Tree Planting for Net-Zero

Assessing the feasibility, effectiveness and cost of a district tree planting programme as a strategy to offset the Borough Council of King's Lynn and West Norfolk's emissions.

Project Title:

Assess the feasibility, effectiveness and cost of a district tree planting programme as a strategy to offset the Borough Council of King’s Lynn and West Norfolk’s emissions.

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Executive Summary

Background:

To comply with the 2015 Paris Accord, the UK Government has set legislation targeting net-zero greenhouse gas (GHG) emissions by 2050 (Committee on Climate Change, 2019). As part of this, it is the responsibility of local authorities (e.g. Borough Councils) to reach net-zero themselves. To achieve this, total GHG emissions must be reduced. For emissions that are difficult to reduce, it is possible to sequester carbon to reach net-zero; this project focuses on tree planting as a means for sequestering this carbon. The purpose of this report is to assess the feasibility, effectiveness and cost of a district tree planting programme to offset the Borough Council of King's Lynn & West Norfolk's (BCKLWN) emissions so as to comply with the governments net-zero by 2050 target.

Required carbon sequestration:

The amount of carbon sequestration necessary to reach net-zero depends entirely on the success of reducing BCKLWN's pre-existing emissions. The latest carbon audit reveals that BCKLWN was responsible for 4632.4 tonnes CO_2e in the 2018-2019 period. However, the plans to move to entirely renewable energy sources means that 1425.2 tonnes CO_2e of scope 2 emissions need not be sequestered. The planned refit of council buildings is also predicted to reduce emissions from heating by 450 tonnes CO_2e per annum. Thus, after these schemes – if we are to assume no further change in emissions – 2757 tonnes CO_2e must be sequestered per year for the council to be net-zero by 2050. However, this is a low-ambition scenario: further reductions can likely be made in scope 1 and 3 emissions, for instance by introducing electric vehicles to the Council's fleet.

Which trees are most suitable?

For such a project, there will be no "perfect" tree (nor woodland), but instead the benefits and suitability of different species much be weighed-up. A key trade-off is whether sequestration capability is prioritised above all else – in which case Conifer plantations would be used – or whether other factors such as biodiversity are to be included. Species suitability varies according to the site, but species such as Oak, Alder, Lodgepole Pine and Scots Pine have been identified as suitable for the (current and future) climate and soil characteristics of the region generally. Forest Research's *Ecological Site Classification-Decision Support Tool* was used to determine which species would be suitable. However, this is not exhaustive and, crucially, species suitability will vary according to *specific* sites' characteristics (for instance, soil type can vary from field to field).

The sequestration benefit of coniferous species such as Scots Pine is found to be approximately 2.7 tC ha^{-1} a^{-1} (tonnes of carbon sequestered per hectare per year), while the sequestration potential of deciduous woodlands generally (including a mixture of species) is found to be approximately 2 tC ha^{-1} a^{-1}. However, as the report states, calculating these figures is complex and figures may vary between sources.

Cost:

To estimate the rough costs of any scheme, the Forestry Commission's Standardised Costs were used. This gives an appropriate cost per tree, including the tree itself, stake, protection (tubing), and labour (both planting and maintenance). These Standardised Costs are £3.79 for small "feather" trees (150-175cm in height and 4-6 years old), and £2.29 for "whips" (100cm-125cm and approximately a year old). These costs were double-checked using the online wholesale stores of two tree-nurseries (Alba Trees and Christie Elite); where – including tree, stake and guards – the cost per Oak tree (whip) would range from £1.00-1.29, while the cost per Scots Pine (whip) would range between £1.07-£1.13. This is without labour: adding the cost of planting and maintenance would likely lead to a similar figure suggested by the Forestry Commission. The cost of planting a mature tree is considerably more expensive. For instance, from Barcham Trees (used by BCKLWN's arboricultural officer) the cost of a single Oak is £166 if 10 trees are bought.

