Forest Research

TECHNICAL DEVELOPMENT

REPORT FCJR059

West Lothian Council
Prospects for Land Restoration using anaerobic digestate for SRC-SRF Production: System Evaluation

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Summary

Site visits to 227ha in ten West Lothian Council owned brownfield and former brownfield sites revealed potential for 89ha of site improvement using anaerobic digestate for planting with forestry that could utilize in the region of 11,000 wet tonnes of the organic amendment. These figures are not a direct reflection of the site's physical capability but include a likelihood judgement. Improved accuracy would require more detailed site survey including soil sampling. All the land potentially suited to anaerobic digestate was considered potentially suitable for biomass production through short rotation coppice or short rotation forestry, and would yield an estimated 800 m3 or 500 air dry tones of timber per annum once established. The majority of the area with potential for anaerobic digestate amendment comprised open space, although a small proportion of woodland on the sites (21ha) had some potential for remediation and replanting. The sites also showed a significant potential for planned production of fuelwood from established trees.

The legislation and codes of good practice affecting use of anaerobic digestate in land remediation to forestry effectively limit the quantity that can be applied and impose conditions on its use. Although anaerobic digestate that meets British Standard PAS110, which requires to be source segregated, will not be classified as a waste it use will still require careful control and matching to the biological needs of the receiving site. Relevant guidance and codes of practice give a wide range of the quantity of organic soil amendments that may be appropriate to site needs with an upper limit of over 500 tonnes dry solids per hectare (1,600 wet tonnes) suggested as potentially justifiable on the most challenging sites. However, an assessment of the available information, including forestry field trails carried out by FC and funded by the Waste Resources Action Programme (WRAP), suggest that an upper application rate of around 60 to 100 tonnes dry matter (200 - 350 tonnes wet weight) per hectare may prove to be a realistic upper limit for most circumstances.

Anaerobic digestate has differing chemical properties to greenwaste compost which may further influence application rates.

Although three-year field trials are still only one year old, anaerobic digestate is considered to have potential as an effective soil amendment for restoration of brownfield soils to forestry end use, whether alone or in mixture with compost. A range of factors need to be considered including potential for odour. Current

information suggests that anaerobic digestate can be as cost effective as compost and potentially more so depending on cost of supply, although this has not as yet been proved.

Results from the 2011 'Luker Report'[1] are summarized as providing a guide to wood fuel that might be utilized within ten existing Council owned buildings if converted to wood fuel heating. This suggests that Short Rotation Coppice (SRC) or Short Rotation Forestry (SRF) grown on brownfield land assessed as having potential for restoration using anaerobic digestate may provide approximately 10% of the wood fuel supply requirement per year.

The main recommendations of this report are that:

- where feasible, anaerobic digestate should be produced to PAS110 standard so as not be classified as a waste and thereby to maximise the potential for beneficial application to land, including sale as a product.

- for brownfield sites that may be made available for restoration to forestry, consideration should be given to a more detailed appraisal of restoration and forestry requirements, including soil sampling.

- should restoration using anaerobic digestate be proposed, a detailed appraisal of conditions and supply chain factors should be undertaken to determine whether to use SRC or SRF systems, although SRF is suggested as the more likely to be suited to sites.

Introduction

Public authorities have obligations to increase recycling and sustainable re-use of waste materials, promote the re-use of vacant and derelict land and to reduce the carbon footprint of their activities.

The planned new West Lothian Council waste recycling facility may yield c 5,000 wet tonnes p.a. (43% m.c.) of digestate (also known as 'Compost Like Output' or CLO) from anaerobic digestion of food and other waste organic matter by 2013. This anaerobic digestate (AD / CLO) requires a realistic economic end-use to maximise recycling benefits.

There is a potential opportunity for an integrated system using the council's AD / CLO to restore some of its legacy of unused brownfield land to grow biomass. The biomass, such as short rotation forestry, could then fuel heat or combined heat and power plants to supply council buildings.

[1] Supporting Investment in Wood Energy in Scottish Councils, Luker S., (2011)

Anaerobic digestate shares some characteristics of green-waste compost – organic matter and plant nutrient contents - and so may be suitable as a soil improver for brown-field reclamation for forestry, alone or in mixture with compost.

There is a need to assess the practical feasibility of an integrated AD / CLO - brownfield - biomass system. The council is part funding a Forest Research and WRAP / Zero Waste Scotland experiment on the use of AD / CLO as a soil improver on council-owned brownfield land.

This report investigates the nature and extent of the council's brownfield land that might be suited to restoration for forestry using AD / CLO, the scale of possible AD / CLO deployment and the biomass production potential that could realistically result. It is also important to assess likely operational costs and the nature of savings that could result from adoption of an integrated system, although this requires further investigation.

Objectives

1. Undertake site visits to assess the extent and relevant forestry characteristics of West Lothian Council owned brownfield land that may be suited to restoration to forestry using 'Compost Like Output' (CLO).

2. Assess the cost effectiveness of CLO within a sustainable system for growing short rotation forests as woodfuel on the sites identified using the results of the WRAP OBF-013-006 anaerobic digestate trial at Addiewell bing, part funded by West Lothian Council.

3. Liaise with the Lanarkshire Wood Energy Project (Steve Luker) to establish as far as possible from that study:
   - the woodfuel production capability of existing WLC woodland
   - the extent of existing WLC woodland on brownfield land that may be suited to re-restoration using CLO
   - the potential for use of biomass boilers within WLC properties (KWh and woodfuel supply/demand), and
   - the potential fossil fuel displacement and carbon benefit.

4. Complete a report on objectives 1 - 3 and identify:
   - Area of potential WLC brownfield new and re-planting sites and their suitability for CLO use
   - Tonnage of CLO that might be deployed (displacing inorganic fertilisers)
   - Tonnage of biomass woodfuel that might be produced.

Work method

The work was subdivided into two main categories comprising site visits and site reports (Objective 1) and subsequent analysis of results to produce the final report (Objectives 2 - 4).

Site visits

West Lothian Council provided outline maps of ten sites amounting to some 227ha owned by the council and considered by them to represent the majority of its land that might be suitable for re-restoration using AD / CLO. Prior to any site visits taking place the site boundaries were plotted on GIS[2] to enable overlay of various GIS datasets available to FC covering a wide range of geographic, ecological, infrastructure, social, regulatory and other land use issues. These data sets were checked against each site to help inform site visits. Ortho-rectified aerial photography supplied by Ordnance Survey was also used to check boundaries, access, vegetation / woodland cover, land use features, electricity lines and other signs of ground features that might be relevant to site visit planning including any signs of previous ground disturbance suggesting industrial activity or restoration.

An online repository of historical Ordnance Survey maps[3] was used to create a GIS historical land use layer for each site, from the First Edition OS Series of c. 1853 - 1868 until the 1990s. This information was compiled to help identify the likely type and sequence of land uses and industrial activities that took place over each site, and the broad timescales involved in development of industry and subsequent restoration.

Following collation of GIS and historical map data, site walkover surveys were conducted. These were aimed at:

- Locating remains and characteristics of mapped historical building, railway, mining and other former land use features or confirming removal / restoration
- Identifying areas of un-restored land such as spoil tips, railway sidings
- Identifying areas of restoration and the restoration practice used
- Identifying woodland planted on restoration land, or regenerated on un-restored areas, and assessing performance against the likely objectives, such as community woodland
- stratifying the land in terms of woodland / open space categories and assessing soil, vegetation / tree status
- Identifying potentially high and sensitive biodiversity value areas and influence of fauna on existing or potential new woodland (such as deer, rabbit, hare and squirrel)
- Identifying wet ground, wetland, water features and drainage on and immediately adjacent to the site

[2] Arcview Arc3 GIS

[3] www.oldmaps.com

- Identifying internal and immediate external access routes and their characteristics
- Understanding the level and type of local community sensitivity and use including public accessibility, formal access provision, informal use, anti-social activity, nature and extent of neighbouring housing and businesses
- Locating obvious signs of utilities such as buried gas or water mains and overhead electricity lines
- Generally understanding the soil, water, community and vegetation characteristics of each site and the possibly sources or location of constraints on restoration and forestry activities.

Site visits were carried out in wet or overcast conditions on 14th and 16th March 2011. Where possible the walkover surveys covered all obvious or pre-identified areas or features. The nature and extent of the sites and the scoping nature of the work was such that there could be no guarantee that all relevant features were seen or discovered on every site. However, the site visits did provide a very much enhanced understanding of the nature of the sites relevant to restoration and forestry characteristics sufficient to make informed assessments.

Walkover notes were made on maps as appropriate.

Site reports

A suite of ten Site Reports were produced describing the main characteristics identified on each site, together with an assessment of their potential for restoration or re-restoration using AD / CLO and for production of fuel wood (Objective 1). The reports also defined the area of brownfield land considered as potentially suited to AD / CLO application (Objective 4, part).

Site Report headings covered: Pen Picture, Location & Community, History, Woodland, Open space, Soils, Terrain & Water Environment, Biodiversity, External Access, Internal Access and Constraints. There followed discussion of Suitability for forestry using AD / CLO and Suitability for woodfuel production. Results covered Potential for forestry using AD / CLO and Suitability for woodfuel production in an AD / CLO system. Each Site Report ended with Conclusions and Recommendations.

Maps were produced for each site covering Location, Historical Features, Constraints, Land Use and Forestry restoration potential using AD / CLO.

The Potential for forestry restoration using AD / CLO included a subjective assessment of the Requirement for AD / CLO and the Feasibility of using it on the site, resulting in the Potential. Each category was classed as 'High', 'Medium' or 'Low' (although a 'Low to Nil' class was also helpful on occasion).

Assessment of AD / CLO potential was strongly influenced by current land use and was generally applicable only to Open Space. This is due to the effective application limit for organic soil amendments resulting from the regulatory regime, which involves

a maximum soil total Nitrogen content and which requires higher levels to be justified by ecological benefit. Soils bearing woodland are likely to have developed, through leaf fall and soil processes, to the point where nil or only a marginal increase in Nitrogen loading can be justified under existing or likely alternative land uses. The main exceptions are likely to fall into two classes:

- Woodland on un-restored disturbed land where humus and organic matter is absent in the tree rooting zone below the soil surface, and
- Woodland on restored disturbed land, affected by poor rooting and growth resulting from poor soil structure and lack of nutrients including Nitrogen.

A subsidiary reason was that the assessment was intended to be realistic and as such required to take into account the likelihood that removal of existing woodland in order to replace with another type of woodland having different objectives would be justified. For example, the likelihood that removal of mixed amenity or timber woodland established at public expense on restored spoil tips could be justified to make way for an alternative biomass production system.

Site mapping enabled an assessment of the areas of land falling into the High, Medium and Low (or Low to Nil) 'Potential for forestry restoration using AD / CLO' categories. In practice there were no High Potential locations.

The ten Site Reports form appendices to this System Evaluation report.

Analysis

The aim of the analysis stage of the project was firstly to assess the cost effectiveness of using AD / CLO within a sustainable system for growing short rotation forests as woodfuel based on experience of the restoration field trail at Addiewell shale tip (Objective 2). Secondly, the analysis defined the tonnage of AD / CLO that might realistically be used on the sites and the tonnage of woodfuel that might result (Objective 4, part).

In practice, the assessment also involves experience gained and results from several restoration research trials carried out by Technical Development staff in Central Scotland, viz:

- Restoration to forestry using PAS100 compost, Greenoakhill Landfill Site, Glasgow planted 2008[4]
- Restoration to forestry using PAS100 compost, Dalquhandy Opencast Coal Site, South Lanarkshire planted 2009[5]
- Restoration to forestry using PAS100 compost and / or PAS110 Anaerobic Digestate, Dalquhandy Opencast Coal Site, South Lanarkshire planted 2009[6]
- Restoration to forestry using PAS100 compost and / or PAS110 Anaerobic Digestate, Addiewell Shale Tip, West Lothian[7].

[4] WRAP Trailblazer project OBF009-009 and 015-002

[5] WRAP Trailblazer project OBF008-004

[6] WRAP Trailblazer project OBF013-003

All the above trials were funded or part funded by the Waste Resources Action Programme, and the Addiewell trial was supported by West Lothian Council with funds from Forestry Commission Scotland. West Lothian Recycling Limited[8] hosted the trial at Addiewell. The trials at Greenoakhill Landfill Site and at Dalquhandy Opencast Coal Site were with the co-operation of the owners Patersons Quarries and Scottish Coal respectively.

A pre-requisite of the analysis of the results of the site visits and reports was an understanding of the regulations governing the application of AD / CLO to land.

Regulatory regime

The regulatory regime is taken to include legislation and relevant codes of good practice and guidelines that describe responsible practices.

There are several Acts, Codes of Practice and guidelines affecting the use of organic soil amendments in land restoration. In general the regulatory authority is Scotland is SEPA, although Forestry Commission Scotland has a responsibility for forestry regulation and grants under the Forestry Acts and the Forestry Environmental Impact Assessment Regulations 1999.

The main relevant legislation and codes relating to use of anaerobic digestate on land are:

- The Code of Practice for the use of sludge, compost and other organic materials for land reclamation 2010: produced by the Scotland and Northern Ireland Forum for Environmental Research to describe best practice in application of organic materials but does not replace codes of practice for specific materials or agricultural land. This code is relevant to the application of AD /CLO to non-agricultural land in land reclamation.
- The Anaerobic Digestate Quality Protocol 2009: governing application of anaerobic digestate that is not classed as a waste in England and Wales, although applicable as good practice in Scotland. This would be relevant to use of PAS110 compliant AD / CLO.
- The Waste Management Licensing Regulations 1994: governing application of wastes to land. This would be relevant to use of AD / CLO that is not PAS110 compliant.
- The Controlled Activities Regulations 2005: governing land operations that may have an impact on the water environment, including application of AD / CLO to land.
- The Forests and Water Guidelines 2003: are effectively a code of good practice but are mandatory in respect of any forestry grant aided or regulated scheme.

[7] WRAP Trailblazer project OBF013-006

[8] West Lothian Recycling Ltd is a partnership between West Lothian Council and Tarmac Northern Ltd

- The Forestry Environmental Impact Regulations 1999: Require approval of forestry schemes over certain thresholds, which would include land restoration to forestry.
- The Code of Practice for the Agricultural Use of Sewage Sludge: covers operational practice for the application of sewage sludge to agricultural land and by extension through the 'Safe Sludge Matrix' to other land growing industrial crops.
- The Nitrate Vulnerable Zones (Scotland) Regulations 2008: applies to Nitrate Vulnerable Zones, which excludes West Lothian. However, the Anaerobic Digestate Quality Protocol recommends compliance outside NVZs where feasible. This covers operational practice including maximum organic manure application limits, which will include anaerobic digestate.
- The Prevention of Environmental Pollution from Agricultural Activity Code of good practice 2005 (PEFPAA Code). The Code provides guidance on measures that will prevent pollution. The sections concerning water pollution have statutory effect through the Water Environment (Controlled Activities) (Scotland) Regulations 2005.

The legislation and guidance is examined in more detail below:

Code of Practice for the use of sludge, compost and other materials for land reclamation 2010

Published by the Scotland and Northern Ireland Forum for Environmental Research, this code covers accepted practice in application of compost, anaerobic digestate, sewage sludge and others. The Code provides for a site assessment process that considers a wide range of factors including physical features, contaminant levels and sample analyses.

The Code recommends that organic amendments should **not** be applied:

- to sites that are subject to flooding or where the permanent ground water table is less than 1 m depth
- within 20m of surface water or 50m of a drinking water supply
- within 100m of a dwelling without a site specific risk assessment
- to ground greater than 25 degrees slope (1:4)
- to ground between 15 degrees and 25 degrees where in liquid form

It is recommended that organic matter should be incorporated to 40cm depth and also that plant growth trials may be beneficial in determining appropriate application rates.

The Code provides Guideline Values for application of organic material. In the case of soil formation for non-food crop production, landfill cap and colliery spoil reclamation the guideline value is 100 - 500 tonnes dry solids / ha. The rate will depend on the nature of the organic amendment, condition of the land and the contaminant concentration in both the organic amendment and soil. Rates at the lower end of the range should be used for organic matter less than 25% dry solids.

The Code states that:

> 'Higher than normal rates of organic matter application should only be considered if it can be demonstrated that they are both beneficial and necessary for planned end use. Applications in excess of that needed for sustainable ecological improvement could be considered as a waste disposal rather than a land reclamation operation'.

Anaerobic Digestate Quality Protocol 2009

Defra funded the Waste Resources Action Programme to produce an Anaerobic Digestate Quality Protocol[9] in association with the Environment Agency that was published in 2009. The Quality Protocol was intended to clarify the point at which AD is not classified as a waste under the EU Waste Framework Directive (2006/12/EC) and:

> "to protect human health and the environment (including soil) by describing acceptable good practice for use of quality digestate in agriculture, forestry, soil/field-grown horticulture and in land restoration".

The Protocol states that "Producers and users are not obliged to comply with the Quality Protocol. If they do not, the quality outputs from anaerobic digestion … will be considered to be waste and waste management controls will apply to their handling, transport and application".

In order to comply with the Protocol "Quality digestate must not be used in such a way as to adversely affect human health or the environment". Although compliant digestate is not a waste, when mixed with other non waste materials "regulatory regimes (other than waste management controls) may apply to the blending activity, e.g. where the quality output from anaerobic digestate is transferred to a brownfield site to be mixed with soils to improve their quality".

Whilst the Quality Protocol was written for England and Wales, the principles apply to Scotland insofar as they derive from European legislation.

The Anaerobic Digestate Quality Protocol specifies good practice, which means that "anyone who uses the quality digestate takes account of all potential environmental issues such as application rates, impacts on soil function, potential for water pollution, etc."

The Quality Protocol requires that records be kept (and therefore measurements be made where applicable) concerning the use of the material. In forestry, which has a wide definition and includes tree biomass crops, the records must include:

[9] Quality Protocol, Anaerobic Digestate, Environment Agency (2009)

- Initial soil PTE analysis (mg/kg dry weight)[10]
- Cumulative soil PTE calculation (mg/kg dry weight)[11]
- Soil nutrient analysis[12]
- Anaerobic digestate analysis (provided by the supplier, typical or actual)
- Application details (date, grid reference, tonnes / ha, hectares, incorporation depth).

Application requirements include compliance with relevant codes of good practice. These include the Defra 'Code of Good Agricultural Practice to Protect Water, Soil and Air Quality'. In forestry or restoration to forestry and including forestry for biomass production, the key code of good practice is the Forests and Water Guidelines, 4th Edition[13].

The Waste Management Licensing Regulations 1994

The Waste Management Licensing Regulations 1994, the Waste Management Licensing Amendment (Scotland) Regulations 2003, and amendments, are made under the Environmental Protection Act 1990 to regulate, amongst others, application of wastes to land.

Guidance on the SEPA website[14] states that:

- "Some activities involving waste materials are exempt from licensing if they meet the requirements detailed in Regulation 17….

- "Although an activity may be exempt from waste management licensing, it is still subject to statutory controls to prevent environmental pollution and harm to human health.

There are two main 'Exemptions' relevant to land improvement using organic wastes, of which 'Paragraph 7' applies to AD / CLO.

Paragraph 7 Exemption for 'Land Treatment for benefit of agriculture or ecological improvement'

Exemption is divided into treatment of land used for agriculture and treatment of land not used for agriculture.

[10] Potentially Toxic Element to humans, flora or fauna, including 'heavy metals' such as lead, cadmium, mercury, copper, chromium, zinc and nickel

[11] The land manager should … 'ensure that the limit values set out in the 'Sludge Code' are not exceeded'. Soil PTE levels should be determined before application and when the predicted concentrations approach 75 percent of the limit values

[12] 'Soil analysis should include pH, extractable phosphorus, potassium, magnesium and total sulphur.' The soil nitrogen supply should be assessed or taken from a recent soil analysis

[13] Forests and Water Guidelines, 4th Edition, Forestry Commission (2003)

[14] www.SEPA.gov.uk

Land Used for Agriculture: AD / CLO can be used under Exemption for treatment of land used for agriculture whether for agricultural benefit or ecological improvement.

SEPA guidance advises that treatment for agricultural benefit requires that "the addition of nitrogen, phosphorous and other plant nutrients in waste material should take account of the soil nutrient status and other sources of nutrient supply and be matched to the needs of the planned crop rotation". Furthermore, "the addition of total nitrogen attributable to the use of waste on the land in any 12 month period must not exceed 250 kilograms per hectare.

Treatment for ecological improvement covers maintenance of wildlife habitats that might otherwise deteriorate, creation of new habitat is created and restoration of old habitat.

Land Not used for Agriculture: Treatment must be justified as ecological improvement.

SEPA guidance[15] states that, amongst others, "land which is forest, woodland, park, garden, verge [etc], can only be treated with wastes that are included within Part 1 of Table 2 of the regulations".

Non PAS110 AD / CLO appears to be a "Waste from anaerobic treatment of waste" under Part 2 of Table 2 of the Regulations[16] which cannot be applied to forest land by exemption under the WML Regulations.

However, SEPA granted a Paragraph 7 exemption for 'the treatment of land for ecological improvement' for the 2011 FC / WRAP forestry field trials using AD / CLO and compost. This exemption applied to an unplanted former opencast coal site and not to land already used for forestry.

Therefore non-PAS 110 AD / CLO can be applied to non-forest restoration land by exemption under the WML Regulations but currently not to forest land. However, it is considered that an exemption would be granted for forest land provided that a sound ecological improvement justification were presented.

Of course, the Regulations do not apply to PAS110 AD / CLO because it is not classified as a waste. Note that accreditation to PAS110 requires waste to be source segregated.

The Regulations state that, in all cases of Paragraph 7 Exemptions, "no more than 250 tonnes … of waste per hectare [can be] used on the land in any period of 12 months"

Paragraph 7 exemption requirements also provide that individual sites cannot exceed 50 hectares and various application documents are required including a plan showing water courses etc, analyses of the waste and soil, together with an application fee. Exemptions extend for a maximum of 12 months but can be renewed. Where the

[15] Technical Guidance Note, Paragraph 7 Exemption, Land treatment for benefit to agriculture or ecological improvement, SEPA (undated)

[16] Code 19 06 04 in Table 2A Part II of the Regulations. This applies to Digestate from anaerobic treatment of municipal waste.

application refers to treatment for ecological improvement (as opposed to agricultural benefit) a technical justification is also required.

Paragraph 9 Exemption for 'The Reclamation or Improvement of land'

Anaerobic digestate is not listed for Paragraph 9 exemption.

The Paragraph 9 exemption only applies to land that has been subject to 'industrial or other man made development', and in the case of most organic wastes requires benefit to agriculture or ecological improvement. Paragraph 9 exemption, amongst others, covers 'Sludges from treatment of urban waste water' such as sewage sludge and 'Off-specification compost consisting only of biodegradable waste'. The latter also qualifies under Paragraph 7.

The Controlled Activities Regulations (CAR) 2005

The Water Environment and Water Services (Scotland) Act 2003 resulted in the Water Environment (Controlled Activities) (Scotland) Regulations 2005 and subsequent amendments[17]. The 'CAR' regulations govern, amongst others, activities involving discharges of polluting matter to all wetlands and into surface and ground waters (replacing the Control of Pollution Act 1974).

The CAR Regulations, following the Control of Pollution Act 1974, provide for a statutory offence of 'causing or knowingly permitting any poisonous, noxious or polluting matter to enter controlled waters'.

The system of regulation is proportionate to risk from lower risk activities where General Binding Rules apply, through Registrations to Licences for higher risk activities. If any activity is already authorised under certain other environmental regulatory regimes it will be considered to be authorised under CAR. These include The Pollution Prevention and Control (Scotland) Regulations 2000 and the Waste Management Licensing Regulations (1994) (under Part II of the Environmental Protection Act 1990).

The General Binding Rules include:

- GBR18 - Storage/application of fertilisers, where not already covered by regulations and
- GBR 20 - Cultivation of land.

The main relevant provisions of GBR 18 cover stand-offs from water courses (2m) and springs etc (50m) and slope limits (15 degrees or 25 degrees for uncultivated land intended for forestry). Importantly, the rules state that 'Fertilizers must not be applied to land in excess of the nutrient needs of the crop'. GBR 20 provides for cultivation standoffs from watercourses or wetlands (2m) and springs (5m). In both cases activities must take place in such a way as to minimise the risk of pollution to the water environment.

[17] Water Environment (Diffuse Pollution) (Scotland) Regulations 2008

Forests and Water Guidelines 2003

Compliance with the Forests and Water Guidelines[18] is a mandatory requirement for all forestry operations and grant schemes regulated by Forestry Commission Scotland as the Scottish Government's forestry department. The Forests and Water Guidelines cover all aspects of forestry operations including drainage, cultivation, planting, maintenance, chemicals and roading. In the event of any pollution incident involving forestry or forest land, non-compliance with the guidelines would be a material factor in respect of prosecution under any relevant legislation.

The Forests and Water Guidelines are considered to be a relevant code of good practice that must be complied with in application of the Anaerobic Digestate Quality Protocol.

The main provisions of the Forests and Water Guidelines include, but are *not limited to*:

- Leave uncultivated buffer strips alongside water courses (20m buffer for >2m watercourse, 10m buffer for 1-2 m watercourse, 5m buffer for <1m watercourse: *all subject to local constraints*. Minimise soil disturbance close to drains and natural water courses
- Observe a 3 - 5m buffer between plough furrows and collecting / cross drains on slopes over 9% (5 degrees)
- Align drains up-valley with slope <3.5% (2 degrees), or less on more erodible soils
- Provide vegetation buffers between drain ends and natural watercourses, preferably on more level ground. Do not connect drains (site or roadside) directly into natural water courses
- Provide collecting / cross drains to control water seeping across the site e.g. at 40 - 70m on slopes <c5% (3 degrees). Do not delay installation of collecting drains following cultivation
- Do not connect or divert natural water courses into drains, including roadside drains, or *vice versa* and do not divert water outwith the natural catchment
- Provide accessible silt traps in highly erodible conditions as back-up sedimentation control. This may include complete cultivation ground.

The Prevention of Environmental Pollution from Agricultural Activity Code 2005

The Scottish Government 'PEPFAA Code'[19] describes good practice for prevention of pollution from a range of agricultural activities including spreading organic and inorganic fertilizers, manures, sludges and slurries. The Code provides lists of 'Dos' and 'Don'ts', some of which have statutory basis, for example under the CAR

[18] Forests and Water Guidelines, Fourth Edition, Forestry Commission (2003)
[19] Prevention of Environmental Pollution from Agricultural Activity. Scottish Executive. Edinburgh (2005)

Regulations and the WML Regulations. Contravention of the Code may be taken into account in any legal proceeding.

The key relevant statements of the PEPFAA Code are:

- Livestock slurries should not be spread within 10m of any watercourse or 50m of any drinking water supply, to steeply sloping fields, when there is flooding or forecast heavy rain, to soil that has been frozen for 12 hours or longer in the preceding 24 hours or is covered in snow.
- Livestock slurries should not be spread at a rate that fails to account for the overall suitability of the land, and should never exceed 50m3 / ha for surface application.
- Livestock manures and slurries 'should be applied in amounts such that nutrient content, particularly of N and P, can be utilised by growing crops. Excessive applications can result in high N and P concentrations in the soil and increased risk of water pollution'.

Whilst the PEPFAA Code applies to agricultural activities rather than reclamation of non-agricultural land, the principles of avoidance of pollution with associated statutory liabilities are relevant. These include matching application rates to soil and plant requirements.

The Forestry Environmental Impact Assessment Regulations 1999

Forestry Commission Scotland (FCS) is responsible for administering the Environmental Impact Assessment (Forestry) (Scotland) Regulations 1999, and amendments. Assessment and approval is required where operations involving afforestation, roading or quarrying (borrow pits) and deforestation exceed relevant thresholds. The threshold area for afforestation (including SRC) outside sensitive areas is 5 ha, and includes any adjacent areas from the previous 5 years. Deforestation threshold is set at 1 ha.

Land restoration to forestry is therefore likely to require determination except on small areas.

Code of Practice for the Agricultural Use of Sewage Sludge 1989

The 'Sludge Code' or 'Code'[20] was published by the Department of the Environment in 1989, was updated in 2001 and complements the Sludge (Use in Agriculture) Regulations 1989 (SI 1989, No. 1263) which covers GB. Although the code relates to the use of sewage sludge on land, the principles are relevant to use of AD / CLO.

[20] Code of Practice for Agricultural Use of Sewage Sludge, DoE (1989)

Amongst other objectives, the Code is intended to ensure that use of sludge avoids public nuisance and water pollution and safeguards the health of humans, animals and plants. Government and industry agreed to the 'Safe Sludge Matrix[21]' and its incorporation into the Regulations which required the phasing out of the use of untreated sewage sludge (as compared to treated sewage sludge) on agricultural land by the end of 1999 and for 'industrial crops' by the end of 2005. Treated sludge may still be used on land for agricultural crops under strict conditions and for industrial crops including willow and poplar Short Rotation Coppice. Untreated sewage sludge can still be applied during land restoration under other legislation, principally the Waste Management Licensing Regulations 1994.

The Code provides for prior soil sampling and gives maximum soil concentrations of PTEs, some of which (Zn, Cu, Ni) increase with increasing pH (alkalinity).

Whilst the Code relates to use of sewage sludge, the principles and chemical limits are relevant to other organic soil amendments.

Nitrate Vulnerable Zones

The EC Nitrates Directive (91/676/EEC) was transposed into Scottish law by the Protection of Water Against Agricultural Nitrate Pollution (Scotland) Regulations 1996. Together with subsequent implementing regulations, this legislation has established a number of Nitrate Vulnerable Zones across Scotland within which agricultural activities are controlled to reduce the risk of eutrophication[22] of surface and ground waters. Safeguards are also relevant to Phosphorus, which can also cause eutrophication.

The Anaerobic digestate Quality Protocol states that "In areas designated as Nitrate Vulnerable Zones (NVZs) under legislation to implement the Nitrates Directive[23], applications of quality digestate must comply with the relevant mandatory Action Programme. These include various requirements for maximum rates of application and permitted application windows for different types of manures and quality digestate". In terms of the legislation, 'there are currently no NVZ restrictions on non-agricultural land as part of a land reclamation project'[24]. West Lothian does not fall within any NVZ.

The Quality Protocol also states that "In all other areas these requirements should be followed wherever practical". The Scottish NVZ rules set an upper limit of 250kg N / ha / year applied as organic manure. The definition of organic manure includes any nitrogen fertilizer derived from animal, human or plant sources and the definition of

[21] Guidelines for the Application of Sewage Sludge to Agricultural Land, ADAS (2001)

[22] The 'enrichment of water by nitrogen compounds, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water' (from PEPFAA Code, 2005)

[23] Nitrate Vulnerable Zones (Scotland) Regulations 2008

[24] Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)

nitrogen fertiliser covers any substance containing a nitrogen compound utilised on land to enhance growth of vegetation. Anaerobic digestate / CLO therefore qualifies as an organic manure under the NVZ rules and under the Anaerobic digestate Quality Protocol should conform where practicable to the application limit of c 250kg N / ha / year.

