



Programme Area: Bioenergy

Project: Refining Estimates of Land for Biomass

Title: D1 Desk Study Plan (WP2) Version 2.1

Abstract:

The methodology of the desk study undertaken during the Refining Estimates of Land for Biomass (RELB) project

Context:

Many significant pieces of work have been undertaken to assess UK “2nd generation” bioenergy feedstock production potential. The RELB project was undertaken to help refine and sense-check these existing estimates, including the ETI's own in-house modelling assumptions, in order to understand what further ‘correction factors’ (if any) may need to be applied to adjust existing estimates. In addition, the project aimed to better understand the process for converting land to 2nd generation bioenergy feedstocks and the impact planting these feedstocks could have on farm businesses. The RELB project had four distinct work packages:

1. A review of latest theoretical estimates of land available for biomass production in the UK and Europe.
2. A desk study to identify additional constraint layers which could be used to refine the ETI's own in-house land availability constraint masks. The suitability of these additional constraint layers was tested through field surveys.
3. A review of the steps and agencies involved in land use change to bioenergy crops and forestry.
4. Case studies of three farmers who have planted bioenergy crops, focusing on the financial and food production impacts of their decision.

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Refining Estimates of Land for Biomass



D1 Desk Study Plan (WP2) Version 2.1

Reference No:

BI2012 RELB_WP2_D1

Date:

19 November 2015

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Note the most up to date methodology and data requirements are included in D4B, the desk study report

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Schedule of work for Work Package 2 – Desk Based Study

WP2 Objective: To analyse the impact of land availability for 2G feedstocks of adding additional datasets to existing BVCM assumptions using GIS analysis and (following WP3) the results of WP3.

Dependencies:

- Availability of appropriate licences to use GIS software – we will use ESRI software and have the necessary licences in place.
- Availability of BVCM land GIS data (constraint masks at 100 m resolution) – Andrew Lovett at UEA has supplied us with the 100 m data for the UKERC 7 and UKERC 9 masks. We have the 1 km resolution data from ETI.
- Availability of 100 m data for “w” masks (with woodland only areas removed) – it has not yet been identified who currently holds this data. Alternatively, woodland could be subtracted from original constraint layers if a woodland only (i.e. woodland with no other constraints) 100 m dataset is provided.
- Understanding of how misalignment between BVCM and OS grid has been addressed so that methods can be replicated.
- Availability of appropriate data licences for additional spatial data layers – licencing requirements have all been identified and the terms of use for the datasets are well understood.

Task 2.1 Identify cell outputs for analysis

A subset of five 50 km x 50 km cell outputs from BVCM have been identified for analysis by ETI. These are cell numbers 19, 40, 46, 72 and 100. Three of these (19, 46 & 100) have been identified as preferable for further field survey (Figure 1). The reasons for these preferences are provided in

Table 1.

Table 1. Land area statistics (from Corine) for 50 km study cells and ETI's reason for the preference for 2G bioenergy crops

Cell	Arable No land constraint mask (None) (ha)	Grass (None) (ha)	Forest (None) (ha)	Arable (9w) (ha)	Grass (9w) (ha)	Forest (9w) (ha)	Suggested Analysis	Reason
19	54,529	120,547	32,341	43,841	72,749	22,137	D+F	BVCM Miscanthus and SRF preference area. Water stressed area.
40	183,740	30,569	3,551	175,021	25,920	3,320	D	BVCM Miscanthus and SRF preference area. On edge of water stressed zone.
46	128,138	66,795	2,612	120,732	61,608	2,454	D+F	BVCM Miscanthus and SRF preference area
72	202,484	12,599	2,587	178,354	9,857	2,293	D	BVCM Miscanthus and SRF preference area. Area with current energy crop production
100	24,900	130,030	45,570	20,258	63,305	34,510	D+F	BVCM SRC Willow preference