Funding opportunities:

There are various funding opportunities available for local authorities wishing to undertake such schemes, ranging from government grants to private investment. However, private investment is unlikely to be an option: businesses may pay for tree-planting schemes with the assumption that the sequestration can offset their own emissions. It is not possible to double-count these, and thus this would not be helpful for BCKLWN to reach net-zero. Instead, two government schemes have been identified as potential sources of funding. These are the Countryside Stewardship Woodland Creation Grant (CSWCG) and the Urban Tree Challenge Fund (UTCF). The CSWCG is the scheme that is most heavily promoted by the Forestry Commission and entitles local authorities for up to £6,800 per hectare of woodland created – the total amount received depends on actual capital costs, such as saplings, protection, fencing (Natural England, 2018). However, the CSWCG is only available for larger sites. For smaller plots, the UTCF is more appropriate, which covers up to 50% of the costs of planting (with the Council covering the other 50%). The UTCF is catered specifically towards planting in urban areas, and so is particularly suitable for BCKLWN.

Recommendations:

The first two of the recommendations in this project focus on what is feasible on the land identified as available for planting. Recommendation 1 involves planting deciduous species such as Oak, Rowan and Alder on the 1.12 ha site at Chalk Road (Walpole St Peter), which would have an anticipated 2.2 tC/year sequestration potential. Recommendation 2 involves planting similar species on 31 separate sites; these total 5.1 ha and would result in 10.2 tC/year sequestered. The rough costs of these two schemes would be approximately £6,412 and £29,198 respectively. Recommendation 3 acknowledges that the previous two recommendations are inadequate to offset the Council's emissions and thus suggests buying land in order to implement a large-scale planting project. Acknowledging the cost and risk of this, no *specific* plan is laid out, but instead several different scenarios are given to demonstrate the various sequestration potentials of different planting outcomes.

1. Background and Required Sequestration

To avert the negative effects of anthropogenic climate change the UK Government has set legislation to target net-zero greenhouse gas (GHG) emissions by 2050 (Committee on Climate Change, 2019). As part of this legislation, it is the responsibility of local authorities (e.g. Borough and District Councils) to reach net-zero on their own GHG inventories. In order to achieve net-zero, overall GHG emissions must be reduced. However, it is inevitable that some emissions – for instance those from water supply - are difficult to reduce; while future technological gains may contribute towards these reductions, in the meantime these must be sequestered if net-zero is to be reached. One of the most prominent methods of sequestering emissions is the planting of trees, which absorb carbon through photosynthesis. The purpose of this report is to assess the feasibility, effectiveness and cost of a district tree planting programme to offset the Borough Council of King's Lynn & West Norfolk's (BCKLWN) emissions so as to comply with the governments net-zero by 2050 target.

Before making suggestions on tree planting programmes, it is important to first understand the scale of sequestration required. The Council's most recent carbon audit shows that BCKLWN was responsible for 4632.4 tonnes CO_2e in the 2018-2019 period. However, recent plans to move to entirely renewable energy sources means that the 1425.2 tonnes CO_2e from scope 2 need not be sequestered. The planned refit of council buildings is also predicted to reduce emissions from heating by 450 tonnes CO_2e per annum. Thus, after these schemes – assuming no further changes in emissions – **2757 tonnes CO_2e must be sequestered per year for the Council to be net-zero by 2050.** However, this is a low-ambition scenario: further reductions can likely be made in scope 1 and 3 emissions, for instance by introducing electric vehicles. However, making these suggestions and coming up with a different target for sequestration is beyond the scope of this report.

2. Species Identification

2.1. Which tree species are most suitable?

To determine which tree species would be suitable to plant within the borough, Forest Research's *Ecological Site Classification-Decision Support Tool* (henceforth referred to as ESC Tool) was used. The ESC Tool takes into account current *and* future climate scenarios within a specific area, as well as soil characteristics. The soil data from the ESC Tool was trusted to be accurate, however it is worth noting several things relating to soil. Firstly, the borough has a wide range of soil types: as appendix 1 demonstrates, the distribution of these different types is complex and makes giving concrete suggestions of which species will and won't thrive rather difficult. Soil varies from site-to-site, and so soil analyses should be undertaken for any large-scale planting scheme.

