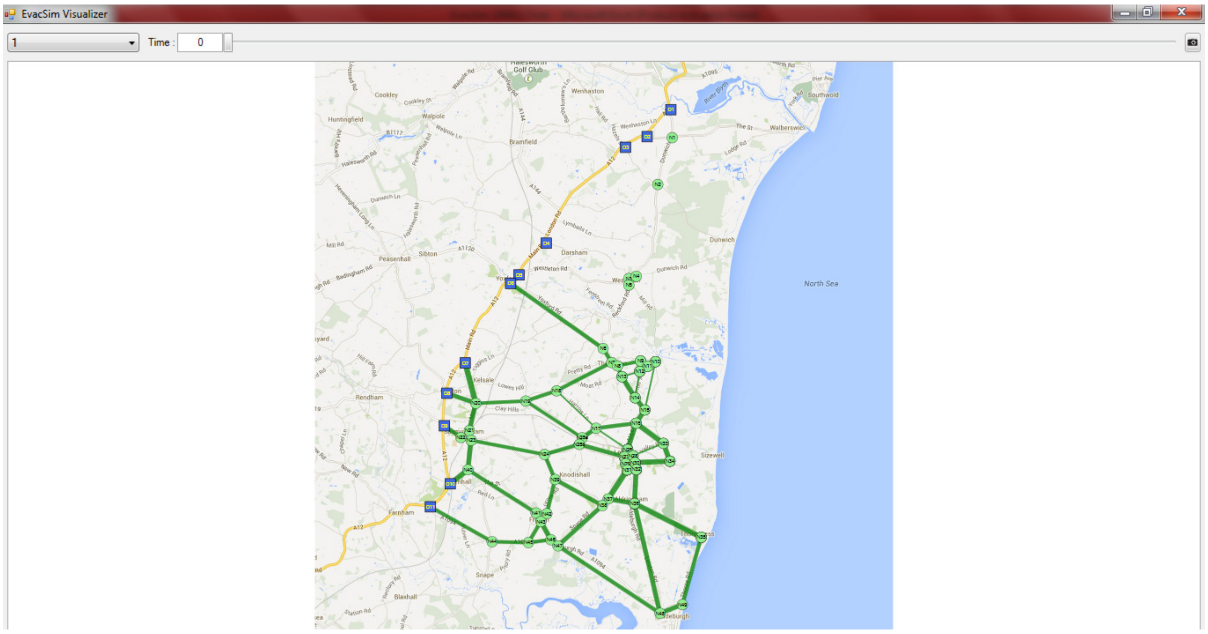
Current Time:	93.0 min

Display Visualizer

Nodes									
Node ID (Unique)	Description (Optional)	Maximum Capacity (veh)	Init Occupancy (Vehicles) (Total=5180)	Node Type (S, D, N)	X-Coordinate (Optional)	Y-Coordinate (Optional)	Occupancy at time: 93.0 min	Cumulative Traffic up to time: 93.0 min	Node Bottlenecks (caused by full node occupancy) {Bottleneck Time: Coming From Node}
D1	A12/Dunwich Rd	0	0	D	645990	275315	0	0	No Bottlenecks!
D2	A12/B1387 (The St)	0	0	D	645127	274335	0	0	No Bottlenecks!
D3	A12/Hazels Lane	0	0	D	644344	273950	0	0	No Bottlenecks!
D4	A12/The St	0	0	D	641464	270474	0	0	No Bottlenecks!

Node A	Node B	Description (Option
N34	N33	Lover's Lane
N34	N30	
N33	N16	Lover's Lane
N33	N28	

5. In the top left hand corner of this worksheet it will tell the user which scenario has been run and the time units that the model is running in (default is 60 seconds and should not be changed). The next column along the top of this worksheet tells the user what the evacuation or ‘Egress’ time is (in the example below it is 93 minutes). This column also tells the user how many iterations of the model were needed in order for all of the population to be evacuated (i.e. ‘Evac Routes Generated’). The next column along the top of the worksheet enables the user to scroll through the model run starting at Time 0 until the end of the evacuation. In order to view the visualizer the user should press the ‘Display Visualizer’ button. This will pop up a new window with the map of the evacuation model and a time scroll bar across the top.



6. The user can select the scenario to the displayed in the top left hand drop down menu (note the model will need to have run the scenario for it to appear on the list) and then scroll through the evacuation timebar and see how the traffic evacuates the area. At any point in time the user can click the 'camera' button in the top right hand corner and this will allow the image to be saved.

7. When in the 'Evac Simulation' worksheet the green cells provide the node or link reference, the yellow cells provide description information, the blue cells are the input values and the red cells provide the output. When the timebar is at Time 0 the 'Initial Occupancy' column should show how many vehicles are within each Source Node at the start of the evacuation. When the timebar is at the end of the evacuation all of the vehicles should have moved into the 'Occupancy at Time X' column within the 11 destination nodes. The bottleneck column tells the user at which points in the evacuation were the nodes or link operating at capacity.

Build Sim:	EvacSim: "1" (19-Aug-13 23:13:17)
Scenario:	1
Time Unit (s):	60

Egress Time (in units) :	93
Egress Time (min) :	93.0 min
Evac Routes Generated :	2975

Current Time:	93.0 min

Display Visualizer

Nodes

Node ID (Unique)	Description (Optional)	Maximum Capacity (veh)	Init Occupancy (Vehicles) (Total=5180)	Node Type (S, D, N)	X-Coordinate (Optional)	Y-Coordinate (Optional)	Occupancy at time: 93.0 min	Cumulative Traffic up to time: 93.0 min	Node Bottlenecks (caused by full node occupancy) {Bottleneck Time: Coming From Node}
D1	A12/Dunwich Rd	0	0	D	645990	275315	0	0	No Bottlenecks!
D2	A12/B1387 (The St)	0	0	D	645127	274335	0	0	No Bottlenecks!
D3	A12/Hazels Lane	0	0	D	644344	273950	0	0	No Bottlenecks!
D4	A12/The St	0	0	D	641464	270474	0	0	No Bottlenecks!
D5	A12/Westleton Rd	0	0	D	640474	269321	0	0	No Bottlenecks!
D6	A12/B1122 (Yoxford Rd)	2550	0	D	640171	269013	1276	1276	No Bottlenecks!
D7	A12/B1121 (Main Rd), Dorleys Corn	2020	0	D	638521	266128	1048	1048	No Bottlenecks!
D8	A12/Carlton Rd	2382	0	D	637858	265030	0	0	No Bottlenecks!
D9	A12/Rendham Rd	2291	0	D	637765	263850	1058	1058	No Bottlenecks!
D10	A12/B1121 (Main Rd), Benhall	3579	0	D	637977	261745	760	760	No Bottlenecks!
D11	A12/A1094	2488	0	D	637256	260913	1039	1039	No Bottlenecks!
S1		0	11	S	645432	266177	0	11	No Bottlenecks!
S2		0	94	S	644859	265822	0	94	No Bottlenecks!
S3		0	515	S	645957	262566	0	515	No Bottlenecks!
S4		0	69	S	647094	259808	0	69	No Bottlenecks!