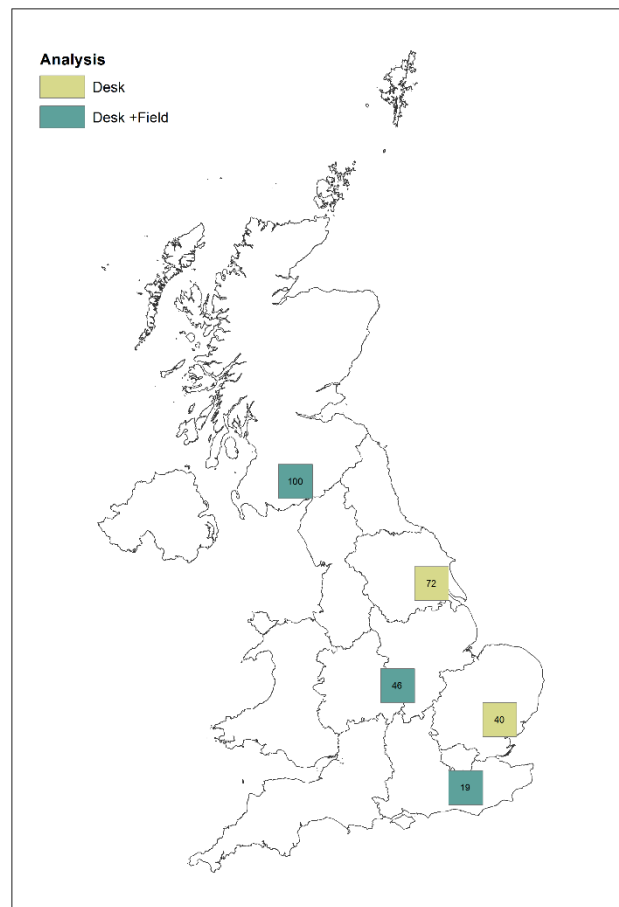


Figure 1. Locations of 50 km x 50 km study cells and the type of analysis to be performed for each

Cells 46 and 72 have areas already planted under the Energy Crops Scheme (ECS). Approved crops under the ECS are short rotation coppice (including willow, poplar, hazel, silver birch, sycamore, sweet chestnut and lime) and Miscanthus. ECS closed for new applications on 31/08/2013. The locations of areas planted under the ECS are available under NE-OS Open Government Licence and provide information on crop type and claimed area.

Task 2.2. Initial revised estimates of land availability using absolute constraints and selection of sub-cells for field survey

Cell misalignment

The cells and sub-cells used within the BVCM are offset from the Ordnance Survey grid by 400m north and 300m west. This is not a large offset at the 50 km grid cell level, but at the scale of the 1 km grid it is significant (Figure 2).

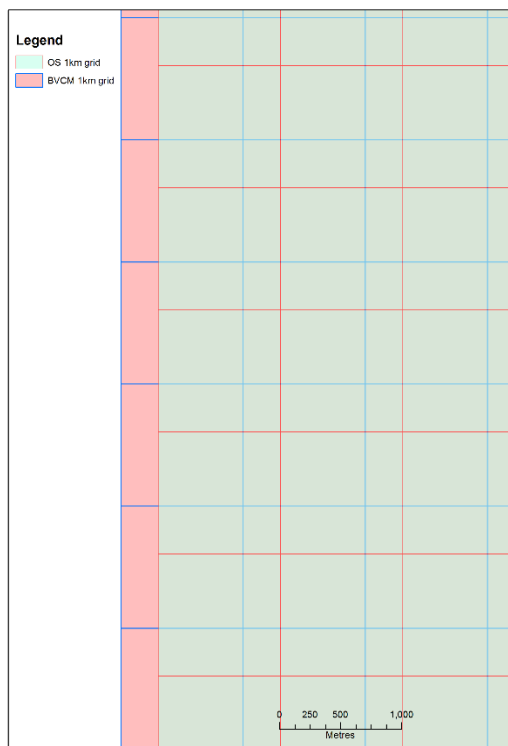


Figure 2. Example of 1 km BVCM grid offset compared to OS national grid

For consistency with the original 100 m constraint mask and for the purpose of field survey, the OS grid cells will be used for analysis in WP2. Following analysis and translation of results to the 1 km grid scale, we will match the BVCM sub-cells to their nearest OS grid cell using a process in GIS. This is consistent with the methodology used in the original BVCM project.

Initial analysis

The initial analysis will use the UKERC 9w constraint mask at 100 m resolution (we are currently trying to identify who can provide this dataset) and other spatial datasets that can be easily applied as additional masks. The output of this analysis will be used to provide initial estimates of land available for biomass production within the study cells and aid the selection of the 1 km sub-cells for field survey in WP3.