Table 1 demonstrates a variety of species that the ESC Tool identifies as Very Suitable, Suitable, Marginal and Unsuitable in three specific areas within the Borough (these were chosen based on the land availability information provided – see section 6). This suitability was determined under the "Medium-high 2050" climate scenario.

A few things from table 1 need to be clarified. Firstly, the unsuitability of Beech is due to the incorporation of future climate data: as Wesche (2003) argues, future warming and decreased rainfall (which is expected to particularly affect the East of England) will make conditions unsuitable for Beech trees.

Secondly, the unsuitability of most tree species in the areas surrounding Burnham Market is due to the high carbonate levels in the soil, which can cause mortality is most species (Forest Research, 2016). However, this is not always the case: if the information in table 1 is true, there would be no trees in Burnham Market (quite obviously not the case), and thus this reinforces a) the importance of taking these results with a slight pinch of salt, but, more importantly, b) for any significantly large planting project, a site-specific soil analysis *must* be undertaken. This is reinforced by Shining Gum being deemed unsuitable at the chosen location within Downham Market, but suitable just 1-2km southeast.

Species	**Suitability**		
	Kings Lynn (TF637200)	**Downham Market (TF608034)**	**Burnham Market (TF832420)**
Sitka Spruce	Unsuitable	Unsuitable	Unsuitable
Scots Pine	Suitable	Suitable	Unsuitable
Lodgepole Pine	V. Suitable	V. Suitable	Unsuitable
Corsican Pine	V. Suitable	V. Suitable	Unsuitable
Common Alder	Suitable	Suitable	Unsuitable
Beech	Unsuitable	Unsuitable	Unsuitable
Oak	Suitable	Suitable	Unsuitable
Rowan	Suitable	Suitable	Marginal
Poplar	Suitable	Suitable	Unsuitable
Silver Birch	Marginal	Marginal	Unsuitable
Hornbeam	V. Suitable	V. Suitable	Suitable
Shining Gum	V. Suitable	Unsuitable	Unsuitable
Wild Service Tree	V. Suitable	Suitable	Suitable

Table 1. The suitability of different tree species for different locations within the Borough, determined using the ESC Tool. Grid references for each site used have been included for reference.

2.2. What is the carbon sequestration of these species?

It is first important to note that the estimation of a tree's carbon sequestration ability is difficult, and figures vary between different sources. There seems to be no universally accepted figure that is widely used, with uncertainty due to varying factors such as soil characteristics, the year of planting, and management (Brainard *et al.,* 2009). The most comprehensive figures for different species are those from Cannell and Milne (1995). While this is an old paper, it is frequently cited by more recent work. Table 2 demonstrates the sequestration abilities of five different forest types, giving the long-term carbon storage of each species per rotation, and then the annual carbon flux. It is interesting to note that the long-term sequestration potential of Beech and Sitka woodland end up being broadly similar (with beech woodland taking longer to reach this so-called equilibrium). This is important in terms of strategy: if trees are planted with the intention that they will be permanent – e.g. in residential areas – then the *long-term* sequestration of carbon will not differ much between these species.

Tree Species (yield class)	**Rotation Length (years)**	**Long-term average amount of carbon in trees, products, litter and forest soil (tC ha^{-1})**	**Net annual carbon flux including trees, products, litter and soil (rate of storage) (tC ha^{-1} a^{-1})**
Sitka Spruce (16)	55	192	3.6
Sitka Spruce (12)	59	167	3.0
Scots pine (10)	71	178	2.7
Beech woodland (6)	92	200	2.4
Oak woodland (4)	95	154	1.8

Table 2. The carbon storage of different forest types of Britain. The data for Sitka Spruce refer to stands subject to intermediate thinning. Adapted from Cannell and Milne (1995).

