SOUTH LANARKSHIRE

TALL WIND TURBINES: LANDSCAPE CAPACITY, SITING AND DESIGN GUIDANCE

Addendum to Landscape Capacity Study for Wind Energy 2016

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1.0 BACKGROUND

Ironside Farrar has been appointed by South Lanarkshire Council (SLC) to update aspects of the recently completed *Landscape Capacity Study for Wind Energy Feb 2016* (LCS 2016) to reflect the increasing size of commercial wind turbines being deployed in wind energy developments.

Many developers are reviewing consented (unbuilt) and new wind energy developments in South Lanarkshire following the change in economic circumstances for onshore wind in the UK. In addition, repowering of existing wind farms is becoming more prevalent.

In order to fully assess the impact of such proposals it is essential that the Council's landscape capacity guidance is up to date and reflects current development trends for taller turbines.

This report therefore updates the elements of the Capacity Study relating to turbine height by assessing the capacity of the landscape to accommodate taller turbines and provides further guidance on local siting and design. It supplements, and should be read in conjunction with, the LCS 2016 and the Council's Supporting Planning Guidance on Renewable Energy 2019. Together, the three documents provide technical support and guidance to the South Lanarkshire Local Development Plan 2 and are material planning considerations.

1.1 Existing Capacity Study

The current Landscape Capacity Study was approved in February 2016 and was subject to public consultation alongside the Council's Statutory Supplementary Guidance for Renewable Energy (adopted March 2016). It is one of a suite of technical reports which support the South Lanarkshire Local Development Plan.

South Lanarkshire's current capacity study and supplementary guidance is based on 5 turbine size categories:

- 15m to <30m
- 30m to <50m
- 50m to <80m
- 80m to <120m
- 120m+

The largest size category of 120m+ reflects the size of turbines used in many currently operating windfarms and applications. In the current guidance there is no upper size limit to this range. However, turbines significantly taller than 120m (e.g. 150m+) are now increasingly proposed and it may be that these appear qualitatively different, in scale and in the landscape, from turbines of ca.120m size.

1.2 Study Scope

Ironside Farrar has undertaken the following review:

1. A background review of larger turbines; their deployment and potential issues associated with them. This includes review of any relevant published (or obtainable in-draft) guidance.

2. Identifying examples of windfarms in South Lanarkshire and other areas in which turbines of ca.140m or greater size are employed or proposed (operational, consented and applications). This is followed by a review of the main characteristics of the proposals and issues (if any) arising relating to turbine size.
3. Site visits to suitable examples of existing wind energy schemes with larger turbines to examine appearance in the landscape and any issues associated with their scale; especially in proximity to significantly smaller turbines or distinctive landforms or features.
4. Preparation of a report:
    - summarising the issues associated with larger size turbines as determined from the review and site visits.
    - proposing a series of criteria to be considered in applications for turbines 150m or greater height
    - proposing a supplement/amendment to the strategic guidance to reflect an additional size category of greater than 150m.

It is emphasised that this study specifically addresses landscape issues relating to increased turbine heights. Considerations relating to other aspects of turbine design, turbine numbers, windfarm size and separation distances are addressed in the LCS 2016 to which this report is an addendum.

2.0 REVIEW OF LANDSCAPE AND VISUAL ISSUES

There is a wealth of material relating to wind turbines and windfarms in the landscape, covering the issues of scale, appearance, siting and design guidance. (South Lanarkshire SPG Renewable Energy provides a list of guidance and information at Appendix 1). This is found in the form of generic guidance as well as in the LVIA sections of environmental statements.

2.1 Current Use of Tall Turbines

At the date of this report, there are a few operational onshore windfarms in Britain with turbines of 150m to blade tip or greater height. These are listed in Table 2.1 below, together with several test turbines, singly or in small groups between 175 and 200m in height and several operational windfarms with turbines of 140 to 149.9m in height. There are also some consented schemes with turbines at 150m or taller. A selection of such developments is shown in Table 2.1.

Table 2.1. Existing/Consented Windfarms with Larger Turbines (at April 2019)

Windfarm (Council Area)	**Turbine heights to blade tip**	**Status**
Calder Water (SLC)	145m	Operational
Clyde Extension (SLC)	140m	Operational
Douglas West (SLC)	149.9m	Consented
Hunterston (N. Ayrshire)	177m, 193.5m (two turbines)	Operational
Lethans (East Ayrshire)	176m, 152m and 136m	Consented
Methil (Fife)	195m (single turbine)	Operational
Middle Muir (SLC)	152m and 136m	Operational
Muirhall Extensions (SLC)	145m and 147m	Operational

There are several windfarm applications in which turbines of 150m and greater are proposed, with the tallest being 220m at Kype Muir Extension in South Lanarkshire (see Table 2.2 below).

Table 2.2. Proposed Windfarms with 150m+ Turbines (at April 2019)

Windfarm	**Turbine heights to blade tip**
Crystal Rig IV (East Lothian/ Scottish Borders)	200m
Cumberhead (SLC)	149.9m and 180m
Kype Muir Extension Variation (SLC)	220m, 200m, 176m and 156m
Sanquahar II (Dumfries & Galloway)	200m and 149m
Stranoch II (Dumfries & Galloway)	175m
Windy Standard III (Dumfries & Galloway)	177.5m and 125m

There are onshore developments outside the UK in which turbines significantly larger than 150m are operating or proposed:

- The Estinnes Windpark in Belgium deploys eleven 7.5MW Vestas turbines at 198m height[1].

[1] https://www.7mw-wec-by-11.eu/

- Kirchheim and Grebenau wind farms in Hesse, Germany have turbines of 131m rotor diameter with a hub height of 164m and 229.5m to blade tip height.
- The largest turbines deployed onshore, at Gaildorf near Stuttgart, Germany, have a hub height of 178m and a total height of 246.5m[2].
- ABO wind is proposing a windfarm at Pajuperänkangas in Finland with Enercon E-160 turbines on 166m towers, giving a total height to blade tip of approximately 246m.

2.2 Aviation Warning Lighting

The requirement for aviation lighting is determined by the Civil Aviation Authority (CAA). Current guidelines require that all structures 150m or greater in height have medium intensity steady red lights mounted[3]. The light specification for medium intensity is 2000cd (candela). In some cases, this lighting specification is required for structures below 150m in height, when near aviation ground facilities. Examples include Neilston and Middleton windfarms which both lie ca.12km to the south of Glasgow Airport.

The CAA has recently published specific guidance for wind turbines of 150m and above[4]. In this case the red lights are to be mounted on the top of the nacelle in a position allowing 360^0 visibility, with 3 lower intensity lights (minimum 35cd) mounted on the tower at half nacelle height.

This requirement is the clearest demarcation between turbines of 150m and taller and turbines below 150m in height, with a few exceptions below 150m as described above. Whereas the perception of height and size is a gradually changing scale subject to judgement, the addition of a highly visible light at night time is a notable qualitative change involving a separate area of considerations. It is noted however that windfarm design and ongoing developments in lighting technology may be able to mitigate potential adverse effects.

2.3 Matters Associated with Size and Scale

There are several key criteria associated with the perception and siting of wind turbines in the landscape, of which the relationship between the size of turbines and the scale of the landscape is a primary consideration. Scale is expressed in both horizontal and vertical dimensions of the landscape itself, but also secondarily in the form of other landscape elements such as trees and houses, often referred to as scale indicators.

Scale in this sense does not refer to a definitive measurement but more to a perception of size, particularly the comparative size between elements. While size can be objectively measured, perceptions of scale are subject to the distance over which objects are seen, and to comparison with other known objects. Two concepts relevant to the perception of scale are:

[2] https://www.altenergymag.com/news/2017/10/27/world-record-for-the-energy-transition--the-world%E2%80%99s-tallest-onshore-wind-turbine-has-been-built-in-the-town-of-gaildorf-near-stuttgart-germany/27357

[3] *Lighting of En-Route Obstacles and Onshore Wind Turbines* DAP Policy April 2010

[4] *Lighting of Onshore Wind Turbine Generators in the UK with a maximum blade tip height at or in excess of 150m Above Ground Level* SARG Policy Statement June 2017

- *Relative size*, in which the size of an object can be determined by comparison with the size of familiar objects within its visual context.
- *Size constancy*, in which the scale of a familiar object is understood when seen within a certain range of distances from the viewer, because of prior knowledge of its size. Size constancy can also allow distances to be determined.