The datasets that will be considered as additional constraint masks (at 100 m grid scale for consistency with the original UKERC masks) include the following- the final datasets included in the desk study are listed in the Desk study report (D4B);

- OS terrain data to exclude areas above a certain elevation (moorland line) or assess the impact on the landscape through a visibility analysis
- Agricultural Land Classification (England) and Land Capability for Agriculture (Scotland) to exclude land most suited to food production (Grades 1 & 2 in ALC)
- Soils data to exclude soils that are not suitable for growing 2G biomass crops (in addition to those with high organic carbon content)
- Water stress data layer to exclude areas of limited water availability and water stress
- Additional data from OS VectorMap® District (Vector) (such as the Surface Water layer containing additional areas to the original layer used)
- National Forest Inventory (NFI) and ancient woodland inventory to exclude protected woodlands
- BAP priority habitats identifies areas of many habitats listed as Priorities for action under Biodiversity 2020
- Registered Parks and Gardens and Historic Environment Records to exclude areas of historic value
- Environmental Stewardship options where schemes might prevent planting of energy crops

Following linkage of 1 km sub-cells within the study cells to their nearest OS cell (and the data they contain), 1 km sub-cells within the study cells that have over 50% of their land area covered by the new mask will be reclassified as 'unavailable'. Initial revised estimates of land available for biomass production in the study cells will be made based on the sub-cell values.

Outputs: The impact of each new constraint layer on land availability in each 50 km x 50 km study cell, quantified in terms of additional land area removed and on maps of 1 km sub-cells (both individually and in addition to UKERC 7w and 9w masks). A summary of each dataset used in task 2.2 including its strengths and weaknesses. A discussion of the overall impact on land availability of adding these datasets including;

1. Identification and discussion of the relative strengths and weaknesses of the constraint datasets that have the greatest additional impact on land availability
2. A discussion and recommendations on whether all additional constraint datasets are required to produce a refined estimate of land availability or whether some datasets are surplus to requirements because they have no impact or are duplicated by other datasets

Identification of 1 km sub-cells for field survey

The objective is to randomly select from 'available' sub-cells (as determined using BVCM) and 'newly unavailable' sub-cells, which will be defined as those sub-cells that were originally available, but additional masks have resulted in them being classed as 'unavailable'.

When ‘newly unavailable’ sub-cells have been identified from the ‘available’ sub-cells, approximately 250 sub-cells within each 50 km cell to be surveyed will be selected at random from this subset, with the split between ‘available’ and ‘newly unavailable’ in proportion to the total in the 50 km cell. It will be ensured that sufficient ‘newly unavailable’ sub-cells will be included in the survey sample (a minimum threshold of ‘newly unavailable’ sub-cells was met by the initial selection).

1:25,000 scale field maps with the extents of the 1 km sub-cells clearly marked will be produced, plus smaller scale overview maps to assist planning of the field surveys.

Outputs – 750 sub-cells (plus extras in case some are inaccessible) identified for field survey and field maps produced

Task 2.3. Creation of additional data layers

In addition to the new constraint mask created in task 2.2, there are spatial data layers that have been identified that cannot be applied directly as masks, but may provide additional constraints or preferences in the form of likelihoods or coefficients. These data are likely to include the following (Final datasets included in the desk study are listed in the final Desk Study Report (D4B));

- OS terrain data processed to produce viewsheds to give an indication of how visible a planted area will be. Highly visible areas are less likely to be preferred for planting.
- Environment Agency flood warning and alert areas – 2G energy crops can potentially provide flood mitigation therefore flood risk areas may be preferred for planting where winter harvest challenges can be overcome.
- Soil properties – some soil properties may be less preferable for growth of 2G energy crops, but are not absolute constraints.
- Nitrate Vulnerable Zones (NVZs) – biofuel production could contribute to lower loadings of nitrogen in NVZs and therefore may be preferred in some high loading areas.
- Land Use Change Area Statistics (LUCAS) – areas of more rapid land use change may be preferred to maintain the character of areas that have little change.
- Farm Business Survey and June Survey of Agriculture county level results could be used to identify the farmer demographic and farm types within the study cells. Certain farm and farmer types may be more likely to grow 2G energy crops.
- Sustainable pollination services for UK crops – outputs of species distribution models for crop pollination. Areas where there are a lower density of pollinators may be less suitable for 2G crops.
- Rural Land Register field boundaries – smaller field sizes and irregular fields are better for 2G crops and not as suitable for 1G crops.