Node A	Node B	Description (Option
N34	N33	Lover's Lane
N34	N30	
N33	N16	Lover's Lane
N33	N28	
N28	N30	
N28	N27	
N30	N29	
N30	N32	
N32	N31	
N32	N36	
N27	N26	
N27	N25b	
N27	N29	
N29	N31	
N31	N37	

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

CUMULATIVE IMPACT ASSESSMENT

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 30 October 2020 **Issue:** 11

1. The Applicants are obliged to consider the impact of their proposed projects in the context of their Cumulative Impact with other projects taking place in the same locality and within a related, or likely to be related, timescale. PINS Advice Note 17 provides useful guidance on how this should be approached.

2. The Examiners will by now be well aware of the whole range of Energy Projects potentially impacting the Sizewell to Friston area. These now include:

   - SPR EA1N wind farm, cable route and substation, plus shared National Grid substation. DCO application accepted by PINS as EN010077.

   - SPR EA2 wind farm cable route, and substations, plus shared National Grid substation. DCO application accepted by PINS as EN010078.

   - National Grid plans for a nine bay NGET substation at Friston (so-called Leiston 400kV Substation) (Ref. 1 page 20 para 2).

   - Sizewell C twin reactor nuclear power station plus related infrastructure (road and rail). DCO application accepted by PINs as EN010012. Ref. 2 provides recent information.

   - Reconductoring of Sizewell to Bramford OHLs. Paragraph 5.1 of Ref. 5. refers.

   - Sizewell B site relocation activities. Ref. 3 refers

   - NGV Nautilus Interconnector and Converter Station. Recorded on PINS NSIP website with DCO application expected Q2 2022. Ref. 4 refers.

   - NGV Eurolink Interconnector connection summary. Ref. 5 refers.

   - Greater Gabbard/North Falls wind farm expansion, with cable route and substation. Ref. 6, Ref. 11 and Ref. 13 refer.

   - Galloper/Five Estuaries wind farm expansion, with cable route and substation. Ref. 6, Ref. 12 and Ref. 14 refer.

   - National Grid SCD1 Interconnector referred to in NGESO Network Options Assessment 2020 (Ref 7 page 51 para 5 refers).

   - National Grid SCD2 Interconnector referred to in NGESO Network Options Assessment 2020 (Ref 7 page 51 para 5 refers).

   - Use of 'Sizewell' as Grid Connection for unspecified future wind farm and interconnector projects until 2030, and more up to 2050 unless an Integrated offshore design adopted (Ref 10 page 112 para 3).

3. However SPR have chosen to only refer (Ref. 8) to potential Sizewell B and Sizewell C developments in their Cumulative Impact Assessment despite the likelihood that ALL of the above projects could be physically or temporally overlapping with those of EA1N and EA2, especially if SPR choose to take full advantage of the extended project timescales potentially allowed by their draft DCO submission.

4. In particular, NGV have specifically raised concerns which they have regarding the feasibility of connecting their Nautilus project to the proposed NGET substation due to site constraints at the substation and the cable route (Ref. 9). If there is sufficient known detail of the Nautilus project to expose these concerns surely this project must warrant inclusion in the list of projects SPR are required to consider for Cumulative Impact Assessments with regard to EA1N and EA2.

5. Although several of the listed projects will fall within Tier 3 of Advice Note 17 it seems extremely likely that there will be pressure from these projects on land and other resources in the vicinity of SPR's EA1N and EA2 projects and that therefore they should be seriously considered within the Cumulative Impact Assessments for EA1N and EA2, which currently seems not to be the case.

6. For all the above reasons the Examiners are requested to consider very carefully whether SPR have adequately addressed the Cumulative Impact Assessment requirements of Advice Note 17 and the relevant underlying legislation, and if not will require additional work to be done.

REFERENCES

Ref. 1 NGET Investment Decision Pack December 2019 NGET_A8.02Generation December 2019. https://www.nationalgridet.com/document/132296/download

Ref. 2 Sizewell C Stage 4 Consultation. https://www.edfenergy.com/sites/default/files/edf-szc4-sumdoc_digital_compressed.pdf

Ref. 3 EDF proposals for relocating some Sizewell B facilities. https://rlfsizewellb.co.uk/

Ref. 4 National Grid Ventures Nautilus Briefing Pack July 2019 https://www.nationalgrid.com/document/125601/download

Ref. 5 National Grid ESO document archived by SASES http://sases.org.uk/wp-content/uploads/2018/08/National-Grid-Briefing-Note-Interconenctors-Sizewell.pdf

Ref. 6 Crown Estate news 28 August 2019 https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2019-28-gw-of-offshore-wind-extension-projects-to-progress-following-completion-of-plan-level-habitats-regulations-assessment/

Ref. 7 NGESO Network Options Assessment 2020
https://www.nationalgrideso.com/document/162356/download

Ref. 8 [APP-569] SPR Appendix 29.5 Cumulative Impact Assessment pages 42 and 43 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001534-6.3.29.5%20EA1N%20ES%20Appendix%2029.5%20LVIA%20Cumulative%20Assessment.pdf

and paragraph 84 of Chapter 31 Conclusions [APP-079]
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001542-6.1.31%20EA1N%20Environmental%20Statement%20Chapter%2031%20Conclusions.pdf

Ref. 9 National Grid Venture PINS representation 9 March 2020
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001723-National%20Grid%20Ventures.pdf

Ref. 10 National Grid ESO Offshore Coordination report
https://www.nationalgrideso.com/document/177221/download

Ref. 11 North Falls Offshore Wind Farm
https://www.4coffshore.com/windfarms/united-kingdom/north-falls-united-kingdom-uk4j.html

Ref. 12 Five Estuaries Offshore Wind Farm
https://www.4coffshore.com/windfarms/united-kingdom/five-estuaries-united-kingdom-uk4i.html

Ref. 13 North Falls Offshore Wind Farm
https://www.northfallsoffshore.com/

Ref. 14 Five Estuaries Offshore Wind Farm
https://fiveestuaries.co.uk/about/

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

SUBSTATION DESIGN PRINCIPLES

Interested Party: Chris Wheeler **PINS Refs:** 20023840 & 20023842

Date: 31 October 2020 **Issue:** 11

1. Introduction The proposed onshore substations and National Grid substation are very broadly defined in the Draft DCO and it follows that the proposed *Outline Substation Design Principles* document should apply to each and every item listed, including fencing, signage, lighting, access and parking. In particular the *Principles* must reasonably be extended to include the National Grid substation for which minimal design information is provided.

2. The currently proposed design of the SPR substations would have a significant adverse Impact on the landscape in the Friston area, especially for properties close to the site and also in Aldeburgh Road, who will receive **no mitigation** from the proposed tree planting, even assuming this grew as stated. This assertion is supported by the independent professional Landscape advice taken by Friston residents, referred to elsewhere.

   It is therefore essential that the design of any such substations should be such as to minimise their landscape visual impact (as well other impacts such as noise, flooding etc.). The current design is regarded as **unacceptable** and should not be consented. However, the proposals below would ensure some improvement to the proposed mitigation and should therefore **be included in any DCO Consent order**.