Horner and McLennan[5] emphasise the importance of visual scale and comparison of objects.

> *"Visual scale refers not to the actual dimensions of things, but rather to how small or large something appears to be in relation to its normal size or to the size of other things in its context"*

They also highlight *proportion*, the proper or harmonious relation of one part to another or to the whole. A proportioning system establishes a consistent set of visual relationships between the parts of a feature, as well as between the parts and the whole:

> *"Although these relationships may not be immediately perceived by the casual observer, the visual order they create can be sensed, accepted, or even recognised through a series of repetitive experiences".*

However, perception can also be confused when visual clues do not conform with expectations. It is much more difficult to determine the distance or size of an object when there are no familiar scale references and landforms are simple, giving few clues for assessing distance. At the extreme, there are several simple optical illusions such as the Ebbinghaus Illusion and the Ponzo Illusion (see Fig. 2.1) which use visual clues to confuse assumptions about scale and distance.

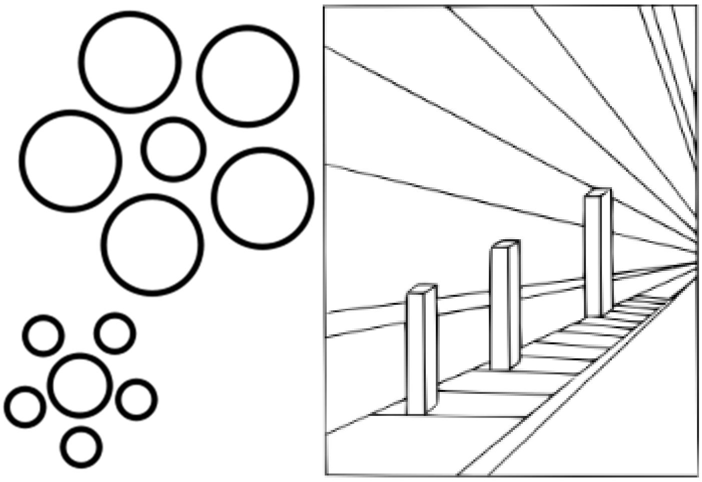

Figure 2.1: ***In the two images above, the middle circles and the posts are the same size, but the use of visual clues (smaller and larger surrounding circles and perspective lines) makes them look a different size***

Taking the above considerations into account; the generally accepted rule is that large wind turbines are more suited to larger scale landscapes with simple, undulating or rounded landforms and patterns. This is because they will be less dominant in these surroundings and there are few or no scale reference objects that would allow perception of their true scale.

5 *Designing Windfarms in the Landscape* SNH Post Consultation Workshop Presentation, 2009

However, the matter of proportion and expectation is also increasingly important in this respect, as the height of turbines and the lateral extent of windfarms increasingly approaches the scale of the landforms and areas in or near which they could be located and has the potential to dominate their character or diminish their stature.

2.4 Existing Guidance

Existing generic guidance on strategic location, siting and design of wind turbines and wind energy schemes of all scales is provided by SNH. Further specific guidance is provided by local authorities in wind energy and landscape capacity studies. This includes South Lanarkshire's LCS 2016[6].

The relationship between turbine size and landscape scale is consistently a key subject in guidance. This is a matter applicable to all sizes of wind turbine, including those greater than 150m in height.

SNH's guidance covers the issues determining siting and design[7] and more strategic matters[8]. Paragraph 2.15 of the siting and design guidance refers to turbine size and scale:

'Choice of turbine size is an integral part of the design process. Identification of the key landscape characteristics, their sensitivity and capacity to accommodate change will inform this. Generally speaking, large wind turbines will appear out of scale and visually dominant in lowland, settled, or smaller-scale landscapes, which are often characterised by the relatively 'human scale' of buildings and features. They are best suited to more extensive, upland areas, and set back from more sensitive upland fringes'.

And in paragraph 3.31:

'Landscape scale and openness are particularly important characteristics in relation to wind turbines because large wind turbines can easily seem to dominate some landscapes. For this reason, landscape scale can dictate the ability of an area to accommodate wind farm development, both horizontally and vertically

Paragraph 3.32 contains additional detailed guidance from SNH with regard to scale.

The guidance also covers aviation lighting, describing the requirement for turbines of 150m or greater, stating in paragraph 2.13:

'…effects are likely to be more significant in areas with less artificial lighting, including remoter rural locations, Wild Land Areas and dark sky sites where the absence of artificial lighting contributes to the feeling of remoteness or the direct appreciation of the night sky. Lit turbines may lessen the contrast between developed and undeveloped areas, e.g. when viewed from nearby settlements'

[6] *South Lanarkshire Landscape Capacity Study for Wind Energy* Feb 2016 Ironside Farrar
[7] *Siting and Designing Windfarms in the Landscape*, v3 Feb 2017, SNH
[8] *Spatial Planning for Onshore Wind Turbines – natural heritage considerations: Guidance,* 2015 SNH

The SLC capacity study and guidance (LCS 2016) is based on the 14 landscape character types (LCTs) of the local authority[9]. The LCTs are subdivided into one or more landscape character areas (LCAs). A detailed analysis of each type is carried out based on landscape character, visual sensitivity and landscape value; in which several criteria such as scale, landform, visibility, designations and perceptual aspects are assessed to determine overall sensitivity.

Broadly speaking, capacity for wind energy developments of different scales is related to sensitivity, with areas of lower sensitivity usually considered to have a higher capacity. The analysis considers capacity in terms of the size of wind turbines. This is strongly related to scale, landform and landscape pattern. Other factors relating to wider strategic objectives and preferred outcomes are also considered when determining capacity for specific areas.

The LCS 2016 indicates the underlying capacity in each LCT for different wind turbine size categories, shown in the form of analysis tables (Table 6.1(a – k)) and capacity maps (Figures 6.1 (a – e). Guidelines on siting and design of wind energy schemes are provided in the tables and text.

The assessment also considers the local authority area as a whole. Sections 6.4 and 6.5 identify strategic areas in which cumulative development is considered to have reached capacity; areas which are not suitable for wind energy development of any significant scale and areas in which capacity for wind energy development remains.

All capacity guidance is necessarily a snapshot in time. Nevertheless, SLC is committed to regularly updating its guidance to reflect changing baseline and trends. The LCS 2016 is itself an update of the original 2010 guidance and this tall turbine guidance should be considered as a supplementary update to the LCS 2016, specifically addressing the trend for increasing height of turbines in operational, consented and proposed schemes.

[9] *South Lanarkshire Landscape Character Assessment* Nov 2010 Ironside Farrar

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3.0 LARGE TURBINES: EFFECTS, SITING AND GUIDANCE

3.1 Introduction

This guidance considers the siting of the largest scale of turbines in the landscapes of South Lanarkshire and its immediate surroundings. It should be read in the context of SLC's existing guidance in LCS 2016 and SNH's siting and design guidance.

Turbine Size Ranges

To allow this matter to be addressed specifically, it is proposed that two new size categories are introduced to the existing scale (Table 3.1 below):

- **120m+ will be replaced by 120m to <150m:** this provides an upper limit to the 120m+ category, but the existing guidance for 120m+ will apply.
- **150m to 250m** will be added. In this case updated guidance will apply, although this is set within the overall framework of the existing guidance.

Table 3.1. Existing and Proposed Wind Turbine Size Categories for SLC

Existing Size Categories	Proposed Size Categories
15m to <30m	15m to <30m
30m to <50m	30m to <50m
50m to <80m	50m to <80m
80m to <120m	80m to <120m
120m+	120m to <150m
	150m to 250m

The proposed upper size limit of 250m is significantly larger than has been deployed or consented to date (see Table 2.1 above). However, the upper limit reflects the current trend in turbine development, onshore applications and deployment in the UK and Europe (see Table 2.2 above and subsequent bullet points).

Landscape and Visual Considerations

It is unlikely that the largest modern turbines can be accommodated in most locations without contemplating a significant level of change in character of the landscape. This guidance is therefore considered in terms of (a) the effects on the landscape; and (b) the appropriate levels of landscape change to be accommodated. The following basic levels of change are expressed as follows in section 2.6.2 of the LCS 2016:

- **Landscape Protection:** Maintain existing landscape character.
- **Landscape Accommodation:** Accept a degree of change providing this does not fundamentally alter key landscape characteristics and visual resources.
- **Landscape Change:** Accept large amounts of change that may fundamentally alter key landscape characteristics and visual resources.