Relevant variables that may influence the likelihood of planting 2G crops will be created from these datasets using GIS processing for use as explanatory variables in multivariate statistical models, where

each observation will be a surveyed sub-cell. Building of the models will require the suitability of sample cells to be definitively known, therefore the models will be built following the results of WP3 (see task 2.4).

Prior to the completion of WP2, ADAS will hold a workshop at their Wolverhampton office (unless otherwise agreed) to review initial WP2 findings, discuss the presentation of results and enable the ADAS and ETI teams to make any refinements to the approach. This is likely to take place during task 2.3.

Outputs: 1 km scale constraint or preference variables for all study sub-cells for use in statistical model.

Task 2.4. Building of statistical models and final evaluation of datasets

This task will be completed when the results of the field survey become available.

Comparison of sub-cell classification from desk study and field survey

The results of the field survey will be used to calculate the numbers of sub-cells that matched and mismatched with the desk study in their classifications of available or unavailable. The results of this analysis will be used to determine:

- (i) constraints for which spatial data were available that could be used to improve the provisional mask by excluding additional areas of land;
- (ii) constraints included in the provisional mask that should be removed because they are excluding areas of land that should be available
- (iii) constraints included in the provisional mask that could not be identified by field survey.

Prediction of surveyed sub-cell unavailability using statistical models

Logistic regression models (with a separate model for each 50 km cell) will be built to predict the suitability of sub-cells for the planting of bioenergy crops based on survey results. The dependent variable will be the sub-cell availability determined by the field survey (surveyor's opinion), where 0 represented sub-cells that were $\geq 50\%$ available, and 1 represented sub-cells that were $< 50\%$ available. The independent variable will be the sub-cell availability based on various combinations of constraint layers (masks), where 0 represented sub-cells that were masked by $\leq 50\%$ and 1 represented sub-cells that were masked by $> 50\%$. The effect that each constraint layer has on the model performance will be assessed by removing each one in turn from the new mask and comparing the results based on Akaike's Information Criterion (AIC) and graphs of odds ratios and their confidence intervals. A final mask will be chosen based on the results of the logistic regression analyses and the analysis of reasons for discrepancies between field survey and desk study results.

Creation of cell typology and prediction of sub-cell availability

A separate analysis will be carried out for each surveyed cell due to the differences in land character and coverage of constraint layers. To enable these models to be applied to other cells in BVCM, a simple typology will be created based on the relative proportions of each of the land cover summaries for areas outside of the UKERC-9w mask and the digital terrain model, with the aim being that it could be applied to all cells in the UK if necessary.

The outputs from this work package (Deliverable 4) will comprise a report that will at least provide;

- Identification of study cells and sub-cells
- Descriptions of datasets used, their strengths and weaknesses

- Methodologies for creation of variables used in statistical models
- Details of models and how they have been applied to each characterised study cell
- Results of sensitivity analysis to determine relative importance of data layers
- Revised area estimates, data and maps from tasks 2.2 and 2.3 for study cells
- Conclusions and recommendations on the datasets to use to create a refined estimate of land availability using UKERC 9w as a baseline land constraint
- A copy of the GIS files for the 50 km x 50 km cells surveyed

Appendix 1 - SCHEDULE 11 - Background IP and Third Party IP

Background IP and Third Party IP

Description of BACKGROUND IP or OTHER THIRD PARTY IP	Legal Type of BACKGROUND IP OR OTHER THIRD PARTY IP (Copyright, know how, patent etc.) If registered IP please give registration number.	Ownership/Control of BACKGROUND IP OR THIRD PARTY IP (please confirm if Prime Contractor/Sub-contractor owns or is licensee of IP)	Category and relevant details A = needed by Prime Contractor/Sub-contractor during Project B = needs to be licensed to other Prime Contractor/Sub-contractors during the course of the Project C = needs to be licensed to the ETI to enable exploitations of the Works and the Arising IP, i.e. through inclusion in a Deliverable.	If the Prime Contractor/Sub-contractor does not solely own the IP for Categories A or B, please provide documentary evidence of rights to that IPR including rights to sub-licence.	ETI Consent for purposes of clause 14.3.6 of the Agreement
Know-how in bioenergy value chain optimisation, land cover maps and constraint masks, and energy crop production	Know how	E4tech owned	a		No consent requested or provided as not incorporated into a Deliverable or required in order to use Deliverables or Results.
Know-how in environmental and agricultural datasets and spatial analysis	Know how	ADAS owned	a		No consent requested or provided as not incorporated into a Deliverable or required in order to use Deliverables or Results.