3. The current design of the EA1N and EA2 substations is understood to be based on the EA1 substation recently constructed near to Bramford NGET substation (Ref. 1), and as described in the ES for that project. Overhead images of the Bramford site and comparison with the EA1N and EA2 documentation confirm this. But it should be noted that the Friston substations potentially have significantly taller harmonic filter equipment (18m high versus 12m documented for EA1 at Bramford) (Ref. 2) and these items of equipment would be both highly visible and are documented as being the most noise producing equipment within the proposed substations (Ref. 3).

   But SPR have offered no justification as to why the Bramford EA1 substation design is the best that can be achieved in the much more environmentally sensitive area of Friston, due to it being currently free of any industrial scale development, unlike Bramford.. It is appears that, despite multiple requests during Consultation, SPR have made no significant effort to achieve a more optimised design, such as by employing independent, industry leading, electrical consultants to advise, as the design shown has been basically unchanged since Phase 2 Consultation.

4. However, NPS EN-1 states (author's emphasis):

   *"4.5.2 Good design is also a means by which many policy objectives in the NPS can be met, for example the impact sections show how good design, in terms of siting and use of **appropriate technologies** can help mitigate adverse impacts such as noise.*

   4.5.3 In the light of the above, and given the importance which the Planning Act 2008 places on good design and sustainability, the IPC needs to be satisfied that energy infrastructure developments are sustainable and, having regard to regulatory and other constraints, are as attractive, durable and adaptable (including taking account of natural hazards such as flooding) as they can be. In so doing, *the IPC should satisfy itself that the applicant has* ***taken into account both functionality (including fitness for purpose and sustainability) and aesthetics*** *(including its contribution to the quality of the area in which it would be located) as far as possible. Whilst the applicant may not have any or very limited choice in the physical appearance of some energy infrastructure, there may be opportunities for the applicant to demonstrate good design in terms of siting relative to existing landscape character, landform and vegetation. Furthermore, the design and sensitive use of materials in any associated development such as electricity substations will assist in ensuring that such development contributes to the quality of the area.*

4.5.4 For the IPC to consider the proposal for a project, ***applicants should be able to demonstrate in their application documents how the design process was conducted and how the proposed design evolved****. Where a number of different designs were considered, applicants should set out the reasons why the favoured choice has been selected. In considering applications the IPC should take into account the ultimate purpose of the infrastructure and bear in mind the operational, safety and security requirements which the design has to satisfy."*

But no evidence has been found in the Application documentation as to how the design process was conducted and what technology and functionality alternatives were considered in order to reduce the adverse environmental impact of the proposed substations.

5. The design of the *Rampion* wind farm on-shore substation near to the NGET substation at Bolney, West Sussex, provides a clear challenge to what SPR are offering for EA1N and EA2. The elevation plans for this (Ref. 4 and extracts in Figs. 1 & 2) show **nothing above 8.3m** in the substation apart from the top of the Super Grid Transformer 'horns' at 10.5m. Everything else is nicely designed to fit below 8.3m, including the service buildings, SVC/STATCOMS etc. It is understood that this type of design is known by specialist engineering contractors as a 'low impact' design (Ref. 5) and it is clear from Ref. 7 that the original design was the subject of considerable improvement as a result of the Consultation and Examination process.

6. The *Rampion* substation plan area (Ref 6 and extract in Fig.3) appears to be about 400m x 100m compared with the 190m x 190m proposed for EA1N and EA2, **so is quite similar in area.** The designed power capability is however 700MW (as per DCO) against the 800MW / 900MW for EA1N and EA2. Also the switchgear is AIS rather than the GIS proposed by SPR, which is why the service buildings are no higher than 6m, but nevertheless it is clear that effort has been made to minimise substation overall height and visual impact.

7. The challenge to SPR has to be why can't they offer a substation design that is much lower profile? Even if the equipment and building height increased to 10m to accommodate the increased power output and use of GIS equipment compared with Rampion it would have far less Adverse Visual Impact than the current SPR design with 15m high service buildings and 18m high harmonic filters.

8. It has also been stated by a local resident with experience of the Galloper wind farm project that GIS circuit breakers are now available which have a significantly reduced height than those used for Bramford EA1 and again this is an area that needs investigation in an effort to reduce the visual and other adverse impacts of the **currently unacceptable design**.

9. SPR have proposed that the cladding and architectural appearance of the EA1N and EA2 substations should be subject to review by organisations such as the Design Council. But these organisations are not believed to be qualified to critique the choice and arrangement of electrical power equipment which is the underlying cause of the landscape impact. And neither can the Local Authorities and other Statutory organisations involved in the Applications be expected to retain specialist staff able to fully challenge the technical design.

10. It is therefore proposed that any DCOs approved for EA1N and EA2 include wording requiring SPR to have the all the related substation designs, including the National Grid substation, reviewed by industry leading independent power engineering consultants against the strict criterion of achieving the lowest possible landscape and other adverse environmental impacts by best choice and layout of power equipment, as was the design approach with the *Rampion* project.

    The outcome of such a review should be signed off by a recognised authority, such as a suitably qualified person nominated by the Royal Academy of Engineering. Clearly such a requirement must run alongside the aesthetic design aspects of the substation being subject to review by the Design Council or equivalent organisation as already proposed by the Applicant.

11. An integrated approach to all aspects of substation design, including structures, landscape, rights of way etc. as envisaged by ExQ1 1.0.8 would be highly desirable and could readily incorporate the principles outlined in paragraph 10 above. An Overview Panel comprising relevant experts together with Local Authority and community representatives to address the respective issues would be very appropriate, as part of a staged review and guidance process. Such a panel would need to be able to address and advise on cumulative impact issues arising from potential other projects.

    The 'design approach' methodology used for the Hinkley Point C Connector Project appears relevant and the timetable to which it was operated could be a guide to this new project.

12. A particular concern is that there remains the possibility of the project being substantially changed in the event that the subsidies required by the Applicant are only partly available through the CfD process. As this would probably be post-DCO consent the Overview Panel would need to authorised to remain active to address such issues until such time as a finalised design has been agreed.