It is considered that AD / CLO used in land restoration, as opposed to sustaining a crop of biomass, would not be capped at 250kg N / ha / year.

Factors affecting AD / CLO use in land regeneration

Influencing factors

Land restoration for tree planting is likely to involve creation of a growing medium using pre-restoration soil forming material (usually the surface ground and deposit/s) and addition of organic matter. These may be supplemented as necessary with fertiliser if the resulting nutrient levels are low.

The Forestry Commission minimum standards for restored soils for tree planting are:

Table 1 Minimum standards for soil forming materials acceptable for woodland establishment[25]

Parameter	Standard	Comments on method
Texture	No limitations; however, the placement location of materials of different texture on site should be related to site factors e.g. topography	Texture (% sand, silt and clay) should be determined by pipette method. Preferred textures include materials with > 25% clay
Bulk density (after placement)	<1.5 g cm-3 to at least 50 cm depth <1.7 g cm-3 to below 1 m depth	
Stoniness: Clay or loam	<40 % by volume of material greater than 2 mm in diameter and <10 % by volume of material greater than 100 mm in diameter	Measure mass of stone >2 mm and >100 mm in a known mass / volume of soil; divide each value by 1.65 to calculate the volume
Stoniness: Sand	<25 % by volume of material greater than 2 mm in diameter and <10 % by volume of material greater than 100 mm in diameter	
pH	Within the range 4.0 to 8.0	Based on a 1:2.5 soil: $CaCl_2$ (0.01 M) suspension

[25] Foot K. & Sinnett D., (2006). Best Practice Guidance for Land Regeneration. BPG Note 5. Imported Soil or Soil Forming Materials Placement. Forestry Commission.

Electrical conductivity	<0.2 S m-1	Based on a 1:1 soil:water suspension
Iron pyrite content	<0.05 %	British Standard 1016 method
Topsoil nutrient and organic content	N >200 kg N ha-1 P >16 mg l-1 (ADAS Index 2) K >121 mg l-1 (ADAS Index 2) Mg >51mg l-1 (ADAS Index 1) Organic matter content >10%	Standard ADAS methods
Specific metal and organic contaminants	These should fall between the Soil Guideline Values (DEFRA and EA, 2002) for residential without plant uptake and industrial / commercial, where no SGVs are available acceptable limits should be derived using a risk based approach for human health. Levels of copper and zinc should not exceed 130 or 300 mg kg-1 respectively.	Determination according to substance using a method comparable with the Soil Guideline Values being used. Approval should be sought from Forest Research on the guideline concentrations being used before soil placement begins.

The main characteristics of pre-restoration sites that will require remediation for tree planting are:

- Compaction (indicated by high bulk density)
- Low Organic Matter content
- High stone content
- Deficiency in major plant nutrients

Restored sites will also require acceptable:

- Landform and drainage
- Soil chemistry (pH, electrical conductivity/salinity, nutrient content, contaminant content).

Whilst this is not an exhaustive list, it covers the key physical parameters that are likely to be critical to success on most sites. The value of AD / CLO in land reclamation is a consequence of these characteristics:

Compaction

Trees will not grow effectively in compacted ground due to impeded root penetration and the effect that compaction has on availability of air, water and nutrients in the soil. Compaction may be inherent, resulting from natural ground conditions or may be man-made, e.g. due to passage of machinery over the site. Soils vary in their susceptibility to compaction, which generally increases with increasing silt / clay fraction and is considerably exacerbated by wet conditions. Even machinery regarded as having relatively low ground pressure such as tracked dozers is likely to cause significant ground compaction if used in wet conditions. Compaction, linked with soil damage from shearing / smearing, will probably be a reflection of poor soil structure in the form of low porosity and air space, and lack of fissuring.

It is essential to relieve compaction during land restoration for green after-use, and to ensure sufficient rootable depth. Forestry Commission guidelines are for a minimum of 1m of rootable depth to satisfy the needs of a range of tree species and provide good soil drainage to the lower part of the soil profile.

Complete cultivation is the most effective means of relieving compaction and can be achieved very effectively by 360 degree excavator in combination with admixture of organic amendments such as AD / CLO to restoration soils.

Low organic matter content

Organic matter is a valuable component of soils, acting as a reservoir of soil moisture and nutrients and hosting micro-organisms and other soil flora and fauna that play key roles in soil processes including generation and release of nutrients. Organic matter includes surface needle litter / leaf mould and material within the soil profile, especially in the topsoil. Although soils with a high organic matter content are less susceptible to compaction, they are susceptible to other forms of soil damage such as shearing and loss of soil fissures. Organic matter is made up of dead plants and organisms comprising, amongst other elements, carbon, nitrogen and oxygen. These are converted and made available by soil process including decomposition and growth of soil flora and fauna. Although soils may include important nutrients such as nitrogen within the organic matter, this may be in a form that is not available or is released only slowly.

Compost or AD / CLO can be a valuable source of new soil organic matter, especially when mixed into soil forming material during cultivation.

High stone content

High stone content reduces the volume of soil available to plant roots and can have a significant impact on survival, stability, growth and drought tolerance. Restoration practices are used to mitigate the effect by importing soil, soil forming material and organic matter on the one hand and by removing the larger rocks and boulders during cultivation.

Addition of AD / CLO increases the soil volume by bulking-up the existing soil forming material. The process of mixing by excavator can also be used to remove larger rocks and boulders.

Nutrient deficiency

Healthy and sustained tree growth requires availability of 'major' plant nutrients which are very likely to be insufficient within soil forming material available on former industrial sites and mineral workings. Nitrogen is especially likely to be deficient, and potassium and phosphorus are likely to be 'low' or deficient also. Other 'minor' plant nutrients may also be sub-optimal, such as magnesium and boron.

The availability of nutrients is influenced by the form in which they are held within the soil, so the total amount present may be significantly greater than the quantity that is available for uptake by plants. Some forms are also more likely to be lost through gaseous exchange or leaching which can lead to pollution, plant damage and perhaps subsequent deficiency following an initial surge. It is therefore important to match the quantity of organic amendment to soil conditions to avoid pollution and unwanted effects on plants and the soil itself. Excessive amounts of soil organic matter can disturb soil chemical and microbial processes by immobilising nutrients, especially if the ratio of Carbon to Nitrogen (C:N) is over 25:1. Organic amendments can contribute to nutrient leaching if the C:N ratio is below 10:1.

Organic soil amendments such as compost and AD / CLO are significant sources of nitrogen, phosphorus and potassium.

The analyses of PAS100 Compost and AD / CLO supplied for the 2011 Forestry Commission / WRAP field trials were characterised as:

- AD / CLO: slightly lower pH, much higher OM, much higher Total N, very high ammonium-N, very low nitrate-N, high extractable P, low-moderate-high extractable K & Mg compared to compost
- Compost: slightly higher pH, much lower OM, much lower Total N, low ammonium-N, higher nitrate-N, high extractable P, high-very high extractable K and Mg compared to AD.

The high ammoniacal-N in AD is converted to nitrate-N by soil bacteria. It may be that future process improvements in the production of AD will reduce the initial high ammoniacal content of the digestate, or that a period of maturation or composting will be required to convert ammoniacal-N to nitrate.

The analysis figures for the Compost and AD / CLO supplied for the 2011 forestry field trials shows that there is some variability between batches, especially in respect of Potassium and Magnesium.

Full analyses of the AD / CLO and compost are provided at Appendix A1.

In appropriate conditions, compost and AD / CLO can be effective sources of plant available Nitrogen and Phosphorus and also of Potassium in the case of compost. Nitrogen in AD / CLO is of a more water soluble and volatile nature and greater care is needed in its application.

Landform and drainage

Clearly landform needs to be suited to end use, which in the case of restoration to forestry or woodland with open space is likely to mean of natural appearance without excessively steep ground. Well designed landform will aid drainage both off site and

into wetlands or water courses as required without erosion and subsequent uncontrolled siltation. The underlying standard for forestry restoration sites adopted by FC Scotland is that slopes should not exceed 1:6 (c17%) or less if the ground comprises more readily erodible material with low clay content such as sand.

Drainage may be required on restoration sites to lead water away from the top of artificial slopes, avoid undesired 'ponding' or uncontrolled runoff, and to service designed water features such as ponds and wetlands, which may also have a silt control function. Healthy tree growth resulting from rootable depth, root anchorage and nutrient supply requires aerated soil, although some species or genera such as Alders have greater tolerance of wet soil conditions and occasional or seasonal water-logging. Good drainage can be achieved with varying mixes of artificial drains and landform. Well designed landform will reduce artificial drainage requirements and poor landform requires a large degree of artificial drainage.

Drainage on forestry restoration sites should follow the Forests and Water Guidelines, referred to in the 'Regulatory Regime' section of this report, in order to comply with best practice as demanded by legislation. In some cases the principles of the Guidelines will justify more stringent controls, including presumption for a 5 - 10m uncultivated buffer alongside loose tipped soil[26]. However, there are additional factors to take into account in the context of adding organic soil amendments such as AD / CLO to soils during restoration operations.

Poor drainage and water logging will undermine the benefits of soil amendments and can cause deteriorating soil conditions and pollution. Problems resulting from such anaerobic soil conditions include:

- Reduction of 'plant available' Nitrogen in Nitrates to less available forms
- Impeding the (desirable) oxidisation of Nitrogen in Ammonium to nitrate, resulting in greater tendency for Nitrogen leaching into the water environment and release of Ammonia, which is toxic to plant roots
- Impeding the (desirable) growth of aerobic bacteria and other soil micro-organisms, flora and fauna so blocking or lowering the rate of conversion and release of nutrients and promoting the (undesirable) development of anaerobic soil communities.
- Leaching of Potassium, which is a major plant nutrient that is highly water soluble and is often already in short supply in restoration soils.
- Generation of Hydrogen Sulphide and associated unpleasant odour.

Soils with a higher proportion of Organic Matter will have a higher absorption and water retention capacity. Addition of organic soil amendments such as AD / CLO to poorly draining soils could therefore exacerbate poor drainage and anaerobic conditions.

[26] Foot K. & Sinnett D., (2006). Best Practice Guidance for Land Regeneration. BPG Note 5. Imported Soil or Soil Forming Materials Placement. Forestry Commission.

Soil chemistry

The availability of nutrients in the soil to plants is very dependent on soil chemistry, including:

- Acidity / alkalinity (pH): there is generally an acceptable pH range for availability of major and minor plant nutrients which is reflected in the recommended soil pH range of 4 to 8 (**Table 1**)
- Excessive alkalinity (pH >8) and high Electrical conductivity / salinity can result in soil conditions that are toxic to plants
- Excessive acidity (pH <4) can increase the availability of certain heavy metals from unavailable forms. For example the availability of the 'Potentially Toxic Elements' Zinc, Copper and Nickel - which are also phytotoxic - is greater in more acid conditions.

Parent soil / soil forming materials are frequently found at either end of the acceptable pH range. For example, the Dalquhandy restored opencast site at Coalburn used in the 2011 Forestry Field Trials had a pH of 4.8 as compared to the oil shale site at West Calder which had a pH of 7.2 to 8.1.

Restoration soils may contain toxic substances from both natural and industrial sources such as PTEs (heavy metals) and hydrocarbons. Acceptable limits in soils / soil forming material, and wastes used for soil amelioration, are given legal force by legislation and standards for soil amendments including BSI PAS100 (Greenwaste Compost) and PAS110 (Fibre Digestate). The level of various contaminants within organic soil amendments is variable because it is dependent on the particular source or sources of waste / raw materials. In some cases batches of amendments will fall outside the standard in one or more parameters. In the context of soil chemical properties, the important requirement is that the finished soil / amendment mix should comply with the relevant overall acceptable contaminant range. It is therefore as necessary to match quantity and characteristics of organic soil amendment to the site, as it is in respect of other soil characteristics such as nutrient and organic matter status.

Organic soil amendments including sewage cake, compost and AD / CLO have neutral to slightly alkaline pH values, near the threshold of pH 8 for forestry soils, and this may be advantageous when mixing with an acidic soil forming material. The amendments may also contain elevated concentrations of contaminants such as PTEs (heavy metals). However, compost and digestate produced to BSI PAS 100 and 110 respectively will have PTE levels below accepted threshold limits. Soil/soil forming materials with which the organic amendments are mixed must also be analysed to determine PTE concentrations, so that overall limits are not exceeded. In practice, it is more likely that the nitrogen content of the organic amendment will be the limiting factor.

Using AD / CLO as a soil amendment

The composition analysis of PAS100 Compost and anaerobic digestate used in the 2011 Forestry Commission / WRAP forestry land reclamation field trials at Addiewell in West Lothian are presented in **Appendix A, Table A2.**

The pros and cons of Compost and AD / CLO as soil amendments are summarised as:

Table 2 Advantages and disadvantages of compost and AD / CLO as forestry soil amendment in land restoration *(Key issues highlighted)*

Finished Soil Parameter	Advantage of Compost and AD/CLO	Disadvantage of Compost and AD/CLO
Ground Compaction	• Reduction in soil bulk density • Compaction relieved during mixing • Reduces post cultivation settlement	
Organic Matter	• Good source to raise restoration soil to acceptable levels • Very beneficial for materials with very low organic matter content such as oil shale • Organic matter can 'lock up' heavy metals in insoluble organic complexes (but see right)	• Suitability reduces with increasing soil organic matter content • Unsuitable for soils already high in organic matter such as peats • Organic matter can *release* heavy metals in soluble organic complexes (but see left)
Drainage	• Improves water holding capacity in soils having low organic matter content • Associated cultivation can improve drainage through the soil profile • Increased resulting vegetation cover can aid surface water filtration and soil stability	• Exacerbates poor drainage in soils having high organic matter content • Risk of leaching and pollution in wet soils • Special attention required to minimise pollution risk
Soil Chemistry:		
pH	• Reduces excessive acidity / increases pH to help achieve acceptable pH range, although effect is likely to be limited • More suited to acidic conditions	• Less suited to alkaline conditions • Increased pH / alkalinity can exacerbate salinity and lead to generation of toxic salts
Nutrients	• Good source of ***Nitrogen*** and, to a lesser extent of Phosphorus, Potassium and Magnesium	• AD has a high initial ammoniacal-N content that could increase pollution risk • Provision of Potassium

		may be low, depending on batch
Salinity / Electrical conductivity	• Salinity of mixed soils has a tendency to fall following mixing with soil	• May raise levels in restoration soils already high in salinity above acceptable level for forestry (although this should not be a problem if compost and AD is PAS specification)
Contaminants	• If supplied under PAS certification will be compliant with acceptable levels • Not classified as 'waste' or subject to waste management regulations if BSI PAS certified	• May raise levels in restoration soils already high in individual contaminants above acceptable level for forestry
Odour	• Compost has no odour and cannot be mistaken for organic wastes such as sewage cake • Development in the AD production process, extra maturation or composting may reduce odour issues	• AD / CLO tested in the 2011 Forestry Field Trials had a strong odour similar to sewage cake (although the odour largely dissipated soon after mixing with soil, it persisted in 'close contact' for a few weeks)

The key characteristics of organic soil amendments such as AD / CLO in the context of land restoration are:

- Organic matter
- Nutrients (Nitrogen)
- Contaminants
- Odour

These are discussed below, together with the key operational factors that should be assessed for candidate sites:

Organic matter

The relationship of AD (anaerobic digestate) to CLO (compost like output) is described in the literature[27]:

- CLO - a generic term used to describe organic rich materials which have been derived from mixed municipal waste feedstocks through some form of mechanical biological (MBT) treatment to produce an organic rich fraction

- AD - also known as 'digestate' and 'fibre digestate' when separated by partial dewatering, anaerobic digestate results from a process whereby organic material is broken down by bacteria in a sealed environment without oxygen.

[27] Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)

This produces biogas which can be used for energy and also digestate. Digestate can be separated into fibre and liquor.

AD is high in organic matter content (**Appendix A, Table A1**), comprising c 90% by weight in the example. Organic matter can make a significant contribution to the physical structure of the soil to which it is applied by[28]:

- Reducing soil bulk density
- Increasing soil moisture available to roots
- Improve aggregate stability, so lowering erosion risk
- Increasing porosity, so improving aeration, water infiltration and drainage.

Addition of organic matter also stimulates soil biological activity to improve nutrient recycling and soil fertility, including soil micro-organisms and fauna such as earthworms, all of which help to turn a mixture of materials into a sustainable, functioning soil ecosystem.

Nitrogen

The chemical benefits from organic matter, including AD / CLO, 'are largely a result of their nitrogen and phosphate content, although levels of potash [K] may be beneficial'[29] and 'vital trace elements' may also be present. Recycled organic matter is usually neutral or slightly alkaline pH which is an advantage on more acidic restoration sites, and can improve the soil buffering capacity and reduce the bioavailability of some contaminants such as nickel and zinc. Conversely, excessive alkalinity can disturb soil processes and limit tree choice and performance.

Nitrogen deficiency is one of the more important factors limiting the reclamation of derelict land[30].

Organic amendments including AD / CLO are a good source of Nitrogen, which is an essential major plant nutrient and is often the most limiting soil chemical factor on plant growth potential on restoration sites. However, Nitrogen is also a potentially important pollutant, because once released in the soil in an available form it is particularly mobile in the water environment, including ground water. High levels of Nitrogen in water can lead to environmental damage including toxic algal blooms, and disturbance of the chemical composition of watercourses with consequent damage to aquatic life.

The amount of Nitrogen provided during restoration must be matched to the requirements of the receiving site for reasons of both legislation and environment.

[28] Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)
[29] Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)
[30] The Nitrogen Cycle of the United Kingdom. A Study Group Report. The Royal Society (1983)

If organic amendments are not processed as a product, for example to BSI PAS specification, then they are classified under legislation as a *waste*. In such cases application rates and operations are strictly controlled under licence or licence exemption by SEPA. This is a process which can be lengthy and expensive since it involves site-based soil sampling and analysis matched to sampling and analysis of the organic amendment to prove both the need for the operation and the acceptability of its risk.

If organic amendments are processed as a product to a specification, for example to BSI PAS specification, then they are not classified as a waste and restoration, cultivation and mixing operations do not fall under waste management licensing restrictions. However, the remaining legislation such as CAR Regulations and the various Codes of Good Practice still apply so as to require a high degree of justification for application rates.

Natural soils are very variable in their Total Nitrogen content, ranging from 5,000-20,000 kg N/ha in good fertile temperate soils[31], although the proportion that is available to plants will be less. In a comparison of six hardwood sites in the UK the Total Nitrogen in the upper 70cm of mineral soil was 4,744 kg / ha, compared to 108 kg in leaf litter, 155kg in roots, 22kg in understory plants and 275kg above-ground in trees[32]. The range in Total Nitrogen in the soil was 1,300 to 7476kg / ha.

Artificial soils including subsoil, mining spoil and overburden can have very low Total Nitrogen, and much of that is likely to be 'fossil Nitrogen' held in unavailable forms. For example, the Total Nitrogen at two forestry reclamation sites in central Scotland were 0.16% (Addiewell, oil shale tip) and 0.236% (Dalquhandy, restored opencast coal site).

Sniffer (2010) reports that 'the average ecosystem in a temperate climate needs about 100kg N / ha / yr to maintain good growth'. For compost, between 5% and 10% of the Total Nitrogen and (and 15% of Phosphorus) is released in the first year of application[33]. AD has a higher proportion of ammoniacal Nitrogen so the relevant figure will be higher.

Published expert guidance suggests in general application of no more than 1,500 kg of Total Nitrogen per hectare in any one application[34]. Forestry Commission restoration guidance repeats this advice and also states, for example, that application rates for sewage sludge should not exceed 1,000 kg of Total Nitrogen during the planting and

[31] Hipkin, A. (2011). Personal communication
[32] [32] The Nitrogen Cycle of the United Kingdom. A Study Group Report. The Royal Society (1983) after Ovington, J.D. 1962 Quantitative ecology and the woodland ecosystem concept. Adv.Ecol.Res., 1, 103-192 and Satchell, J. (ed.) 1983 Ecology of an English Oakwood. Berlin: Springer-Verlag (in press)
[33] WRAP, Using quality compost to benefit crops. WRAP (undated)
[34] Bending, N.A.D., McRae, S.G and Moffat, A.J. (1999). Soil-forming materials, Their Use in Land Reclamation. The Stationary Office, London

establishment phase, which in the forest industry is usually taken as at least 5 years. Some restoration operations will encounter the lower extremes and may justify applications at or even above the upper end of the scale to 'kick start' a new soil ecosystem[35]. On land restoration sites 'SEPA have supported a maximum N rate from sewage sludge up to a maximum of 3,000 kg N ha-1 where a comprehensive and satisfactory risk assessment has been carried out'[36].

Recent guidelines published by Sniffer (2010)[37] in Scotland suggest a range of 100 to 500 tonnes of dry solids per hectare for soil formation in colliery spoil restoration and landfill caps etc. This equates to about 200-800 wet tonnes / ha of compost and 300-1,600 tonnes / ha of AD, yielding up to 8,500 kg and 23,500kg of Total Nitrogen respectively. The maximum rates 'will vary depending on the condition of the land and contaminant concentration in both the organic soil amendment and the soil'.

For comparison, the upper AD application rate used in the 2011 forestry field trials on oil shale at Addiewell was 200 wet tonnes / ha (64 dry tonnes) yielding 3,000kg Total Nitrogen.

However, Sniffer (2010) goes on:

'depending on the site specific environmental conditions, particularly in the case of colliery spoil, the maximum application rate may need to be considerably higher than 500 tonnes [dry solids] per hectare, depending on the condition of the land, soil pH, and the quality of the organic material(s) used. Application rates in excess of 500 tonnes [dry solids] per hectare would need to be justified to the environmental regulator and approved in advance'.

The guidance continues:

'**Higher than normal rates of organic matter application should only be considered if it can be demonstrated that they are both beneficial and necessary for the planned end use. Applications in excess of that needed for sustained ecological improvement could be considered as a waste disposal rather than a land reclamation operation**'.

The above guidance is emboldened by the author of this report because it is considered to be a crucial statement.

The Sniffer advice also states that the risk of excessive mobile nitrogen from high application rates may be reduced by mixing with material having a high C:N ratio which will capture some mobile nitrogen.

[35] Hipkin, A. (2011). Personal communication
[36] Mark Aitken, Personal communication to A. Hipkin
[37] Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)

Although AD / CLO has somewhat different characteristics to sewage sludge, there is a developing consensus on the general *quantum* of acceptable Nitrogen application rate.

Forestry field trials by FC funded by WRAP[38] on both loam and clay soils on a reclaimed landfill site in Glasgow from 2008 to 2010, investigated the growth effect of increasing levels of 20mm PAS100 compost equivalent to addition of:

Control	Nil
'12.5%'	2,500kg TN / ha (~ 300 tonnes wet compost / ha)
'25%'	5,000kg TN / ha (~ 600 tonnes wet compost / ha) and
'50%'	10,000kg TN / ha (~ 1,200 tonnes wet compost / ha)

After two seasons this revealed problems arising from higher application rates:

- Excessive top growth of Silver birch at 10,000kg TN / ha, and to a lesser extent the 5,000kg TN / ha treatment, resulting in trees with insufficient rooting to maintain the stem stability
- No increased growth or soil plant nutrient content from 5,000 to 10,000kg TN / ha
- Heavy weed growth in all compost treatments, especially the higher rates
- Oversupply of available Nitrogen [compared to the uptake ability of the plants] in the 5,000 to 10,000 tonnes TN / ha plots.

The conclusion of the 2008-2010 forestry field trails was that application of compost equivalent to somewhere between the 2,500 and 5,000kg TN / ha would be optimal. This would supply sufficient nutrients for a more than doubling of tree growth with both soil organic matter content and pH approaching and trending over time towards recommended levels.

Available Nitrogen is held in nitrate (NO_3) and ammoniacal (NH_4) form. Ammoniacal Nitrogen is released into the environment faster than nitrate Nitrogen, in particular by leaching into surface and groundwaters and as such is a greater pollution risk than compost. AD / CLO has a very much higher proportion of ammoniacal Nitrogen than compost as shown in **Table 3**:

[38] Hipkin, A. The Greenoakhill Trailblazer Project: The use of compost to manufacture topsoils for brownfield regeneration with tree planting at the Greenoakhill Landfill Site, SE Glasgow. WRAP, 2010

Table 3 Summary of actual AD / CLO and compost nitrogen analysis in 2011 forestry field trials[39]

Parameter	AD	PAS100 20mm Compost	Units
Total N	4.63	1.17	% dry matter
N, Ammoniacal	20,505	998	mg/kg DM
N, Nitrate	4.0	12.2	mg/kg DM
To supply 3,000kg TN / ha	64	256	Dry tonnes / ha
To supply 3,000kg TN / ha	206	422	Wet tonnes / ha
To supply 3,000kg TN / ha	366	684	Wet m3 / ha

Compost and AD / CLO have quite different chemical properties in respect of Nitrogen availability[40]. Therefore, a detailed assessment of both the proposed AD / CLO amendment and the needs of the receiving site is required. The aim should be to ensure that quantity and type of amendment is appropriate and will not have unwanted side effects.

A detailed assessment of the chemical characteristics of AD / CLO and compost is beyond the scope of this report. However, research currently underway at the Addiewell and Dalquhandy trial sites aims to provide information on soil and plant effects of using AD / CLO in land restoration to forestry, both alone and mixed with compost.

Contaminants

Contaminants are defined here as components of the organic amendment that are not a beneficial justification for its application, whether physical or chemical. Compost and AD / CLO meeting PAS 100 / 110 standards will have physical contaminants (plastics, glass, metal fragments) below defined thresholds. Physical contamination is not regarded as a constraint on forestry use since appearance is unlikely to be important.

However, chemical contamination is important because in addition to upper limits allowed under PAS accreditation, guidelines and legislation concerning improving soils with organic amendments establishes limits on contamination levels in the finished soil. For example, the Sludge (Use in Agriculture) Regulations 1989 and the PEPFAA Code (2005) provide limits of 'PTEs' (such as 'heavy metals') in soils after application of sewage sludge (**Appendix A. Table A3**). These limits are a reflection of potential

[39] Source: Hipkin, A (2011). WRAP Interim Report, Dalquhandy Project, Site Restoration using Anaerobic Digestion 'Fibre'. AD/CLO and compost used at Addiewell was similar but data is incomplete at time of writing

[40] And also in other important characteristics such as salinity / electrical conductivity

harm to humans or the wider environment resulting from ingestion, uptake or modification of chemical processes in soil, plants and organisms. Upper site limits are defined for different categories of end uses from the most to the less sensitive. Higher concentrations of contaminants may be permissible in forestry as compared to more sensitive end uses such as housing.

When planning application of any soil amendment it is necessary, in order to comply with legislation and codes of practice, to understand both the chemical composition of the amendment and of the receiving soil or soil forming material profile so as not exceed threshold or guideline limits.

Site soil analysis data from site sampling is required in order to define application rates, with sampling intensity and analysis specification designed to cover likely contaminants and within-site variation.

The data will enable optimum (and maximum permissible) soil amendment application rate to be calculated based upon desired characteristics such as major nutrient status, organic matter and acceptable contamination level.

Odour

Excessive and unpleasant odours are most relevant to public perception and acceptance of operations involving use of organic soil amendments. Across much of the Central Belt of Scotland communities are sensitive to any suggestion of the use of sewage sludge or materials perceived as waste in land reclamation. This is partly a result of their perception of use of sewage sludge in the recent past (up to around 2005).

Compost, especially PAS100 compost, is unlikely to have the appearance of waste or any unpleasant odour. However, the AD / CLO used in the 2011 forestry field trails had strong odour not dissimilar to that of sewage sludge and a sludge-cake like appearance.

During the 2011 forestry field trials AD / CLO odour was mitigated on incorporation into the soil during cultivation and mixing and gradually diminished to background levels over a week or so. Nevertheless, 'close-to' the site itself remained pungent for weeks during the spring and odour was remarkable for its tendency to 'cling' to boots and clothing.

Although both compost and AD / CLO should be largely sterile on receipt, the presence of contamination cannot be completely discounted so workers require to use PPE and adopt good hygiene in respect of washing and meal breaks.

There are a range of technologies and processes for the production of AD / CLO which are understood to influence the physical and chemical characteristics of the product.

It may be important to consider how potential input streams to the digestion process can be managed to influence the eventual output characteristics of the digestate product.

The odour characteristics of the AD / CLO production technology is a relevant factor when planning application of AD / CLO to land. Technology choice, adjustments in the digestate production process (including input material source segregation), improvements in technology and further treatments may well significantly improve odour characteristics compared to the digestate used in the field trials, given that it is an important end product characteristic.

Any negative public and neighbour perception of any odorous AD / CLO may be addressed, at least in part, by appropriate advance community information and / or consultation so as to address concerns prior to restoration operations commencing. Therefore, although odour may be an issue it need not prevent use of AD / CLO in land restoration.

Should AD / CLO be intended for use in the managed urban environment and in close contact with people, such as in parks and gardens, absence of odour is very likely to be a key requirement. Absence of odour would also be important for other non-forestry or agricultural uses.

Identifying operational factors

When assessing or planning a programme of restoration to forestry using AD / CLO as a soil amendment it is necessary to consider a wide range of site characteristics that will influence the benefits, risks and costs of the operation. This will enable a reasonable and deliverable potential programme to be compiled.

The key operational factors are summarised in **Table 4**. Note that additional factors may on occasion be relevant, such as a neighbouring land use of SSSI or nature reserve.

Table 4 Key factors to consider for application of AD / CLO to land and incorporation for restoration to forestry

Factor	Implication	Action
Local Community	Potential local concerns e.g. noise, smell, disruption, change	Consider advance community engagement programme
Access	Existing or potential for HGV access required	Check feasibility
Utilities	Constraints to area and access e.g. buffers and crossings	Check & consider implications
Watercourses	Constraints to area and method e.g. drainage and buffers	Check & consider implications
Slope	Constraints to area and method e.g. avoid steep slopes	Check & consider implications
Current use	Constraints to area and method e.g. existing woodland & unsuitable areas / habitats	Check & consider implications e.g. net areas available for AD / CLO
End use	Method specification e.g. higher intensity/cost for production forestry, lower for amenity	Consider implications e.g. net areas available for AD / CLO and quantity required
Timescale	Constraints on timing e.g. availability of sufficient AD / CLO and duration of winter weather restrictions	Plan operations with regard to weather windows
Receiving soil characteristics	Constraints on method and AD / CLO quantity	Consider soil survey requirements & mitigation of soil constraints e.g. decompaction by cultivation
Completed soil specification	Affects method and AD / CLO quantity	Consider operational requirements
Aftercare	Establishment of restoration vegetation / crop will require maintenance operations e.g. seeding, planting, weeding, protection	Ensure robust specification & suitable provision

Growing SRC-SRF on restored land

Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF) are the two systems designed with the primary aim of growing woody biomass from trees for energy. The short duration of the crop capitalises on the fact that trees have their highest annual increment in the early years. Crops of fast growing species grown on short rotation will therefore maximise volume production on a year by year basis. Conventional forestry accepts a reduction in total volume inherent in longer rotations as a trade-off for higher value timber yield such as saw-logs.