These figures *do* correspond with other similar analyses. For instance, Nijnik *et al.* (2009) argue that thinned stands of beech (YC 6) would sequester 2.3 tC ha^{-1} a^{-1} (tonnes of carbon sequestered per hectare per year), and that thinned stands of Sitka (YC 12) would sequester 2.8 tC ha^{-1} a^{-1} – both calculations similar to those above. Another interesting analysis – with similar results – comes from Poulton *et al.* (2003), who found that a reforested deciduous woodland, dominated predominantly be Oak (but featuring other species), gained 2.0 tC ha^{-1} a^{-1} over the 120 year period. This is also reflected by Cannell's (1999) assertion that hardwood species *generally* sequester 2 tC ha^{-1} a^{-1}. It thus seems to be universal that 1 ha of deciduous hardwood species sequesters *approximately* 2 tC ha^{-1} a^{-1}, and thus this is the figure that will be used. The sequestration potential of ground-level plants has not been considered as these are unlikely to contribute significantly to the numbers: when carbon is stored in plants, it is done so predominantly in its wood (Dewar and Cannell, 1991) and thus shrubby plants have limited (but not zero) sequestration ability.

3. Cost

It is obvious that the cost of any scheme will vary depending on its specific details. However, this section aims to provide a broad overview of the different costs associated with tree planting projects, for instance the saplings/whips themselves, tree guards, fencing, etc. The Forestry Commission's (2020) Standardised Costs of planting give the best estimates of the cost-per-tree. This suggests that the cost of the tree itself, stake, protection (tubing), and labour (planting and maintenance) will be £3.79 for small "feather" trees (150-175cm and 4-6 years old), and £2.29 for "whips" (100cm-125cm and 1 year old). This was double checked using the online stores of two tree-nurseries (Alba Trees and Christie Elite); where – including sapling, stake and guards – the cost per Oak (whip) would range from £1.00-1.29, while the cost per Scots Pine (whip) would range between £1.07-£1.13. Adding labour to this would likely lead to a similar figure to those suggested by the Forestry Commission, and thus these (Forestry Commission) figures will be used. However, these costs are based on the price for small whips, *not* mature trees. If these were to be used, costs would be considerably higher. For instance, from Barcham Trees – used by BCKLWN's arboricultural officer (Saunders, 2020) – the cost of a *single* 3-4m Oak is £166 if 10 are bought (Barcham, 2020). While this may be expensive, planting mature trees means that the tree is more likely to establish itself, as it is less vulnerable than smaller saplings.

4. Funding Opportunities

There are several funding opportunities available for local authorities wishing to undertake such schemes, ranging from government grants to private investment. However, private investment is unlikely to be an option: businesses may pay for tree-planting schemes with the assumption that the sequestration can offset their own emissions. It is not possible to double-count these, and thus this would not be helpful for BCKLWN to reach net-zero.

Instead, government schemes such as the Countryside Stewardship Woodland Creation Grant (CSWCG) will be more viable. The CSWCG is the scheme that is most heavily promoted by the Forestry Commission. This entitles local authorities for up to **£6,800 per hectare of woodland created** – the total amount received depends on actual capital costs, such as saplings, protection, fencing (Natural England, 2018). The amount that a scheme can claim per capital item is shown in the official government document. There is also a yearly £200 payment for maintenance, however, local authorities *are not* eligible for this. There are several criteria that any planting scheme must meet to be eligible. **The one that most heavily affects BCKLWN is that the minimum area per application is 3ha, the minimum block size is 0.5ha, and the minimum width per block is 20m.**

For areas that are not eligible for CSWCG, there is also the Government's Urban Tree Challenge Fund (UTCF), which covers 50% of the costs of planting, with an upper limit of £1.15 per whip (100% standardised cost £2.29). The UTCF is suitable for sites that do not meet CSWCG requirements. The UTCF requirements are that: "any individual or organisation can submit up to five distinct applications to the UTCF, each of which can contain up to three planting sites or projects. Planting sites cannot exceed half a hectare and must contain a minimum of 150 and a maximum of 5,000 small trees per site" (Forestry Commission, 2020). The current application window for Round 2 has been extended to the 30th June, with planting for this round expected to commence winter 20/21. It is currently unclear whether there will be a third round.