13. The Examiners are asked to recognise and support the concerns and suggestions raised above.

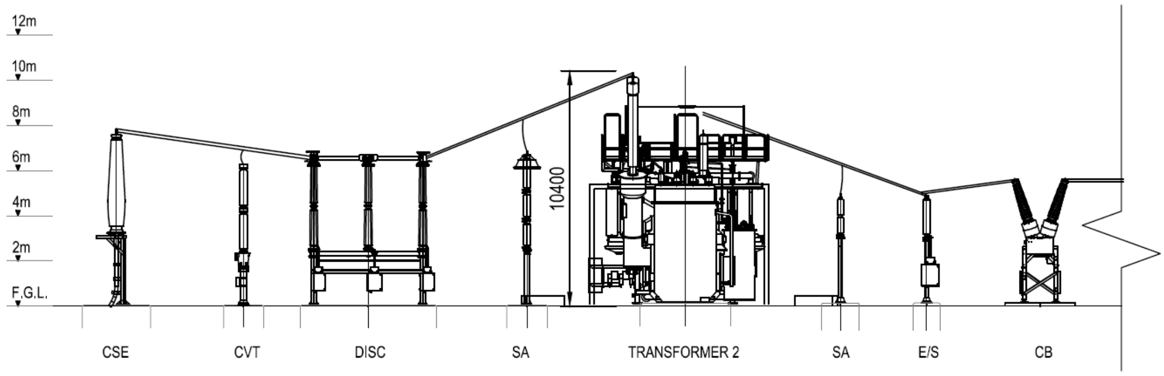


Figure 1

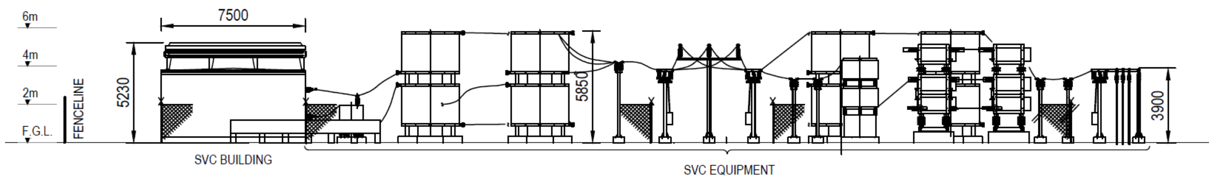


Figure 2

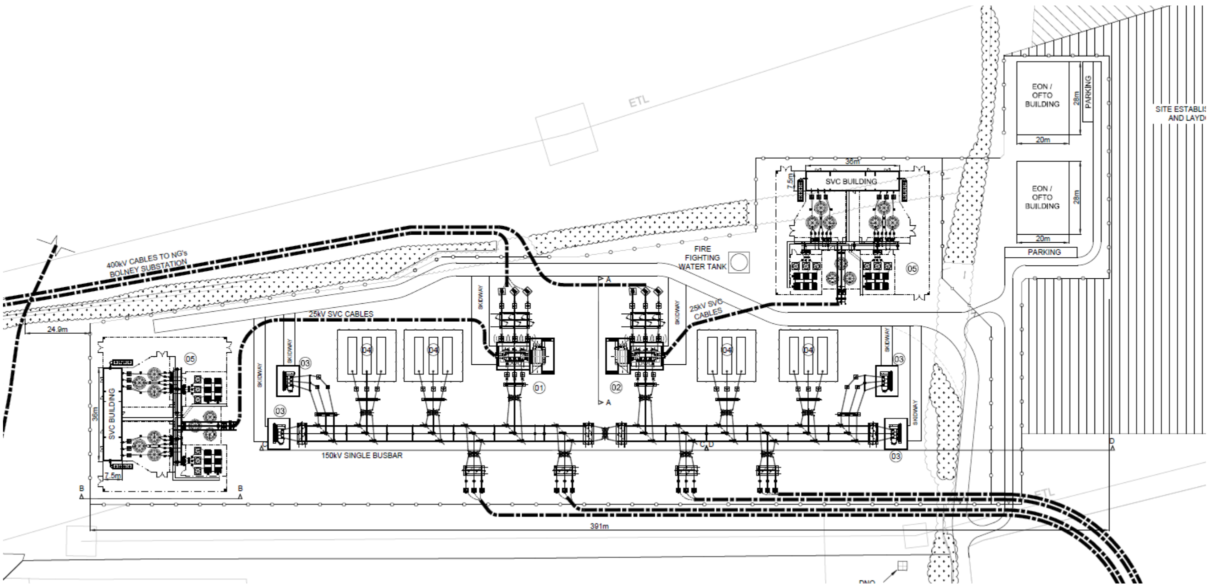


Figure 3

References

Ref. 1 Statement made by Ian McKay of SPR at public meeting held at Thorpeness Country Club on 15th October 2018 at about 19:30.

Ref. 2 http://content.yudu.com/web/2it8t/0A4226m/SDDF/html/index.html?page=26

Ref. 3 EA1N ES 6.3.25.2 Appendix 25.2 CIA page 18 para 50, states:

50. Investigative noise modelling and subsequent analysis of the operational noise level at SSR2 and SSR5 NEW shows that the highest noise level is attributable to the Harmonic Filters of the onshore substation.

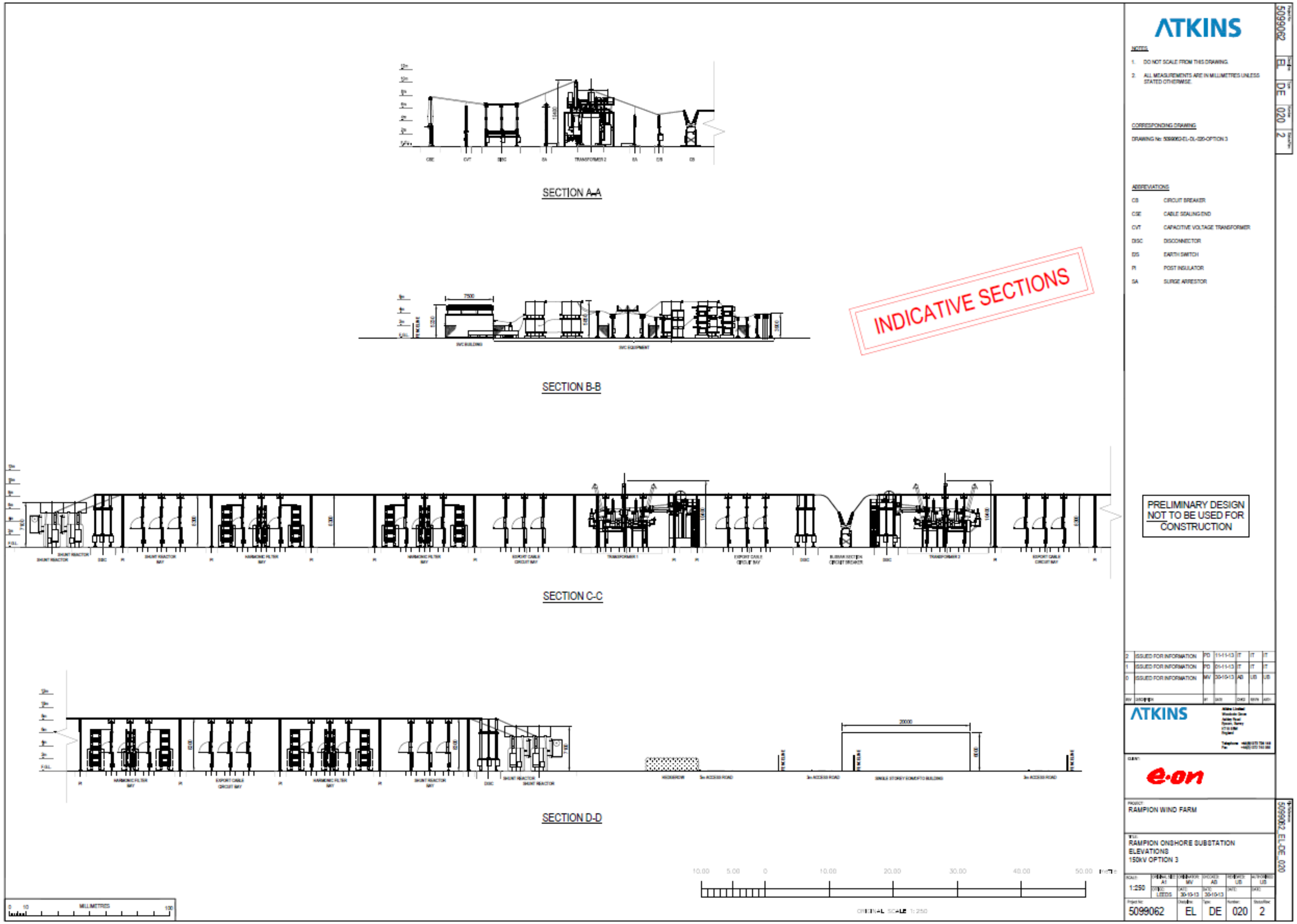
Ref. 4 EN010032-001313-E.ON - Design and Access Statement Version 2.pdf page 15, see drawing below.