Short Rotation Coppice is a highly intensive system requiring good site conditions and ongoing site management (weeding) to achieve its potential over rotations of typically 3 - 4 years. Restoration sites are by their nature not ideal for SRC where biomass production is the main aim. In these conditions the less specialised and more robust SRF system is likely to be more suited to objectives, providing that the slightly longer rotation of 10 - 15 years can be accommodated. For example, SRF is more adaptable to changing management priorities and opportunities because it can be grown on longer or to maturity if desired. The main attributes of the SRC and SRF systems for optimum effectiveness are summarised in **Table 5**. Note that SRC can be grown in less suitable conditions than tabulated but costs and productivity will suffer greatly, and also that SRF use conifer species such as Sitka spruce, although calorific content (as opposed to timber volume) may not be optimum:

Table 5 Indicative comparison of SRC and SRF biomass production systems

Characteristic	SRC Optimum	SRF Optimum
Usual Species	Willow (Poplar in best conditions)	Birch, ash, alders, sycamore, aspen, sweet chestnut
Rotation	3 years (initial 4 years)	10-15 (-20) years
Volume Production, solid	10 m3 / ha p.a. (6-15)[41] [42]	10 m3 / ha p.a. (6-12)[43]
Tonnage Production	8 a.d.*tonnes / ha p.a. (4-10)[44]	8 a.d. tonnes / ha p.a. (5-10)
Site conditions		
Slope	Level or gently undulating / sloping	Ideally < 15% (1:6) Potentially up to 30% (1:3)
Soil	Moderately to very fertile	Low to high fertility
Surface soil stones/rocks	Absent / few	Not sensitive or Absent / few if mechanised

[41] Impacts of the Production of SRC on Poorer Quality land. AEA (2007)
[42] Establishment and Management of Short Rotation Coppice. Tubby, I. & Harrison, A. Forestry Commission (2002)
[43] Short Rotation Forestry: Review of growth and environmental impacts. McKay, H (Ed). Forest Research Monograph 2. Forestry Commission (2010)
[44] a.d. = air dry, c 30% moisture content (wet basis)

		planting
Drainage	Good	Good to seasonally poor
Plants	Clones (rods / cuttings)	General Forestry (bare root / plug)
Planting machinery	Specialised SRC	General Forestry Manual / mechanised
Weeding	Intensive (100%), Chemical	Extensive (30-50%), Chemical & / or physical
Susceptibility to deer / rabbits	Very	Moderately
Genetic base & susceptibility to pests & diseases	Narrow More susceptible	Broad Less susceptible
Regeneration	Coppice	Coppice & singling or re-planting
Harvest	Winter only	Year round / Subject to nesting & local restrictions
Harvest equipment	Specialised SRC	General Forestry
Access for harvest	Good	Good to poor
Ground prep cost on Brownfield land (e.g.)	Additional to SRF (De-stoning)	High (complete cultivation & organic amendment)
Plants, Planting & Establishment cost	~£1,500 / ha	~£1,500 / ha
Woodfuel type	Chip	Chip (i.e. log processed to chip) or log
Woodfuel storage	Heap Short term unless air dry	Chip - Medium term (air dry) Log - stack to air dry
Woodfuel drying	Heap ventilation under cover	Chip - heap, covered Stack - outdoor or covered
Haulage (from site)	Grain wagon / curtain-sider	Timber wagon - large volumes Flatbed - smaller volumes
Harvesting cost to forest road	~£14 / a.d. tonne	~£12 / a.d. tonne (round timber)

* a.d. = air dry, c 30% moisture content, wet basis

The annual biomass volume production from SRC and SRF is broadly similar, so a distinction has not been made in the assessment of the tonnage of biomass that might be produced through use of AD / CLO.

Results

The review of information and the site assessments made of the ten West Lothian Council-owned brownfield sites have provided information on the opportunity for using AD / CLO for restoration or re-restoration of the sites to forestry. This has also been combined with information on SRC and SRF to assess the cost effectiveness of these biomass systems on such sites.

Opportunity to use AD / CLO for SRC-SRF on restored land

The data from the ten West Lothian Council brownfield Site Reports (**Appendix B, Site Reports Summary**) has been used to report on the following project objectives:

- Area of potential WLC brownfield new planting sites using AD / CLO (NP)
- Area of potential WLC brownfield re-planting sites using AD / CLO (RP)
- Tonnage of CLO that might be deployed

Of the 227ha of land assessed, the total area considered potentially suitable for restoration or re-restoration using AD / CLO is 89ha (39%), of which 20ha (9%) was ranked as 'Medium' requirement and 69ha (30%) as 'Low' Requirement. These figures are not a direct reflection of the site's physical capability but include a likelihood judgement. For example, whether taking all known and apparent factors into account would justify clearance of existing forestry in order to enable AD / CLO application.

The majority of the 89ha assessed as having potential for use of AD / CLO was unplanted open space, including some 49ha at Linwood, which was largely unused farmland rather than brownfield land. However, some 21ha of land currently planted or regenerated with woodland was considered to have some potential for use of AD / CLO should clearing of the woodland be justified. However, most of this (13ha) was made up of land at Easton Bing occupied by an established mixed species restoration scheme utilised by the local community, albeit with varying tree performance due to the poor soil conditions. The relatively small area of woodland identified for possible felling and re-planting utilising AD / CLO is a result of the success of trees already planted even in difficult conditions. Sites carrying an established and growing tree crop in reasonable health are not clear candidates for felling to permit further soil improvement i.e. soils are generally already functioning sufficiently to support woodland, so the environmental benefits of woodland have already largely been achieved.

In assessing the quantity of AD / CLO that might be utilised on the sites identified as having some potential for use of AD / CLO, a judgement has been made of the likely maximum tonnage that is most consistent with the information presented in this report. This has been set as follows:

- 'Low' AD/CLO Requirement sites at 100 tonnes (wet)/ha ~ 1,500kg total N
- 'Medium' AD/CLO Requirement sites at 200 tonnes (wet)/ha ~ 3,000kg total N

Although higher application rates might be justified for individual site conditions, it is probably equally likely that lower rates would be required on others. Factors to consider include:

- Most sites have a functioning soil, albeit probably not up to ideal standards, with some Organic matter, Nitrogen and other nutrients already present
- Even the most severe un-restored land assessed (such as the oil shale at Hermand Oil Works bing) has regenerated with functioning woodland (birch)
- The application rate used for 'Low' requirement sites is in itself designed for restoration land with very low Organic matter and soil nutrient content
- The especially high potential application rates mentioned in guidance reviewed[45] of up to or over 500 tonnes dry solids per hectare would need site specific justification following detailed site investigation
- Higher application rates carry higher, and potentially very much higher, environmental and organisational risk.

Actual appropriate application rates can only be assessed from site specific soil sampling data.

No assessment has been made of the potential to use AD / CLO to woodland as a routine fertiliser application other than for woodland assessed as having potential for re-restoration. This is because:

- Use of AD / CLO in forestry needs to be justified by the requirement of the crop, and successful crops are likely to be growing on soils that are not significantly short of Nitrogen and other AD / CLO benefits
- A lack of reliable information to counteract the above argument.

[45] 500 tonnes dry solid [~1,600 wet tonnes AD and 800 wet tonnes Compost per hectare]. 'Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)

The area of potential WLC brownfield new and re-planting sites with potential for use of AD / CLO and the Tonnage of CLO that might be deployed is summarised in **Table 6**.

Table 6 Possible AD/CLO requirement for new and replanting from the 10 WLC site assessments varying and likely Total Nitrogen application rates

AD/CLO Requirement - Class 10 WLC sites	Area (ha) NP	Area (ha) RP	AD/CLO Wet tonnes/ha for:			**Likely AD / CLO Level Wet tonnes**
			1,500kg TN 100 T/ha	3,000kg TN 200 T/ha	6,000kg TN 400 T/ha	
Medium	13	7	2,000	4,000	8,000	**4,000**
Low	55	14	6,900	n/a	n/a	**6,900**
	68	21				**10,900**

FIGURES HIGHLIGHTED ARE THE MORE LIKELY

Opportunity to produce SRC-SRF on land restored using AD / CLO

The AD/CLO opportunity results, together with generalised information on SRC-SRF production and costs, have been used to address the following two project objectives:

- Tonnage of biomass woodfuel that might be produced - this is a direct combination of the area available for biomass and the likely average volume / tonnage production. No distinction has been made between SRC and SRF since the costs and likely AD / CLO application requirements are broadly similar and system selection will be a combination of additional physical, economic, logistics and organisational factors outwith the scope of this report

- The cost effectiveness of AD/CLO within a sustainable system for growing short rotation forests as woodfuel. This is discussed below:

> **Sustainability:** Any system of growing short rotation forests that does not impoverish the human or ecological environment is environmentally sustainable. Restoration to forestry using AD / CLO will meet this criterion because it involves improving brownfield land to the point where woodland will thrive, complete with gradual development of soil flora / fauna and other associated ecosystem components. The proviso is that, as is the case, care has been taken in site assessment to exclude areas that may have a higher environmental value left undisturbed or managed for an alternative land use.
>
> Economic sustainability is an additional factor which is not assessed in this report because the cost of producing woodland or woodfuel is only one factor: others include owner's policy

(such as waste recycling and use of soil amendment, in-house supply of biomass for building heating etc) and obligations

Cost Effectiveness of AD / CLO: The level of detail available at present is not sufficient for a finely-tuned economic appraisal so generalised statements apply.

Restoration of the brownfield land assessed to productive forestry is likely to require both complete cultivation and addition of organic amendment. The two main likely candidates for organic soil amendment are PAS100 greenwaste compost and PAS110 or non-PAS110 Anaerobic Digestate. It should also be noted that ongoing FC field research (at Addiewell and Dalquhandy) may (or may not) suggest that a combination of the two is advisable, but that cannot be assumed here.

The cultivation of brownfield land required is most likely to involve complete cultivation to 1m depth using tracked 360 degree excavator. This method applies to both to AD / CLO and compost. Site organisation and quantities of amendment requiring haulage to site and incorporation are all likely to be similar. Therefore, the differentiating factor of cost effectiveness at site-cost level is the cost of purchasing the amendment. The 2011 forestry field trials using commercial supply of amendment cost:

- Compost £5 per wet tonne plus haulage
- AD / CLO £0 per wet tonne plus haulage

The cost of AD / CLO amendment from West Lothian Council, excluding haulage, is not known. This is partly because the cost attributable to production of AD / CLO will be included in the economic appraisal of the waste recycling process. For example, it is possible that AD / CLO would be supplied to restoration sites on the basis of disposal at nil income. Alternatively, and especially if an alternative sale market were forthcoming for AD / CLO, the cost of supply of AD / CLO would logically be the equivalent value of income foregone.

The *calculated* results drawn from site surveys and an assessment of the factors outlined in this report concern the quantity of AD / CLO and woodfuel that may be produced in a combined system. The results concern the brownfield land comprising the ten West Lothian Council owned sites surveyed and is summarised in **Table 7**.

Table 7 Potential quantity of AD / CLO use and SRC-SRF woodfuel production

Factor	Description
Gross Area	227ha
Net Area (Re-restoration)	89ha
Net Area (Felling)	21ha
Net Area (Open)	68ha
AD / CLO requirement (estimated **maximum**, restoration)	10,900 wet tonnes
AD / CLO requirement (Re-planting)	Not known, site dependent probably limited
Woodfuel Production (90% of Net Area at 10m^3/ha p.a.)	800 m3 p.a. 500 a.d.[46] tonnes p.a.

Wood Energy Development in WLC

West Lothian Council is considering the potential for installing wood fuel heating systems in council owned buildings. The council has been included in a study funded by the Central Scotland Green Network with support from the Central Scotland Forest Trust and Forestry Commission Scotland. The project report concerning West Lothian was produced in April 2011[47].

The main conclusions relevant to land restoration using anaerobic digestate for production of SRC-SRF are provided in **Table 8**.

The 'Luker' report derives a figure for potential supply of woodfuel from existing council woodland using figures from a survey of North Lanarkshire Council woodland. The potential supply of wood fuel from West Lothian Council's own 1,276ha as c. 2,948 a.d. tonnes per year, using a flat rate figure of 2.31 a.d. tonnes per hectare per year.

[46] a.d. = air dry, c 30% moisture content (wet basis)
[47] Supporting Investment in Wood Energy in Scottish Councils, Luker S., 2011

Table 8 Summary of selected data from the 2011 Luker report on wood heating installations for West Lothian Council

Factor	Description
Building selection criteria	Existing buildings, >£20k p.a. energy cost, secure future, suitable access and space for plant
Number of buildings	10
Heat supply technology	Woodchip With gas supplement and possibility of pellets
Total installed capacity	6420kW
Wood / gas proportion	85% / 15% energy
Total heat requirement	20,264 MWh
CO_2 saved compared with gas heating	4,250 tonnes CO_2
Total capital cost	£4.6M (2012)[48]
Total annual energy savings	£0.5M (2012)[49]
Carbon Reduction Commitment	£51k p.a. Reduction in levy to Council compared to gas
Employment	13 FTE (new) Worth £128k in Gross value to the West Lothian economy

The 'Luker' report does not provide information on the extent of existing WLC woodland on brownfield land that may be suited to re-restoration using AD / CLO. Similarly, it does not specifically state woodfuel required for the 10 West Lothian installations. However, this is estimated to be in the order of 5,000 a.d. tonnes[50] of chip per annum. This would be equivalent to c 6,000 fresh felled tonnes or 7,000m3 of felled broadleaved (hardwood) timber. Coniferous (softwood) timber requirement would be higher because it is less dense. Allowing for conversion of felled to standing volume this equates to approximately 8,000m3 standing broadleaves according to conventional forestry growth measurements. This may be nearer to 7,000m3 conventional measure when allowing for whole tree harvesting that would include biomass from branches and tops. These figures are dependent on species, form and moisture content concerned.

Therefore, SRC-SRF grown on brownfield land assessed in this report as having potential for restoration using AD/CLO, estimated at 800m3 per year (once the first rotation is fully established), may provide approximately 10% of the wood fuel supply requirement to the 10 potential new heat installations in council owned buildings identified by Luker.

[48] Funded by the 'Energy Supply Contract' if an 'ESCO' is used

[49] Savings would not all accrue to the council if an 'ESCO were used because they also fund the ESCO

[50] a.d. = air dry, c 30% moisture content (wet basis)

The council's own 1,300 ha of existing woodland, after allowance is made for environmental, amenity and other constraints would provide c. 60% (3,000 a.d. tonnes) of the requirement for the 10 installations.

Conclusions

1. The regulatory regime, comprising both legislation and codes of good practice, create a duty of care that will restrict the amount of AD / CLO that can be applied to brownfield land.

2. AD / CLO that meets PAS110 standard, which must be source segregated, and is therefore classified as a product will not require Waste Management Licensing exemption for use on land.

3. AD / CLO that does not meet PAS110 standard, for example because it is not source segregated, is classified as a waste and will require Waste Management Licensing exemption.

4. WMLR exemption for AD / CLO is currently only available under Paragraph 7, and then only for non forest land. However, it is considered that an exemption would be granted for forest land provided that a sound ecological improvement justification were presented.

5. Forest land and woodland is listed as 'Land not used for agriculture' in Paragraph 7 so AD / CLO cannot be applied to such land under the WML Regulations.

6. AD / CLO does not currently qualify under Paragraph 9 'The Reclamation or Improvement of land'.

7. Land restoration to forestry is likely to require determination under the Forestry Environmental Impact Assessment Regulations 1999 except on small areas.

8. AD / CLO has several valuable properties for use as a soil organic amendment for land restoration.

9. In appropriate conditions, AD / CLO can be an effective source of plant available Nitrogen and Phosphorus. Nitrogen in AD / CLO is of a particularly water soluble and volatile nature and great care is needed in its application.

10. Application rates of up to 500 tonnes dry solids per hectare (300 - 1,600 tonnes AD) are countenanced for organic amendments in recent expert guidance[51] for soil formation in colliery spoil restoration and landfill caps etc, with even higher doses potentially justifiable.

[51] Code of Good Practice for the use of sludge, compost and other organic materials for land reclamation. Sniffer (2010)

11. However, guidance continues 'Higher than normal rates of organic matter application should only be considered if it can be demonstrated that they are both beneficial and necessary for the planned end use. Applications in excess of that needed for sustained ecological improvement could be considered as a waste disposal rather than a land reclamation operation'.

12. Application rates are frequently considered in terms of amount of Total Nitrogen applied. Although AD / CLO has somewhat different characteristics to sewage sludge, there is a developing consensus on the general *quantum* of acceptable Nitrogen application rate.

13. Application of equivalent to somewhere between the 2,500 and 5,000kg TN / ha are likely to be optimal in most cases. Information included within this report suggests that a normal upper limit of 3,000 kg Total Nitrogen per hectare would be prudent for use in planning, although higher application rates may (or may not) be justified due to specific site conditions.

14. Approximately 200 tonnes per hectare of AD / CLO provides 3,000 kg of Total Nitrogen and 350 tonnes provides 5,000kg Total Nitrogen (based on AD / CLO analysed).

15. AD / CLO has a very high proportion of ammoniacal Nitrogen, which is released into the environment faster than nitrate Nitrogen, in particular by leaching into surface and groundwaters and as such there is a greater pollution risk than alternatives such as compost.

16. A detailed assessment of both the proposed AD / CLO amendment and the needs of the receiving site is required. The aim should be to ensure that quantity and type of amendment is appropriate and will not have unwanted side effects.

17. The odour characteristics of the AD / CLO production technology is a relevant factor when planning application of AD / CLO to land. Technology choice, adjustments in the digestate production process (including input material source segregation), improvements in technology and further treatments may well significantly improve odour characteristics compared to the digestate used in the field trials, given that it is an important end product characteristic.

18. Should AD / CLO be intended for use in the managed urban environment and in close contact with people, such as in parks and gardens, absence of odour is very likely to be a key requirement. Absence of odour would also be important for other non-forestry or agricultural uses.

19. The biomass volume production from SRC and SRF is broadly similar, so a distinction has not been made in the assessment of the tonnage of biomass that might be produced through use of AD / CLO.

20. Of the 227ha of Council brownfield land assessed, the total area considered potentially suitable for restoration or re-restoration using AD / CLO is 89ha (39%), of which 20ha (9%) was ranked as 'Medium' requirement and 69ha (30%) as 'Low' Requirement. Medium and 'Low' requirements were estimated at 200 and 100 tonnes of wet AD per hectare respectively.

21. The total potential requirement for AD / CLO on the Council brownfield sites assessed was up to 10,900 tonnes, which is equivalent to around 2 years of production at 5,000 tonnes AD / CLO per annum. This is an estimate and would require confirmation by site sampling.

22. There is not considered to be significant additional potential for use of AD / CLO on established forestry crops or at replanting.

23. The woodfuel production potential from SRC or SRF on Council owned brownfield land restored using AD / CLO was estimated as c. 800m^3 standing volume or 500 air dry tonnes per year.

24. SRC-SRF grown on unplanted brownfield land assessed in this report and restored using AD / CLO may provide c. 10% of the wood fuel supply requirement to the 10 potential new heat installations in council owned buildings identified by Luker. Existing council owned woodlands may provide a further c. 60%.

Recommendations

1. Where feasible AD / CLO should be produced to PAS110 standard so as not be classified as a waste and thereby to maximise the potential for beneficial application to land, including sale as a product.

2. Decisions concerning AD / CLO production process and technology should consider the relevance of odour and ammonia content characteristics for proposed end uses.

3. If West Lothian Council produce AD / CLO consideration should be given to the use of AD / CLO in land restoration.

4. Consideration should be given to partnership or other arrangements whereby the Council would have access to ongoing, third party areas of land requiring restoration should a significant surplus AD / CLO be generated.

5. For brownfield sites that may be made available for restoration to forestry, consideration should be given to a more detailed appraisal of restoration and forestry requirements including soil sampling.

6. Consideration should be given to sustainable production of wood fuel from forestry already fully established on the brownfield sites assessed.

7. Should restoration using AD / CLO be proposed, a detailed appraisal of conditions and supply chain factors should be undertaken to determine whether to use SRC or SRF systems, although SRF is suggested as the more likely to be suited to sites.

8. Should restoration using AD / CLO be considered further, a detailed appraisal of operational costs and method should be undertaken.

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References

As detailed

TD Job Number 373.71.11

Appendix A: Technical data

Analyses of AD / CLO and Compost from 2011 WRAP / Forestry Commission Field Trials

Table A1 Typical nutrient analysis for AD / CLO with compost comparison

Parameter	AD / CLO[52]	PAS100 Compost*	250kg N/ha equivalent from AD (kg/ha)**	3000kg N/ha equivalent from AD (kg/ha)[53]	Units
pH	7.8	7.6*			
Elec. Conductivity	tba uS/cm	693*			
Bulk Density	562 kg/m3**	617**			
Mass - Dry	30.7% m/m DM	55.5%*	5,319**[54]	63,831[55]	Kg/ha DM
Mass - Fresh			17,326**	207,919	Kg/ha
Loss on Ignition (Organic Matter)	90.0% m/m DM	33%*	4,788**[43]	57,456	DM, kg OM
N, Total	4.70% m/m DM	1.7%*	250**[56]	3,000[57]	kg N
N, Ammoniacal	10,086 mg/kg DM		54**[58]	644[43]	kg NH_4-N
Phosphorus	0.820% m/m DM	0.24%*	100**[43]	1,200[43]	Kg P_2O_5
Potassium	0.120% m/m DM	0.78%*	18**[43]	216[43]	K_2O
Magnesium	0.100% m/m DM		9**[43]	106[43]	Kg MgO
Sulphur	0.980% m/m DM		130**[43]	1,560[43]	Kg SO_3
Chlorine (H_20 sol)	4,725 mg/kg DM		3.39**[43]	41[43]	Kg WS Cl
Sodium (H_20 sol)	593 mg/kg DM		0.42**[43]	5[43]	Kg WS Na
Salmonella	Absent		Absent	Absent	
E. coli	<230 CFU/g DM		1.22M	14.6M	CFU

* Source: Scottish Water, Pod Soil Booster specification

**Source: NRM Ltd. Analysis of AD / CLO and Compost from 2011 Forestry Field Trials i/d 20658-30574, 2/11/

[52] PAS110 Certificate of Analysis, Scottish Water Deerdykes Digestate Cake 6/10/10
[53] Calculation is direct extrapolation from 250kg / ha figures i.e. * 3000/250 = * 12
[54] Calculation is: 1,000kg DM AD/CLO * 4.7% TN = 47kg TN / tonne DM. For 250kg TN = 250kg / 47kg = 5.319 tonnes DM. Dry to Fresh conversion is (* 100/30.7)
[55] Calculation is: 1,000kg DM AD/CLO * 4.7% TN = 47kg TN / tonne DM. For 3,000kg TN = 3,000 kg / 47kg = 63.83 tonnes DM. Dry to Fresh conversion is (* 100/30.7)
[56] 5,319 kg DM *4.7% = 250kg TN. Pers Comm A Hipkin 30/8/11
[57] 63,831 kg DM * 4.7% = 3,000kg TN. Pers Comm A Hipkin 30/8/11
[58] Converted from DM e.g. N, Ammoniacal = 16.47kg * 100/30.7 = 53.65kg

Table A2 Actual AD / CLO and compost analysis in 2011 forestry field trials[59]

Parameter	AD	PAS100 20mm Compost	Units	Upper Limit (PAS100/110)
pH	8.0	7.6		
Elec. Conductivity	3,370	809	uS/cm	
Total N	4.63	1.17	% dry matter	
Phosphorus (ext)	121	112	Ext. mg/l	
Potassium (ext)	648	2,446	Ext. mg/l	
Magnesium (ext)	108	397	Ext. mg/l	
Loss on Ignition (OM)	67	23	% dry matter	
C:N ratio	8.4	11.6		
N, Ammoniacal	20,505	998	mg/kg DM	
N, Nitrate	4.0	12.2	mg/kg DM	
Boron	1.25	2.25	% dry matter	
Arsenic*	1.86	7.50	% dry matter	
Selenium	1.33	0.66	% dry matter	
Sulphur	1.53	0.20	% dry matter	
PTEs: Cadmium	0.2	0.5	mg/kg	1.5
Chromium	226	27.2	mg/kg	100
Copper*	136	51.3	mg/kg	200
Lead*	28	106	mg/kg	200
Mercury*	0.09	0.09	mg/kg	1
Nickel*	31.0	24.1	mg/kg	50
Zinc*	580	173	mg/kg	400
TPH#	760	1,020	mg/kg DM	400
PAH##	2.52	2.80	mg/kg DM	2.1

\# Total Petroleum Hydrocarbons C6-C40
Poly Aromatic Hydrocarbons
* Phytotoxic

[59] Source: Hipkin, A., (2011). WRAP Interim Report, Dalquhandy Project, Site Restoration using Anaerobic Digestion 'Fibre'. AD/CLO and compost used at Addiewell was similar but data is incomplete at time of writing

Table A3 Maximum permissible concentrations of PTEs in soil after application of sewage sludge[60]

Potentially Toxic Element (PTE)	Maximum Concentration (mg / kg dry solids)	Maximum average annual rate of PTE addition over 10 years (kg / ha)
Zn	200 - 300[b]	15
Cu	80 - 200 [a]	7.5
Ni	50 - 100 [a]	3
	For pH 5.0 and above	
Cd	3	0.15
Pb	300	15
Hg	1	0.1
Cr[d]	400	15
Mo[d]	4	0.2
Se[d]	3	0.15
As[d]	50	0.7
F[d]	500	20

[a] Range from pH 5.0 to >7.0

[b] Revised figure recommended in The UK Code of Practice for Agricultural Use of Sewage Sludge (amended 1996)

[c] 0-25 cm, excludes figures for grassland 0-7.5 cm

[d] Recommended, not regulatory limit

[60] Sludge (Use in Agriculture) Regulations 1989 and PEPFAA (2005)

Appendix B: Site reports

Table B1 Site Report Summary AREAS HIGHLIGHTED ARE WHOLLY OR LARGELY WOODED

Site	Area (ha)	Wood (ha)	Open (ha)	Open Space Forestry Potential using AD/CLO					SRC-SRF Potential using AD/CLO on identified areas					Overall Site Potential for AD/CLO use and woodfuel
				Rqt*	Fby**	Potential			Rqt*	Fby**	Potential			
				HML	HML	H	M	L	HML	HML	H	M	L	
1. Fauldhouse Colliery	19	16	3	-	-	-	-	-	-	-	-	-	-	Not suited to AD/CLO. Good potential for supply of wood fuel from crop
2. Loganlea Colliery	12	11	1	-	-	-	-	-	-	-	-	-	-	Not suited to AD/CLO. Good potential for supply of wood fuel from crop
3. Whitrigg Bing	43	22	21	HL	M		7	3	HL	L			L	Limited potential for AD/CLO. Needs community & ecological ass't. Good pot'l for wood fuel from crop
4. Easton Bing	13	13		M	L-nil			13	M	L-nil			L-nil	No potential for AD/CLO or SRC/SRF unless clearance of community woodland contemplated
5. Caputhall Wood	18	11	7	M	M		4		M	L			L	Limited potential for AD/CLO if woodland cleared. Higher risk site. Low potential for SRC/SRF
6. Caputhall Depot	24	18	6	M	L			2	M	M		M		Very limited potential for AD/CLO. Good potential for supply of wood fuel from crop
7. Hermand Oil Works	8	7	1	M	M		3	1	M	M		M		Part suited to AD/CLO & SRF/SRC after SI but Costly. Some potential for wood fuel from thinning
8. Gavieside-Polbeth Wd	4	2	2	-	-	-	-	-	-	-	-	-	-	No realistic potential for AD/CLO. Some potential for wood fuel from woodland
9. Gavieside	10	2	8	M	H		6	1	M	H	H			Suited to AD/CLO although probably low volumes. Good potential SRC/SRF
10.Linhouse	76	22	54	H	L			49	L	H	H			Limited potential for AD/CLO. Good potential for SRC/SRF
	227	**124**	**103**				**20**	**69**						
							9%	**30%**						

* Requirement ** Feasibility

Assessment of Potential for AD/CLO use and SRC/SRF production in an AD/CLO system used in the Site Reports

The assessment of potential is based on an empirical judgement of the requirement for remediation using AD/CLO on the one hand and feasibility of AD/CLO and SRC-SRF operations on the other.

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so.

The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

Example:

The overall site is classified as **Medium Potential** (southern spoil tip slopes) and **Low Potential** (north western rough grassland) for AD / CLO use:

	Potential	Requirement		
		High	Medium	Low
Feas-ibility	High	High	Medium	Low
	Medium	**Medium**	Medium	**Low**
	Low	Low	Low	Low

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:

Blue (Medium Potential)= 7 ha

Yellow (Low Potential) = 3 ha (excludes 2 ha internal open space areas < 0.5 ha).