These levels of change are also articulated in SNH's siting and design guidance[10]. Further detail on landscape typologies relating to increasing levels of wind turbine development is given in Table 2.1 of the LCS 2016. These are used throughout the guidance as a basis for understanding and providing guidance on appropriate levels of development.

The updated guidance seeks to highlight the key issues associated with larger turbines. The following matters are considered to be the most critical:

- **Horizontal and Vertical scale**
- **Aviation Lighting**
- **Extensions and siting near smaller turbines**
- **Replacing smaller turbines with larger turbines,** (i.e. Repowering or amending a consent where this involves replacement of consented but unbuilt turbines with larger proposed models)

This chapter (3.0) reviews the landscape and visual issues generically, including the main effects and the potential for mitigation by siting, design or other means.

Chapter 4.0 concludes by identifying areas in South Lanarkshire in which the large turbines could most easily be accommodated and provides guidelines for ensuring the best/ most appropriate landscape fit.

3.2 Horizontal and Vertical Scale

As discussed in 2.3 above, the concept of *relative size* argues that the scale of an object is not a matter of absolute size, but how objects are perceived relative to other objects or features in their context. Furthermore, the proportional relationship between the scale of a turbine/ windfarm and its landscape setting is an important consideration in how the landscape or view may be perceived.

Large turbines will be best suited to landscape types of the largest scale, with gradual slopes, indistinct landforms, simple patterns and few or no smaller scale elements or features.

An extensive horizontal scale is perhaps the most important consideration: both in terms of absolute area and in the sense of scale engendered by the delineation of landforms or land use patterns such as field boundaries and blocks of trees. An extensive area of land will be more able to accommodate a large wind energy scheme without being dominated and can have 'strategic depth' in which larger turbines can be set back from the edge of an area or from a sensitive visual receptor. Large horizontal scale landforms and patterns will help accommodate large turbines by diminishing their apparent scale.

A large vertical scale may help to accommodate large turbines by diminishing their apparent scale. Higher landforms in combination with topographic hollows or screening 'dead ground' may also be able to fully or partly screen the turbines. However, the landform will need to be considerably greater than the turbine size in order that the turbines do not diminish the perceived stature of the landform[11].

[10] See paras 4.5 and 4.6 of *Siting and Designing Wind Farms in the Landscape version 3a* August 2017 SNH

[11] Para 3.32 of SNH's current siting and design guidance suggests that turbines should be *'of minor scale in relation to the other key features of the landscape'*.

Flat or gently undulating landscapes without distinctive landforms provide a less ready scale indicator to a turbine than would a distinctive hill or escarpment. Furthermore, it is more difficult to judge distance in such landscapes.

Estinnes Windpark, Belgium. The turbines are 198m tall but difficult to scale accurately due to the large horizontal scale and indistinct landform

Scale indicators within a landscape, such as houses, trees, roads and electricity lines, can provide a means by which the scale of wind turbines and/or their distance from the viewer can be assessed. Open or uniformly covered landscapes with few such references would be more able to accommodate larger turbines. It is however the case that, once a turbine is more than a certain number of times larger than a familiar scale indicator in the landscape, it becomes difficult to compare the two objects meaningfully. Thus, where there are relatively few houses or trees seen at distance over a relatively flat landscape, they may not prove to be a clear scale indicator.

Hoprigshiels (3x115m) and Ferneylea (2x76m) turbines in Scottish Borders: Scale indicators in the landscape including tree belts and fields allow the relative scales and positions of the turbines to be understood

Overhead electricity transmission lines with lattice towers, typically ca. 25-55m tall, are intermediate in size between houses/trees and commercial wind turbines and can provide a ready scale reference for turbines. This is especially so if the line passes from a receptor location into the windfarm, providing visual clues through perspective. Consideration should be given to the visual relationship of turbines and existing electricity transmission lines as seen from surrounding areas outside the site including where possible avoiding siting large turbines near the lines and vice-versa. Undergrounding of transmission lines associated with schemes should be considered, preferably to a location well beyond the turbines.

3.3 Aviation Lighting

The effects of aviation warning lighting for wind turbines is becoming an increasingly frequent consideration as wind turbines increase in size. The assessment of effects, including visual representation[12], is a developing area. SNH has noted potential effects in its latest siting and design guidance[13] and is in the process of preparing more detailed guidance on the assessment of lighting.

Aviation lighting extends the landscape and visual effects of a proposed development into low light periods (i.e. night time and the periods of dawn and dusk and more exceptionally very dull daylight conditions), creating effects overlapping with and additional to those experienced in daylight.

Despite the different landscape baseline and nature of effects in low light, it is possible to define and assess both landscape and visual effects based on the characteristics of the receiving landscape or views in low light (position and character of skylines; amount, type and location of existing artificial lighting etc.), and the details of the aviation lighting (intensity, colour and number of lights, position relative to landform and other lighting etc.).

The nature of any specific baseline landscape or view will of course vary, much as in different periods of the day depending on weather conditions and time of day. Low light period variations relate to the time period and weather, e.g. dawn, dusk or full night; clear or cloudy skies; the presence or absence of moonlight and starlight; weather and visibility conditions. However, the key factor defining many low light landscapes and views is the degree to which they are affected by artificial lighting, and the characteristics and distribution of that lighting.

The potentially negative environmental effects of artificial lighting is a factor widely recognised in a number of ways. This includes the design and positioning of lighting in developments to minimise light spillage and in a wider sense the recognition of the importance of natural light at night time, particularly through the designation of Dark Sky Areas and Parks:

> *'An IDA International Dark Sky Park (IDSP) is a land possessing an exceptional or distinguished quality of starry nights and a nocturnal environment that is specifically protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment'.*[14]

Although there are no Dark Sky Parks within South Lanarkshire, there is within a neighbouring authority. This notwithstanding, the description above captures the qualities of dark night skies which would be appreciated in the less developed upland landscape character areas of the local authority and immediate neighbouring authorities.

Experience of existing aviation lighting on windfarms and transmission towers demonstrates that in clear conditions the lights are highly visible on clear nights at distances of 10km or more[15]. In areas with little or no background lighting the effects may therefore be significant over some distance. Furthermore, in the case

[12] See paras 174-177 of *Visual Representation of Windfarms – Guidance* v2.2, Feb 2017, SNH
[13] See *Siting and Designing Wind Farms in the Landscape* (paras 2.11-2.13)
[14] International Dark Sky Association website http://darksky.org/idsp/parks/
[15] The lights on Craigkelly Transmitter in Fife are clearly visible from central Edinburgh at 15km and Mount Eagle Transmitter on the Black Isle from the A9 at Bogbain south of Inverness at 17km.

of wind turbines, the rotation of blades can cause a notable blinking effect when the blades pass in front of the light and a flickering reflection effect when the light is seen in front of the blades.

It is therefore possible that in rural areas, including the settings for settlements, the type of medium intensity aviation lights required for 150m+ wind turbines could lead to significant landscape and visual effects in low light periods. These effects would be different in nature and additional to those in daylight hours. The effects should be taken into account in considering a wind energy proposal, recognising that some of the affected locations are valued for their remoteness from developed locations and artificial light or may provide a dark night-time setting for a settlement.

Craigkelly Transmitter lights seen at ca. 15km above rooftops in central Edinburgh

Potential for mitigation of aviation lighting through siting and design measures is relatively limited. The following measures would apply in specific circumstances:

- Use of siting, topography and trees to screen turbines to higher than hub height when seen from sensitive viewpoints.
- If the screening is not possible at the specified turbine height, consider selectively reducing the heights of the turbines that are visible at near hub height – either to below 150m or to a height where the lights would be screened.
- It is understood that warning light intensity can be reduced where the scheme has horizontal meteorological visibility for more than 5km in all directions[16] although it is not clear how variable lighting could be operated to reliably respond to these circumstances. While this may reduce more distant effects it is unlikely to make a great deal of difference close to a scheme located in a naturally dark location.
- More promising recent developments in mitigation include proximity-activated lighting; in which lighting is radar-activated by approaching

[16] *Lighting of Onshore Wind Turbine Generators in the UK with a maximum blade tip height at or in excess of 150m Above Ground Level* SARG Policy Statement June 2017 (item 4g)

aircraft passing within a close distance (one system activates within 5.5km horizontal/ 300m vertical clearance[17]). This would provide a significant level of mitigation in locations where aircraft rarely pass within the prescribed distance, but less so where aircraft pass frequently within the activation zone.