Ref. 5 Extract from email from leading electrical contractor dated 26 April 2019 referring to the eventual 'as built' Rampion 400MW substation (author's bolding): *"We successfully designed and delivered a **low impact** design for the Rampion project, however the design is bespoke for each specific application, and there are a number of factors that need to be taken in to account including rating, AC or DC transmission voltage, etc. These factors will effect the size and shape of the final solution."*

Ref. 6 EN010032-001313-E.ON - Design and Access Statement Version 2.pdf page 14, see drawing below.

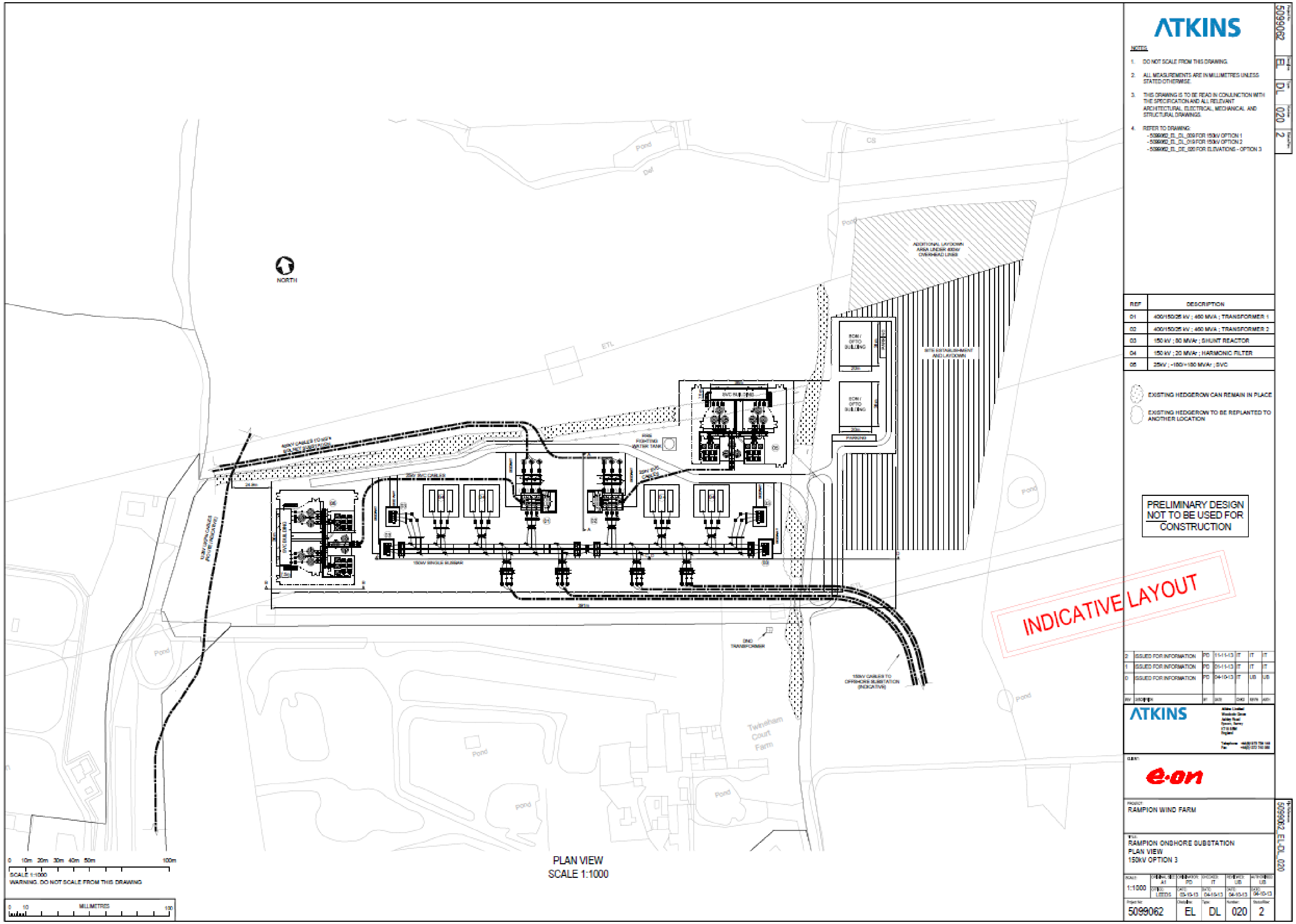
Ref. 7 EN010032-001265-E.ON - Onshore Substation Design and Access Statement https://webarchive.nationalarchives.gov.uk/20180612145228/https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010032/EN010032-001265-E.ON%20-%20Comparison%20between%20Version%201%20and%202%20of%20the%20Onshore%20Substation%20Design%20and%20Access%20Statement.pdf

Ref 4



ATKINS
NOTES
1. DO NOT SCALE FROM THIS DRAWING.
2. ALL MEASUREMENTS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
INDICATIVE SECTIONS
PRELIMINARY DESIGN NOT TO BE USED FOR CONSTRUCTION
RAMPION WIND FARM
RAMPION ONSHORE SUBSTATION ELEVATIONS 150kV OPTION 3
1:250
5099062 EL DE 020 2

Ref 6



ATKINS
NOTES
1. DO NOT SCALE FROM THIS DRAWING.
2. ALL MEASUREMENTS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
PRELIMINARY DESIGN NOT TO BE USED FOR CONSTRUCTION
INDICATIVE LAYOUT
NORTH
PLAN VIEW
SCALE 1:1000
RAMPION WIND FARM
RAMPION ONSHORE SUBSTATION
PLAN VIEW
150kV OPTION 3
1:1000
5099062 EL DL 020 2

WRITTEN REPRESENTATION FOR SPR EA1N and EA2 PROJECTS (DEADLINE 1)

WIND FARM PROJECT DOWNSIZING SUMMARY

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

Date: 23 October 2020 **Issue:** 4

1. Introduction. The frequency with which approved offshore wind farm projects have been downsized relative to their original DCO consent is a matter for severe criticism if the on-shore environmental impact is not commensurately reduced and/or provision made for subsequent project upgrading without fresh on-shore construction.

   It is requested that if, despite all the community and other objections, the Applicants projects are to be consented then the DCOs must incorporate wording requiring the Applicants to construct projects which deliver no less than the full power proposed in their application (subject perhaps to a small margin say 5%) and that they shall not be allowed to modify such power limits by means of a so-called Non-Material Change.

2. Why is downsizing important? This is because DCO Consents allocate critical land and other resources to the Applicant after full examination of the needs of the project and their impact, environmental and otherwise. And also after consideration of the economic, efficiency and coordination aspects of the projects.