5. Recommendations

Firstly, it remains **highly unlikely that tree planting alone will be enough for BCKLWN to reach net-zero**, and that emissions reductions are essential, reflecting Brainard *et al.*'s (2009) assertion that "storing carbon in British woodlands [is] only…a small stopgap strategy". For illustration, assuming 2050 emissions of 2757 tonnes CO_2e, it would require 1021 ha of Scots pine to be planted by 2050, or 34 ha (85,000 trees) per annum to achieve carbon-neutrality. First and foremost, the recommendations made must be feasible within the constraints of the Council's available land area for planting, information for which was provided by Henry Saunders on 12/05/2020. The information provided had little detail, with only a road-name and the village/town – Google Maps was used to infer the specific parcel of land identified for planting. Once this was identified the OS Roam feature on https://digimap.edina.ac.uk/ was used to measure the area of these patches. **For 26 of the initial 58 areas provided, it was not clear where the area for planting was, either through no identifiable empty space, or the road being a country road surrounded by fields, most of which are unlikely to be owned by the Council: these have not been included in the below recommendations.** The remaining 32 areas – shown in appendix 2 – total 6.2 ha. All but one of these sites (Chalk Road, Walpole St Peter) are small plots of land predominantly in residential/urban areas. For these, it is clear that commercial-type forestry (i.e. coniferous plantations) is not feasible. These recommendations thus work from what is *feasible* on these parcels of land, rather than making overly ambitious, unrealistic plans. Table 3 below provides a brief overview of recommendations 1 and 2, while table 4 details recommendation 3.

	Hectares Planted	**Cost**	**Funding**	**Sequestration Potential**
Recommendation 1	1.12 (Chalk Road, Walpole St Peter)	£6,412	Potential for 50% of costs to be covered by UTCF, but only up to 0.5 ha. Upper limit thus ~£1,431	2.2 tC per year
Recommendation 2	5.1 (31 different sites)	£29,198	Potential for 50% of costs to be covered by UTCF.	10.2 tC per year

Table 3. A summary of recommendations 1 and 2.

Recommendation 1:

Planting on larger plots of land should be prioritised due to the larger sequestration and biodiversity benefits of larger habitats. However, Chalk Road (Walpole St Peter) was the only continuous site larger than 0.5 ha, with a total of 1.12 hectares. However, because the total area is less than 3 ha, this site will not be eligible for the CSWCG **unless a further 1.88 hectares close to the site are found.** The *total site* is also too large for the UTCF. However, if the planting of the site is split into two (so that half is planted first), the site is likely to then be eligible (assuming applications can be made before June 30th or there is a Round 3). The remaining half could thus form an application for subsequent UTCF rounds, or the council could pay the entire costs without the support of a funding scheme. This site should be planted with a mixture of deciduous trees, such as Oak, Rowan, Alder, Poplar and Hornbeam at a recommended spacing of approximately 2m (Woodland Trust, 2020) which would result in approximately 2500 trees/hectare. The use of whips is recommended due to their low-cost and ease of planting. A combination of such deciduous species would be expected to sequester approximately 2 tC ha^{-1} a^{-1}, as section 2.2 argues. By ensuring a variety of species, the risk of pests and disease are minimised (Forest Research, 2020). Buying from respected nurseries also minimises this risk. Using the Forestry Commission's Standardised Cost (£2.29 – explained in section 3), planting the entire estimated 1.12 hectares at 2500 trees/ha would cost £6,412. £1,431 of this could be reclaimed as part of the UTCF (50% of planting cost of 0.5 ha). **Planting this area would result in a carbon sequestration benefit of approximately 2.2 tC/year.**