Data that comprises Background IP or Third Party IP

Description of Data	Ownership/Control of IP (please confirm name of owner of Data)	Usage 4 = Data used to derive other data or information and that is incorporated into a Deliverable	Related Deliverable (please explain usage in detail)	Derived Data Terms (please set out detailed terms: e.g. whether terms permit Derived Data to be incorporated into a Deliverable, who owns Derived Data, any rights to the Third Party IP owner to such Derived Data) [Please make sure each row contains a link to any licence terms available electronically]	ETI Consent for purposes of clause 14.3.6 of the Agreement	IS IP being used
CORINE 2006	European Environment Agency	4	D4B: Identify land areas of Arable, Grass and Forest	EEA standard re-use policy: unless otherwise indicated, re-use of content on the EEA website for commercial or non-commercial purposes is permitted free of charge, provided that the source is acknowledged (http://www.eea.europa.eu/legal/copyright). Copyright holder: European Environment Agency (EEA).	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	No
European Soil Database	European Commission - Joint Research Centre	4	D4B: Differences to Harmonized World Soil Database	The JRC agrees to provide the data free of charge http://eusoils.jrc.ec.europa.eu/ESDB_Archive/octop/octop_data.html	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms including, for example, not providing data from this database to the ETI.	No
National Parks	Magic, CCW, CRTB SEDSH	4	D4B: Impacts of excluding high naturalness score areas in Natural Parks	England (both available under NE-OS-OGL) http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml Wales (both available under OGL): http://lle.wales.gov.uk/Catalogue?Text=national+park&Page=&INSPIRE=False	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	No

Description of Data	Ownership/Control of IP (please confirm name of owner of Data)	Usage 4 = Data used to derive other data or information and that is incorporated into a Deliverable	Related Deliverable (please explain usage in detail)	Derived Data Terms (please set out detailed terms: e.g. whether terms permit Derived Data to be incorporated into a Deliverable, who owns Derived Data, any rights to the Third Party IP owner to such Derived Data) [Please make sure each row contains a link to any licence terms available electronically]	ETI Consent for purposes of clause 14.3.6 of the Agreement	IS IP being used
Areas of Outstanding Natural Beauty		4	D4B: Impacts of excluding high naturalness score areas in Natural Parks	England (both available under NE-OS-OGL) http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml Wales (both available under OGL): http://lle.wales.gov.uk/Catalogue?Text=national+park&Page=&INSPIRE=False	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	No
The datasets below will be accessed for the purposes of Work Package 3						
Priority Habitat Inventory	Natural England		D4B: Impacts of excluding priority habitats	Advised that this falls under the Open Government licence. (Email 29/7/15).	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the Open Government Licence and that the Prime Contractor warrants it shall comply with such terms.	Yes
EA Flood Warning Areas, Flood Risk Areas and Flood Warning Areas	Environment Agency	4	D4B: Impact of excluding or positively selecting flood risk areas	Open Government Licence http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	Yes

Description of Data	Ownership/Control of IP (please confirm name of owner of Data)	Usage 4 = Data used to derive other data or information and that is incorporated into a Deliverable	Related Deliverable (please explain usage in detail)	Derived Data Terms (please set out detailed terms: e.g. whether terms permit Derived Data to be incorporated into a Deliverable, who owns Derived Data, any rights to the Third Party IP owner to such Derived Data) [Please make sure each row contains a link to any licence terms available electronically]	ETI Consent for purposes of clause 14.3.6 of the Agreement	IS IP being used
Water Resource Availability and Abstraction Reliability	Environment Agency	4	D4B: Impact of excluding water stressed areas	Open Government Licence http://data.gov.uk/dataset/water-resource-availability-and-abstraction-reliability-cycle-2	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	No
Nitrogen Vulnerable Zones	MAGIC	4	D4B: Impact of excluding or positively selecting NVZ	Datasets available under the Public Sector Mapping Agreement End User Licence http://www.magic.gov.uk/Copyright_Information_Data_Download.htm	If this dataset is to be used, the Prime Contractor shall seek consent from the ETI under clause 14.2.6 and provide written evidence from the Licensor that the permitted usage including the creation of derived data is consistent with the terms of this Agreement.	Yes
Energy Crops Scheme	Natural England	4	D4B: Examine areas where biomass crops are already grown	Supplied under the Natural England and Ordnance Survey Open Government Licence. http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	Yes
Environmental Stewardship Scheme Agreements	Natural England	4	D4B: Impact of excluding areas where environmental schemes are in practice	Supplied under the Natural England and Ordnance Survey Open Government Licence. http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	Yes