   It obviously follows that if a project is not constructed to its full extent but makes use of all the land and other resources allocated then there must be a loss of economy and efficiency, and if subsequently the 'missing' power is provided by a subsequent project then clearly there is a lack of coordination.

3. Rampion example. A particularly outrageous example of the impact of downsizing is the Rampion project in West Sussex. This gained approval for the construction of a 20km cable route not just across open countryside, or even AONB designated land, but across the brand-new South Downs National Park! Post DCO consent it was downsized by 43%, but has nevertheless been constructed using the same cable route and virtually all the allocated substation land near to Bolney NGET substation. Enquiry of the developers has also revealed that the cables etc. used were also downsized to the minimum required for the reduced power, so further development of the Rampion seabed (now under consideration) will require a fresh cable route and a fresh allocation substation land and equipment.

   This clearly makes no sense and has only arisen because of lack of constraint within the wording of the original approved DCO.

4. The summary below provides information on a number of offshore wind farms in England which have been researched. Where possible the source of key information is given, typically from DCO extracts. The reduced power data is mostly taken from a recent *Renewable Energy Foundation* chart which is appended and is presumed correct.

Project Name	DCO power approved (up to)	Reduced power output (% reduction)
Galloper (Sizewell)	504 MW	353 MW (- 30%)
Rampion (Brighton)	700 MW	400 MW (- 43%)
Dudgeon (Norfolk?)	560 MW	402 MW (- 28%)
Triton Knoll (Norfolk?)	1,200 MW	900 MW (- 25%)
Walney Extension (Cumbria)	750 MW	659 MW (- 12%)
Greater Gabbard (Sizewell)	500 MW	504 MW (0%)

Data Sources

Galloper Wind Farm Extract from DCO:

"SCHEDULE 1 Article 2
Authorised project
PART 1
Authorised development
1. A nationally significant infrastructure project as defined in sections 14 and 15 of the 2008 Act on the bed of the North Sea approximately 27 kilometres off the coast of Suffolk and partly within the Renewable Energy Zone, comprising—
Work No. 1—
(a) an offshore wind turbine generating station with a gross electrical output capacity of up to **504 MW** comprising up to 140 wind turbine generators each fixed to the seabed by one of four foundation types"

Rampion Wind Farm Extract from DCO:

"SCHEDULE 1 Articles 2 and 3
Authorised project
PART 1
Authorised development
1. A nationally significant infrastructure project as defined in sections 14 and 15 of the 2008 Act on the bed of the English Channel approximately 13 km from the Sussex coast, comprising—
Work No. 1 –
(a) An offshore wind turbine generating station with a gross electrical output capacity of up to **700 MW** comprising up to 175 wind turbine generators each fixed to the seabed by one of six foundation types"

Dudgeon Offshore Wind Farm

" Our ref: 12.04.09.04/227C
DEPARTMENT OF ENERGY AND CLIMATE CHANGE
ELECTRICITY ACT 1989 (Section 36)
CONSTRUCTION AND OPERATION OF A WIND FARM GENERATING STATION KNOWN AS DUDGEON OFF THE COAST OF NORFOLK
1. Pursuant to section 36 of the Electricity Act, the Secretary of State for Energy and Climate Change ("the Secretary of State") hereby consents to the construction and operation by Dudgeon Offshore Wind Limited ("the Company"), on the areas outlined in

red on Figures 1 and 2 annexed hereto and duly endorsed on behalf of the Secretary of State, of an offshore wind turbine generating station ("the Development") located approximately 32 kilometres from the coast of Norfolk[1].

2. The Development shall comprise:

(a) wind turbine generators of the size and type chosen by the Company

(subject to compliance with any requirements as to their size imposed by or under these conditions);
(b) inter-turbine cabling;
(c) up to 3 offshore sub-stations;
(d) up to 4 meteorological masts; and,
(e) an accommodation platform.
3. The maximum generating capacity of the Development shall not exceed **560MW** at any time."

Further Dudgeon Reference: https://www.statkraft.co.uk/power-generation/offshore-wind/dudgeon/

"Dudgeon Offshore Wind Farm was granted consent in 2012 and will be located 32km (20 miles) off the coast of the seaside town of Cromer in North Norfolk. Its consent allows for up to 560MW of installed electricity generation capacity, however after thorough planning it was decided that the optimal installed capacity will be approximately **400 MW**."

Triton Knoll Wind Farm Extract from DCO:

"SCHEDULE 1 Article 2
Authorised Project
PART 1
Authorised Development
A nationally significant infrastructure project as defined in sections 14 and 15 of the 2008 Act on the bed of the North Sea approximately 33 kilometres off the coast of Lincolnshire and 46 kilometres off the coast of North Norfolk within the Renewable Energy Zone, comprising—
Work No. 1 — an offshore wind turbine generating station with a gross electrical output capacity of up to **1200 MW** comprising up to 288 wind turbine generators each fixed to the seabed by one of five foundation types"

and as amended:

"Amendments to Part 1 (Authorised Development) of Schedule 1 (Authorised Project)
5.—(1) Part 1 (Authorised Development) of Schedule 1 (Authorised Project) is amended as follows.
(2) In the first paragraph of the description of Work No. 1, for "1200 MW" substitute "**900 MW**"

Walney Extension Wind Farm Extract from DCO:

"SCHEDULE 1 Article 3
AUTHORISED PROJECT

PART 1

Authorised Development

1. A nationally significant infrastructure project as defined in sections 14 and 15 of the 2008 Act on the bed of the Irish Sea approximately 19 kilometres off the Isle of Walney coast and partly within the Renewable Energy Zone, comprising—

Work No. 1 –

(a) an offshore wind turbine generating station with a gross electrical output capacity of up to **750MW** comprising up to 207 wind turbine generators with rotating blades, each fixed to the seabed by one of two foundation types,"

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Mr Chris Hill
Project Manager
Greater Gabbard Offshore Winds Limited
c/o Airtricity
20 Garrick Street
London
WC2E 9BT

19 February 2007

Dear Mr Hill

ELECTRICITY ACT 1989 ("the Act")

APPLICATION FOR CONSENT UNDER SECTION 36 OF THE ACT TO CONSTRUCT AND OPERATE AN OFFSHORE WIND FARM NEAR THE INNER GABBARD AND GALLOPER SANDBANKS IN THE OUTER THAMES

APPLICATION FOR A DECLARATION UNDER SECTION 36A OF THE ACT TO EXTINGUISH PUBLIC RIGHTS OF NAVIGATION SO FAR AS THEY PASS THROUGH THOSE PLACES WITHIN THE UK TERRITORIAL SEA WHERE STRUCTURES FORMING PART OF THE OFFSHORE WIND FARM ARE TO BE LOCATED

1. THE APPLICATION

1.1 I am directed by the Secretary of State for Trade and Industry ("the Secretary of State") to refer to the application submitted on 17 October 2005 ("the Application") by Greater Gabbard Offshore Winds Limited ("the Company"), for the consent of the Secretary of State under section 36 of the Act ("section 36 consent"), to the construction and operation of an offshore wind farm with a generating capacity of up to 500MW, comprising up to 140 wind turbines, located in two neighbouring sites, together with up to four electricity sub-stations and up to six meteorology masts.