Recommendation 2:

The remaining 31 areas were all smaller parcels of land in urban areas. Two of these (Nar Ouse Way and Parkway) currently *are* large parcels of land, but major developments are planned on these sites, significantly reducing planting potential. It is unclear how much land will be available after the development, and so Ged Greaves' suggestion of 10% of the original total area will be used. This reduces potential planting area from 1.87 ha to 0.187 ha at Nar Ouse Way, and from 7.77 ha to 0.77 ha for Parkway. Once this is considered, these 31 areas total approximately 5.1 hectares. On these, the types of planting that should occur is similar to that in recommendation 1. It is likely that these smaller plots of land *may* be eligible for UTCF. **These 5.1 ha should have the potential to sequester a further 10.2 tC/year if all these sites are planted.** The costs of planting on these sites will be similar to recommendation 1, and thus using the Forestry Commission's Standardised Cost (see section 3) planting these (estimated) 5.1 ha at 2500 trees/ha would cost £29,198. These sites would be eligible for UTCF funding, so the costs could technically be split 50:50 between the Council and UTCF. However, as section 3 states, each organisation can only make 5 distinct applications each including up to 3 sites: priority should thus be given to the largest sites with the most sequestration potential.

Recommendation 3:

While recommendations 1 and 2 will provide carbon sequestration, it is still far from what is necessary for BCKLWN to come anywhere close to net-zero. The final – and most ambitious – recommendation is thus buying land in order to implement a *large-scale* planting programme, with a mixture of deciduous (as above) and coniferous (e.g. Scots Pine) species. The exact size of any such project would depend on the land available and the Council's level of acceptable risk/expenditure. It is meaningless to make broad recommendations with something of this scale and no knowledge of what the Council would be willing to undertake, so instead table 4 illustrates 5 different planting scenarios (the bottom demonstrating what is necessary to achieve net-zero). The top 4 scenarios assume a mixture of deciduous and coniferous species, and this uses an average of the aforementioned 2 tC ha^{-1} a^{-1}, and Scots Pine's 2.7 tC ha^{-1} a^{-1} – a 50/50 mix would mean an approximate sequestration potential of 2.35 tC ha^{-1} a^{-1}. **All of these scenarios would be eligible for the CSWCG.**

Hectares Planted per Year (2021-2050)	Cost per Year (Excluding Land Costs)	Total Hectares Planted by 2050	Annual Carbon Sequestration by 2050
5	£28,625	150	352.5 tC ha^{-1} a^{-1}
10	£57,250	300	705 tC ha^{-1} a^{-1}
15	£85,875	450	1057.5 tC ha^{-1} a^{-1}
20	£114,500	600	1410 tC ha^{-1} a^{-1}
34 hectares of Scots Pine	£194,650	1021	2757 tC ha^{-1} a^{-1}

Table 4. Five different ambitious planting scenarios.

6. Summary

This project has explored the feasibility, cost and effectiveness of a district tree planting scheme to offset the Borough Council of King's Lynn and West Norfolk's emissions in order to reach net-zero by 2050. Three recommendations have been made: the first two of these focus on planting on pre-identified council land, totalling approximately 6.2 ha with an estimated 12.4 tC sequestered per year. However, it is clear that these two alone will not make a significant difference to BCKLWN's net-emissions – as such recommendation 3 suggests buying land to plant trees. Acknowledging the cost and size of such a project, no *specific* plan is laid out, but instead several different scenarios are given to demonstrate the potential sequestration benefits of this.