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

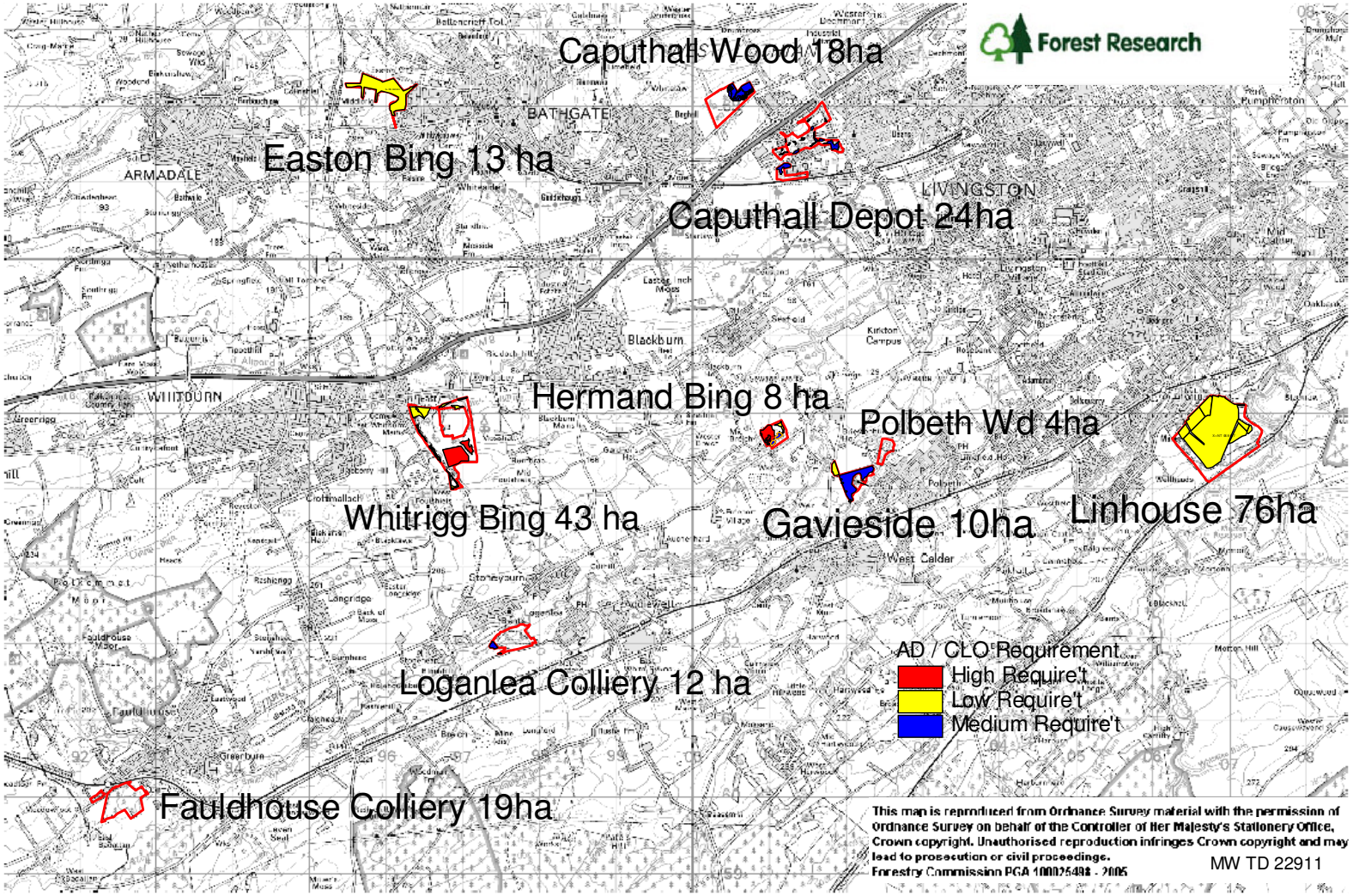
The overall site is classified as **Low Potential** for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low (Use AD/CLO Potential)		Nil
Feasibility of SRF/SRC	High	High		Nil
	Medium	Medium		Nil
	Low	**Low**		Nil

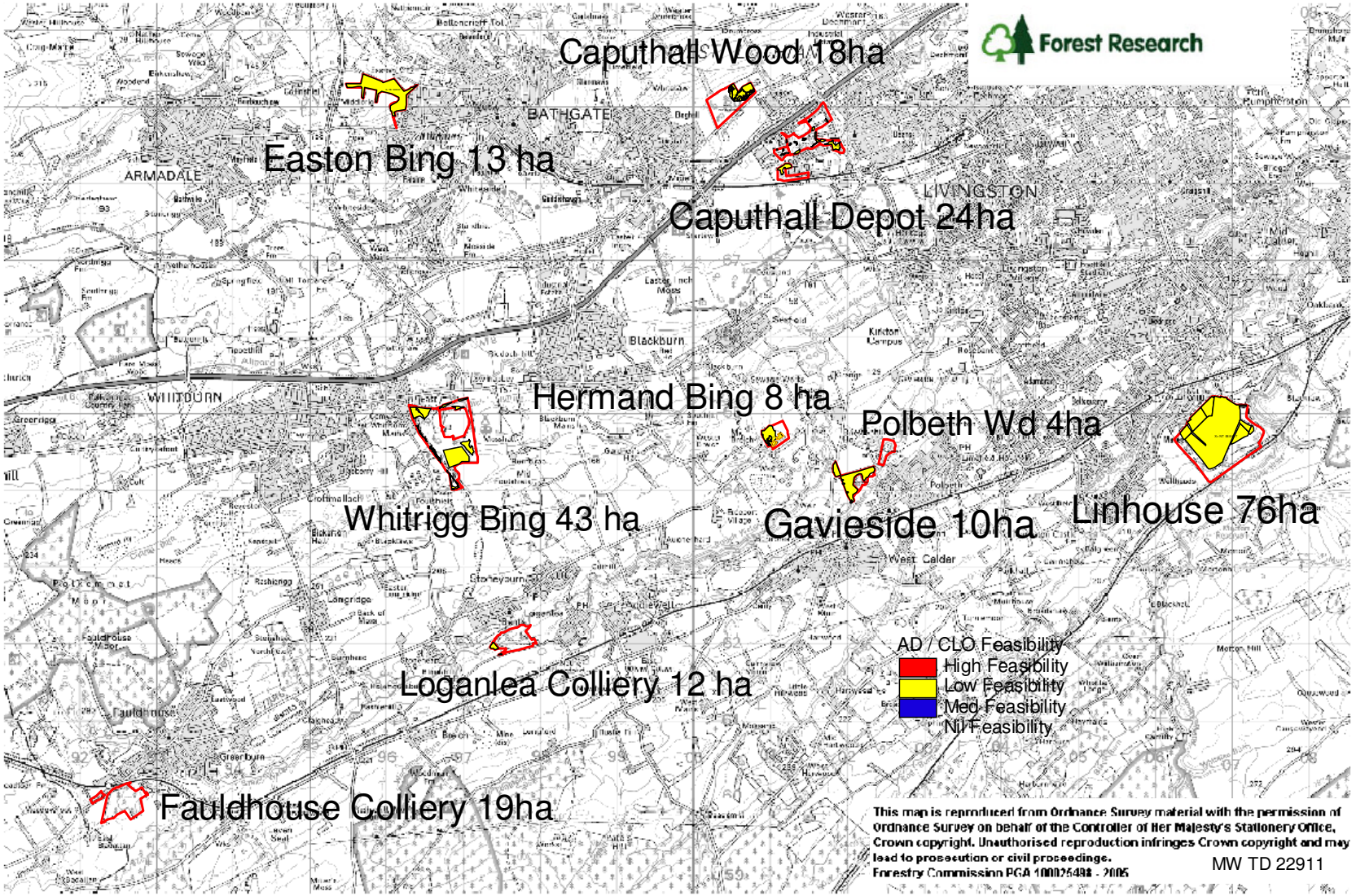
End

APPENDIX B

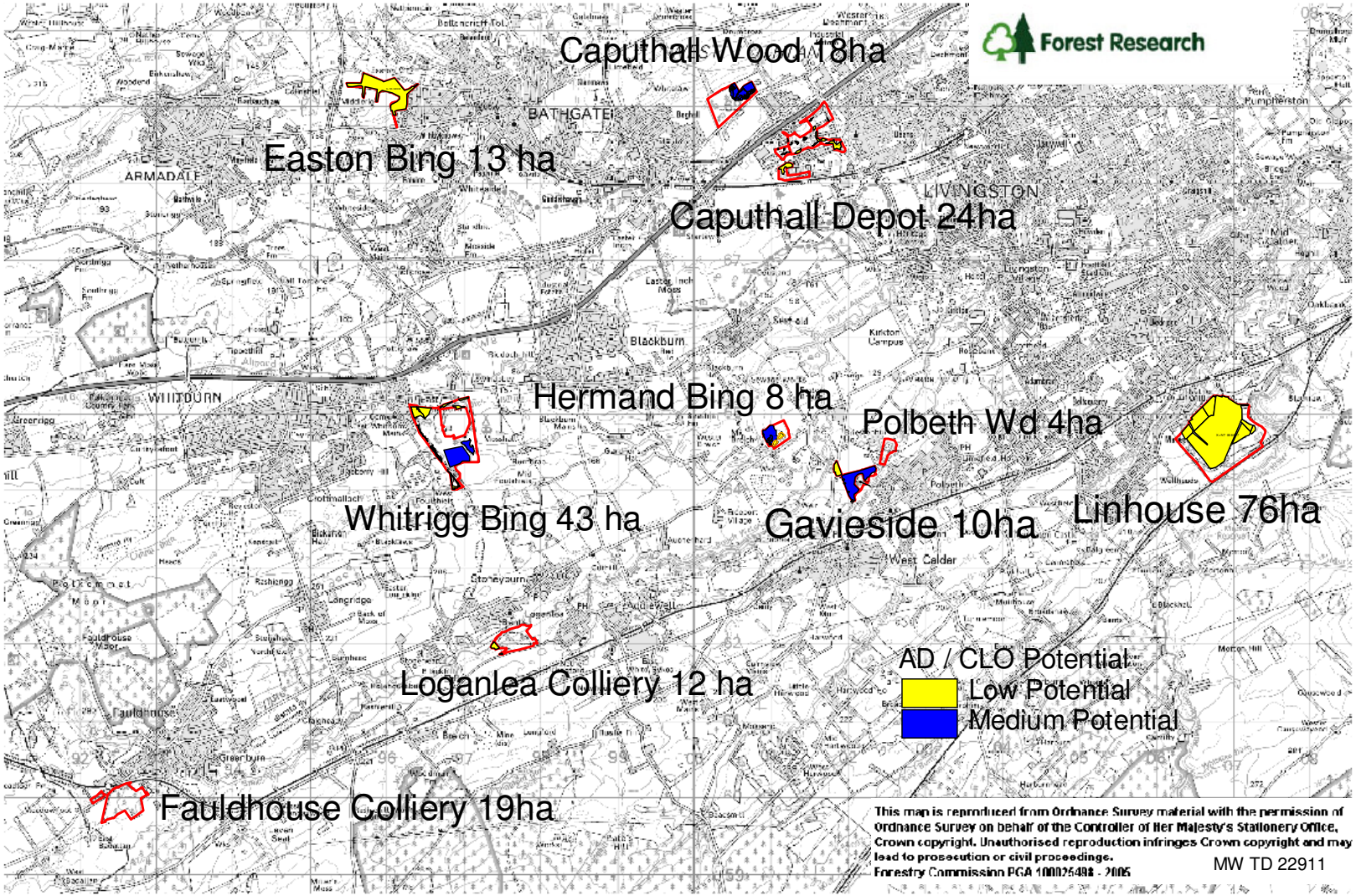
Map B. Land restoration using AD / CLO Requirements, Feasibility and Potential
Requirement



Feasibility



Potential


Forest Research
Caputhall Wood 18ha
Easton Bing 13 ha
Caputhall Depot 24ha
Hermand Bing 8 ha
Polbeth Wd 4ha
Linhouse 76ha
Whitrigg Bing 43 ha
Gavieside 10ha
Loganlea Colliery 12 ha
Fauldhouse Colliery 19ha
AD / CLO Potential
Low Potential
Medium Potential
This map is reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office, Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings.
Forestry Commission PGA 100025498 - 2005
MW TD 22911

Site: B1. Fauldhouse Colliery (19ha)

SITE VISIT 16TH MARCH 2011. WEATHER: SUNNY

Description

Pen Picture

Fauldhouse Colliery site is now a semi mature, fully stocked commercial conifer plantation with some local community use, growing accessible timber. Although some soils are restored with coal mining spoil there is no obvious evidence of nutrient deficiency.

Location & Community (NS 926 600)

Fauldhouse Colliery is situated on the southern limit of Fauldhouse, adjacent and south of the B7010 'Shotts Road' and the railway. A small plot of land is also located slightly westwards, adjacent and to the north of the road.

History

The site was largely undisturbed in 1856, when the farm and steading of Knows was located on the centre and another building, possibly cottages, was present by the road in the north. A railwayline ran across the south part of the area. By 1864 the current railway was located to the north and a new mineral railway ran from the south, north eastwards through the site where Knows had been. A mine spoil heap was present in the east, together with a disused railway track forming the site's north east boundary. There was little change by 1898 and 1909. By 1921 Fauldhouse Colliery Pit No.1 was marked by the spoil tip, reached by a new mineral railway from the north. The small plot of land north of the B7010 was occupied by Braeside Terraces.

By the map date of 1957-63 the colliery is no longer shown as active, although there is still railway access from the north. The southern railway is disused and there are two new spoil areas shown. The mine buildings are shown on the 1958-9 map, so there are likely to have been removed between 1958 and 1963. Mine spoil is shown on the 1967 map that covers only the north part of the site. The mine spoil, former railwayline beds and other features are shown as being removed at some point between 1980 and 1987 and by 1991 the south part of the site (and therefore almost certainly the north) was planted with conifers.

FC records show that Fauldhouse Colliery was the subject of a forestry Dedication scheme approved 15/5/1981. Approximate visual dating of the plantation trees suggests planting in the mid 1980s.

Braeside Terraces were removed some time between 1980 and 1991 probably by 1987, and possibly with the lower (roadside) of the two terraces after the upper terrace.

Map and Dedication scheme evidence suggest that Fauldhouse Colliery was restored and planted in the first part of the 1980s.

Woodland

The majority of the woodland comprises fully stocked c 25 year old, semi-mature Sitka spruce, planted on single mouldboard ploughing. The southern part of the site includes proportions of Lodgepole pine both in mixture and pure groups. A network of rides subdivide the plantation. There is no evidence of serious windblow although the Lodgepole pine is breaking in places.

The strip of land along the north edge of the Fauldhouse Colliery site by the B7010 is occupied by a variable species and stocking mix including Alder, Scots pine and Japanese larch. Larch is also scattered through the east of the plantation.

The site of the former Braeside Terraces is planted with mixed broadleaves including Alder, now at pole stage.

There are no obvious signs of nutrient deficiency on the site.

Open space

Open space is limited to rides, the wayleave under an electricity line and small areas of disturbed land on the north east boundary where the eastern railway was previously sited.

Soils

Soils are generally light brown and brown mineral soil, with evidence of mixing with mining spoil in places, especially in the south of the site where Lodgepole pine is concentrated.

Terrain & Water Environment

The Fauldhouse Colliery site is more or less level in the north, falling more steeply south of the southernmost ride. This may be a result of the grading of the southernmost spoil bing. No running drain or burns were seen within the site and there are none marked on the OS maps, although water will drain southwards into the Breich Water some 200 - 350m southwards, with tributaries close to the south western and south eastern property boundaries.

Biodiversity

There are no significant areas of open or woodland priority habitat but the presence of national or local Biodiversity Action Plan habitats or species, or of European Protected Species, cannot be discounted without ecological assessment. Badger may be present and Roe deer are likely. No large old trees suitable for bat roots were seen.

External Access

There is direct access to a track entrance directly off the B7010 which is suitable for HGVs. Limited roadside tree pruning or clearance would probably be required for road access visibility splays.

Internal Access

Although there are no remaining railwayline beds or tracks within the site, there is a network of relatively soft grassy rides.

Constraints

An11-kV overhead wood-pole electricity line crosses the north and east of the site, and a low voltage overhead line runs along the north side of the B7010 Shotts Road next to the small outlying plot. The woodland is used regularly by the public for walking, as evidenced by desire lines along rides. The south ride, which at planting would have enjoyed southerly views down over lower ground, has several now unserviceable benches, showing that public access was envisaged after restoration.

Discussion

Suitability for forestry using AD / CLO

Currently unplanted

There are no open areas suitable for AD / CLO use.

Currently planted

There are no areas suitable for AD / CLO use because there is no evidence of nitrogen deficiency and the existing tree crop is growing well.

Suitability for woodfuel production

The existing woodland is suitable for timber harvesting, yielding a variety of products including, eventually, sawlogs. Harvesting will yield a proportion of smaller dimension softwood suitable as woodfuel. Timber harvesting will be necessary prior to windblow that will develop if felling is left indefinitely. Harvesting could be programmed as a wood supply and carried out in phases to avoid sudden wholesale clearance.

The area could be replanted with broadleaved Short Rotation Forestry or with a replacement crop of commercial conifers, primarily Sitka spruce, which would probably optimise biomass production.

Establishment of SRC, on the more level areas, following felling would be excessively costly, requiring de-stumping and levelling of furrows and is not considered a realistic option.

Conclusions

Fauldhouse Colliery is not suited to any AD / CLO use in its current condition but has good potential for supply of wood fuel.

Recommendations

Fauldhouse Colliery should be managed as a commercial forestry block with appropriate community access provision. Harvesting should ideally be phased to avoid sudden clearance of the whole site and promote a more varied future structure. Replanting design should follow current standards to increase diversity and wildlife value. Products both now and in the future can include woodfuel. The few existing areas of broadleaved and mixed conifer / broadleaved planting are suited for amenity rather than timber production and can yield only very small quantities wood in thinnings.

Contact

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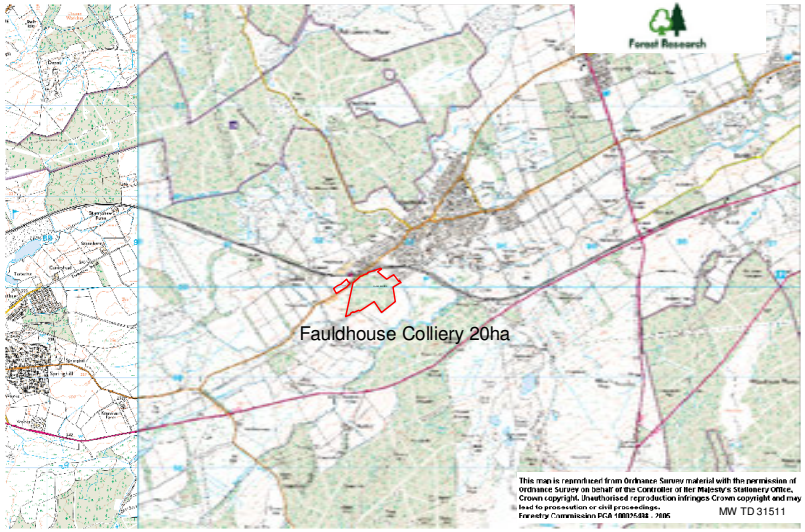
March 2011

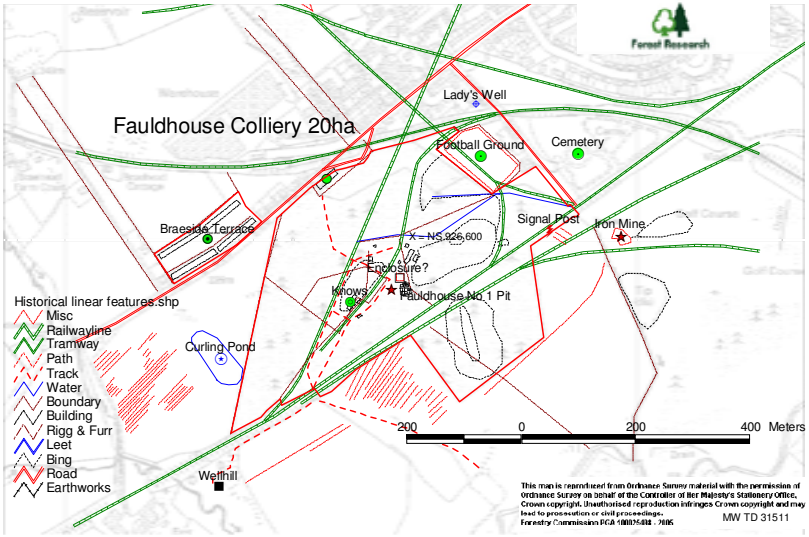
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

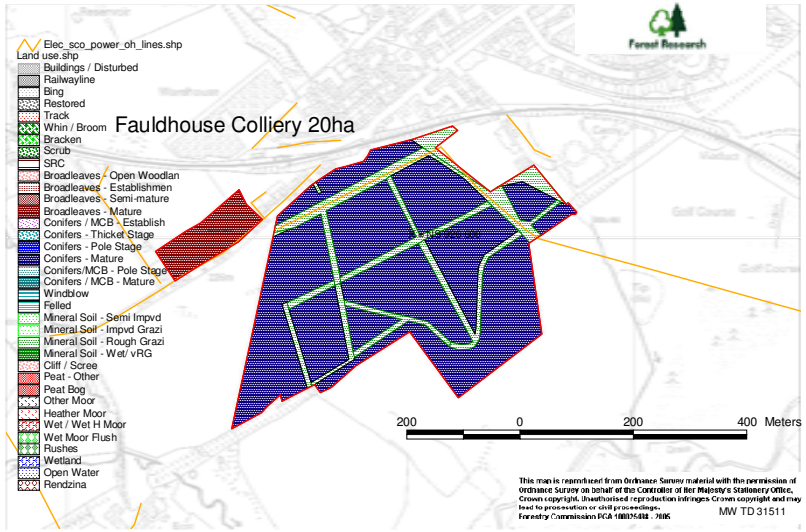
SITE REPORT B1 MAPS, FAULDHOUSE COLLIERY



Location Map



Historical Features



Constraints and Land Use

NOT APPLICABLE

Forestry restoration potential using AD/CLO

Site: B2. Loganlea Colliery (12ha)

SITE VISIT 14TH MARCH 2011. WEATHER: RAIN

Description

Pen Picture

Loganlea Colliery site is now a semi mature, largely well stocked larch plantation growing accessible timber with a formal path network linking directly to Bents village. Although soils are restored with coal mining spoil there is no evidence of nutrient deficiency or severe compaction.

The 12.5 ha ownership includes two small areas of land (0.5ha) having an undefined boundary and lying within a field of improved grazing to the west of the woodland, which may be 'lost land'.

Location & Community (NS 977 620)

Loganlea Colliery is situated about $^1/_4$ mile west of Loganlea, adjacent and to the north of the unclassified public road running westwards out of the village. The northern boundary is formed by the Breich Water, over which a footbridge crosses giving access to the woodland from Bents village $^1/_4$ mile to the north. The woodland is provided with a formal blaes-surfaced circular footpath linking the footbridge with the road and back.

There are several locations where drinking takes place and repeated evidence of fires associated with drinking dens being lit deliberately to destroy semi-mature trees.

History

The site was largely undisturbed in 1853, with Muirhousedykes Colliery and a shaft shown on or very near to the easternmost boundary, and Brucehill enclosure / steading on what is now grazing land the extreme west by the road.

Loganlea Colliery was located just north of the road in the south of the site by 1895, complete with a small spoil tip to the north and railway access from the east. However, most of the site was undisturbed at this time. By 1909 the spoil tip had grown in size and was accompanied by filter beds. The railway sidings had extended westwards. Little change is shown in the 1916 and 1922 maps but by 1957 there were additional sidings and a larger spoil tip that by now was spread over most of the ownership. The mine is still shown with railway-lines and extensive spoil in 1967. By 1980 the colliery buildings and railways had been removed leaving the derelict spoil land, which is shown as planted with conifers and broadleaves by 1985. The 2 ha

central area adjacent to the southern road is not shown as planted at this time, which accords with different estimated planting dates for these woodland areas.

FC records show the central 2 ha area formerly occupied by the mine buildings and sidings as approved for new planting on 8/1/1990, which accords with visual assessment. The remainder of the site formerly largely occupied by the spoil tips are planted with trees estimated at 25 years or so of age.

Map, visual and grant scheme evidence suggest that the larger part of Loganlea Colliery was restored and planted between 1980 and 1985 and the central former buildings area was planted in or soon after 1990.

Woodland

The majority of the woodland comprises reasonably well stocked c 25 year old, semi-mature Hybrid larch, planted flat (probably with ripping). There are variable proportions of Scots pine and a few broadleaves scattered throughout. The north facing slope adjacent to the Breich Water in the north west is planted with Birch and Alder.

The 2 ha southern part of the site formerly occupied by the mine buildings is planted with blocks of Hybrid larch on shallow ploughing, with some Lodgepole pine and areas of mixed broadleaves including Alder (thought to be Italian).

The woodland is well drained without obvious wet areas but there is evidence of fire damage to larch and Scots pine caused by setting fires at the base of trees. Crops are currently stable with no obvious incipient windblow.

Open space

There are two small areas of land immediately to the west (0.5ha and 0.05ha) within the ownership boundary but outside the woodland fence, the smaller of which is the site of the former Brucefield steading near the road. These areas are now included within an improved grassland field. This appears healthy and fertile, although map evidence suggests that the larger northern area is restored spoil tip.

Soils

Soils are generally light brown and brown mineral soil, with evidence of mixing with mining spoil in places.

Terrain & Water Environment

Slopes are more or less level in the south, falling more steeply northwards towards the Breich Water in the north. This is likely to be, at least in part, a result of the grading of the spoil bing over the site. A ditch running alongside the path in the east

runs down towards the burn and was running with water at the time of the site visit. The Breich Water itself is a fairly substantial natural watercourse running eastwards.

Biodiversity

The riparian habitat along the Breich Water is the most likely higher biodiversity area. There are no significant areas of open or woodland priority habitat but the presence of national or local Biodiversity Action Plan habitats or species, or of European Protected Species, cannot be discounted without ecological assessment. Badger may be present and Roe deer are likely. No large old trees suitable for bat roots were seen.

External Access

Loganlea Colliery is served by the unclassified public road forming its southern boundary, which runs the $^{1}/_{4}$ mile from the Loganlea residential area in the east. Two miles to the west this joins the A701 near the A71 crossroads. Although single track, the road alignment is generally suitable for limited HGV use given agreement with the roads authority.

Internal Access

There are no tracks or rides within the woodland other than the narrow path routes.

Constraints

An 11kV overhead wood-pole electricity line crosses the grazing in the extreme west but does not affect the woodland itself. The circular, formal path route is provided for public access but there are no benches or other facilities. The presence of utilities elsewhere on the site, such as alongside the southern road boundary, cannot be discounted.

Discussion

Suitability for forestry using AD / CLO

Currently unplanted

There are no open areas suitable for AD / CLO use within the woodland.

The 0.05 ha and 0.5 ha small areas of improved grazing do not appear to be nitrogen deficient although they are likely to have benefited from routine inorganic fertiliser applications. Whilst there may be a theoretical opportunity for AD / CLO application to the northern area that was formerly part of the spoil tip, this may not be necessary in the context of the management of the larger grazing field of which they form part. However, some AD / CLO application and deep cultivation might be justified if the land was turned over to forestry, albeit probably at relatively low application rates.

Currently planted

There are no areas obviously suitable for AD / CLO use because there is no visual evidence of nitrogen deficiency and the existing tree crop is growing well. Detailed soil analysis might reveal a degree of nitrogen deficiency that could partially justify AD / CLO application. However, although the soil structure would benefit from the complete cultivation to >50cm depth involved in AD / CLO application, permissible quantities are likely to be so low as to render this an unlikely option.

Suitability for woodfuel production

The existing woodland is suitable for timber harvesting, yielding a variety of products including, eventually, sawlogs (albeit that larch / pine logs are lower value than spruce). Harvesting will yield a proportion of smaller dimension softwood suitable for woodfuel. Timber harvesting will be necessary prior to windblow that will develop if felling is left indefinitely. Harvesting could be programmed as a wood supply and carried out in phases to avoid sudden wholesale clearance.

The area could be replanted with broadleaved Short Rotation Forestry or with a replacement crop of conifers, primarily larch and pine, which would probably optimise biomass production.

Establishment of SRC, on the more level areas, following felling would be excessively costly, requiring de-stumping and (in places) levelling of furrows and is not considered a realistic option even if there was a desire to replace the existing attractive woodland characteristics.

The small 0.5 ha of improved grazing is not well suited to planting with SRC, partly due to the relatively steep slope northwards to the Breich Water, which would render it more difficult to harvest.

Conclusions

Loganlea Colliery is not suited to any significant AD / CLO use but has good potential for supply of wood fuel from the existing woodlands.

Recommendations

Loganlea Colliery woodland should be managed as a commercial forestry block with appropriate community access provision. Harvesting should ideally be phased to avoid sudden clearance of the whole site and promote a more varied future structure. Replanting design should follow current standards to increase diversity and wildlife value. Products both now and in the future can include woodfuel. The few existing

areas of broadleaved planting are suited for amenity rather than timber production and can yield only very small quantities wood in thinnings.

The small area of improved grazing could accommodate both AD / CLO and SRF but the benefits would be marginal.

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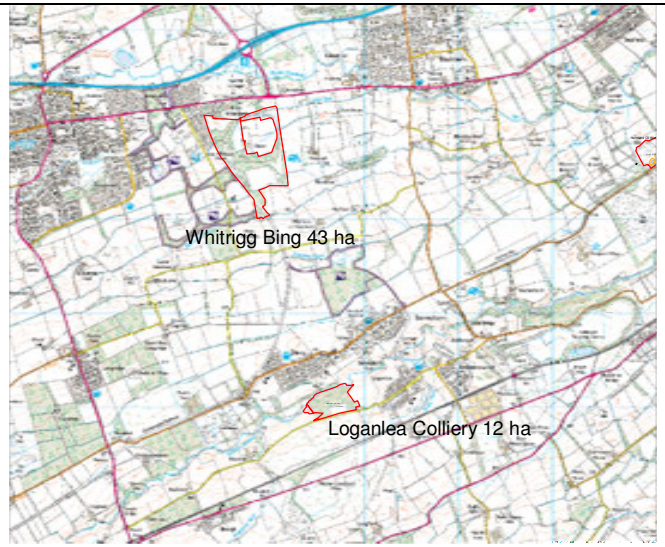
March 2011

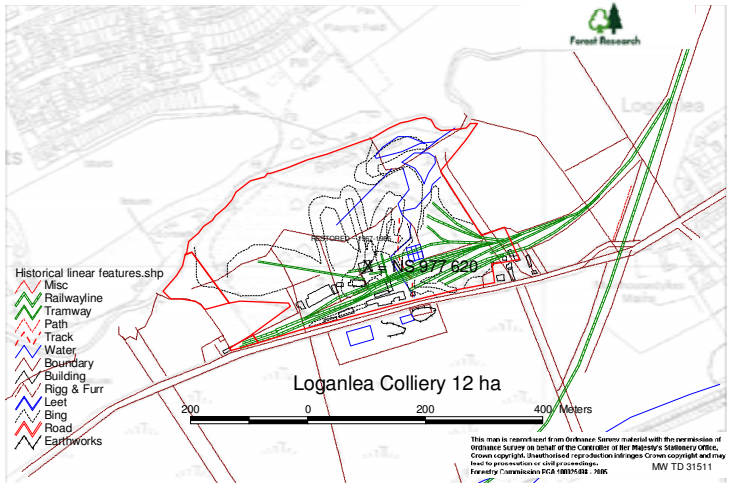
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

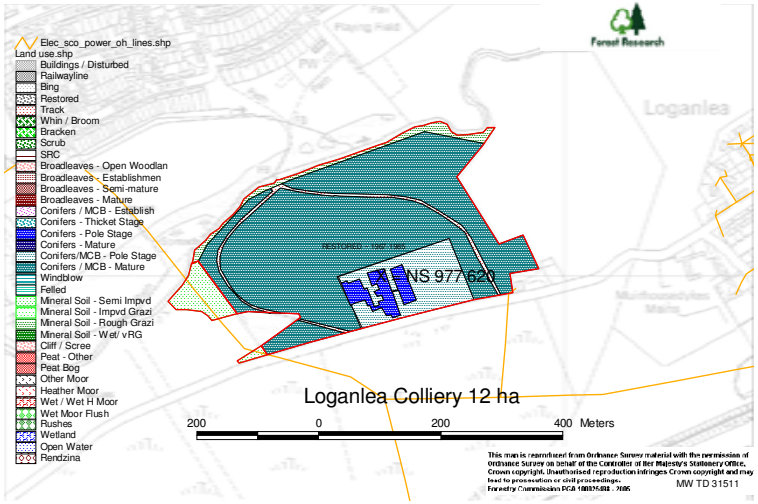
SITE REPORT B2 MAPS, LOGANLEA COLLIERY



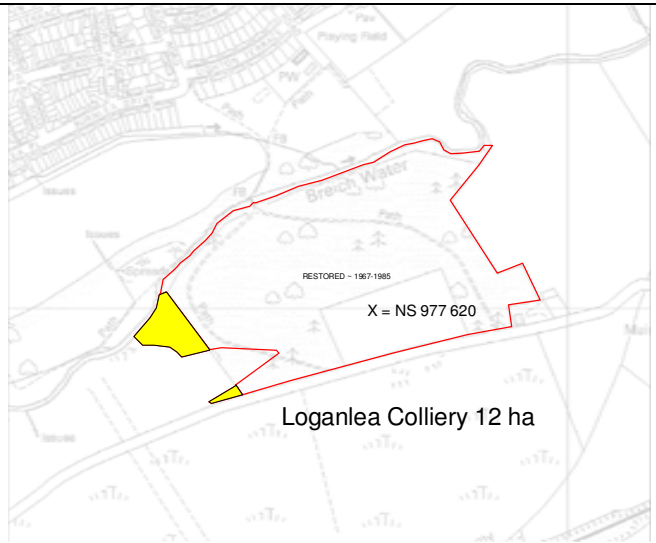
Location Map



Historical Features



Constraints and Land Use



Forestry restoration potential using AD/CLO

Site: B3. Whitrigg Bing (43ha)

SITE VISIT 14TH MARCH 2011. WEATHER: RAIN

Description

Pen Picture

Whitrigg Bing is a former colliery site with associated spoil tips that has been restored by removal of buildings and levelling / grading of spoil. The site is split by a former farm access road and pre 1856 'green lane' that runs north-south down to the Bickerton Burn at the southern tip. In the north of the eastern half but excluded from the site itself there is a large zone, surrounding the site of the former Dales Farm (pre 1856 to post 1967), that appears never to have formed part of the mine or spoil tips. This area comprises commercial depots and hard-standings within a steel security fence, apparently originating some time after 1980. The site proper has been partially planted with well stocked spruce, mixed conifers and broadleaved mixed woodland. The main spoil tip remains, albeit re-graded and covered with grass / heath on a thin soil cover.