Renewable Energy Foundation chart listing actual installed capacities

REF
RENEWABLE ENERGY FOUNDATION

Search/Filter List of Renewable Generators

Search again | Back to Generators | Home

Your search returned 41 sites with a capacity of 8,507 MW. In the year to the end of Oct-2018, there were 38 of these sites with a capacity of 8493 MW generating approximately 24,328 GWh and receiving 35,137,839 ROCs.

Page 1 of 1 in descending order of IC (kW)

ID	Generator Name	Country	IC (kW) ▼	Technology	Subsidy	Accreditation	Commissioned	RLF	ALF	LatestData	Latest MWh p.a.	Latest ROCs p.a.
G01177FWEN	Walney Extension	England	659,000	Off-shore wind	None	2017-09-02	2017-09-02			Mar-2018	603,527	
R00021RPEN	London Array Offshore Windfarm	England	630,000	Off-shore wind	RO	2012-11-04	2012-11-04	41.1%	40.0%	Sep-2018	2,209,960	4,125,530
G00008FWSC	Beatrice Offshore Wind Farm	Scotland	588,000	Off-shore wind	None	2018-07-18	2018-07-18			Oct-2018	138,968	
R00007RPWA	Gwynt y Mor	Wales	576,000	Off-shore wind	RO	2013-09-30	2013-09-30	28.6%	36.7%	Sep-2018	1,852,120	3,377,330
R00032RPEN	Race Bank	England	573,300	Off-shore wind	RO	2017-06-08	2017-06-08	41.1%	43.2%	Oct-2018	2,168,090	3,182,570
R00014RPEN	Greater Gabbard	England	504,000	Off-shore wind	RO	2011-02-23	2011-02-23	38.1%	41.0%	Sep-2018	1,811,450	3,362,620
G01178FWEN	Dudgeon Offshore Windfarm	England	402,000	Off-shore wind	CfD	2017-09-19	2017-09-06			Aug-2018	1,586,750	
R00034RPEN	Rampion	England	400,200	Off-shore wind	RO	2017-11-26	2017-11-26			Sep-2018	628,554	1,000,040
R00027RPEN	West of Duddon Sands Offshore Wind Farm	England	388,800	Off-shore wind	RO	2014-02-10	2014-02-10	43.8%	43.1%	Sep-2018	1,467,430	2,789,160
R00031RPEN	Galloper Wind Farm	England	352,800	Off-shore wind	RO	2017-11-05	2017-11-05			Sep-2018	777,551	1,192,480
R00022RPEN	Sheringham Shoal	England	317,000	Off-shore wind	RO	2011-09-02	2011-09-02	37.3%	40.6%	Sep-2018	1,128,430	2,090,200
R00015RPEN	Thanet Offshore Wind Farm	England	300,000	Off-shore wind	RO	2010-07-02	2010-07-02	32.6%	34.7%	Sep-2018	912,654	1,694,010
R00025RPEN	Lincs Wind Farm	England	270,000	Off-shore wind	RO	2012-08-27	2012-08-27	38.7%	41.5%	Oct-2018	980,735	1,597,070
G01175FWEN	Burbo Bank Extension	England	259,000	Off-shore wind	CfD	2016-11-12	2016-11-12	38.4%	37.2%	Oct-2018	843,030	
R00029RPEN	Humber Gateway Offshore Wind Farm	England	219,000	Off-shore wind	RO	2015-03-02	2015-03-02	42.9%	41.9%	Sep-2018	802,922	1,463,410
R00028RPEN	Westermost Rough	England	210,000	Off-shore wind	RO	2014-09-12	2014-09-12	44.9%	48.5%	Oct-2018	891,236	1,442,890
R00023RPEN	Walney Offshore Wind Phase II	England	183,600	Off-shore wind	RO	2011-08-25	2011-08-25	44.6%	45.4%	Oct-2018	730,382	1,161,050
R00019RPEN	Walney Offshore Wind Phase I	England	183,600	Off-shore wind	RO	2011-02-07	2011-01-13	40.6%	38.7%	Oct-2018	622,513	998,040
R00020RPEN	Ormonde Wind Farm	England	150,000	Off-shore wind	RO	2011-08-18	2011-08-18	38.1%	35.2%	Sep-2018	461,960	831,151
R00012RPEN	Gunfleet Sands I	England	108,000	Off-shore wind	RO	2009-07-24	2009-07-24	34.7%	34.2%	Oct-2018	323,334	404,994
R00011RPEN	Inner Dowsing Offshore Wind Farm	England	97,200	Off-shore wind	RO	2008-04-20	2008-04-20	34.6%	35.2%	Oct-2018	299,552	366,163
R00010RPEN	Lynn Offshore Wind Farm	England	97,200	Off-shore wind	RO	2008-03-28	2008-03-15	34.1%	35.2%	Oct-2018	299,804	366,272
R00002DTSC	Aberdeen Offshore Windfarm - Demonstration	Scotland	96,800	Off-shore wind	RO	2018-07-02	2018-07-02			Sep-2018	57,550	
R00003SPSC	Robin Rigg Offshore Wind Farm (East)	Scotland	90,000	Off-shore wind	RO	2010-04-20	2010-04-20	34.6%	35.1%	Sep-2018	258,082	468,485
R00007RPEN	Barrow Offshore Windfarm - A	England	90,000	Off-shore wind	RO	2006-01-01	2006-01-01	35.8%	33.8%	Oct-2018	266,764	222,268
R00002SPSC	Robin Rigg Offshore Wind Farm (West)	Scotland	90,000	Off-shore wind	RO	2009-07-18	2009-07-18	34.9%	36.8%	Sep-2018	290,330	390,544
R00006RPEN	Kentish Flats Ltd - A,C	England	90,000	Off-shore wind	RO	2005-08-01	2005-08-01	31.1%	30.2%	Sep-2018	238,164	220,284
R00005RPWA		Wales	90,000		RO	2009-07-15	2009-07-15	34.6%	35.7%	Sep-2018	281,124	384,622

WRITTEN REPRESENTATION FOR
SPR EA1N and EA2 PROJECTS (DEADLINE 1)

CW OFH3 SCRIPT v11

Interested Party: C C Wheeler **PINS Refs:** 20023840 & 20023842

My name is Chris Wheeler. I am a Friston resident, a member of the Sizewell Stakeholder Group, a contributor to the National Grid Offshore Coordination Project, and a supporter of SASES. My background is as a Chartered Engineer.

1. NGESO Consultation

I want to raise a Planning Issue concerning National Grid ESO's compliance with NPS EN-5 2.2.6, which relates to certain environmental obligations.

I have a letter *(see below)* from Duncan Burt, Director of Operations, which states:

"National Grid has published a document on its website called ***'National Grid's Commitments when undertaking works in the UK'.*** This document explains how we will meet our obligations under Section 38 and Schedule 9 of the Electricity Act 1989".

It defines Stakeholders as: Organisations and individuals who can affect or are affected by our works. We also refer to communities which includes those stakeholders (organisations and individuals, including residents) who have a particular interest in the local area affected by the works.