These and other measures that are proposed by developers should be addressed through positive discussion with both the CAA and SNH on how to best mitigate impacts whilst ensuring the maintenance of aircraft safety.

3.4 Extensions and Siting Near Smaller Turbines

It is almost inevitable that, as turbine size increases, turbines of 150m+ will be located close to existing turbines that are considerably smaller; either as an extension windfarm or within a more crowded landscape. Erection of large turbines close to smaller turbines can make a development appear uncoordinated or unbalanced, as well as influencing the perception of distances or perspectives. The extent to which this occurs depends on the degree of size difference; the appearance of the turbines; the proximity and position of the turbines to one another; the nature of the landscape context or view and the position of the turbines relative to the viewer.

The size difference between the proposed turbines and other operational turbines in the area is the most obvious consideration. Gross size differences between turbines, such as turbines being twice the height of their neighbour are easily perceived. However, such occurrences are not common. In cases of lesser contrast, the concept of *size constancy* and many of the other controlling factors cited in 2.3 above can moderate the apparent differences between turbines.

Muirhall Windfarm, South Lanarkshire: The 6 turbines to the right are 125m tall. The 5 turbines to the left are 145/147m tall. The size difference is perceptible but not overt in a wide undulating landscape where it is difficult to tell distances.

In respect of appearance, there is relatively little variation between most commercial scale wind turbines. Experience also indicates that when moving around an area, the potential for differences between different scale turbines to be readily apparent is often reduced by variations in topography and landscape

[17] Terma obstruction light control system:
https://www.terma.com/media/362001/faa_scanter_5000_type_approval.pdf

features within and around a windfarm site and changes in the relative position of the viewer to the turbines. However, the following specific considerations may help reduce visual disparity and contrast where proposed large turbines are to be located near existing smaller turbines:

- Ensuring consistency in appearance is important in reducing the apparent contrast between two sets of turbines of any size. This includes giving consideration to using turbine models that have visually similar hub, blade or tower designs.
- Consistency in turbine proportions is important. This may include a consistent proportion of rotor diameter to hub height when the two developments are seen together; or using similar rotor diameters on different height towers where only upper parts are likely to be seen.
- Using a lower landform elevation for siting taller turbines will even out blade tip height differences, such that the combined sets of turbines will appear as a more evenly balanced composition when seen from a distance.
- Placing larger turbines further away from key viewpoints than existing turbines may still lead to apparent flattening of perspective and condensing of distance, but these effects together with contrast in scale is much more exaggerated when the larger turbines are placed to the fore.

Windy Standard I and III Windfarms (Photomontage)[18]: three sizes of turbine (55m, 125m and 177.5m. Seen from Blackcraig Hill the differences in size are clear

Windy Standard III Windfarm (Photomontage): the closer turbines are 125m and those further away 177.5m. Seen from Cairnsmore of Carsphairn the difference in size is not apparent due to the similar proportions of the turbines and the lower ground elevation of the taller turbines

[18] The photomontages are extracts from the Environmental Statement for Windy Standard III, which is currently (April 2019) at appeal stage.

- Larger windfarms are more able to 'absorb' different size turbines due to the differences in vertical scale becoming a secondary consideration to the broad horizontal scale occupied and the greater visual confusion engendered by large numbers of turbines.

Calder Water and Whitelee Windfarms, South Lanarkshire: The more distant turbines are 110m tall. The closer turbines are 145m tall. The size difference is perceptible but not overt due to the sheer number of turbines.

3.5 Repowering and Changes to Consented Sites

Repowering of existing windfarms that currently have relatively small turbines is becoming a more relevant consideration as the oldest windfarms approach their consented operational lifetime. Furthermore, a number of currently consented, but unbuilt, wind farm sites have received new applications seeking to take advantage of larger turbines. It is likely that some of these sites will propose to be powered with turbines of 150m or greater height. In this case, all the generic considerations of scale, lighting and size contrast covered by existing published guidance, the LCS 2016 guidance and this guidance would apply.

However, it is worth considering specific situations which may arise where the effects, adverse or beneficial, of repowering with significantly larger turbines can be notable:

- Replacing many small turbines with fewer, larger turbines can present a simpler, less cluttered appearance
- Large turbine blades rotate more slowly than smaller turbine blades, presenting a less busy, less cluttered appearance
- Spacing between larger turbines is greater than between smaller turbines, which also reduces clutter but may mean more area is required to accommodate a windfarm
- Larger turbines will have a wider visibility and will, for most visibility conditions, be more prominent when seen at distance
- Aviation lighting will be required, leading to effects in low light
- Larger turbines require larger scale infrastructure, including access/ delivery roads and crane platforms, leading to direct and permanent effects of a greater magnitude. This is particularly the case where

steeper ground which would require larger cuttings and embankments to maintain appropriate road gradients and geometry.

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4.0 LOCAL SITING AND DESIGN GUIDANCE

Further to the generic considerations in Chapter 3.0, the following guidance considers the areas in South Lanarkshire that would be most able to accommodate 150m – 250m turbines, noting that proposals must also satisfy the other criteria set out in the Council's Renewable Energy SPG.

In the LCS 2016, only 3 out of 14 landscape character types were identified as having underlying capacity for turbines of 120m+ height[19]:

- **Plateau Moorlands**
- **Rolling Moorlands**
- **Southern Uplands**

These are also the areas into which 150m – 250m turbines are likely to be most comfortably accommodated, compared with other landscape types. None of the other landscape character types were identified as having capacity for turbines taller than the 80 - <120m category. This indicates that, in principle, it would be very unlikely for turbines taller than 150m to be easily accommodated in these areas without potentially unacceptable landscape and visual effects.

The following guidance outlines the key characteristics of each of the three types; analyses the advantages and disadvantages for siting 150m – 250m turbines; identifies the most suitable landscape character areas within each type and lists guidelines for siting and accommodating the turbines.

Figures 6.1e and f in this report show areas with underlying capacity for turbines of 120m to <150m and 150m to 250m height. These overlap the sequence of Figures 6.1a – e in the LCS 2016 which show capacity for turbines from 15m to over 120m height. Figure 6.1e in this report replaces 6.1e in the LCS 2016.

Reference should also be made to LCS 2016 Tables 6.1 and 6.2 and figures 6.3 and 6.4 for information on capacity, cumulative effects and guidelines for all landscape character types and areas in South Lanarkshire, including the three described in detail below.

4.1 Plateau Moorland

Description (see Figure 4.1 for location of LCAs)

Plateau Moorland is a large scale, undulating upland landscape covering extensive areas. It lies mainly on the northern and western fringes of South Lanarkshire, extending into neighbouring local authority areas. It comprises large unenclosed areas of moorland, often with extensive areas of commercial forestry plantation. More recently very large scale windfarms have become characteristic over much of this type. Its lower slopes merge predominantly with the Plateau Farmlands.

There are two main areas; the Western Plateau (Clyde and Ayrshire Basin Moorlands) and the Central Plateau. Smaller fragments of Plateau Moorland are scattered across Plateau Farmland areas in the north and further small areas are located in the centre of the local authority area. Plateau Moorland is

[19] See Section 6.3, Table 6.1 and Figure 6.1e of the 2016 capacity study

distinguished from the similar Rolling Moorland to the south due to its lower elevation and less dissected nature, with fewer distinguishable hill landforms.

Analysis of landscape

Advantages: large area, wide horizontal scale, elevated with interior set well back from edges, uniform land cover; few obvious scale indicators except for windfarms; limited feeling of wildness; close to settlements with existing lighting from roads, traffic, houses etc.

Disadvantages: few landforms effective for screening - relies on extensive horizontal scale and strategic depth of areas to absorb development; already significantly developed for wind energy.

Landscape Character Areas

Five landscape character areas are identified: **(i) Western Plateau: Whitelee Moor/ Calder Water; (ii) Central Plateau: Black Law; (iii) Central Plateau, Forth/ Tarbrax/ West End; (iv) Western Plateau, Broken Cross/ Coalburn; (v) Western Plateau, Red Moss/Middle Muir**

Guidelines for 150m-250m Turbines

The most suitable areas would be (i) and (ii). These are by far the largest in extent, particularly when neighbouring local authority areas are taken into account and are identified in the LCS 2016. Areas (iii) and (iv) of the Plateau Moorland are likely to be too small to comfortably accommodate this size of turbine without affecting smaller scale more settled adjacent landscape types, particularly Rolling and Plateau Farmland and Upland River Valleys. However, area (v) is located within a wider area of upland landscape character (principally Rolling Moorland) and is already partially occupied by operational turbines.