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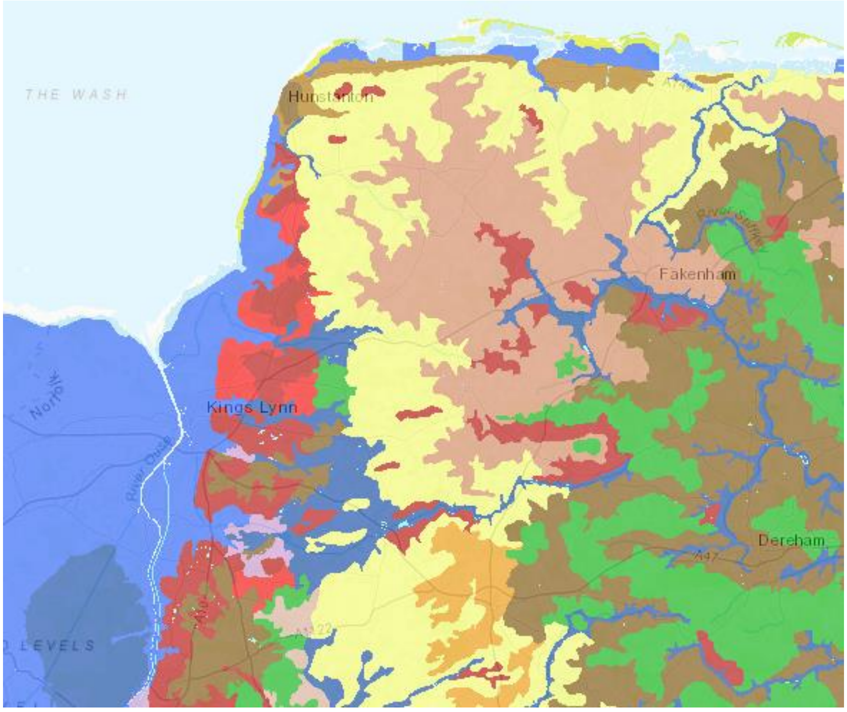
Appendices

Appendix 1 – soil types within the region. A key has not been provided because these soil types were not used to determine species suitability, the map has only been included to demonstrate that soil across the Borough is not uniform (Source: http://www.landis.org.uk/soilscapes/)



Appendix 2 – all 32 sites and their area and eligibility for the two schemes identified. The "sites" column refers to whether the entire area is continuous, or whether – for example – it is separated by a road.

	Site Address	Village/Town	Sites	Area (m^2)
1	Sutton Estate	Burnham Market	2	4290
2	Crofts Close	Burnham Market	1	400
3	Goodricks	Burnham Thorpe	1	500
4	Warrens Road	Clenchwarton	1	800
5	Wildfields Road	Clenchwarton	1	2300
6	Brady Close	Denver	1	330
7	Retreat Estate	Downham Market	1	500
8	Snape Lane	Downham Market	1	4900
9	Town Close	East Winch	1	520
10	Manby Close	Hilgay	1	1480
11	Pearce's Close	Hockwold	1	530
12	Collingwood Road/Nelson Drive	Hunstanton	1	300
13	Hardwick Roundabout	King's Lynn	1	545
14	Riversway	King's Lynn	1	3300
15	Pleasance Close	King's Lynn	1	560
16	Oak Circle/Bishop's Road	King's Lynn	2	3000
17	Hillside	Marham	1	1050
18	Priory Road	North Wootton	1	540
19	Jarvie Close	Sedgeford	1	3450
20	Bluestone Crescent	South Creake	1	680
21	Tower Road	Terrington St Clement	2	1570
22	Caves Close	Terrington St Clement	1	370
23	Alma Avenue	Terrington St Clement	1	2200
24	Westfields	Tilney St Lawrence	1	1700
25	Lode Avenue	Upwell	2	2860
26	Townley Close	Upwell	1	350
27	Hankinsons Estate	Walpole St Peter	1	770
28	St Andrews Close	West Dereham	1	1200
29	Turners Close	Wimbotsham	1	600

30	Nar Ouse Way	King's Lynn	1	1872
31	Parkway	King's Lynn	1	7772
32	Chalk Road	Walpole St Peter	1	11180