The area is well served by a formal, signed path network linking to the adjacent Whitburn community and shows evidence of significant public use, including a 'pets cemetery' on the highest point of the former main bing. The area is also signed as Whitrigg Community Woodland at the main entrance.

Location & Community (NS 968 646)

Whitrigg Bing is situated immediately south east of the East Whitburn area of Whitburn, south of the A705 and east of a former railwayline the runs north-south (see maps).

Following restoration the whole area was provided with comprehensive signage and a network of paths that are now surfaced with blaes and augmented by various informal desire lines. The paths link onto and along the former railwayline to Whitburn on the west and also a public road serving commercial properties within the centre of the site where the property is designated as Whitrigg Community Woodland by a threshold sign. There is ample evidence of local public use on site, including dog walkers and a pets cemetery located on the highest point of the regraded bing, which is open and affords views southwards.

History

The site later occupied by Whitrigg Colliery was undisturbed farmland in 1856, with a patchwork of fields surrounding Dales Farm lying to the east of the railwayline running roughly south-north. Although the situation was unchanged in 1899, by 1916

Whitrigg Colliery Pit No 5 was situated to the west of the road giving access to Dales Farm, and served by a railway branch line curving southwards from the north west part of the site where it met the main railway. A second branch line originated at the same junction which trended generally eastwards north of the Latch Burn to another mine shown as Burnbrae Mine Pit No 4. This route forms the north eastern site boundary. At this time the spoil tip was relatively modest and was located immediately to the north west of the mine buildings, with the majority of the ownership being undisturbed. The situation was not greatly changed by 1938 but by 1958 the spoil tips had both grown to the north west of the mine and spread over the north - south mine access road to the east. A cableway lead from the mine south eastwards to a new spoil tip located at the extreme south end of the site. By 1967 the spoil tips occupied the whole of the site to the west of the mine buildings, where there was also a large settling pond, and much of the land to the east and south served by a cableway. A fireclay mine was located just north of the northern boundary but Whitrigg No 5 pit was disused. By the 1973-80 map the railways are disused and uplifted and the mine buildings are removed, but the spoil tips remain and extend across to the easternmost boundary. Dales Farm is removed but the Fireclay Mine buildings are still in place. Little changes by the 1980-94 map except that the Fireclay Mine buildings are removed.

Map and visual evidence suggests that the larger part of Whitrigg Bing was restored and planted in the second half of the 1980s, with a strip along the former railway in the west approved for planting in April 1991.

Woodland

A significant proportion of the woodland, especially in the centre and around the commercial sites occupying the middle of the area, comprises reasonably well stocked c 25 year old, semi-mature pure Sitka spruce with significant areas of Hybrid larch, especially in the west and extreme south east and some Lodgepole pine. It appears from visual assessment and FC records (SFGS approved 12/4/91) that a strip down the western boundary alongside the old railwayline was planted slightly later in the early to mid 1990s. This includes the southern projection, located on former spoil tip, which includes Scots pine, Hybrid larch and mixed broadleaves. Most of the strip comprises Hybrid larch with Alder, Birch and proportions of mixed species including Hawthorn, Ash and Scots pine.

A small area of younger (c. 10 year) mixed conifer planting including Scots pine and larch is located west of the northern access footpath on a raised mound. This feature may be associated with what appear to be relatively new settlement ponds within a security fenced enclosure adjacent and to the east. The small woodland area shows evidence of soil problems (e.g. acid contamination and/ or locally shallow 'soil') in the form of group yellowing and browning of foliage.

Planting at Whitrigg Bing is generally on double mouldboard shallow ploughing on wetter more level areas, especially in the spruce, and flat elsewhere (probably with ripping).

The woodland is reasonably well drained without obvious ponding. Deep ditches are located along the northern boundary (Latch Burn) and at the south end south of the main former spoil tip. These watercourses were flowing at the time of the site visit.

Open space

Whitrigg Bing includes three main areas of open space.

In the west adjacent to the central road, just north of the site of the former colliery buildings is an area previously partially occupied by sidings, a few smaller mine buildings and a settling pond (until beyond 1980). This is now an area of wet level mineral soil including areas of sedge and rough grass (e.g. including *Deschampsia cespitosa*) bounded by a deep ditch along the roadside. The surface has been partially stripped into a bund in the southern part and at least one capped borehole is visible.

The extreme north west of Whitrigg Bing comprises an area of level rough grassland that appears from map evidence never to have been disturbed.

The largest area of open space is located in the south of Whitrigg Bing and forms the summit and southern slope of the re-graded main spoil tip dating from the 1950s and 1960s. This area comprises a very shallow surface skim of soil forming material including some organic matter over coal shale spoil and is vegetated with mixed grasses (including *Fescue* and *Agrostis*), with patches of heather towards the east and areas of moss / sedge.

In addition to the larger areas of open space, the woodland planting includes integral limited internal open space. This is especially so with the formal footpath running southwards along a low ridge formed down the west side of the site alongside the old railwayline boundary.

Soils

Soils are generally light brown and brown mineral soil, with evidence of high clay content and mixing with mining spoil in places. For example, the deep drain running northwards on the east boundary of the southern tip shows clear evidence of layers of mining spoil overlaying a clay-rich subsoil and a heavy soil / spoil mix forming the upper horizon.

Natural soils will be clay rich, probably gleyed and subject to waterlogging. The arc of Sitka spruce around the central commercial zone in the north east of the site, that appears from map evidence never to have been disturbed (except for a lagoon existing some time between 1967 and 1980) is formed on natural clay loam mineral soil with accumulated organic matter.

The main southern re-graded spoil tip comprises a shallow skim of organic matter and soil forming material overlying coal shale spoil. Visual evidence suggests that this is compact and probably nutrient deficient.

Terrain & Water Environment

The majority of Whitrigg bing comprises gently sloping ground resulting from re-grading spoil tips and level ground on the largely undisturbed area. Although the southern tip of the site formerly housed a spoil tip, this has been removed leaving a level site at more or less natural level with the surrounding countryside. The spoil tip located in the south of the eastern half of Whitrigg Bing is now the highest ground within the site. Ground falls relatively steeply northwards (occupied by conifers) and southwards (open space) from a level summit.

The Whitrigg Bing site is reasonably well drained without obvious significant ponding or surface erosion. This is in part a result of shallow slopes used in restoration profiles. The Latch Burn comprises a deep ditch flowing eastwards and forms the northern boundary. The extreme southern tip is bounded by the natural course of the Bickerton Burn and there is a deep ditch draining westwards forming the southern boundary adjacent to the main spoil tip.

A group of reed-beds / lagoons within a modern steel green security fence is located in the north of the western half of the site close to the Latch Burn. This feature appears to have been installed within the last 10 years or so and may be associated with mine-water discharge from the unplanted main pit area adjacent.

Biodiversity

The most likely area of high biodiversity value is the open southern 'main' spoil tip, which now has characteristics of an impoverished, heathland habitat developing on the thin organic rich surface.

The internal woodland open space, along the low ridge on which the 1990s mixed conifer and broadleaf planting took place, is augmented by Hawthorn and shrubs forming a 'woodland edge' habitat. This open space is also of high amenity value. The north western (probably largely undisturbed) and north-central areas of open space occupied by wet / rough grassland vegetation are likely to be of lower biodiversity value although this would need to be confirmed by ecological assessment.

The presence of national or local Biodiversity Action Plan habitats or species, or of European Protected Species, cannot be discounted without ecological assessment. Badger may be present and Roe deer are likely. No large old trees suitable for bat roots were seen but a few may be present on the periphery of the site.

External Access

Whitrigg Bing is served by the unclassified public road that runs due south from the A705 and bisects the site. This is suitable for HGVs as it serves the commercial depots (Robert Wiseman milk tankers and car transporters regularly use this road).

Internal Access

There are no tracks within the woodland other than the path routes, which are only suitable in dryer conditions for light 4wd vehicles used for maintenance. This category includes the route of the former railwayline forming the western boundary, which is now occupied by a loose surfaced footpath.

This north - south access road terminates in the centre of the site, from which access southwards is limited to the route of the formal paths.

Constraints

An 11kV overhead wood-pole electricity line runs along the old railwayline on the western boundary and eastwards across the centre of the site to the commercial zone.

The primary constraint to further restoration at Whitrigg Bing is the high level of use as a community woodland by the local population, and the fact that the site is in general well restored and developing well as a woodland. The largest area of open space left, on the former southern spoil tip, appears to have high biodiversity value and also safeguards views from the highest point, although there may be an opportunity for limited planting along the lower slope. The summit hosts a pet cemetery and is likely to be an especially sensitive location.

The presence of housing near to Whitrigg Bing is also a potential constraint in that any re-restoration would need particular local community acceptance.

Discussion

Suitability for forestry using AD / CLO

Currently unplanted

There are three main areas of open space. The north western area that appears to have suffered little if any disturbance would be suitable for woodland planting and is, or could be made, accessible along path routes for light vehicles from the nearby

access road. However, this area may be sensitive due to neighbouring housing so the nature of ground preparation and new planting would need careful consideration.

The former mine siding etc area in the centre of the site, alongside the access road, has the appearance of wasteland and is clearly disturbed. This area would probably be suited to re-restoration of some type and planting, although the area is also at least superficially suited to expansion of the commercial zone. Partial surface soil stripping suggests that this may have been considered in the more recent past, although this may also have been associated with mine-water discharge treatment.

The southern main re-graded spoil tip is superficially suited to re-restoration to relieve compaction and amendment of soil structure with organic additives prior to woodland planting, which could include short rotation forestry or even coppice. However, the area may be sensitive for biodiversity, community and landscape reasons.

Currently planted

There are no areas obviously suitable for AD / CLO use because there is no visual evidence of nitrogen deficiency and the existing tree crop is growing well. The only observed exception is the small area of 10-15 year old mixed conifers near the northern lagoon compound, but this is unlikely to amount to a viable amendment area.

Detailed soil analysis might reveal a degree of nitrogen deficiency that could partially justify AD / CLO application to restored areas planted with conifers when eventually felled. However, permissible quantities are likely to be so low as to render this a very unlikely option.

Suitability for woodfuel production

The existing Sitka spruce dominated woodland is suitable for timber harvesting, yielding a variety of products including, eventually, pallet or even sawlogs (albeit that larch / pine logs are lower value than spruce). Harvesting will yield a proportion of smaller dimension softwood suitable as woodfuel. Timber harvesting will be necessary prior to windblow that will develop if felling is left indefinitely. Harvesting could be programmed as a wood supply and carried out in phases to avoid sudden wholesale clearance.

The area could be replanted with broadleaved Short Rotation Forestry or with a replacement crop of conifers, primarily spruce, larch and pine, which would also be effective for biomass production.

Large scale harvesting would tend to be precluded by the lack of internal rides and tracks suitable for heavy forestry machinery, and the disruption and damage to the

formal and well used internal path network that would be entailed. Therefore the site is more suited to small scale, patch clear felling that would reduce operational impact and help to diversify the woodland structure over time. There will also be opportunities for small scale (and costly) thinning that would yield fuelwood.

Establishment of SRC, on the more level areas, following felling would be excessively costly, requiring de-stumping and (in places) levelling of furrows and is not considered a realistic option even if there was a desire to replace the existing woodland characteristics.

The open 'heathland' area of the southern main spoil tip could be technically suitable for SRF or SRC production, but biodiversity, community and landscape constraints are likely to militate against this option.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The overall site is classified as **Medium Potential** (southern spoil tip slopes) and **Low Potential** (north western rough grassland) for AD / CLO use:

	Potential	Requirement		
		High	Medium	Low
Feas-ibility	High	High	Medium	Low
	Medium	**Medium**	Medium	**Low**
	Low	Low	Low	Low

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map as:
Blue (Medium Potential)= 7 ha
Yellow (Low Potential) = 3 ha (excludes 2 ha internal open space areas < 0.5 ha).

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The overall site is classified as **Low Potential** for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low		Nil
Feasibility of SRF/SRC	High	High		Nil
	Medium	Medium		Nil
	Low	**Low**		Nil

Conclusions

Whitrigg Bing may have limited potential for AD / CLO, although this would require ecological assessment of the two main areas concerned. It would also be necessary to build a case for further intervention acceptable to the local community. However, the woodlands already established on Whitrigg Bing have good potential for supply of wood fuel in planned phases.

Recommendations

Whitrigg Bing should be managed as a community woodland block with appropriate harvesting that can include regular biomass production as a by product, although this would not be the most cost effective supply of fuelwood in its own right. Harvesting of the pure conifer areas (largely Sitka spruce) should ideally be phased to avoid sudden clearance of large parts of the site and to promote a more varied future structure. Replanting design of these areas should follow current standards further to increase diversity and wildlife value. The existing areas of broadleaved and mixed conifer / broadleaf planting are suited for amenity rather than timber production and can yield only very small quantities wood in thinnings.

If AD / CLO use is strongly favoured for reasons not specific to Whitrigg Bing, an ecological assessment should be carried out on the 'heathland' area of the southern former spoil tip and the disturbed and undisturbed rough grassland / sedge areas in the north of the property. However, the areas concerned may not utilize significant amounts of AD / CLO, especially in relation to the effort required for implementation at this site.

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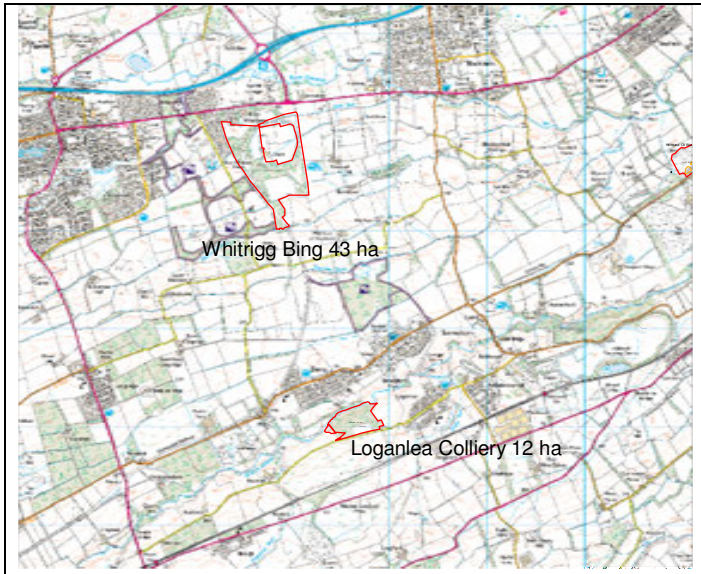
March 2011

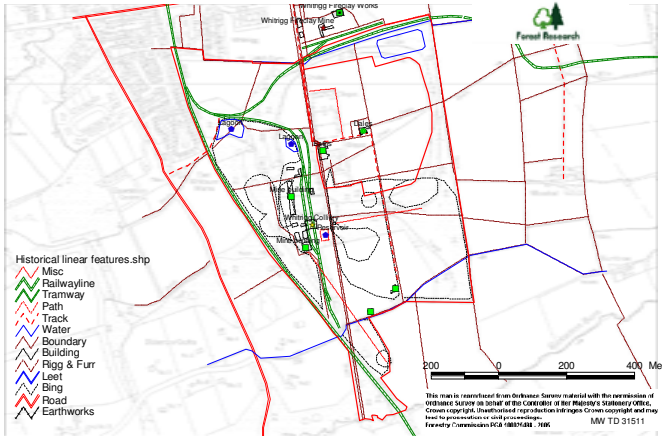
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

SITE REPORT B3 MAPS, WHITRIGG BING



Location Map



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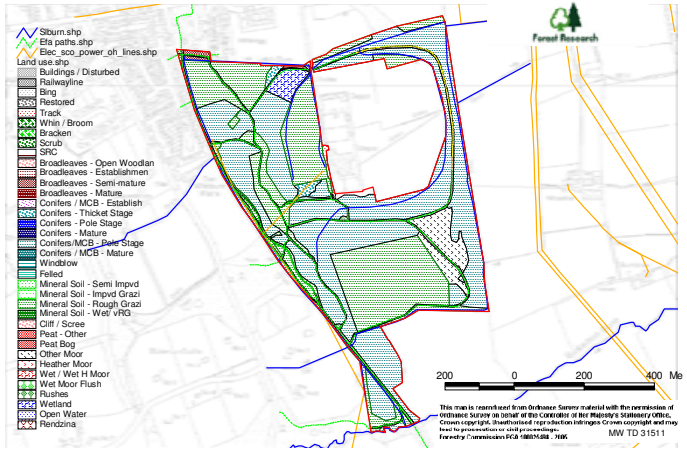
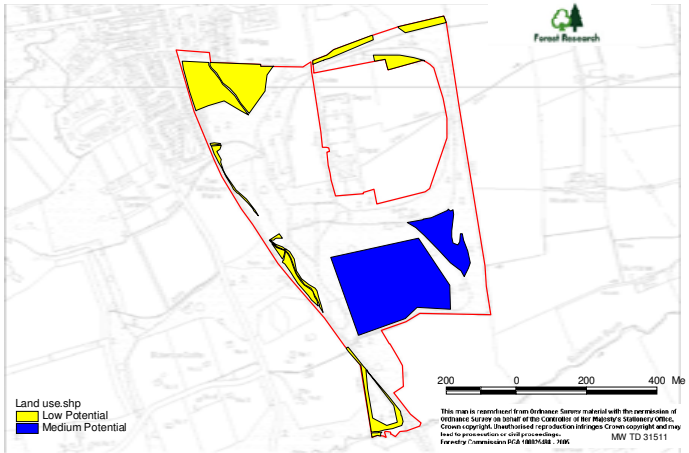


Constraints and Land Use



Forestry restoration potential using AD/CLO

Site: B4. Easton Bing (13ha)

SITE VISIT 16TH MARCH 2011. WEATHER: FINE

Description

Pen Picture

Easton Bing is a former colliery site with associated spoil tips that closed in 1973 and has been restored by removal of buildings and grading of spoil into an extensive hill feature. The remaining site has been laid out with c 20 year old mixed broadleaf woodland, with a proportion of larch and groups of pine. The improved grassland on the south and west facing slopes of the restored bing have been sold and are no longer part of this site, although they benefit from the protection of the shelterbelts forming part of the woodland. Easton Bing has been provided with main formal loose surfaced public footpaths giving signed access from the neighbouring residential area to the east into the full extent of the main block of woodland. The site is effectively fully restored and planted, and although the woodland shows some signs of localised shallow soils and low growth rates it is considered to be fully established.

Road access is along a narrow track in the south from the A89 on outskirts of Bathgate and off an unclassified public road forming the northern boundary. There are no internal access tracks although light 4wd vehicle access could be achieved if necessary, in dry weather along footpath routes.

Location & Community (NS 960 692)

Easton Bing is situated immediately to the west of Bathgate adjacent to residential areas just north of the A89 and east of the A801 (see maps).

Following restoration the woodland area was provided with route signage and a central spine of paths that are now surfaced with blaes and augmented by various informal desire lines. The main path trends westwards to the level summit where views are gained over restored grassland southwards. This path also links down the hill slope of the restored bing to the unclassified road to the north. The main public access is gained from the residential areas to the east up the access track from the south and a narrow spur of woodland along the former railway route to the mine from the north east.

Visual evidence suggests that the woodland is well used by the local community, with few obvious signs of antisocial activity.

History

The site later occupied by Easton Colliery was undisturbed farmland in 1856, with a patchwork of fields to the north east of Middlerig Farm. By 1897 a small Colliery marked 'Disused' was located in the east, with an access track from the south and a single track railway taking access from the north east. Although a shaft was marked, no spoil tip was present. Records suggest that mining, whether for coal or silver / nickel / lead, had commenced in 1896. The colliery was active again in 1922 under its government name as Hopetoun Colliery (Easton Pit No 1), with buildings, sidings, settling pond and spreading areas of spoil. The situation was similar in 1958 with railway and buildings marked as 'Mine' and a tramway spreading a new spoil tip to the north west, in addition to the larger spoil heap marked to the north east. In 1967 the mine was evidently still working, recorded as Easton Colliery, surrounded by extensive areas of spoil, although the entire disturbed area was shown as coalesced, with no detail of internal feature location. Photographs from around this time show a large partially conical spoil tip to the north east of the mine buildings, and another shows two spoil heaps to the north of the mine, corresponding with the maps of 1922 and 1958. Photographs also reveal a large lagoon, which coincides with a feature marked on the 1958 map slightly to the north west of the buildings. The map dating 1973-86 is very similar to the 1967 map except that field boundaries and the former 'Oak Bank' wood are no longer marked, indicting that they had been cleared since 1967. Records reveal that the Easton Colliery closed in 1973 and was abandoned in 1974. The mine buildings, railway and all other features had been removed by the 1989-94 map and the area of spoil was shown as extending throughout the whole site, well to the west of the area occupied by the former spoil tips prior to restoration.

Map and visual evidence suggests that the entire ownership area of Easton Bing was restored and planted in the late 1980s or early 1990s. This appears to have involved spreading the spoil tips in the east across the site to the west, overlaying the original terrain present in 1967.

Woodland

Easton Bing is approximately 40% planted woodland in the north and east, adjacent to improved grassland in the south and west. Only the woodland forms the West Lothian Council ownership. The main body of the woodland occupies the level, south-east part of the site and the north and east facing slopes and summit of the restored former spoil heap in the centre and north. Three shelterbelts protrude from the main woodland block to subdivide fields on the south and west facing slopes, and the route of the former railwayline is now a wooded spur to the north east.

The whole area appears to have been planted about 18 years ago (around 1992), predominantly with broadleaves such as Alder, Sycamore, Goat willow and Birch, with some Oak, Ash, Hawthorn and Norway maple. The low-lying south eastern area,

adjacent to a deep running ditch forming the property boundary, is largely broadleaved but there are increasing proportions of conifers towards the north and summit in the centre of the site. The conifers are estimated to amount to approximately 20 - 25% of the woodland, comprising Lodgepole pine and Hybrid larch, with some Scots and Corsican pine, mostly planted as groups, although also scattered through broadleaves, especially larch and especially in the shelterbelts.

Planting at Easton Bing is generally close spaced (1 - 1.5m) on shallow ploughing on the main hill feature. The more level south east area was apparently flat planted, mostly with broadleaves and possibly along rip lines.

There are no obvious signs of tree ill health except that tree growth (mostly broadleaved) is occasionally poor on areas of the main spoil tip area, corresponding to very shallow soils. Growth rates appear good in the south east of the site and fall somewhat up the slopes towards the summit. There are signs of the onset of tree instability with some windblown Lodgepole pine planted on furrow ridges towards the summit.

Open space

Open space within the woodland itself is limited to path routes and a small area towards the summit.

Soils

From limited visual evidence the woodland soils are developed on dark mine spoil, with relatively little organic matter, especially on the main re-graded spoil mound in the northern centre of the site where the surface litter and humus layer appears directly to overlie spoil.

Visual evidence from windblown Lodgepole pine (on furrow ridges in the centre) and Goat willow (flat planted in the south east) suggests that at least some trees are rooting into the spoil to c30cm depth or greater. However, the compaction found over much of the hill coupled with slow tree growth in places suggests that there are areas with very shallow rootable depth.

Terrain & Water Environment

The majority of Easton Bing comprises gently sloping ground, slightly steeper to the north, forming the flanks of one single extensive hill feature with its summit at about the centre of the site. The hill results from re-grading the spoil tips in the east over the whole site. There is more level ground in the south east of the site, although this is also formed on mine spoil.

The Easton Bing site is reasonably well drained without obvious significant ponding or surface erosion. This is in part a result of shallow slopes used in restoration profiles. The only ditches seen were the pre 1856 burn forming the south eastern boundary with neighbouring housing and a restoration period ditch collecting run-off from the south facing fields that leads into it. The former burn is now a deep ditch, which was flowing with water when seen in mid March.

Biodiversity

The most likely area of high biodiversity value is the south eastern apart of the site and the north east spur along the former railway, due to slightly better conditions for tree and ground vegetation cover, supporting greater diversity. However, the more 'heathland' conditions present in areas of the hill feature formed on the re-graded spoil tip may also have special value.

The presence of national or local Biodiversity Action Plan habitats or species, or of European Protected Species, cannot be discounted without ecological assessment. Badger may be present and there are reputed to be about a dozen resident Roe deer. No large old trees suitable for bat roots were seen but a few may be present on the periphery of the site.

External Access

Easton Bing is reached by a narrow lane that comprised the 1898 and later mine access from the A89 Armadale to Bathgate road to the south. This lane is within the ownership and is partly formed on a raised embankment, with modern housing to the east and farmland to the west. The road entrance lies between housing that fronts onto the A89 where it is bitumen surfaced. With some upgrading and neighbour liaison this access would be suitable for occasional rigid HGV use only. The north boundary of the site and the north east spur fronts onto a 'single track' unclassified council road.

Map evidence suggests that a new access route, no longer in existence, was formed from the A89 to the south across intervening farmland to the site when it was restored some time after 1989. This utilised a former boundary projection southwards from the main property that was at one time the head of the mine railway sidings.

Internal Access

There are no tracks within the woodland other than the path routes, which are only suitable in dryer conditions for light 4wd vehicles used for maintenance. This category includes the route of the former railwayline forming the north east spur, which is now occupied by a loose surfaced footpath.

This access lane from the south terminates at the southern boundary of the site proper.

Constraints

The site visit revealed no evidence of overhead or underground utilities, although the latter cannot be discounted.

The primary constraint to further restoration of the planted areas at Easton Bing is fact that it is already restored and is in general developing well as accessible woodland used by the local population.

The presence of housing near to Easton Bing is also a potential constraint in that any re-restoration would need particular local community acceptance.

Discussion

Suitability for forestry using AD / CLO

Although there is visual evidence of poor rooting depth and potentially poor soil nutrient status in places, the woodland is not obviously suitable for AD / CLO use because it is now fully established developing as a reasonably healthy mixed species community woodland. The use of AD / CLO would need to be justified by an over-riding need to change the woodland composition e.g. to establish fast growing biomass on the site.

Detailed soil analysis might reveal a degree of nitrogen deficiency that could partially justify AD / CLO application involving deep cultivation to parts of the restored woodland. These areas would be those showing particularly poor growth, together with areas planted with conifers, or even broadleaves, if windblow develops as is expected. However, specific areas and permissible quantities are likely to be so low as to render this a very unlikely option.

Suitability for woodfuel production

The existing mixed woodland of less than 20 years is not likely to produce significant quantities of timber from thinning or eventual clearance of windblown conifers, although it could yield small amounts from time to time. Although it would be technically feasible to clear part or all of the woodland for re-restoration to be followed by establishment of biomass, this would appear to be an unlikely option in view of the current use and woodland characteristics.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The overall site has a **Medium Requirement** but **Low or Nil Feasibility** and as such is classified as **Low to Nil Potential** for AD / CLO application.

	Potential	Requirement		
		High	Medium	Low (to Nil)
Feas-ibility	High	High	Medium	Low
	Medium	Medium	Medium	Low
	Low or Nil	Low	**Low to Nil**	Low

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:

Blue (Medium Potential) = 0 ha

Yellow (Low to Nil Potential) = up to 13 ha.

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The overall site is classified as **Low to Nil** Potential for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low		Nil
Feasibility of SRF/SRC	High	High		Nil
	Medium	Medium		Nil
	Low to Nil	**Low**		**Nil**

Conclusions

Unless clearance of parts of the now fully established and developing mixed species community woodland can be contemplated, the woodland area on Easton Bing has no realistic potential for AD / CLO use.

Recommendations

The woodland areas of Easton Bing should be managed as a community woodland block with appropriate harvesting that can include regular biomass production as a by product, although this would not be the most cost effective supply of fuelwood in its own right. Management should ideally allow for replacement of windblown conifers over time.