All the areas in which the turbines could be located already host substantial wind energy developments with turbines between ca.110-147m in height. The addition of larger turbines could therefore often be, or at least perceived as, an extension of an existing scheme; or would be a repowering exercise replacing existing turbines at the end of their commercial or consented life.

To avoid potential domination of neighbouring smaller scale landscapes, larger turbines should be located towards the centre of larger Plateau Moorland areas where they will be less likely to be close to scale indicators in the surrounding farmland, seen at a greater distance and seen behind existing smaller turbines. Peripheral Plateau Moorland areas are therefore shown with a lower capacity then the core parts in Figure 6.1f. Siting larger turbines between sensitive landscape and visual receptors and existing smaller turbines should be avoided where possible, as this will lead to an increased perception of the larger turbine size through exaggerated perspective.

Aviation lighting is likely to have a less adverse effect in areas (i) and (ii), as these areas are closest to extensive urban areas already characterised by artificial lighting.

Repowering of significant areas presents an opportunity to site large turbines in an area which has become characterised by existing wind energy schemes. The replacement of 110-147m turbines by 150-250m turbines may not present a significant change in overall character, provided that effects on peripheral areas close to more sensitive landscape and visual receptors are carefully managed as described above.

4.2 Rolling Moorland

Description (see Figure 4.2 for location of LCAs)

Rolling Moorland is an upland type that extends across a large part of western South Lanarkshire, being in the Clyde and Ayrshire Basins Moorlands between the Avon valley and the Southern Uplands. This type is similar to the Plateau Moorlands but has a more dissected plateau, with greater elevation and more rolling topography; but with lesser elevation and steepness than the Southern Uplands to the south. Prominent hills include Cairn Table and Hagshaw Hill. This type is currently less developed with windfarms than the Plateau Moorland partly as its topography is more varied. The type extends extensively westwards into East Ayrshire where it is still less developed.

Analysis of Landscape

Advantages: large areas, elevated with interior set well back from edges, uniform land cover, potential for rolling landforms to screen turbines; few obvious scale indicators except for windfarms.

Disadvantages: Some landforms are more prominent on a modest scale; some perceptions of wildness, key viewpoint hills; divided by valleys (some extensively settled); already significantly developed for wind energy; some areas lie within a local landscape designation.

Landscape Character Areas

Two landscape character areas are identified: **(i) Hagshaw/ Dungavel (North of Douglas Water); (ii) Crawfordjohn/ Cairn Table (South of Douglas Water).**

Guidelines for 150m-250m Turbines

The Rolling Moorlands are slightly less suitable for development of extensive windfarms than the Plateau Moorlands, primarily due to their more distinctive landform, which in some areas can be of a relatively modest scale as well as there being noted hills with panoramic views. However, this varies across the area with the most distinctive landforms, such as Hagshaw Hill and Cairn Table tending to be southwards, closer to the Southern Uplands. These are the areas which would be least able to accommodate the tallest turbines without adverse visual or vertical scale effects; due either to their nature as a viewpoint, having a relatively modest vertical scale above surrounding valley features and/or a distinctive form.

Most of the areas in which the turbines could be most comfortably located either already host substantial wind energy developments, or have similar developments consented. Turbines vary between 55m and 149.9m height. The addition of larger turbines could therefore often be, or at least perceived as, an extension to an operational or consented windfarm, or would be a repowering exercise, replacing existing turbines at the end of their commercial or consented life.

To avoid potential domination of neighbouring smaller scale landscapes, larger turbines should be located towards the centre of Rolling Moorland areas. There they will be more remote from scale indicators in the surrounding valleys, seen at a greater distance behind existing smaller turbines and/or partly screened by rolling landforms. Peripheral Rolling Moorland areas are therefore shown with a lower or no capacity in Figure 6.1f. Siting larger turbines between sensitive landscape and visual receptors and existing smaller turbines should be avoided where possible, as this will lead to an increased perception of the larger turbine size through exaggerated perspective.

Aviation warning lighting is likely to have a less adverse effect in area (i), which is closest to settlements and more densely populated farmland and valleys characterised by some artificial lighting. However, this is not to the same extent as Plateau Moorland LCAs (i) and (ii). There may be some opportunity to use topography and, in occasional situations, forestry to screen lighting.

Repowering is a matter more likely to arise soon in this area, which holds some of the oldest wind energy infrastructure. However, given the smaller size of the turbines, the remaining lifetime of existing extensions and the relatively distinctive landforms, some care should be taken in the timing of repowering and the siting and numbers of 150-250m replacement turbines, such that lengthy periods in which there are awkward juxtapositions of small and large turbines are avoided.

4.3 Southern Uplands

Description (see Figure 4.3 for location of LCAs)

Southern Uplands is an upland type located in the south of South Lanarkshire. The type comprises ranges of large scale steep rounded hills separated by deep *Upland Glens* and the *Broad Valley Upland* of the Clyde. Eastern areas are extensively affected by forestry, the M74 communications corridor and latterly by extensive windfarm development. Western and southern areas are much less developed and less afforested, having some aspects of wildness in their character, but also with extensive evidence of past mining around Leadhills.

Analysis of Landscape

Advantages: large areas; high landforms; interior set well back from edges; uniform land cover; potential for rolling landforms to screen turbines; few obvious scale indicators except for windfarms in some areas.

Disadvantages: many landforms are steep and/or distinctive; perceptions of wildness; key viewpoint hills; several steep sided smaller scale valleys; extensive areas lie within local landscape designations; some areas already significantly developed for wind energy.

Landscape Character Areas

Three landscape character areas are identified: **(i) East of Clyde/ Daer; (ii) Lowther Hills (Around Daer Water); (iii) Lowther Hills (West of Clyde/ Daer)**

Guidelines for 150m-250m Turbines

The Southern Uplands are the least suitable of the three upland LCTs for hosting large turbines. This is particularly due to a prevalence of distinctive rolling and steep sided conical landforms compared with the undulating/ gently rolling landforms of the other LCTs. Furthermore, western parts of the Southern Uplands have a higher scenic value and less settled character. Nevertheless, the LCS

2016 assesses area (i) as having underlying capacity for turbines of 120m+.The other two areas are more sensitive due to their distinctive character and relative lack of development, separating extensively developed areas within South Lanarkshire, East Ayrshire and Dumfries & Galloway and are unlikely to be able to accommodate turbines over 120m height.

Most areas in which the large turbines could be most comfortably located either already host substantial wind energy development, or have similar developments consented. Turbines vary between 125m and 140m height. The addition of larger turbines would therefore often be, or appear to be, as an extension to an operational or consented windfarm; or as a repowering exercise, replacing existing turbines at the end of their commercial or consented life.

Larger turbines should be located towards the centre of Southern Upland areas, where they will be less likely to be close to scale indicators in the surrounding valleys and glens, potentially screened by the hill landforms and seen at a greater distance behind existing smaller turbines. Peripheral parts of Southern Upland areas are therefore shown with a lower or no capacity in Figure 6.1f. Siting larger turbines on lower outer slopes or between sensitive landscape and visual receptors and existing smaller turbines should be avoided where possible, as this will lead to an increased perception of the larger turbine size through exaggerated perspective.

Aviation lighting is likely to have significant adverse effects in all of the LCAs, as they are sparsely settled areas characterised by low levels of artificial lighting. However, areas close to the M74 corridor are probably the most characterised by lighting, from a combination of motorway traffic, the railway and a string of small settlements and may therefore be slightly less sensitive.

Repowering of significant areas presents an opportunity to site large turbines in an area which has become characterised by existing wind energy schemes. The replacement of 125-140m turbines by 150-250m turbines may not present a significant change in overall character if effects on peripheral areas close to more sensitive landscape and visual receptors are carefully managed, as described above.