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LUCAS	European Commission	4	D4B: Examine land use change, and if recently changed land is more suitable for conversion	The LUCAS_SOIL data are the property of the European Union, represented by the European Commission, represented by the Directorate General-Joint Research Centre, which is allowed to authorize third parties to use these data free of charge. http://eusoils.jrc.ec.europa.eu/projects/Lucas/Data.html	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor, including specifically paragraphs 3-6 of those terms.	No
Agricultural Land Classification	Natural England	4	D4B: Identify land grades, impact of excluding Grades 1-2	Supplied under the Natural England and Ordnance Survey Open Government Licence. http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that it has checked that such data may be used under the terms of the link provided and that the Prime Contractor warrants it shall comply with such terms.	Yes
Land Capability for Agriculture, Scotland 1:50000	James Hutton Institute	4	D4B: Identify land grades, impact of excluding high Grades	James Hutton Open User licence document reference: UK-201704253.03.	The ETI provides consent under clause 14.2.6 for this data to be used on the basis that the Prime Contractor warrants that complies with those terms and subject to Clause 12.9 of this Agreement.	Yes
European Topsoil Physical Properties	Joint Research Council	4	D4B: Identify soil textures, impact of excluding >90% clay, sand, silt	European Topsoil data are the property of the European Union, represented by the European Commission, represented by the Directorate General-Joint Research Centre, which is allowed to authorize third parties to use these data free of charge.		Yes

Description of Data	Ownership/Control of IP (please confirm name of owner of Data)	Usage 4 = Data used to derive other data or information and that is incorporated into a Deliverable	Related Deliverable (please explain usage in detail)	Derived Data Terms (please set out detailed terms: e.g. whether terms permit Derived Data to be incorporated into a Deliverable, who owns Derived Data, any rights to the Third Party IP owner to such Derived Data) [Please make sure each row contains a link to any licence terms available electronically]	ETI Consent for purposes of clause 14.3.6 of the Agreement	IS IP being used
VectorMap District	Ordnance Survey	4	D4B: Identify buildings and water bodies, impact of excluding these	Ordnance Survey Open Data product. Free to download and use for commercial purposes.		Yes
Ancient Woodland Inventory	Natural England	4	D4B: Identify ancient woodland, impact of excluding	Supplied under the Open Government Licence for public sector information.		Yes
Ancient Woodland Inventory	Scottish Natural Heritage	4	D4B: Identify ancient woodland, impact of excluding	Available under OS Open Data licence. You must always use the following attribution statement to acknowledge the source of the information: Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right (year)		Yes
National Forest Inventory	Forestry Commission	4	D4B: Impacts of excluding woodland, differences to CORINE	Open Government Licence http://forestry.gov.uk/datadownload		
Parks & Gardens	English Heritage	4	D4B: Identify historic parks & gardens, impact of excluding	Available under OS Open Data licence. You must always use the following attribution statements to acknowledge the source of the information: <i>© English Heritage [year]. Contains Ordnance Survey data © Crown copyright and database right [year]</i>		Yes

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				<i>The English Heritage GIS Data contained in this material was obtained on [date]. The most publicly available up to date English Heritage GIS Data can be obtained from http://www.english-heritage.org.uk.</i>		
Gardens & designated landscapes	Historic Environment Scotland	4	D4B: Identify historic parks & gardens, impact of excluding	Licensed under UK Open Government Licence http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ <i>If this data is reproduced it must be attributed with the following: Contains Historic Environment Scotland and Ordnance Survey data © Historic Environment Scotland - Scottish Charity No. SC045925 © Crown copyright and database right [year].</i>		Yes
OS Terrain 50	Ordnance Survey	4	D4B: Identify areas of land above a certain altitude	Ordnance Survey Open Data product. Free to download and use for commercial purposes.		Yes

Glossary

Word	Definition
Viewshed	The geographical area that is visible from a location. It includes all surrounding points that are in line-of-sight with that location and excludes points that are beyond the horizon or obstructed by terrain and other features (e.g., buildings, trees).