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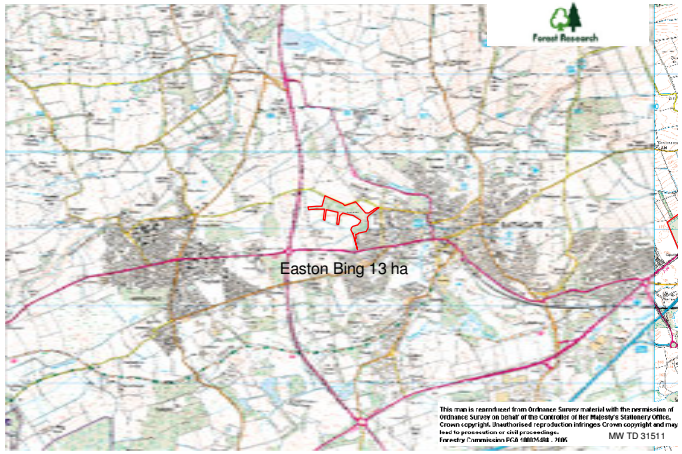
March 2011

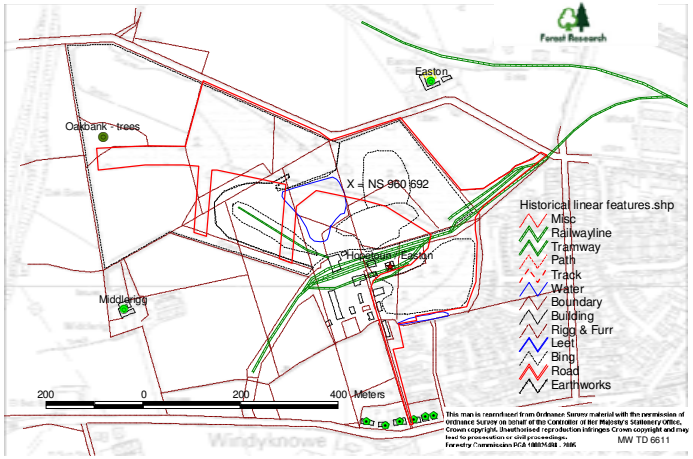
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

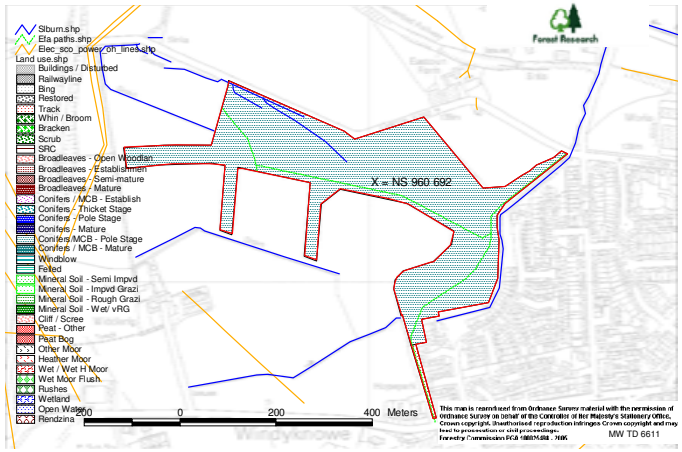
SITE REPORT B4 MAPS, EASTON BING



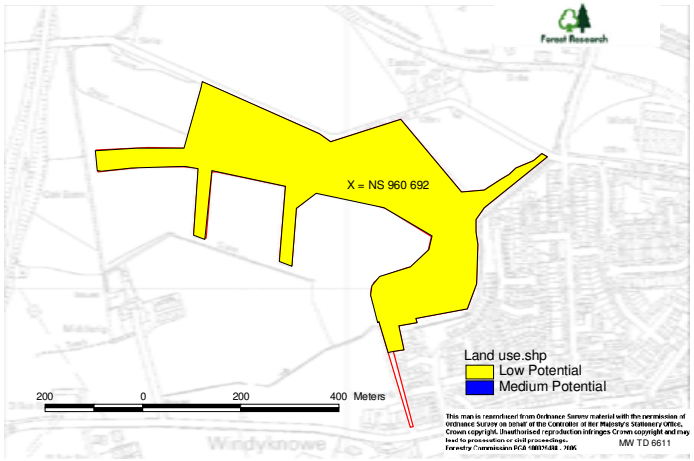
Location Map



Historical Features



Constraints and Land Use



Forestry restoration potential using AD/CLO

Site: B5. Caputhall Wood (18 ha)

SITE VISIT 16TH MARCH 2011. WEATHER: FINE

Description

Pen Picture

Caputhall Wood is a partially planted block of former rough grazing and very wet, boggy, rushy ground adjacent to the A89 just north east of Bathgate. The woodland was planted by the Central Scotland Forest Trust in about 1999 with a pure block of Sitka spruce on peaty ground in the west half and mixed broadleaves and mixed conifers in the east. The eastern part of the east end of the site appears to have been overlain with a 'surcharge' of imported soils and / or soil forming material, including rubble, spread over the original ground surface, which was apparently then ripped prior to planting.

Caputhall Wood is particularly wet in the south west and along the north side of the A89 where there are open water ponds and rush / tufted hair grass open space. The remainder of the area is stocked with trees, although growth on the areas adjacent to the wet open ground and in parts of the 'surcharged' zone is poor and sparse.

Road access is from a good quality unclassified road almost at its junction with the A89. Access into the wood is along a short track over a deep, culverted roadside ditch and would be suitable for limited HGV use if upgraded.

Location & Community (NT 004 690)

Caputhall Wood is located within farmland at the foot of a shallow ridge adjacent to the north side of the A89, opposite a very large distribution deport located over the main road and close to Junction 3a of the M8. The wood lies within 250m of the edge of the Boghall district of Bathgate, although the woodland access is nearly a mile north east up the A89 from the Boghall estate roundabout. Although no surfaced paths have been installed there is a track route that becomes a path leading from the site entrance in the east. The track and path are clearly regularly walked by the public apparently entering from the north east i.e. not from the Bathgate direction. This appears to be regular use by one or a small number of local people, without obvious signs of any antisocial activities. Aerial photography of 2004/5 suggests that a path route (probably mown) or mown fire trace was formerly in existence from the current desire line in the north west, down the western boundary and then winding north eastwards to finish on the north east boundary. This route was not found on the site visit and may have fallen into disuse.

Caputhall Wood lies within the FCS WIAT 1 km zone.

History

The site later occupied by Caputhall Wood comprised three fields of undisturbed farmland in 1856, within a patchwork of fields to the north of the Bathgate to Broxburn road, along which appears to be marked a drain. By 1922 the fields had been combined into one, which was the case in 1938 and 1957-8 and up to 1973-84 also. The map of 1967-70 also shows the site as rough pasture (as distinct from better land to the south). The map recorded as 1976-92 shows the site as re-subdivided by a single boundary (still existing, but not corresponding to any 1856 boundary) roughly into north eastern and south-western halves. The north eastern half includes a short track loop reached from the unclassified road to the north east, corresponding with the position of the current entrance and adjacent electricity substation.

FC records show that Caputhall Wood was the subject of an FC Woodland Grant Scheme with Community Forest Premium proposal approved in October 1998, with Central Scotland Forest Trust acting as agent for a public sector owner.

Woodland

Caputhall Wood is approximately 60% woodland of about 12 years, i.e. planted in about spring 1999. Crop growth is very variable with areas and groups of thriving trees, both conifers and broadleaves, at or approaching closed canopy. These are interspersed with areas of poor growth where trees, although often present at planted spacing of a variable 2 - 3 m, are far from closing canopy, giving the appearance of rough open space with scattered 'scrub'.

The woodland divides roughly into a lesser eastern and larger western area. The eastern part appears to be formed on surcharged soil / rubble spoil. This area is bisected by an unmade access track and in addition to rough open space is planted with an intimate and group mix of conifers (Sitka spruce, Scots pine, Japanese larch and some Lodgepole pine) and broadleaves (including Alder, Birch, Sycamore and Ash). Planting appears to be flat, possibly into rip lines.

The larger western part of the site comprises wet open space to the west and south, and both conifer and broadleaved woodland.

About half of the stocked woodland in the west is a single block of mostly pure Sitka spruce on single mouldboard plough ridges at about 2.5 m spacing. Soil conditions here appear predominantly to be peaty. Tree growth and health appear good over most of the area, but as the block dips southwards towards the wet open space there are increasingly severe signs of nutrient (nitrogen) deficiency with yellowing and poor growth. The southern fringe is occupied by young Scots pine, some severely stunted

by nutrient deficiency, growing on substantial plough ridges in very wet peaty ground conditions.

The remaining woodland in the western part of the site is also mostly planted on plough ridges, at about 3 m spacing, with mixed broadleaves.

Open space

The open space within the Caputhall Wood amounts to approximately 40% of the total area, although this is very difficult to estimate because the area occupied by original planting is probably somewhat greater. Much of the technically 'planted' area is failed or occupied by a very sparse tree cover that is some time from closing canopy.

The open space in the eastern part of Caputhall Wood, falling generally to the sides of the access track, is located on a clay-rich mineral soil with some rubble. These areas are rough grassland having a proportion of Tufted Hair Grass (*Deschampsia cespitosa*), signifying wet but not extremely infertile soil.

The largest block of open space at Caputhall Wood is found to the west, southwest and south along the A89. The whole site dips slightly south and westwards, so this open space occupies the lowest ground at the site, which is correspondingly the wettest. Three ponds are located near the A89 which may or may not be artificial. There are substantial areas of thick Rushes (*Juncus* spp), which merge into Tufted Hair Grass and other grasses on slightly higher and drier ground.

Soils

Much of the site is located on organic rich mineral soil or peat. Geological GIS mapping records peat across most of the Caputhall Wood site, as a strip running up the north side of the A89. The occurrence of peat at this location is probably reflected in the property boundary matching, as it does, the pre 1856 field divisions.

Limited site survey verifies the presence of peat, especially under the healthy Sitka block in the west, but the west of the site also includes dark brown and organic-rich clay rich mineral soils. Whatever the exact balance between more peaty and more mineral rich soils, the west part of the site clearly includes a relatively high organic matter component. The health of Sitka spruce growing on the drier peat and the presence of rushes in the wetter parts indicates that soil nutrient status is not significantly low. The localised conifer yellowing and areas of poor growth are likely to be largely due to water-logging and species choice than with nutrient deficiency.

The eastern third of Caputhall Wood appears to have been surcharged by an overlay of imported clay rich mineral soil or subsoil, spread out in such a way as to leave a bank dropping some 2m in an arc down to the apparent 'natural' ground surface.

Rubble is evident at the ground surface in places. This area corresponds roughly to the location advised by council staff as having been a 'tip' and so is suspected to be landfill. Conifer and broadleaved tree growth on the eastern 'surcharge' ground is variable, which is likely to be due partly to low nutrient status in places but may also result from compaction, which is highly likely in the circumstances.

Terrain & Water Environment

Although Caputhall Wood is generally level, especially over the 'surcharge' zone in the east, the original landform still allows for a general slight fall to the south and west. The drains forming the western and southern boundaries both flow to a confluence in the south corner of the site.

The site is surrounded by drains running along or close to the boundaries that discharge southwards into the Bog Burn, which swings west and northwards to flow into the Bathgate Water, the Logie Water and then the River Avon towards the north. There is also a central drain running down from the north in the western half of the site corresponding with an 1856 field boundary. This was deep at the time of the site visit in March. The north boundary is marked by a drain running westward, which then joins the western boundary drain running south.

Three small ponds are located in the wet open space in the south of the site by the A89. These do not appear to be linked into the boundary ditches.

The west of the site was extremely wet when visited in mid March, with remarkably deep water (well above boot tops) sitting in plough furrows leaving an impression of significant, if perhaps seasonal, water-logging in parts of the west and the south.

Biodiversity

The most likely area of high biodiversity value is the wet southern and south eastern apart of the site.

The presence of national or local Biodiversity Action Plan habitats or species, or of European Protected Species, cannot be discounted without ecological assessment. No signs of badger were seen but Roe deer are likely to use the site. No large old trees suitable for bat roots were seen but a few may be present on the periphery of the site.

External Access

Although Caputhall Wood lies alongside the A89, access is formed off the unclassified public road to the north close to its junction with the main road. The access comprises c170m of largely unsurfaced track which first crosses a wide culvert over a deep roadside ditch and passes just south of an electricity substation. There may be buried electricity cables crossing this route. Map and visual evidence suggests that

the track was originally linked to a loop around the site of the adjacent electricity substation. The track entrance would require upgrading for regular HGV use but the track itself is not within the site boundary.

The unclassified road in the vicinity of the site entrance would is suitable for HGVs, although the entrance itself is only c 40m from the main road junction.

Internal Access

The only internal access at Caputhall Wood comprises a rough track from the site entrance across the eastern 'surcharge' part of the site, which is continued as an informal footpath down the bank at the edge of the tip zone across the low lying, wet ground in to the west. The footpath loops through the Sitka spruce and around the north side of the site.

Constraints

The site visit revealed evidence an underground utility wayleave crossing the north western part of the site marked as a high pressure gas (with a 50m wayleave either side), and also a 33kV wood pole electricity line along the northern boundary. These wayleaves would not have a significant impact on operations at Caputhall Wood.

There is an electricity sub station just to the north of the access track leading to the site from the north east. No overhead cables are mapped or visible at this location, so the facility is presumed to serve underground cables which may therefore cross close to, or under, the access track. The presence of further utility constraints cannot be discounted.

The site entrance would require upgrading, possibly including extension of the culvert and installation of a bell mouth, prior to HGV use.

There are a number of constraints to use of AD / CLO at Caputhall Wood. In addition to soil status and ground condition, these include the fact that the woodland was established with FC grant aid in about 1999, and is largely 'established', so there is no obvious justification for felling and restocking at this early stage in the woodland's development.

Discussion

Suitability for forestry using AD / CLO

Although there are areas of poor growth in the woodland, these are likely to be associated more with water-logging and compaction than with significant nutrient deficiency. Furthermore, much of the site is located on organic rich mineral soil or peat.

It is therefore highly likely that pre AD / CLO application soil assessments over most of the site would not reveal a significant opportunity for AD / CLO addition, although the 'surcharged' / disturbed eastern part of the site would benefit from complete cultivation associated with AD / CLO application and probably some use of AD / CLO.

The high degree of seasonal, and perhaps permanent, waterlogging at the site would tend to militate against addition of an organic rich soil amendment, due to likelihood of anaerobic soil conditions leading to release of ammoniacal nitrogen, and preventing development of a healthy soil profile.

There would also be a potential for watercourse pollution, although these might be addressed by pollution risk assessment and operational design and management.

Suitability for woodfuel production

The existing mixed woodland of less than 15 years is not likely to produce significant quantities of timber from thinning or eventual clearance of conifers for another one to two decades or more. This is exacerbated by the relative isolation of the most productive conifer block across low and wet terrain with no complete track access. Although it would be technically feasible to clear part or all of the woodland for re-restoration to be followed by establishment of biomass, this would appear to be an unlikely option in view of the current use and woodland characteristics.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The eastern part of the site located on imported infill material has been assessed as having a **Medium Requirement** and a **Medium Feasibility** and as such is classified as a **Medium Potential** for AD / CLO application.

	Potential	Requirement		
		High	Medium	Low
Feas-ibility	High	High	Medium	Low
	Medium	Medium	**Medium**	Low
	Low	Low	Low	Low

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:
Blue (Medium Potential)= 4 ha
Yellow (Low Potential) = 0 ha.

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to the forested area located on imported infill material if identified for re-restoration with AD / CLO.

The eastern part of the site is classified as having a **Medium** Potential for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low		Nil
Feasibility of SRF/SRC	High	High		Nil
	Medium	**Medium**		Nil
	Low	Low		Nil

The western part of the site (the majority) is not considered suitable for application of AD / CLO but is stocked with woodland that will eventually produce timber and / or woodfuel.

Conclusions

If clearance of parts of the now partially established and developing mixed species woodland in the smaller eastern part of the site can be contemplated, there is some potential for AD / CLO use. However, this would require careful scoping as Caputhal Wood would be a higher risk site. Drier open space is limited and is unlikely to justify any significant AD / CLO addition, if any. The remaining areas of woodland and the wet open space are unsuitable for AD / CLO use.

Recommendations

Caputhall Wood should be managed as a mixed woodland block with, eventually, appropriate harvesting that can include regular biomass production as a by product, although this would not be the most cost effective supply of fuelwood in its own right and would be 10 or more years away.

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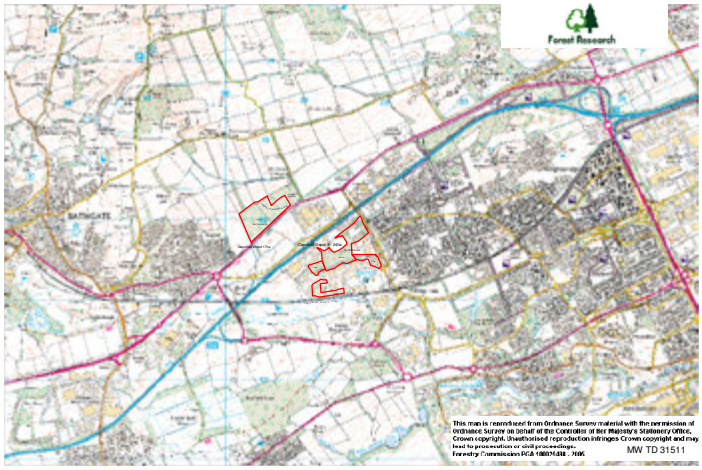
March 2011

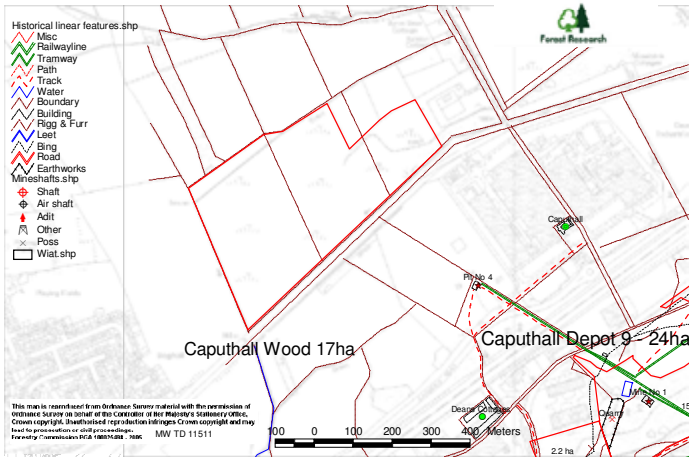
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

SITE REPORT B5 MAPS, CAPUTHALL WOOD



Location Map



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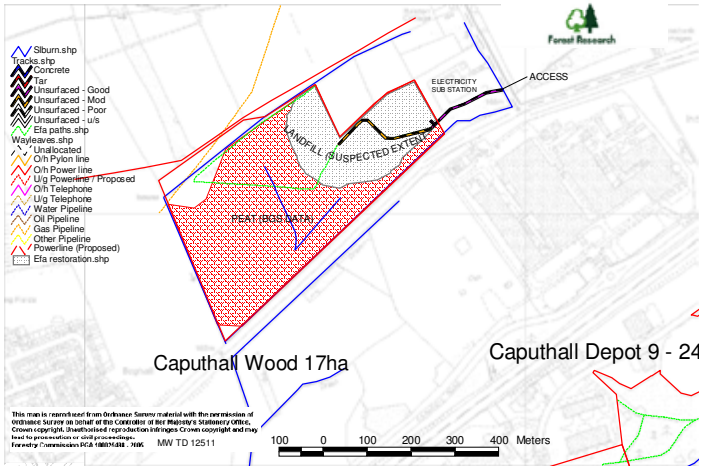

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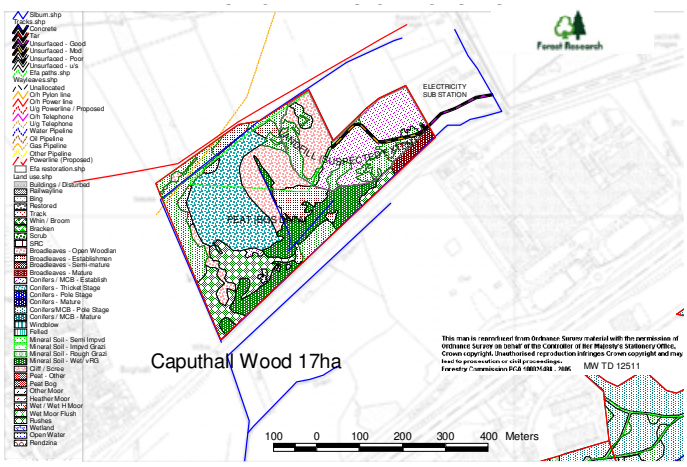
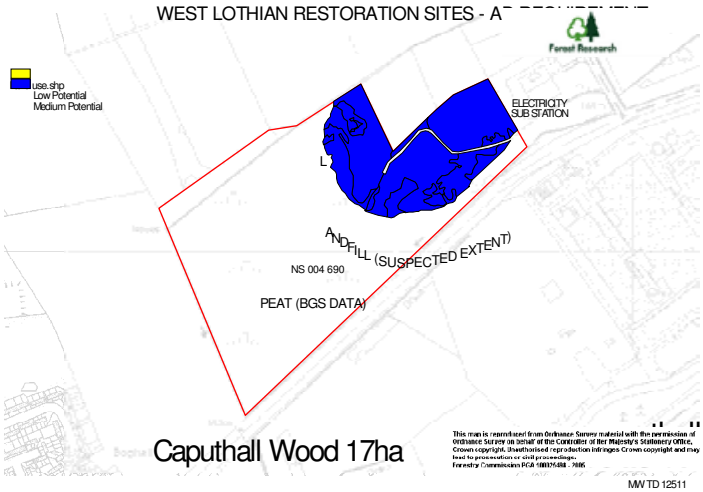


Land Use



Forestry restoration potential using AD/CLO

Site: B6. Caputhall (24 ha)

SITE VISIT 16TH MARCH 2011. WEATHER: FINE

Description

Pen Picture

Caputhall comprises mostly semi-mature coniferous woodland and small areas of internal open space within the Deans Industrial Estate, on land restored after a century of mining, quarrying and processing of oil shale. The woodland is fully stocked, predominantly with Sitka spruce but also large proportions of Hybrid larch and some Scots and Lodgepole pine, both pure and in mixture. These areas are in the process of motor-manual rack and matrix thinning by students from Oatridge College, which has been taking place over some time. Most of the area lies within the loop of Caputhall Road, which serves the Industrial Estate and is level to undulating but dips more steeply to the south. Although the woodland is attractive and is served by a central access path with spurs leading to Caputhall Road, there is other no formal public access infrastructure and little public use (or abuse).

The area of land covered by this report comprises a main central area lying within the loop formed by the Caputhall Road. This has partially segregated 'extensions' to the north east, south east and west. The area also includes a smaller separate southerly area adjacent to the railwayline.

The woodland at Caputhall enjoys several frontages onto roads used by HGVs, but there is no internal road access infrastructure other than the 'spine' route followed by the central footpath as it climbs eastwards uphill from the western bend of Caputhall Road.

Location & Community (NT 015 686)

The Woodland at Caputhall is located on the north western fringe of Livingston, within and at the core of Deans Industrial Estate, the units of which are located around its periphery. Caputhall is just to the south of the M8, which is reached via the A89 at Junction 3 or 3a.

History

The general area around Caputhall was enclosed open farmland in 1856, when two farms with steadings were located to the north and south of an east-west road. Caputhall was situated to the north under what is now the distribution depot, and Deans was located in the west, at the loop of what is now Caputhall Road. The railway, which still forms the southern boundary, was in existence at this time as the North British Railway.

By 1898 the Deans Oil Works (established in 1893 to manufacture crude oil from oil shale) was in place to the north of the railway to the south east of the area now occupied by the industrial estate. A tramway headed north-west across the central part of the site to mines and small quarries located in the west, centre and north east of the main site area. Deans and Caputhall steadings were also present. A spoil tip was located just to the west of the Deans Oil Works, although outside the report site boundary. Buildings marked 'Burnhead Cottages' were now located on the north side of the east-west road, to the west of the site boundary.

The Oil Works spoil tip had extended further west into and across most of the southern site by 1922. Various shafts, buildings and old quarries were still present in the main site area to the north but the tramway had been removed. The situation was largely unaltered in 1938, with both steadings still in use.

The oil works was disused in 1957-8 and there is no map evidence of any ongoing mining of quarrying at that time, although the spoil tip was by now much larger, occupying all of the main central site area having obliterated Deans Farm.

The old oil works site had been given a new lease of life by the maps of 1967-70, with a railway siding and three large new buildings having appeared at the 'Works', the southern two of which still exist. Researches suggest that the oil works had been dismantled in 1948, and steel sheds erected for a Royal Engineers depot in 1951. These sheds are now used by businesses on the estate. Otherwise the spoil tip remained unchanged, together with the small pits or small tips, originally showing on the 1898 map, scattered across the north eastern site extension. The maps of the period 1973 - 1984 showed little change, although Caputhall steading disappeared in this period.

The maps spanning the period 1976 - 1992 show the east half of the large northern distribution depot located on the site of Caputhall. More particularly, the central spoil tip had by now been restored, with the Caputhall Road looping around the new industrial estate buildings.

It is understood that the spoil tip was removed in the early 1970s for construction of the M8 and the Deans Industrial Estate was formed by the Livingston Development Corporation in the 1980s. These limited researches together with tree age estimates suggest that the site was restored after the early 1970s and planted in the first half of the 1980s.

Woodland

The majority of the Caputhall site is planted with conifers of about 25 years of age comprising Sitka spruce, Japanese / Hybrid larch with some Scots pine, in groups and intimate mix. Growth rates and form are reasonably good. Some mixed broadleaves including pole stage Alder are found in the north east of the site, some of which is located on the route of the remains of the early east-west road pre-dating the industrial activity in the area. The oldest trees on the site are located in the west along the short stretch of the pre-1856 roadway just north of the former Deans steading. Parts of the south and west of the main central area have been rack and matrix thinned by students from Oatridge College over the last few years, with small bings of roundwood produce stacked in the wood. Thinning was underway at the time of the site visit in March 2011.

The smaller southern site near 'Rankine Square' is partially planted with c 15 - 20 year old mixed conifers (Sitka spruce, Larch and Scots pine) with some Goat willow and Alder to the west. Part of this block is a mixture of scrub-willow regeneration and un-used open space. Access to the block, suitable for off road forestry machinery only, is via a short earth ramp from an industrial estate access road spur.

Open space

There is relatively little internal open space within the Caputhall site. The central east-west access route includes small landscaping 'scallops' alongside the ride. Snow drops were present here at time of site visit in March 2011. The largest individual area of open space is located in the north eastern 'extension' where the historical maps from 1898 onwards show small earthworks / tips of pit features. One such feature was co-incident with a low mound seen on the site visit. This area, which is fenced and has the general appearance of disturbed land, was largely outwith the furthest extent of the oil works spoil tip shown on the historical maps. The pre 1856 east-west road line passed through this area.

The open space associated with the smaller 'Rankine Square' southern site area occupies land sloping down to the woodland from the industrial estate access road and disturbed ground between industrial units and the woodland.

Vegetation occupying the various areas of open space comprises mostly grasses.

Soils

Geological maps suggest that the original surface deposits across the Caputhall site were of till (glacial clay) in the east and sand / gravel in the west, with some peat to the south. However, the removal of the oil shale tip and infilling of various small quarries is likely significantly to have altered the surface deposits. Soils appear to range from a light brown loamy mineral soil in the west to a clayey mineral soil in the

south west (both areas outwith the mapped spoil tip zone). There are no obvious areas of former shale spoil at the surface across the central woodland area, although soil pitting was not carried out so this cannot be discounted. However, the apparent tree stability and healthy growth of the tree crops suggest that most, if not all, of the oil shale was removed leaving restoration soils comprising former glacial deposits with a greater or lesser element of shale mixed in.

Terrain & Water Environment

The Caputhall site area falls in undulations from the higher level area in the north east 'extension' towards the south and west. There is moderately steep ground in the south and southeast where the woodland areas drop sharply to the rear of the row industrial units lining the southern part of the Caputhall Road.

Apart from a moderately steep drop from the industrial estate branch road, the southern site occupies level to slightly sloping ground abutting the railway.

There are no obvious natural watercourses on or close to the site, although there does appear to be a network of drains generally trending southwards across the railway into the Lochshot Burn and eventually the River Almond in the south. A cut-off drain is located at the top of the bank above a range of industrial units along the south edge of the central area, and there is a short drain in the north-west. The outfalls of these drains were not located during the site visit.

Biodiversity

The most likely area of higher biodiversity value is the western limit of the site at the turn of the Caputhall Road loop. This area includes the remnants of the pre 1856 tracks, with older Sycamore etc and may have remained untouched by the spoil bing and its restoration grading. Snow drops were present in groups in the north of the main site area at the time of the site visit in March.

The Tailend Moss SSSI is located on the south side of the railway immediately south of the small outlying block near Rankin Square, but there is no direct physical connection.

The presence of national or local Biodiversity Action Plan habitats or species, or of European Protected Species, cannot be discounted without ecological assessment. No signs of badger were seen but Roe deer are likely to use the site. A small number of larger, older trees that might be suitable for bat roots were seen in the west and north but a few more may be present elsewhere on the periphery of the site.

External Access

Caputhall is well served by HGV access from Junction 3a and 3 of the M8 (c $1^{1}/_{2}$ and $2^{1}/_{2}$ miles respectively). The woodland site is located within the loop of the Caputhall Road, which serves as the main spine access for Deans Industrial Estate and as such is suitable for HGV use.

Internal Access

There is no internal access within the woodland area other than the rough, undulating central ride through the main block. However, it would be feasible to create new harvesting access facilities off various road frontages e.g. the western area at the site of the former pre-1856 track, which is currently a footpath entrance off Caputhall Road. The south east 'extension' of the main central woodland area is separated by a narrow neck of steeper ground.

Constraints

The site visit did not reveal evidence of unrestored shafts or utility wayleaves, although the presence of underground utilities and drains connected with the industrial estate cannot be discounted.

A site entrance bell mouth and transfer point would require to be established prior to HGV use associated with commercial scale harvesting of timber.

The presence of apparently healthy semi mature conifers and broadleaves across most of the site and the likely removal of much, if not all, of the former shale spoil during restoration around 1980 suggests that there is unlikely to be a need for soil amendments that would justify application of compost or AD / CLO. It is also possible that parts of the site have received infill materials, some of which may best be left undisturbed.

Discussion

Suitability for forestry using AD / CLO

It is likely that pre application soil assessments would not reveal a significant opportunity for AD / CLO addition, even in respect of intensive short rotation forestry, except potentially on small areas where re-restoration is required.

Any use of AD / CLO on the site likely to generate smell would need to be considered carefully in relation to the existing neighbouring businesses present. There would also be a potential for watercourse pollution, although these would be addressed by pollution risk assessment and operational design and management.

Suitability for woodfuel production

The existing largely conifer woodland of 20 - 25+ years is now capable of producing useful quantities of timber from thinning. Furthermore, patch / coupe clearfelling and replanting could be programmed to maintain a timber supply starting within the next decade. Following clear felling of parts of the site it would be feasible to establish areas of short rotation forestry (conifers or broadleaves). Any exploitation of timber producing capacity should include some provision for improved internal access, even if only for off road forestry machinery to an HGV loading point.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to the scattered small areas of open space across the site.