4.4 Other Potential Locations

As discussed above, it is considered unlikely that any other landscape character type within South Lanarkshire would be able to comfortably accommodate 150m – 250m turbines. Nevertheless, as this is strategic level guidance, the merits of applications within areas other than the three upland types assessed above would also be considered on a case by case basis. In this circumstance, the characteristics of the proposals and the specific location would be assessed against a series of considerations. While in every case the relevant LCS 2016 guidance should be the starting point for considering applications, the most important considerations are likely to be related to scale and the proximity of sensitive receptors, as follows:

- The height of turbines relative to the vertical and horizontal scale of the receiving landscape
- The number of turbines and extent of the proposed scheme relative to the horizontal scale and extent of the receiving landscape

- The type, number and location of scale indicators in the receiving landscape
- The overall character and value of the receiving landscape type, based on objective factors such as land cover, landform, scale and pattern as well as subjective factors as scenic quality and wildness[20]
- The extent to which surrounding landscape character areas provide a larger scale context to the location of the proposed scheme (e.g. is the area adjacent to one of the upland types considered in 4.1 - 4.3 above?)
- The position of the proposed scheme relative to the boundaries of the landscape character type/area (e.g. is it located fully within the area or does only part of the scheme overlap the area?)
- Relationship with other wind energy schemes, particularly the type of smaller scale scheme with smaller turbines that may be located in upland fringe or lowland areas
- The potential for closer proximity to sensitive visual receptors such as residential properties and settlements.

Review against these considerations may support the development; lead to the conclusion that the proposals are not appropriate to the location; or that modifications to the proposals, such as reduced turbine size or numbers, may allow it to be accommodated without untoward effects.

4.5 Developments of Fewer Than Three Turbines

This tall turbine guidance, together with the relevant LCS 2016 guidance, should be applied to single or paired turbines of 150m or taller; applying the same guidelines as for schemes involving multiple turbines. Nevertheless, it is likely that slightly different considerations may apply, including the following:

- Horizontal extent of the receiving landscape is likely to be of less importance
- As a consequence of a more limited area being required to accommodate one or two turbines, proposals are more likely to be located closer to scale indicators and sensitive visual receptors such as residential houses and settlements.