And provide opportunities for engagement from the early stages of the process, where options and alternatives are being considered and there is the greatest scope to influence the design of the works. These words must clearly refer to the times at which Grid Connection options are being considered using the CION process.

But so far as I am aware no one in Friston has had any meaningful contact whatsoever with National Grid regarding a Grid Connection in our locality or the construction of a new substation.

How therefore can this application be valid when it is the inappropriate choice of Grid Connection which is fundamental to the current misconceived projects.

2. Alternative Solution

I would like to suggest an alternative approach to the Applicant's projects which uses existing technology but which could be more efficient, economic and coordinated, and substantially reduce environmental impact.

For East Anglia 1 the Applicants used two cable trenches with a total of six conductors, and about 10 acres of substation land at Bramford, to land 700MW of power using HVAC, this after gaining non-material change approval to downsize their original 1.2GW HVDC project.

But with their East Anglia 3 project the Applicants are showing that by using HVDC technology they can land 1.4GW of power at Bramford, double that of East Anglia 1, using just one cable trench with three conductors and the same substation area. That's an efficiency improvement of four times for the cabling and trenching and two times for the substation footprint.

So why are we now discussing the need for four cable trenches with twelve conductors and two wind farm substations plus a brand new National Grid substation together covering 30 acres of land at Friston? And this at a site where by my estimation some 100 acres of land would be rendered unfit for human habitation because of the potential noise levels. And all this to deliver just 20% more power than East Anglia 3.

My proposal is that by linking the outputs of the proposed East Anglia 1 North and East Anglia 2 projects the combined power could reasonably be delivered with HVDC using just one cable trench with three conductors and one converter station. And given the long distance capability of HVDC that converter station, which might be 24m high, could be sited on brownfield land, for example at Bradwell or perhaps Bramford, where a suitable site is almost certainly available. And the Applicant may even have residual consent under their East Anglia 1 DCO for a cable route to Bramford.

And further, the CION analysis which found a Grid Connection at Bramford to not be the most economic for these new projects must have been made on the basis of HVAC using four trenches with twelve conductors as previously explained. But if the two projects had been linked as I have proposed, and HVDC used, then only a quarter of the cable trenches and conductors would have been required.

In that case an alternative financial conclusion could well be reached showing a Grid Connection at Bramford to be the most economic, which was in any case what the Applicants had originally expected, and scored most highly by National Grid on a non-financial basis.

And in addition the CION analysis clearly states that the major project risk to National Grid in allowing a connection at Bramford would be NIL.

I request that this alternative approach receive serious consideration for the reasons that I have given and that the current proposals be decisively rejected.

3. Cumulative Impact

Final comments about need for list of projects considered for cumulative impact to be taken from information held by Local Authorities, Ofgem, BEIS, Trade Papers etc. not limited just to those which have high visibility in the public domain.

Thank you.

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08/02//2019

Dear Mr Wheeler,

Re: **Scottish Power Renewables EA1N and EA2 Projects**

Thank you for your letter dated 3rd January 2019 requesting information regarding the approach taken by National Grid concerning the connection applications for Scottish Power Renewables' EA1 and EA2 projects in the South East of England.

As the GB Electricity System Operator, we are required under the Electricity Act (1989) and the terms of our licence to offer the most economic and efficient connection offer in response to a customers' application. In providing such an offer our teams are required to engage with Transmission Owners and Customers to satisfy our duties and obligations.

In the case of the offer made to Scottish Power Renewables for their EA1N and EA2 projects, engagement with the Customer and the TO has been ongoing for a considerable period and the nature of this project and the technology chosen by the customer has evolved during this period.

For offshore generation projects, such as EA1N and EA2 and Interconnector projects applying to connect to the transmission network the application process requires National Grid to carry out the Connection and Infrastructure Options Note (CION) process. This process is an assessment of the connection options that provide the overall most economic and efficient connection point. The process is conducted by the GB Electricity System Operator and involves the project developers and the Transmission Owner. A guidance document providing detailed information on this process is available on our website via the following link: GB ESO CION Process

I am aware that since the connection offer for EA1N and EA2 was issued, SASES have asked National Grid a range of questions relating to the offer made to the customer. I understand that answers to many of these questions have been provided but your letter from 3rd January 2019 requires further clarification which I have pleasure in enclosing.

Yours sincerely

[redacted]

Duncan Burt
Director of Operations

Q1. Given that the original choice of cable route from Bawdsey to Bramford was deemed most economic and efficient in 2010 why was widening or reopening this route not regarded as most economic and efficient in 2017 to allow completion of SPR's projects?

The Bawdsey to Bramford cable route was initially designed by SPR to connect their four offshore wind projects (EA1, EA1N, EA2, EA3) from the onshore landing point at Bawdsey to the National Grid Electricity Network at Bramford. The initial project design proposed this 3.6GW cable route and the CION assessment confirmed that for the offshore design proposed, this was the optimal solution.

Following technical design and configuration changes it was discovered that the capacity of SPR's original cable route was only capable of connecting 1.9GW of capacity. This change prompted SPR to request a review of the connection option. The CION process was re-opened and the assessment identified alternative connection sites as the most economic and efficient connection option. This resulted in a split connection, such that 1.9GW (EA1, EA3) would use the Bawdsey to Bramford cable route and 1.7GW (EA1N, EA2) would connect at a new substation in the Leiston area.

Q2. Given National Grid's obligations under schedule 9 of the Electricity Act 1989 to have regard for the environment in agreeing arrangements for grid connections, please explain how your changed guidance to SPR to use a connection at Sizewell / Leiston has fully satisfied this requirement?

The connection offer process requires National Grid to offer the most economic and efficient solution in response to a customer's application, the CION assessment process ensures that we take account of information from developers and Transmission Owners in developing the connection options.

For SPRs project, the technology changes had a significant impact on the connection requirements of the project, this change had material impact on the connection option previously offered and required us to re-open the CION assessment.

Following the assessment, we met with the customer and the transmission owner to review the connection options. The selection of the preferred connection option considered the cost benefit analysis and the environmental, planning, consenting, technical and deliverability issues associated with each connection option.

The preferred connection offer forms the basis of the connection offer issued to SPR, the CION process remains a 'live' process both pre-offer and post customer signature. This evolves with the project to reflect any changes that may affect the connection option and will be reviewed throughout the development of the project.

The connection offer forms one part of the process that National Grid ESO, National Grid Electricity Transmission and SPR are required to follow in developing the East Anglia offshore wind projects. Following offer signature, the project will undertake further development through the options appraisal process where technically feasible strategic options are assessed. These also form part of our obligations under the Electricity Act 1989.

Q3. Will NG ESO please provide a full copy of the current version of the mandated statement referred to in National Policy Statement EN-1, paragraph 2.2.7, which states that 'transmission and distribution licence holders are also required under Schedule 9 of the Act to produce and publish a statement setting out how they propose to perform this duty (of 2.2.6) generally'.

National Grid has published a document on its website called ***'National Grid's Commitments when undertaking works in the UK'*** this document explains how we will meet our obligations under Section 38 and Schedule 9 of the Electricity Act 1989. These obligations relate to the preservation of amenity and regularly reviewing how we manage those duties, including our consultation process.

A copy of this document can be found via the following link: National Grids Commitments when undertaking works in the UK