The site open space has been assessed as having a **Medium Requirement** and a **Low Feasibility** and as such is classified as a **Low Potential** for AD / CLO application.

	Potential	Requirement		
		High	Medium	Low
Feas-ibility	High	High	Medium	Low
	Medium	Medium	Medium	Low
	Low	Low	**Low**	Low

The remaining forested parts of the site (the majority) are regarded as being unsuitable for AD / CLO use.

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:
Blue (Medium Potential)= 0 ha
Yellow (Low Potential) = 2 ha (excludes 1 ha internal open space areas < 0.5ha).

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to the small scatted unplanted areas of the site which are classified as having a **Medium Potential** for SRF / SRC within an AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low		Nil
Feasibility of SRF/SRC	High	High		Nil
	Medium	**Medium**		Nil
	Low	Low		Nil

The remaining, forested, part of the site (the majority) is not considered suitable for application of AD / CLO but is stocked with woodland that will produce significant amounts of timber and could be restocked in due course with SRF if desired.

Conclusions

Caputhall is a healthy and relatively attractive semi-mature conifer woodland that has the capacity to yield woodfuel from commercial thinnings and planned clearfelling over the next decade. There is also the potential for designating parts or the majority of the site for short rotation forestry if desired. However, there is no clear justification for use of AD / CLO soil amendments on this site.

Recommendations

Scoping or planning of any forestry development of Caputhall should include further site assessment.

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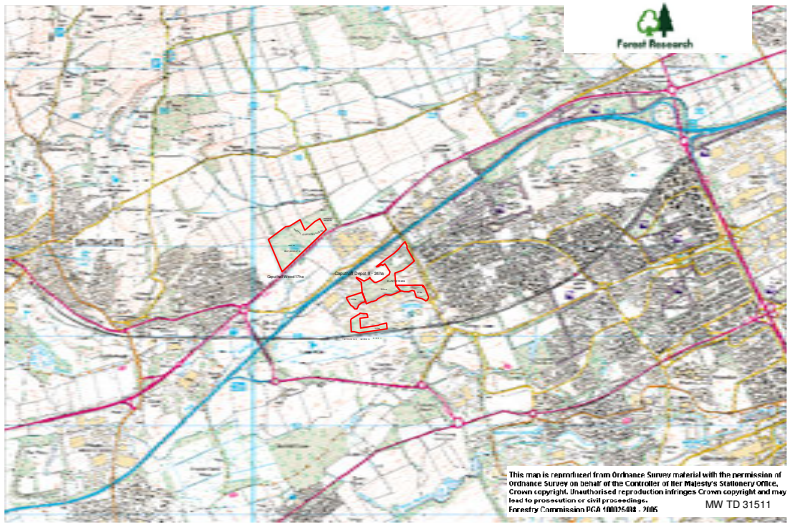
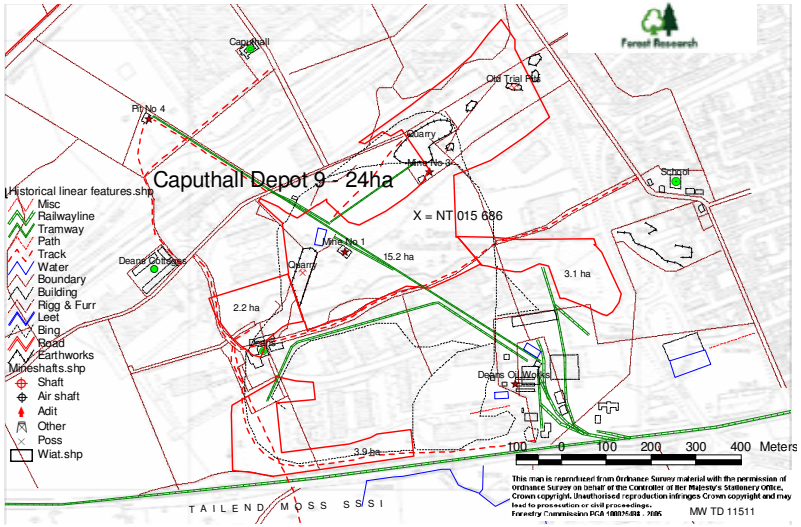
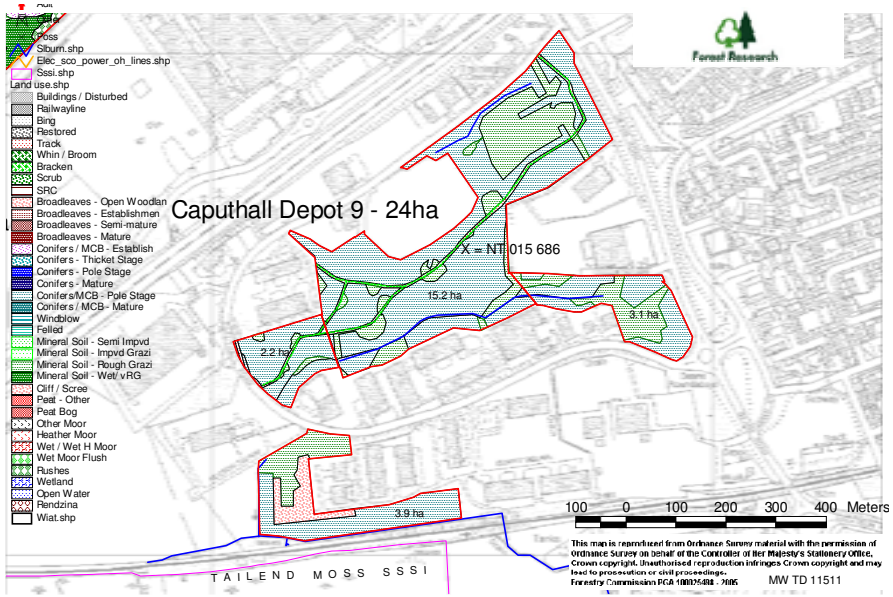
SITE REPORT B6 MAPS, CAPUTHALL



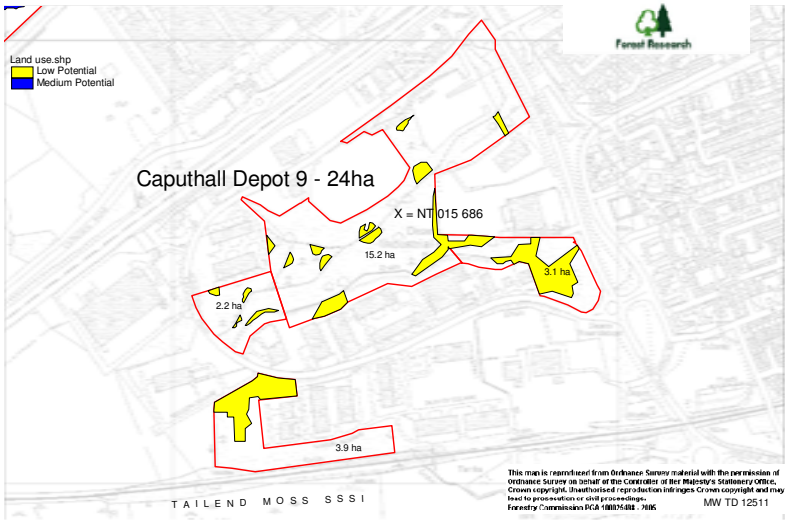
Location Map



Historical Features



Constraints & Land Use



Forestry restoration potential using AD/CLO

Site: B7. Hermand Oil Works Bing (8 ha)

SITE VISIT 14TH MARCH 2011. WEATHER: FINE

Description

Pen Picture

The site is located on the north side of the B7015 a mile north west of West Calder and includes a strip of pre 1856 woodland bounded to the north by the route of a former railway line that served the Hermand Oil Works and other locations including limited mining within the strip.

The majority of Hermand Oil Works Bing is the remains of a shale crude oil works spoil tip following levelling of much of the spoil and probably removal of the remainder. The former Oil Works itself, also known as Breich Oil Works, was situated outside the investigation site boundary immediately to the west. The bing has subsequently been covered by natural regeneration, largely of birch. It should be noted that the unmarked western boundary cuts across the western edge of the shale bing at a point where steep 'quarried' faces remain in large mounds of shale which appears at least partially 'vitrified' into hard boulders. The eastern side of the bing area, which lies to the north of the old railwayline, comprises a wetland that was formerly a large lagoon that may have been associated with mine-water pumping from deep mines to the south.

Location & Community (NT 010 647)

Hermand Oil Works Bing is located about a mile to the north west of West Calder, adjacent to the north side of the B7015 just opposite the entrance to the Five Sisters Business and Industrial Park and overlooked by the Five Sisters oil shale bing just to the south. Hermand Oil Works was located immediately to the west of Hermand bing on an area now occupied by a bus and coach depot. There is no obvious community physical connection to the site, which is clearly not used by locals. The nearest houses are three on the north side of the B7015 some 70m, 120m and 250m to the east of the site boundary. Slightly further away at c 350m to the east are two rows of about a dozen early C20th terrace houses marked as 'Oakbank Cottages'. Mid Breich farm is located some 400m to the west of the site. The villages of Seafield and Blackburn are situated along the A705 to the north just under and just over a mile away respectively. It should be noted that the Five Sisters Business Park is about 300m to the south of the site.

History

The general area around Hermand was enclosed farmland in 1856, with Mid Breich steading to the west of the site. The OS map shows woodland on either side of the

B7015 and the mansion house and home farm of Westwood away to the south. Westwood house was probably owned by the Captain Robert Stewart, who also owned the Westwood Oil Company and operated a paraffin oil works there between 1866 and 1871.

Industrial development had taken place in the area by 1897. The railway line was in place passing parallel with the north side of the B7015 about 50m from the road, effectively enclosing most of the pre 1856 woodland strip. There was a small spoil tip to the north side of the railway in the field to the east of the site linking to a cluster of features representing a mine marked as 'Old Level' and 'Old Shaft', also outside the site. The woodland strip was occupied by a miners' row to the east, near the then road bridge over the railway, together with small spoil heaps and various buildings near to two 'Old Shaft' features. One of the old shafts and spoil tip, with associated small buildings, was located within what is now the site boundary, but a much larger spoil heap is marked to the north of the railway in the south west part of the present site apparently associated with the Oil Works. Just over the site boundary to the west lay the complex of buildings comprising Hermand Oil Works. Tramways connected the oil works to a Pit No.4 to the west beyond Mid Breich and separately along the south side of the railway through the 'strip' of the present site to the old pit shafts.

The 1915-1917 OS map shows that the Hermand bing had extended slightly away from the west covering slightly more that half of the present site north of the railway. The 1:25,000 OS map shows very clearly the 'fingers' resulting from tipping spoil from tramway tubs. These tipping features are no longer in place. The tramways themselves have disappeared by 1915-17 and the oil works itself appears disused, with fewer buildings than in 1908-9 and no map name. By 1922 Hermand Oil Works is marked as 'Disused' and by 1957 most of the buildings are absent. However, at the time of the 1957 survey there were major developments to the south of the B7015 where the early 'Five Sisters' conical bings were spreading over a large area, completely obliterating the former Westwood mansion and farm. Researches reveal this to be the Westwood Crude Oil Works, which operated between 1941 and 1962. A complex marked as 'Works' was located to the east of the conical bings reached by a branch line from the earlier railway and a tramway heading north west across the site of the former Hermand Oil Works. The original railway along the south side of the Hermand site had been dismantled by 1957, as far eastwards as the new southerly branch to Westwood at Oakbank Cottages.

The 1957 OS map shows that a large lagoon had been constructed immediately to the east of the Hermand bing occupying the remainder of the present site north of the railway. However, it should be noted that the Hermand Oil Works itself was, by this time, disused and largely removed. The Hermand bing and lagoon occupied the whole of the current bing site boundary by 1957.

The 1966-67 map reveals further development of the Westwood Oil Works site with buildings, sidings and the 'Five Sisters' bing at more or less is present extent. The Lagoon on the Hermand bing site is marked as being subdivided into two halves at this time, both of which contained water. A boundary (probably a fence) had been erected along the northern edge of the bing and lagoon by 1966-67, which is likely to be the current ownership boundary.

By the time that the 1984-86 maps were prepared the Westwood Oil Works appears to have ceased operating as such, with railway lines and several buildings removed. There is also map evidence that a few large new buildings were erected. The Hermand bing is shown as disturbed land / spoil with no internal features, but the spoil area itself had moved eastwards to occupy the western of the former two lagoons, suggesting that the bing had been spread into one half or that it had been infilled in some other way. The eastern lagoon is not shown as holding any water.

There was little substantive change by the date of the map produced between 1980 and 1994, although this map does not show areas of spoil which must have existed. The former lagoon embankment is shown at the north east of the Hermand bing site together with the route of the former railwayline but little else.

To summarise the map evidence of activity at Hermand, the Hermand Oil Works was developed and at its full extent between 1864 and 1897, during which period several small mine shafts and associated spoil tips were created and disused. Hermand Oil Works closed between 1908-9 and 1915-17, by which time the spoil tip had extended slightly to reach its present extent. The tip at that time was clearly laid out using tramways and tubs. The lagoon was in place by 1957 with a narrow subdivision, at which time the bing appears unchanged and still showing the tramway / tub features suggesting that the bing had not been further disturbed. The lagoon appears to be coincident with development of the large 'Works' and Five Sisters bings to the south, although there is no obvious connection such as a drain, burn or other feature. The lagoon, shown as firmly subdivided (possibly indicating a central track-way for cleaning) was holding water in 1966-67, when the industrial area marked as 'Works' in 1957 is shown as 'Mine'. By 1984-86 the large Westwood works to the south (which closed in 1962) appears to be in alternative use and the Hermand bing disturbed area had been spread into the eastern side of the lagoon, indicating a degree of levelling by the mid 1980s. The lagoon became disused during the same period (1967 - 1984-6) as the large mine / works to the south.

Therefore, evidence suggests that the Hermand bing was created between 1864 and 1908, the lagoon was co-incident with the later Westwood Oil Works and Westwood Mine in the 1950s and 1960s and is most likely associated with these facilities,

possibly for settling pumped mine water. The tip was probably levelled, at least partially, between 1966-67 and 1984-86 at around the time that the works / mine to the south ceased operation. The site walkover also suggested that there may have been an element of landfill or deposition of fly-tipping in the centre-east and southern part of the tip partly coinciding with the infilled eastern lagoon.

Researches reveal that the Hermand Oil Company was formed in 1885 to produce crude oil, becoming the New Hermand Oil Company Ltd in 1899. The then 'New Hermand Oil Works' closed in February 1903 and was offered for sale. At this time the works produced crude oil and Sulphate of Ammonia, and used equipment including 'One bench of 32 Pumpherston Patent Retorts', 'Ammonia and Naptha Scrubbers' and a 'Sulphate of Ammonia manufacturing plant'. The plant and mineral rights were sold to the Pumpherston Oil Company in around 1905.

Woodland

The Hermand Oil Works bing site is largely covered with woodland, in two distinct areas. The strip along the south of between 40m and 60m width includes the remains of the pre 1856 woodland and railway / tramway disused between 1922 and 1957 with large but low grade mixed broadleaves including Beech and Sycamore corresponding to these timescales. There is now little obvious evidence of the former railway, tramway, mine-shaft or spoil heap.

To the north of the old railway lies the main site, occupied by the remains of the oil shale bing, which has clearly been partially levelled, and possibly also quarried since excavation mounds and faces remain, as does a vegetated mound of shale in the west half. Most of this area is covered by scrubby Downy birch which is well stocked with natural regeneration and has mostly full canopy closure. The birch is consistent with having arisen following levelling of the bing which is thought to have taken place in the 1970s or early 1980s.

The birch woodland is clearly growing on unrestored waste-ground, with remains of an oil tanker, discarded drums, tyres, vehicles and other rubbish slowly decaying.

Parts of the centre-east and south-east of the site, including parts of the former westernmost lagoon that has been infilled, is planted with mixed broadleaves (including oak) in tubes estimated at 10 years or more in age. Much of this planting is heavily browsed by deer and is struggling to reach canopy closure, probably at least in part due to compaction. FC Records reveal that parts of Hermand Bing were the subject of a WGS scheme approved in August 2000. Two small areas were marked for new planting, one at the site entrance lying across the former railway, and the other coinciding roughly with the infilled lagoon area just eastwards. Two remaining raised tip features were identified for new natural regeneration in the west. The largest of

these, at least, has no tree cover at present. The owner was West Lothian Council and the agent at the time was Central Scotland Forest Trust.

Open space

There is relatively little internal open space within the Hermand bing site, which is associated with the partially levelled shale tip and the lagoon. There is a 10m - 15m high heap of shale lying within the woodland in the centre of the west of the site and limited small areas in the south-centre and south-east within the levelled zone planted a decade or so ago with mixed broadleaves in tubes. These areas are vegetated mostly with grasses. The largest individual area of open space is the floor of the eastern lagoon which is now largely wet grassland and marsh.

Soils

Geological maps suggest that the original surface deposits across the Hermand site were of till (glacial clay). However, the present ground is made up of oil shale on the bing, sediments of unknown origin within the lagoon and a mixture of original soil and mining spoil from tips and railway lines in the southern woodland strip.

The shale material was presumably processed to remove the crude oil by retorting between 1886 and 1903, but the Hermand Oil Works also produced Sulphate of Ammonia, which may have left a legacy in the spoil. The widespread and relatively uniform natural regeneration of birch suggest that the shale was not overly compacted or contaminated in respect of tree growth following levelling.

The soft surface of the remaining western lagoon and the thick marshy vegetation suggest that the soils in the lagoon are uncompacted. The relative lack of Willow or Alder natural regeneration on the floor of the old lagoon may be due to a former high water table, or some form of contamination or other factors.

Most of the soils within the woodland strip appear from brief inspection to comprise or to originate from natural soils developed since before industrialisation, that is reasonably fertile mineral soils with a proportionate organic component.

The south-centre and eastern lagoon in the south-east of the bing area is suspected of being infilled with imported materials possibly including landfill which was then planted with mixed broadleaves. Tree growth suggests that the soil cover here is compacted.

Terrain & Water Environment

Hermand Oil Works bing and the surrounding area is generally level with a slight fall to the north. The site is flanked by two open drains dating from before 1856. The westerly drain trends northwards from the boundary of the former Hermand Oil Works

to the River Almond some half mile away, whilst the eastern drain trends north eastwards to the Breich Water, about a third of a mile away. The latter runs northwards along the edge of the eastern lagoon embankment and marks the eastern site boundary. This drain is a significant depth at the south east of the site where it crosses the woodland strip, and extends under the B7015 towards the south. Although there is no obvious watercourse south of the road the historical and current maps show the presence of a former natural burn and subsequently a drain running alongside the Westwood Oil Works railway branch.

The lagoon within the east of the Hermand bing site is slightly higher than the bed of the drain, although there is a breach / low point in the lagoon embankment at this point. Therefore it is likely that the lagoon was filled from some source and discharged into the eastern drain. The fact that the map evidence is consistent with lagoon use during the time that the Westwood Oil Works was in operation (1941 to 1962), which was long after the Hermand Oil Works closed in 1903, suggests that the lagoon served the Westwood site. One possibility is that the lagoons were constructed to take mine water pumped from the nearby old shafts, relieving flooding problems at the Westwood mine to the south.

The southern woodland strip is served by a pre 1956 open drain, which was partially obliterated by mining spoil prior to 1897. This drain trends westwards under the complete tree canopy and is no longer running with water.

Biodiversity

The most likely area of higher biodiversity value is the wet grassland and marsh on the floor of the remaining former lagoon. The large old broadleaves within the woodland strip could provide bat roosting or hibernating cover.

It is likely that Roe deer use the woodland, two of which were seen on the lagoon embankment.

The presence or absence of priority local or national biodiversity action plan habitats or species would require confirmation by ecological survey.

External Access

Hermand Bing is accessible from the B7015 running alongside the southern woodland strip. The pre 1856 access is still present as the site entrance off the B7015, which is now a soft earthen entrance gateway with old steel barrier, leading to the south-central and south-east areas of suspected infilling. The site entrance would need upgrading by provision of bellmouth and hard surfacing prior to any future HGV access. Sightlines are reasonable allowing for some tree pruning. An overhead 11kV

electricity line crosses the public road near the site entrance, although this is not a constraint on access.

Internal Access

There is no formal internal access within the woodland area other than the small open area within the site entrance, although this is also accessible from the neighbouring coach depot located on the former oil works site.

Given the largely level shale surface across much of the site north of the old railwayline it would be relatively easy to open up access into the birch woodland on the former bing.

Constraints

The site visit did not reveal evidence of utility wayleaves within the property, although an 11kV overhead electricity line crosses the road close to the site entrance.

A site entrance bell mouth and transfer point would require to be established prior to HGV use associated with commercial scale harvesting of timber.

All parts of the site are subject to some form of potential constraint, including:

- The upper profile of shale on the bing itself is likely to be relatively low in organic matter and major nutrients but there is clearly sufficient for birch growth. The shale may or may not also be compacted at lower rooting depth, although no evidence of shallow rooting was observed. However, it is likely that re-restoration of the shale bing would benefit from use of AD / CLO.
- The eastern lagoon soil may be affected by metals and compounds associated with mining or processing of oil shale. The soil here is likely to have high organic matter and potentially nitrogen content making it unsuitable for use of AD / CLO.
- The south-central and south-east areas of the site north of the old railway appear to be compacted and are likely to comprise infill material, potentially including waste imported for landfill or inert capping material. This area might benefit from re-cultivation and admixture with AD / CLO, but any landfill near the surface would militate against this.
- The southern woodland strip includes mining features such as a small century old spoil heap and unmarked old shaft, but the greatest constraint to change here is the presence of large old broadleaved trees with landscape and potentially high biodiversity value. Soil status is also likely to be unsuitable for use of AD / CLO.

Discussion

Suitability for forestry using AD / CLO

The partially levelled oil shale bing on the Hermand Bing site would probably be capable of re-restoration including incorporation of AD / CLO and / or compost within the shale surface profile. This would of course require felling of the developing birch woodland across the area, and this would be subject to ecological assessment.

Whilst it may be technically feasible to re-restore the levelled suspected 'infill' area and eastern lagoon, the need for AD / CLO amendment may be relatively limited in relation to the cost and potential problems arising from disturbance of these areas.

The southern woodland strip is effectively mature broadleaved woodland without obvious justification for clearance and restoration, which in any case would be unlikely to require much if any organic amendment.

Suitability for woodfuel production

The existing largely birch woodland of c 30 years is now capable of producing useful quantities of timber from thinning, and associated low intensity vehicle access.

Although patches or the whole area could be felled and replanted with short rotation forestry (probably birch) or SRC, such areas should ideally be cultivated and, subject to site investigation and soil analysis, improved by addition of soil amendment. AD / CLO could be used subject to reaction of the few residents living nearby and adjacent businesses.

The southern woodland strip is in reality only capable of producing small quantities of firewood, and the lagoon and suspected infill areas would require significant restoration for any organised wood fuel use, which would be especially costly and potentially risky too.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to the birch dominated semi-mature woodland on the levelled shale within the main part of the site.

The western part of the site located on levelled shale has been assessed as having a **High Requirement** and a **Medium Feasibility** and as such is classified as a **Medium Potential** for AD / CLO application.

	Potential	Requirement		
		High	Medium	Low
Feas-ibility	High	High	Medium	Low
	Medium	**Medium**	Medium	Low
	Low	Low	Low	Low

The levelled suspected 'infill' area and eastern lagoon hasbeen assessed as having a **Low Requirement** and a **Low Feasibility** and as such is classified as a **Low Potential** for AD / CLO application.

The remaining parts of the site are regarded as being unsuitable for AD / CLO use due to various constraints and associated risks.

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:
Blue (Medium Potential)= 3 ha
Yellow (Low Potential) = <1 ha.

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been

categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to the forested area located on levelled oil shale material if identified for re-restoration with AD / CLO.

The western part of the site is classified as having a **Medium** Potential for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low		Nil
Feasibility of SRF/SRC	High	High		Nil
	Medium	**Medium**		Nil
	Low	Low		Nil

The eastern part of the site is not considered suitable for application of AD / CLO but is partially stocked with woodland that will eventually produce timber and / or woodfuel.

Conclusions

Hermand Oil Works Bing is a varied woodland with some potential for woodfuel production from thinning or patch clear felling in its present condition. The former oil shale spoil part of the site would probably be capable of re-restoration using organic amendments such as AD / CLO and compost, and then subsequent production of SRF / SRC, although tree growth may not match that on undisturbed land elsewhere. Given the historical site uses, proposals would need to be well scoped and include evidence from intrusive site investigations and analysis. The work would also be likely to be costly.

Recommendations

Options for management of Hermand Oil Works bing include:

- Retain and manage by low intervention, albeit that this could include limited woodfuel production from thinnings.

- Re-restore the shale spoil area for replanting with woodland / biomass. Scoping or planning of any forestry development of Hermand should include a more detailed site assessment including intrusive site investigations and sampling.

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April 2011

The list of products/manufacturers in this report is not comprehensive, other manufacturers may be able to provide products with equivalent characteristics. Reference to a particular manufacturer or product does not imply endorsement or recommendation of that manufacturer or product by Forest Research.

Appendices

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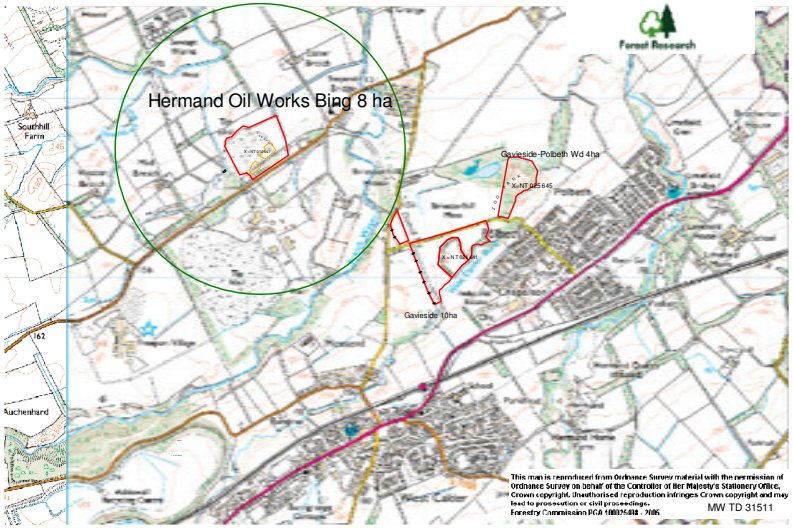
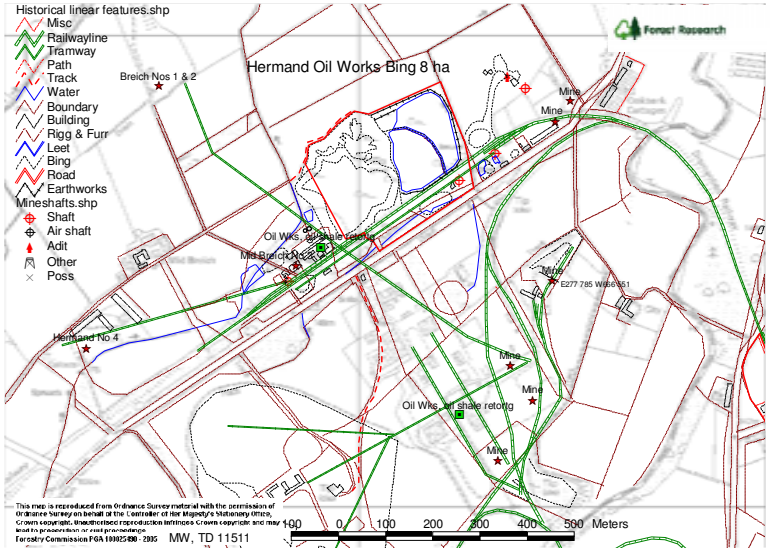
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

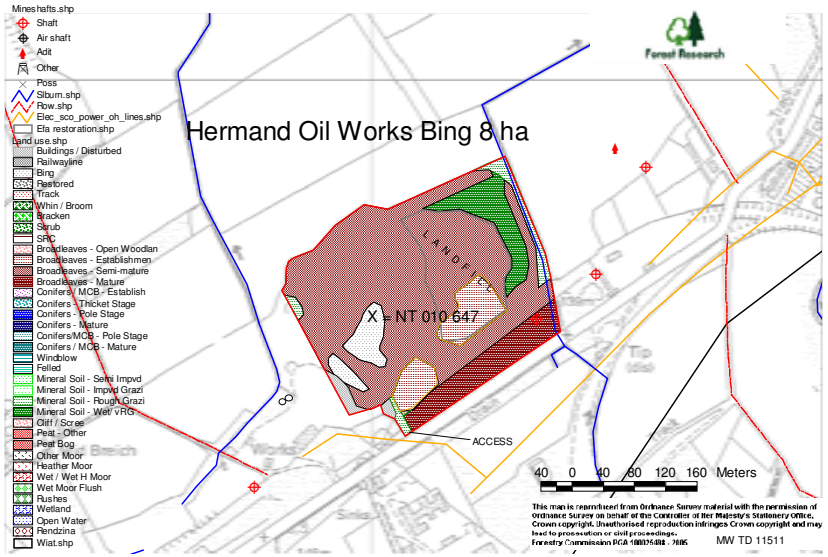
SITE REPORT B7 MAPS, HERMAND OIL WORKS BING



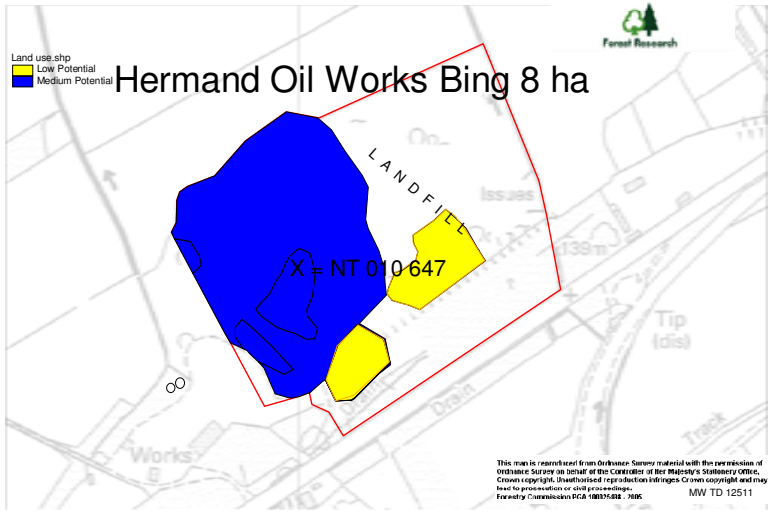
Location Map



Historical Features



Constraints and Land Use



Forestry restoration potential using AD/CLO

Site: B8. Gavieside-Polbeth Wood (4 ha)

SITE VISIT 14TH MARCH 2011. WEATHER: DAMP

Description

Pen Picture

The site, which is described here as Gavieside-Polbeth Wood, lies along the west bank of the West Calder Burn about 300 m west of Polbeth village. The most striking feature of this area is that most of the property has been taken over by the Five Sisters Zoo Park, which is based just west, on part of Briestonhill Moss. The woodland now includes various enclosures and accommodation buildings for animals, fences and tracks on the level ground above the steep bank down to the burn.