[20] See LCS 2016 landscape assessment tables in Appendix 6

Figure 4.1 Location of Plateau Moorland Areas

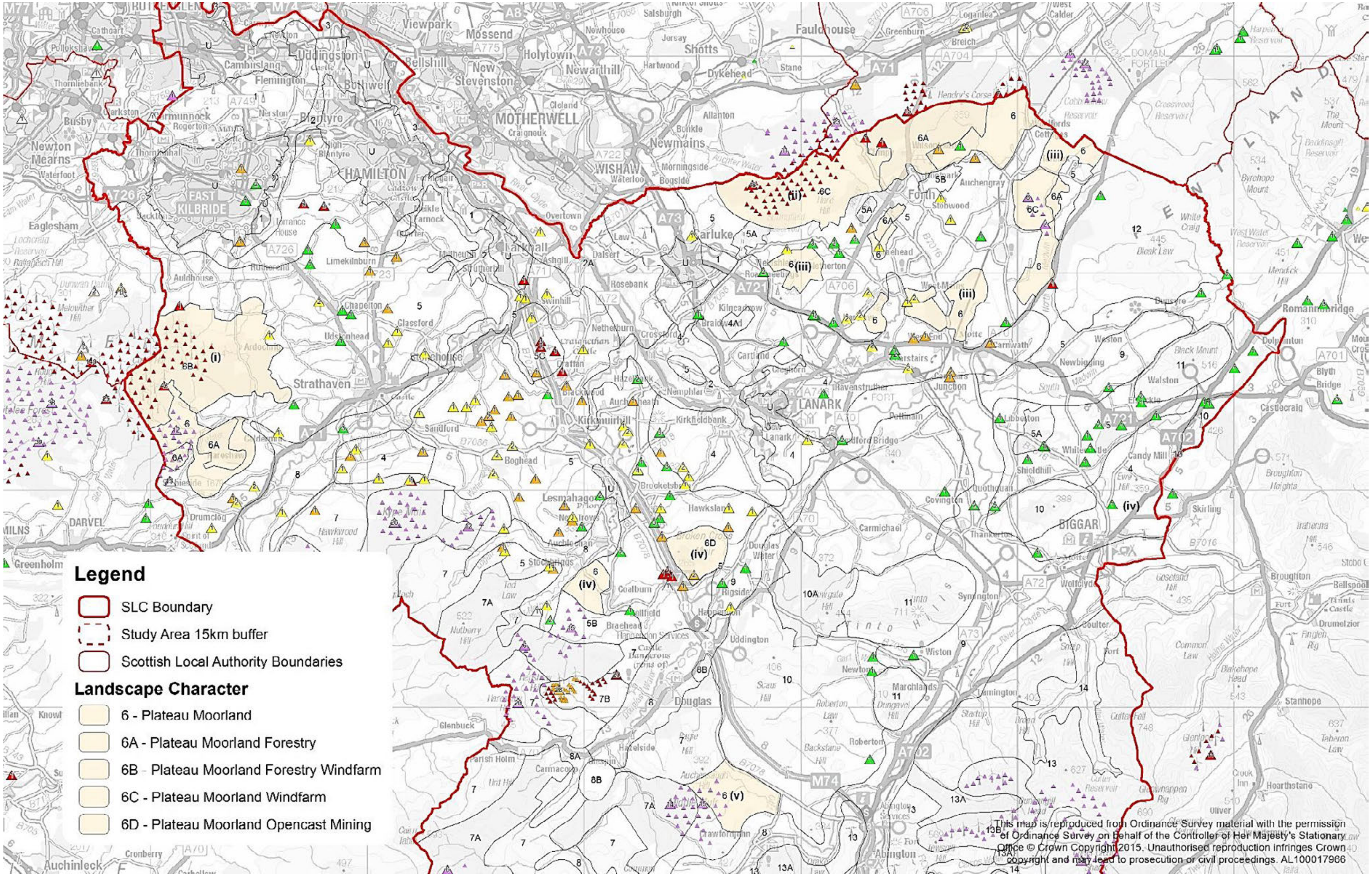


Figure 4.2 Location of Rolling Moorland Areas

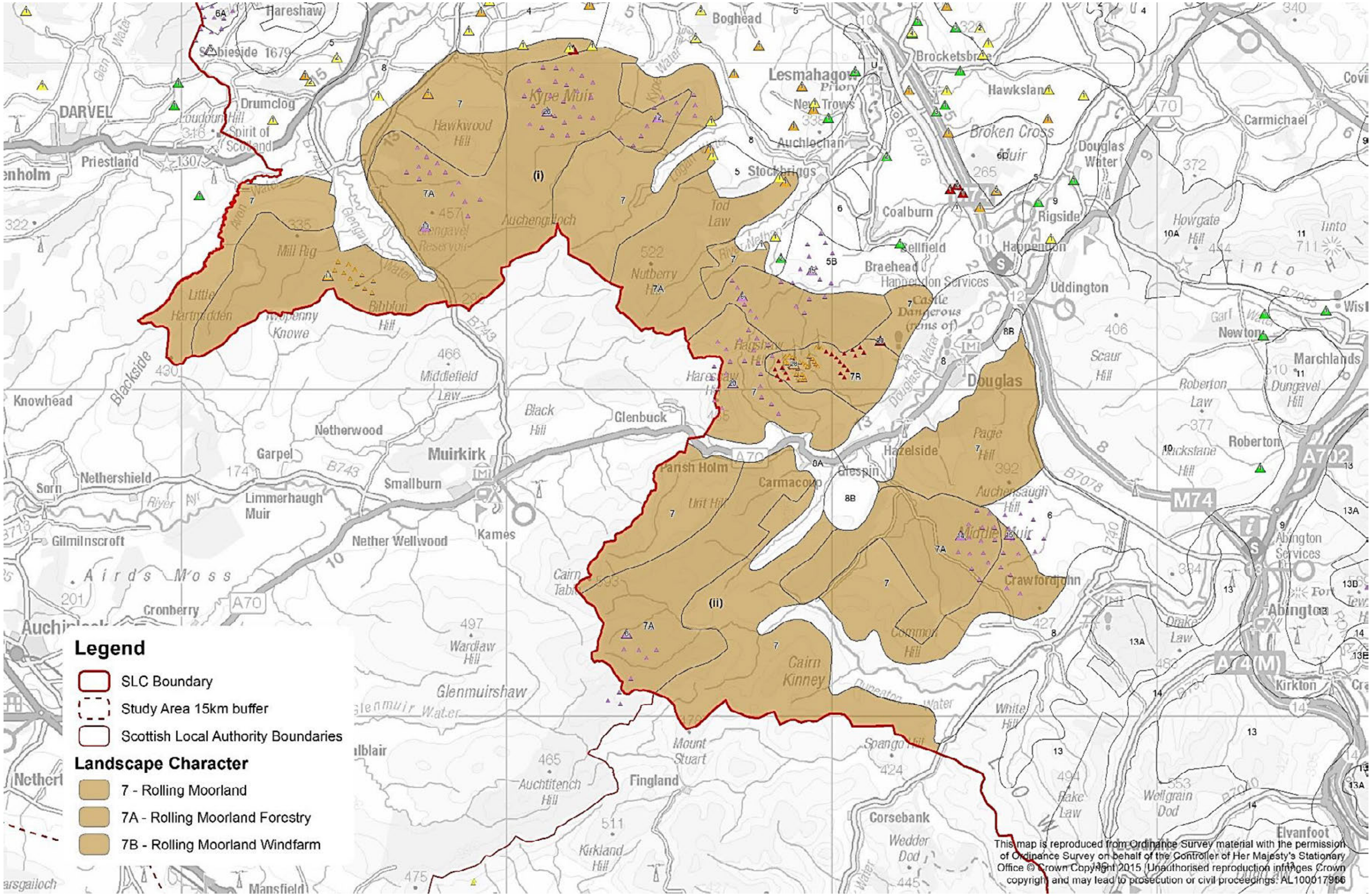
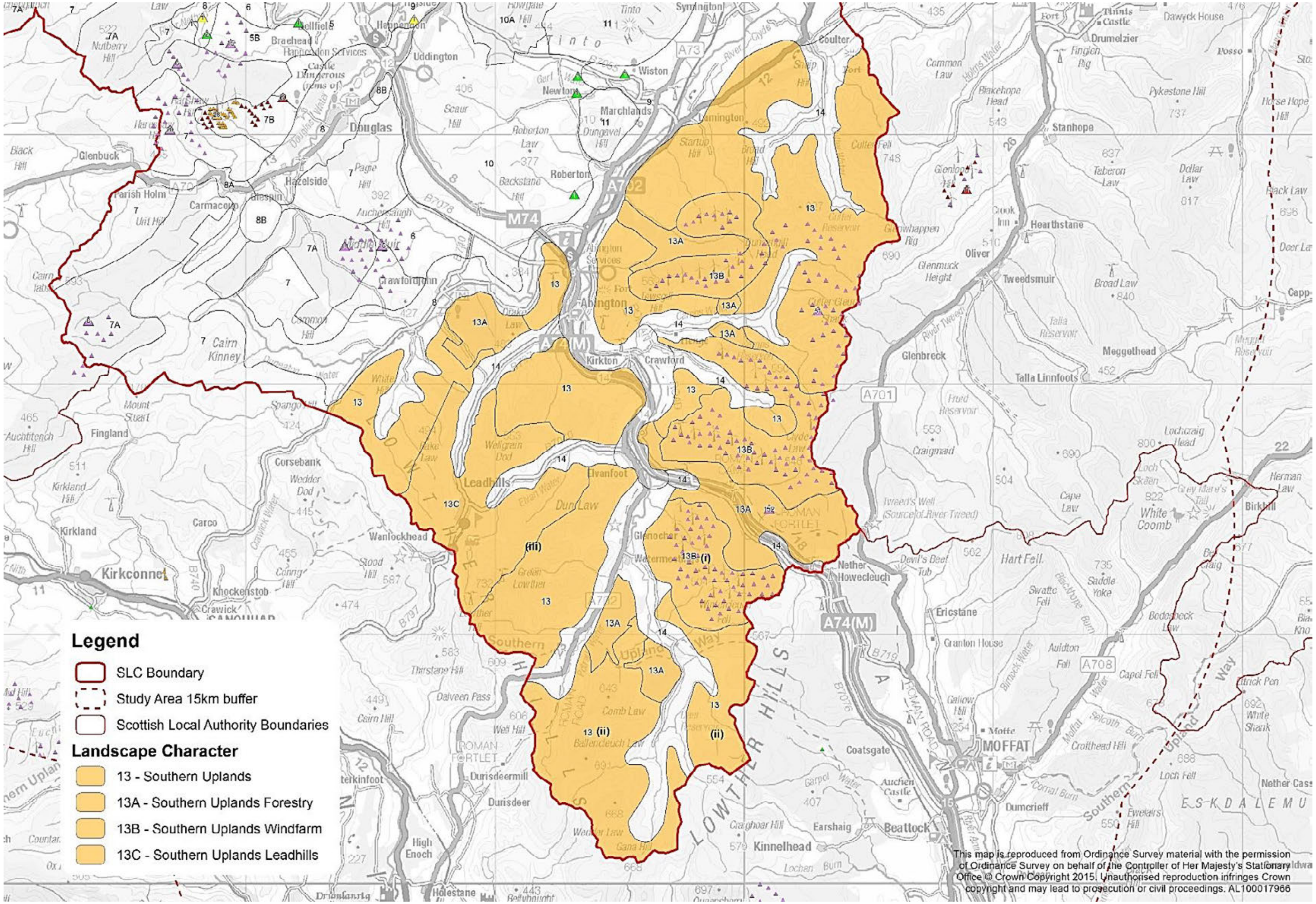
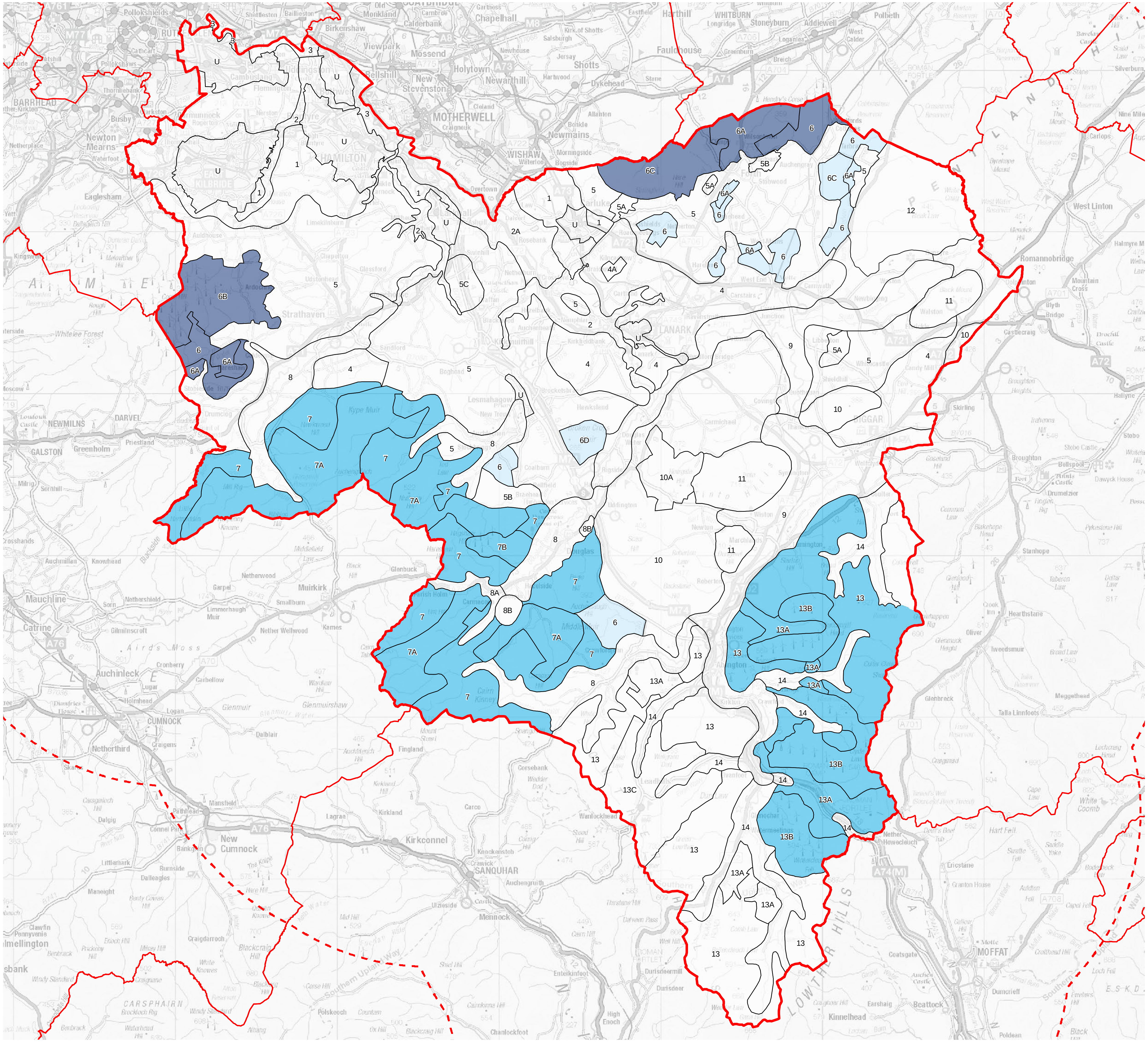


Figure 4.3 Location of Southern Upland Areas





South Lanarkshire Landscape Capacity Study for Wind Energy

Addendum: Tall Wind Turbines Capacity and Siting Guidance

September 2017 8945 GIS 111

Legend

- SLC Boundary
- Study Area 15km buffer
- Scottish Local Authority Boundaries
- Landscape Character Areas

Landscape Capacity (120m to <150m)

- High
- Medium
- Low
- None

Note:
Refer to Table 6.1 for more detail on background assessment and capacity for specific turbine sizes.

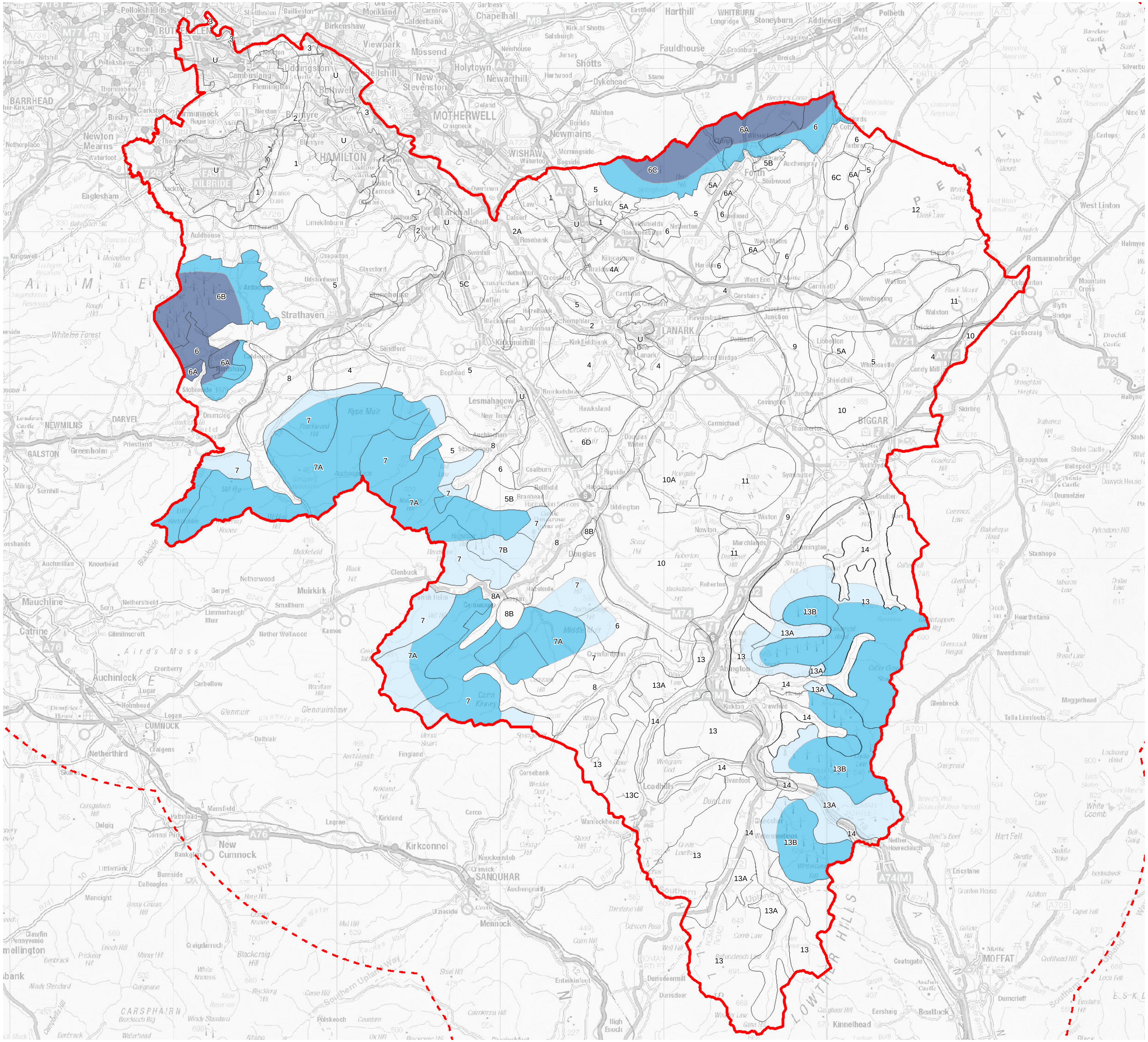
Landscape Character Types	
Code	**Type**
1	Urban Fringe Farmland
2	Incised River Valley
2A	Incised River Valley Broad Valley Floor
3	Broad Urban Valley
4	Rolling Farmland
4A	Plateau Farmland Forestry
5	Plateau Farmland
5A	Plateau Farmland Forestry
5B	Plateau Farmland Opencast Mining
5C	Plateau Farmland Windfarm
6	Plateau Moorland
6A	Plateau Moorland Forestry
6B	Plateau Moorland Forestry Windfarm
6C	Plateau Moorland Windfarm
6D	Plateau Moorland Opencast Mining
7	Rolling Moorland Foothills
7A	Rolling Moorland Forestry
7B	Rolling Morrland Windfarm
8	Upland River Valley
8A	Upland River Valley Incised
8B	Upland River Valley Opencast Mining
9	Broad Valley Upland
10	Foothills
10A	Foothills Forestry
11	Prominant Isolated Hills
12	Old Red Sandstone Hills
13	Southern Uplands
13A	Southern Uplands Forestry
13B	Southern Uplands Windfarm
13C	Southern Uplands Leadhills
14	Upland Glen

Figure 6.1e

Underlying Landscape Capacity for Wind Turbines (120m to <150m)

N

0 2.5 5 10 Km



SOUTH LANARKSHIRE COUNCIL

South Lanarkshire Landscape Capacity Study for Wind Energy

Addendum: Tall Wind Turbines Capacity and Siting Guidance

June 2019 8945 GIS 112

Legend

- SLC Boundary
- Study Area 15km buffer

Landscape Capacity (150 to 250m)

- High
- Medium
- Low
- None
- Landscape Character Areas

Note:
Refer to Table 6.1 for more detail on background assessment and capacity for specific turbine sizes.

Landscape Character Types	
Code	**Type**
1	Urban Fringe Farmland
2	Incised River Valley
2A	Incised River Valley Broad Valley Floor
3	Broad Urban Valley
4	Rolling Farmland
4A	Plateau Farmland Forestry
5	Plateau Farmland
5A	Plateau Farmland Forestry
5B	Plateau Farmland Opencast Mining
5C	Plateau Farmland Windfarm
6	Plateau Moorland
6A	Plateau Moorland Forestry
6B	Plateau Moorland Forestry Windfarm
6C	Plateau Moorland Windfarm
6D	Plateau Moorland Opencast Mining
7	Rolling Moorland
7A	Rolling Moorland Forestry
7B	Rolling Morrland Windfarm
8	Upland River Valley
8A	Upland River Valley Incised
8B	Upland River Valley Opencast Mining
9	Broad Valley Upland
10	Foothills
10A	Foothills Forestry
11	Prominant Isolated Hills
12	Old Red Sandstone Hills
13	Southern Uplands
13A	Southern Uplands Forestry
13B	Southern Uplands Windfarm
13C	Southern Uplands Leadhills
14	Upland Glen

Figure 6.1f

Underlying Landscape Capacity for Wind Turbines (150 - 250m)

N

0 2.5 5 10 Km