The land not occupied by the zoo comprises a strip of steep mixed broadleaved mature scrub and woodland along the eastern edge down the West Calder Burn, and a more level area of mixed semi-mature woodland in the north. Both areas exhibit remnants of the former industrial use of the site.

Access is now very limited due to the encroachment of the zoo park and the steep, loose nature of the remaining strip above the deep and fast watercourse. Furthermore, the woodland entrance is located at the top of the winding C class Polbeth Road leading down to a narrow stone bridge with 5 tonne weight restriction.

Location & Community (NT 025 645)

Gavieside-Polbeth Wood lies along the west bank of the West Calder Burn about 300 m west of Polbeth village and is reached by a C class road running north west from the A71 within Polbeth, which also links back to West Calder. Polbeth has a population of about 1700 and falls within the 20% band of most deprived communities measured by the Scottish Index of Multiple Deprivation. The woodland also lies within the FCS 1km 'Woodlands In and Around Towns' (WIAT) zone.

History

The general area around Gavieside-Polbeth Wood was enclosed farmland at the time of the first OS map in 1853. By 1895 most of the site was covered by spoil tipping with a central mound and a smaller heap to the north-west. There were also spoil heaps outside the western boundary. Four small sets of buildings were present, which may have been unroofed. These comprise two in the north, one on the east-centre and one in the south east by the burn. The first three were later recorded by the NCB as 'Shale Mines'. A small pond and outflow trending north-east into the neighbouring field was present near the most north easterly mine. This pond is still present. A railway was in use passing roughly east-west across the southern neck of

the site where it meets Polbeth Road. The brick bank reinforcement either side of the West Calder Burn is still present. Although the railway bridge and associated embankment have now been removed, the structure must have been substantial.

The 1907 map shows the tip and various buildings still in existence, and a track along a short embankment had appeared from what is now the site entrance off the Polbeth Road in the south as far as the centre-east mine buildings on the main tip area. The current western boundary of the site follows a railway that appeared on the 1907 OS map, which branched off the southern east-west railway and headed north eastwards past the spoil tip and out into the open farmland to the north. This branch railway led $1^{1}/_{2}$ miles to a works located south of the River Almond and Livingstone Village.

The western railway was removed by 1957, and the various mine buildings were not shown on the 1959-62 map, although there are actually still traces to be seen on site. The spoil tip and track embankment were still present at this time but the east-west railway in the south had gone. The spoil tip and associated features were all gone by the time of the 1992-94 OS map suggesting that the site had been at least partially levelled between about 1959 and 1994. The size of the trees in the remaining central woodland are consistent with a degree of site restoration in the 1980s, although some of the trees along the steep burn-bank and in the north where building footings remain are likely to be older.

Research reveals that the Gavieside Paraffin Oil Works was located about 100m due west of the Gavieside-Polbeth Wood boundary, operated between 1863 and 1879 and was demolished in or soon after 1880. The works was served by several shale mines. It is likely that the mines and spoil within the woodland site are all associated with the oil works.

Woodland

The remaining woodland is relatively uniformly aged at approximately 20 years plus or minus perhaps 5 years. The trees are frequently multi-stemmed and of poor form giving the appearance of having regenerated naturally over a relatively short timescale. This would be consistent with natural regeneration onto spoil that was disturbed during tip re-grading. There are no signs of ploughing, ripping or raised planting and no planting lines, although spacing and canopy closure are relatively uniform. There is, however, a short ride in the north east along the edge of which the trees appear in a straight line, so some planting cannot be discounted.

The woodland comprises a preponderance of Sycamore, with Downy birch, Ash, Beech and at least two pine. A few larger Goat willow are also present. The woods are only semi-mature and still relatively low in timber content, much of which is, and will remain, low grade.

Open space

Almost all the open space within the site boundary is now associated with the paddocks used by the Zoo Park. Although they were not inspected on the site visit the surface appears to support healthy grassland. The remaining small areas of open space are associated with a short track leading to the north, largely under the tree canopy.

Soils

Geological maps suggest that the original surface deposits across the Gavieside-Polbeth Wood site were of till (glacial clay). However, the present ground under most of the woodland on site is made up of leaf-litter / humus over what is assumed to be mining spoil from tips and railway lines.

The widespread and relatively uniform woodland suggests that the mining spoil was not overly compacted or contaminated in respect of tree growth following any levelling that is likely to have taken place.

Most of the surface within the steep eastern woodland strip along the West Calder Burn appears from brief inspection to comprise or to originate from natural soils developed since or before industrialisation, that is reasonably fertile mineral soils with a proportionate organic component.

Terrain & Water Environment

The terrain at Gavieside-Polbeth Wood is predominantly level, and gently undulating towards the north. However, the eastern strip along the West Calder Burn is generally steep and frequently at or close to the angle of repose.

The woodland is bounded on the east by the West Calder Burn, which was 2 - 3m wide and fast flowing with a large volume of water when visited in March 2011. The land adjacent to the burn is steep, often soft and wooded, with no obvious signs of erosion into the watercourse. No other drainage was seen on site.

The small, roughly square pond marked on the 1895 OS map is still in existence under the tree canopy in the north east of the site adjacent to open farmland. The pond appears stagnant and heavily shaded.

Biodiversity

The most likely area of higher biodiversity value is the soft and often wet ground associated with the West Calder Burn, much of which is steep. Although the majority of trees on site were semi-mature broadleaves, assumed to be naturally regenerated,

the presence of a few large older broadleaves suited to bat roosting along the eastern burn and northern field boundary cannot be discounted.

It is likely that Roe deer use the woodland.

The presence or absence of priority local or national biodiversity action plan habitats or species would require confirmation by ecological survey.

External Access

Gavieside-Polbeth Wood lies adjacent to a wide single track C class county road. The site access is located at the top of the steep bank leading eastwards down to a bridge over the West Calder Burn, which is subject to a 5 tonne weight limit. The road runs in a straight line westwards across level ground to a junction and eventually to the B7015 in the north and B792 to the south near West Calder. These latter roads would be suitable for occasional rigid timber-HGV use. The road eastwards over the bridge is unsuited to HGV access.

There is currently no bellmouth access into the site from the public road so any HGV use would require significant upgrading, even if it were desired to create an internal access route into the woodland area from this point.

Internal Access

Although there is a limited network of light vehicle tracks within the level area of the site these are entirely associated with and originating from the Zoo Park, which has also encroached over the southern part of the site to an extent that would prevent installation of a separate access track for the woodland. Therefore, any work within the remaining wooded areas would require access through the Zoo Park itself.

Constraints

The site visit did not reveal evidence of utility wayleaves but these cannot be discounted within the area occupied by Zoo Park enclosures.

Access to the woodland on the site is now effectively limited to the Zoo Park.

All parts of the site are subject to some form of potential constraint, including:

- Most of the level area in the centre of the site is occupied by Zoo Park Enclosures.
- The northern area and eastern areas of woodland retain evidence of mine buildings which suggest that the associated shafts may not have been fully capped. The mine buildings themselves may now have historical value.

- The eastern boundary of the site is extremely steep and adjacent to the substantial West Calder Burn.
- There is effectively no vehicle access to the site independent of the Five Sisters Zoo Park, and even access on foot is difficult.
- Although the site is covered either by paddocks or semi mature largely broadleaved woodland, the material comprising the soils is likely to have varied origin and may contain contaminants.
- The presence of the Zoo Park adjacent to, and within, the site is clearly an important fact that would constrain future use of the site.

Discussion

Suitability for forestry using AD / CLO

The presence of the Zoo Park over most of the site and the established woodland growing on surface soils with reasonably high organic matter content effectively preclude addition of AD / CLO.

Suitability for woodfuel production

The existing largely birch woodland of c 20 - 30 years is now capable of producing limited quantities of firewood grade timber from thinning, assuming that associated low intensity vehicle access can be arranged.

The woodland is not considered to present an opportunity for cost effective SRF or SRC due to access, topography, neighbouring use and current use.

Conclusions

Gavieside-Polbeth Woodland is a semi-mature broadleaved woodland of low timber value regenerated on partially levelled mining spoil. Much of the east of the site is steep and adjacent to a major watercourse and most of the rest has been occupied by the Five Sisters Zoo Park, which also effectively now controls access. The woodland has some limited biomass potential but no obvious opportunities for AD / CLO use exist.

Recommendations

Options for management of Gavieside-Polbeth Woodland include:

- Retain and manage by low intervention, albeit that this could include limited woodfuel production from thinning.

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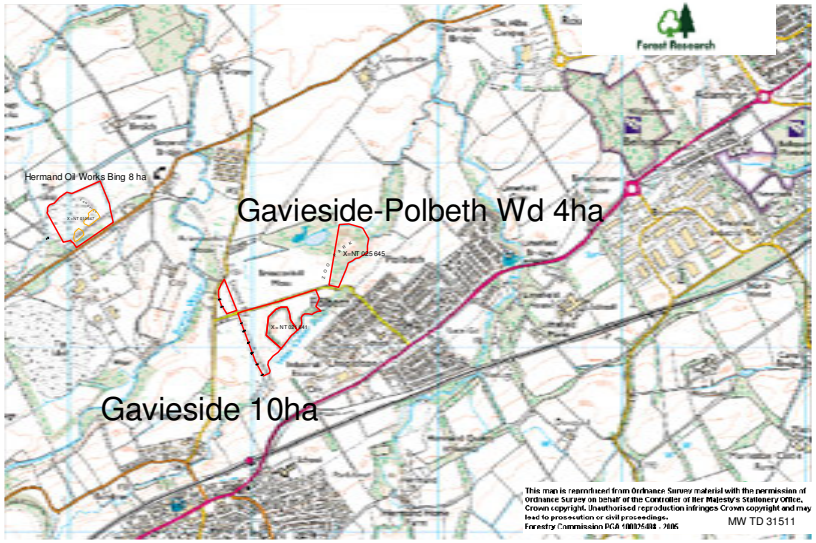
May 2011

The list of products/manufacturers in this report is not comprehensive, other manufacturers may be able to provide products with equivalent characteristics. Reference to a particular manufacturer or product does not imply endorsement or recommendation of that manufacturer or product by Forest Research.

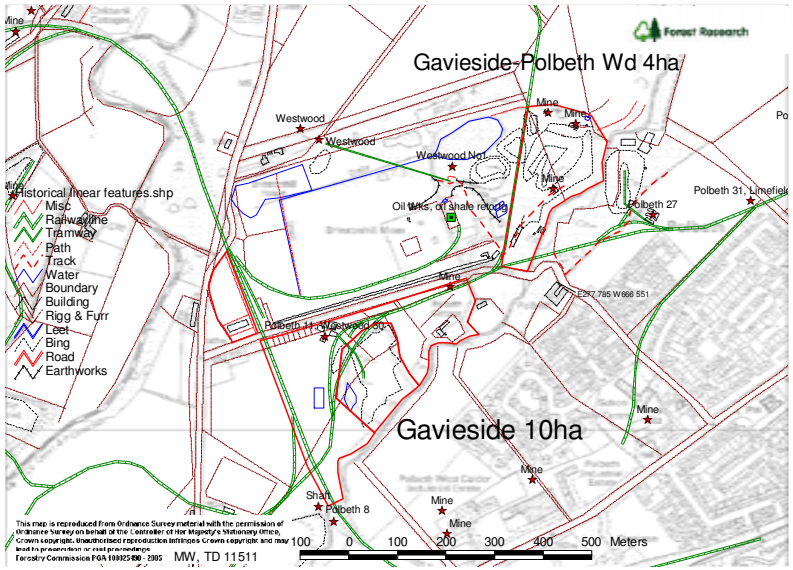
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

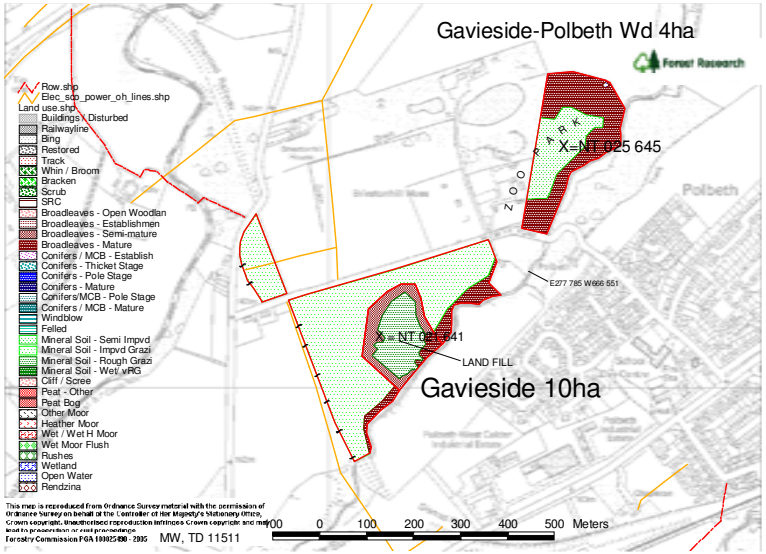
SITE REPORT B8 MAPS, GAVIESIDE-POLBETH WOOD



Location Map



Historical Features



Constraints and Land Use

NOT APPLICABLE

Forestry restoration potential using AD/CLO

Site: B9. Gavieside (10 ha)

SITE VISIT 14TH MARCH 2011. WEATHER: DAMP

Description

Pen Picture

The land at Gavieside lies largely between the south side of the unclassified Polbeth Road and the West Calder Burn, over which lies the outskirts of Polbeth to the south east. The site falls into two main categories. Firstly, the majority (~8ha) comprises level improved grazing on what was formerly the spoil tips, sidings, miners rows and mine buildings of the pre 1895 Polbeth 11 / Westwood 30 oil shale mine, which was abandoned in 1927. These features have been completely removed and the ground effectively restored. Buildings and railways were removed between 1922 and 1957 and the spoil tip between 1984 and 1994. A small part of the area (1ha) lies just over the Polbeth Road to the north. The remainder of the site (~2ha) is located in the centre, on the north bank of the West Calder Burn and comprises what is suspected to be a raised landfill within a bund formed by the partial excavation and removal of spoil from the tip that was formerly present on site. The landfill is surrounded by a shelterbelt and security fence, with the raised centre occupied by rubble and rough grassland.

Location & Community (NT 021 641)

Gavieside lies along the north bank of the West Calder Burn about 150 m west of, but across the burn from, Polbeth village. The site is south of and adjacent to a C class road running east-west from the A71 within Polbeth, which also links back to West Calder. Polbeth has a population of about 1700 and falls within the 20% band of most deprived communities measured by the Scottish Index of Multiple Deprivation. The site also lies within the FCS 1km 'Woodlands In and Around Towns' (WIAT) zone.

History

Gavieside and the surrounding area was undisturbed open farmland at the time of the first OS map in 1853, with Briestonhill Moss marked to the north over the east-west road from Polbeth. By 1895 long miners' rows had appeared on the edge of the moss to the north whilst the site itself was occupied by a mine and associated features. The Mine was marked as Pit No 11 and comprised shafts and mine buildings close to the road in the north, with a railway passing through the site from the south west to the north east, where it ran along the south side of the road to Polbeth. Another railway cut through the area from south to north, the line of which now forms the site's (unmarked) western boundary. A large spoil tip with tramway was laid out to the south east of the mine almost as far as the West Calder Burn. There was a rectangular reservoir located to the west and small rectangular enclosures along the

road in the north-west, some with small buildings, which may have been existing or former gardens, allotments or housing plots. To the north of Polbeth Road lay a large school building with paddock to the north, the western boundary of which forms the current unmarked property boundary at that point.

The disposition of mine buildings, railways and spoil heap was largely unchanged in 1907, 1917 and 1922. Researches reveal that the mine was known as Polbeth Pit No 11 or Westwood No 30 and was an oil shale mine abandoned in 1927. The OS maps suggest that all the buildings and the railways, with the exception of the railway running south-north along the western boundary, were removed between 1922 and 1957, although the spoil tip remained to be removed some time between 1984 and 1994. Researches suggest that the villagers of Gavieside were told to leave in March 1939. By 1994 the railway in the west was completely removed leaving an unmarked property boundary. Part of the area occupied by the spoil tip was shown in 1992-94 as a rough open area surrounded by a narrow shelterbelt. This area was identified by site visit as having been land-filled.

Woodland

The only woodland on site comprises a c 15m wide shelterbelt of 15 - 20 year old mixed broadleaves surrounding a mesh security fence (partly breached) and the landfill area itself. The shelterbelt, which is steep towards the west and east where it forms a gully down to the West Calder Burn, is separated from the grazing land by a stockfence. The National Inventory of Woodlands and Trees shows the landfill area as being stocked with young conifers at some time prior to 2006, but these are now completely gone. The north bank of the West Calder Burn is sparsely occupied by mixed broadleaves of varying age.

Open space

Almost all the open space within the site boundary now comprises improved grassland on restored land. The restoration has been such that the grassland shows no obvious signs of its former dereliction or industrial history. The fence along Polbeth Road is barely stockproof, although the field was occupied by sheep at the time of the site visit. The western boundary is unmarked and blends with grazing of identical appearance to the west. The small area of improved grazing to the north of the road, formerly partly occupied by the school, is also now improved grazing and is similarly unmarked on its western boundary.

The area roughly corresponding with that of the mine spoil tip removed between 1984 and 1994 comprises a completed raised landfill covered with rough grasses and herbs, with some Goat willow regeneration. There is evidence of rubble and inert waste at the surface. The location gives the appearance of the spoil tip having been wholly or

largely removed leaving a bund into which was placed the landfill material to bund top height of perhaps 3 - 5 m above surrounding ground level.

Soils

Geological maps suggest that the original surface deposits across the Gavieside site were of till (glacial clay). However, the present ground under most of the site appears to be restored soils with a natural or partially natural soil surface of clay loam, having additional humus under the shelterbelt. The nature of the soils on the c $1^{1}/_{2}$ ha open landfill area were not inspected in detail but are clearly sufficient to support a thick ground vegetation.

Terrain & Water Environment

The terrain at Gavieside is predominantly level but steepening down to the West Calder Burn along the southern boundary. The central landfill area is flat topped but raised up above the surrounding grazing land by 3 - 5 m.

The West Calder Burn, which forms the southern boundary, is a substantial watercourse that was full and fast flowing at the time of the site visit. The burn lies at the foot of a short steep bank down from the field / landfill. No other drainage was observed on site but the presence of field drains into the burn cannot be discounted.

Biodiversity

The most likely area of higher biodiversity value is the bank forming the north side of the West Calder Burn where there may also be a few large older broadleaves suited to bat roosting.

The presence or absence of priority local or national biodiversity action plan habitats or species would require confirmation by ecological survey.

External Access

Gavieside lies adjacent to a wide single track C class county road running east-west along the northern boundary of the main site (and the southern boundary of the small extra area). The site access is effectively a field gate located along this road. The road heads eastwards to Polbeth down a steep bank leading down to a bridge over the West Calder Burn, which is subject to a 5 tonne weight limit. Site access by HGV would therefore need to be along Polbeth Road from the west where the road runs in a straight line across level ground to a junction and eventually to the B7015 in the north and B792 to the south near West Calder. These latter roads would be suitable for occasional rigid timber-HGV use.

There is currently no bellmouth access into the site from the public road so any HGV use would require a suitable facility.

Internal Access

There are no internal access tracks on the site but it would be relatively straightforward to create a transfer point or track on the improved grazing if required.

Constraints

A 11kV wood pole overhead electricity line is present in the small northern area and down but just outside the unmarked western site boundary south of Polbeth Road. The site visit did not reveal other evidence of utility wayleaves but these cannot be discounted.

The majority of the site is now effectively restored to improved grazing having soils of sufficient nutrient status and structure to support a reasonably healthy grass sward, albeit probably with periodic fertiliser input.

The landfill area is likely to be capped with only a shallow layer of soils suitable for tree growth (if any) and clearly includes rubble and inert material at the surface. Any excavation or cultivation of the surface would be likely to expose or release material best left undisturbed *in situ*. As such this area would not be suitable for re-restoration.

Any operations on site would need to ensure protection of the West Calder Burn.

Discussion

Suitability for forestry using AD / CLO

The area of improved grazing has potential for re-cultivation and incorporation of a modest component of AD / CLO in advance of tree planting, subject to soil sampling, protection of the West Calder Burn and local community liaison. The main constraint to the use of AD / CLO would be likely to be the effect on the nearby Five Sisters Zoo Park, particularly in respect of any odour associated with the use of AD / CLO, albeit a temporary side effect.

The landfill area is not realistically suited to use of AD / CLO or other activity causing disturbance.

Suitability for woodfuel production

Given complete cultivation supported by admixture of a suitable organic soil amendment such as AD / CLO or compost, the current areas of improved grazing would be suited to SRF, and possibly SRC, biomass production.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The improved grazing on restored ground south of Polbeth Road is assessed as having a **Medium Requirement** and **High Feasibility** and as such is classified as a **Medium Potential** for AD / CLO application.

	Potential	Requirement		
		High	Medium	Low
Feas-ibility	High	High	**Medium**	Low
	Medium	Medium	Medium	Low
	Low	Low	Low	Low

The smaller area of largely undisturbed land including the former school site to the north of Polbeth Road is assessed as having a **Low Requirement** and **High Feasibility** and as such is classified as a **Low Opportunity** for AD / CLO application.

The landfill area is not considered suitable for AD / CLO use due to its size and the risks involved in disturbing such material.

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:
Blue (Medium Potential)= 6 ha
Yellow (Low Potential) = 1 ha.

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The improved grazing is classified as **High** Potential for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low		Nil
Feasibility of SRF/SRC	High	**High**		Nil
	Medium	Medium		Nil
	Low	Low		Nil

Conclusions

Most of Gavieside is suited to complete cultivation and admixture with an organic soil amendment prior to tree planting and biomass production if desired. However, the quantity of soil amendment required would depend on soil organic and nitrogen content as revealed by soil sampling, and this is not expected to be significant.

The landfill area is best left undisturbed.

Recommendations

Options for management of Gavieside include:

- Retain as improved grazing.
- Take soil samples and scope as a potential AD / CLO and biomass production site.

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May 2011

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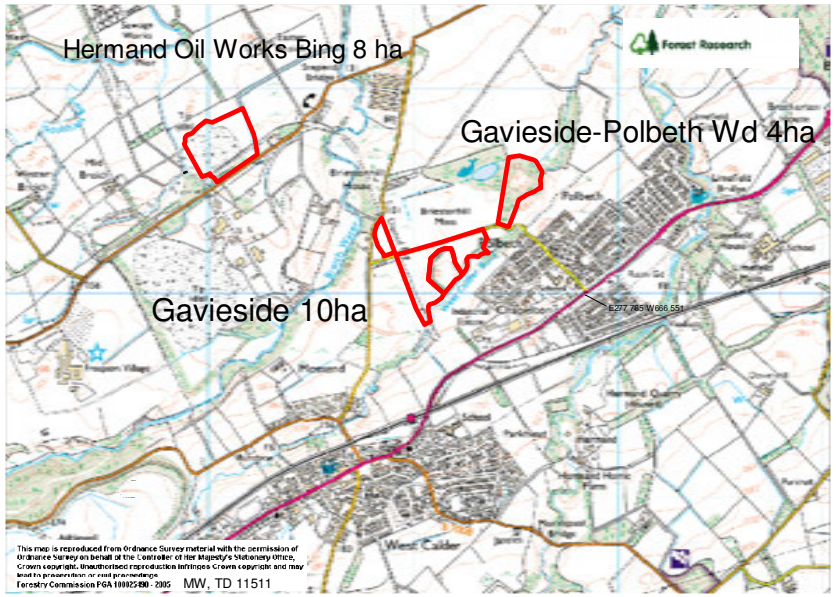
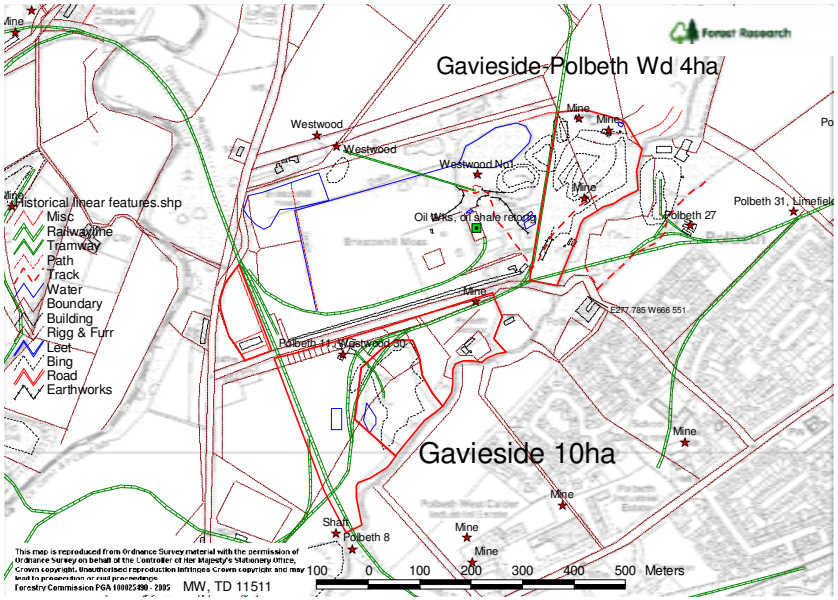
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

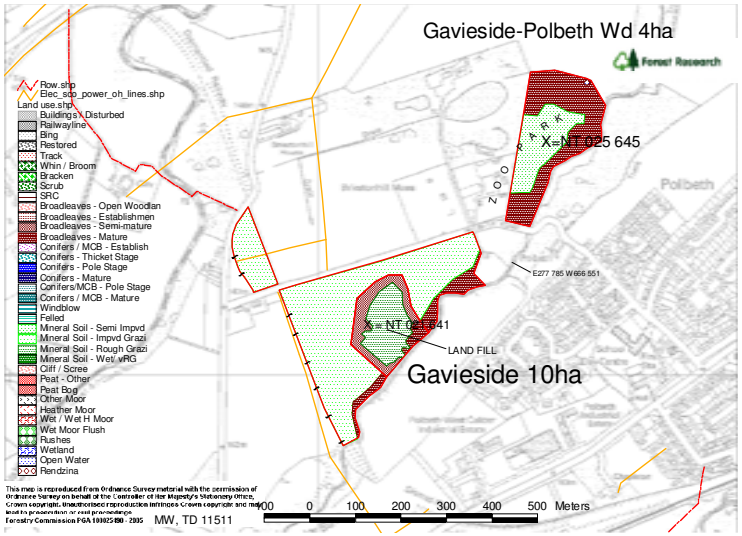
SITE REPORT B9 MAPS, GAVIESIDE



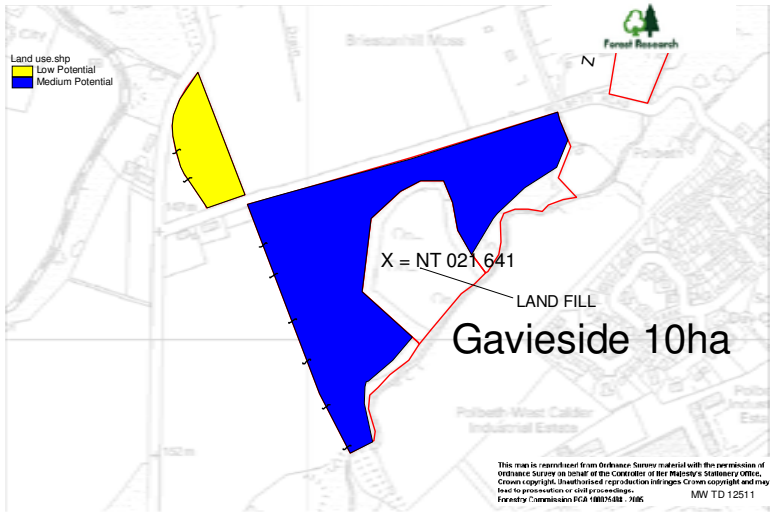
Location Map



Historical Features



Constraints and Land Use



Forestry restoration potential using AD/CLO

Site: B10. Linhouse (76 ha)

SITE VISIT 14TH MARCH 2011. WEATHER: DAMP

Description

Pen Picture

The land at Linhouse comprises a large expanse of open farmland surrounded by belts of mixed broadleaf and conifer woodland planted in the early to mid 1990s. There is clear evidence that the centre of the site has been disturbed and partially re-contoured by earth movement with the apparent intention of creating a fairly level, contiguous area by diverting the former Wellhead Burn (sic) away from the centre and around the northern periphery of the site. The area affected by earth movement is estimated at approximately 10 ha. The land is generally fair to good quality, if occasionally wet, mineral soil grazing ground but lack of management over the past few years has resulted in spread of rushes, rank grass and incipient colonization by willow natural regeneration over what can now be classified as rough grazing. The site is completely ringed by a good quality grit surfaced footpath, which falls within the site boundary in the west and south and forms the boundary in the north east. Part of the site bordering the railway in the south is signed as a Scottish Wildlife Trust 'Linhouse Glen Wildlife Reserve', occupied largely by gorse with some broadleaved woodland. The site appears to have suffered severe fire damage in the last season or so and was recorded as having been planted with conifers prior to 2006.

Location & Community (NT 068 647)

Linhouse is located on the southern edge of Livingston just east of Murieston and south of Nether Williamson. The site can be reached by road and foot from the A71 through a light industrial estate to the north, although the access road is incomplete and stops short of the site boundary. Most public access is along made-up footpaths from the residential road leading through Murieston and from areas to the north. The site itself is served by a network of paths that appear to be well used by locals, with few signs of any anti-social behaviour. The area has a relatively benign score in the Scottish Index of Multiple Deprivation, although Linhouse falls completely within the WIAT 1 km zone.

History

The land at Linhouse is shown on the first edition OS map of 1853 as enclosed farmland with a burn running from beyond Wellhead Farm outside the south western boundary through the site in a north easterly direction to join the Murieston Water just beyond the north-west boundary. The southern site boundary is formed by the railway that is still in use, and a track is shown heading north westwards from the railway to Murieston Road just north of the site boundary. A second track can be

traced heading generally north eastward into the site from the south west to cross over the 'north westward' track. The map also shows areas of enclosed scrub or woodland and shelter belts, roughly forming an 'L' shape, the foot of which runs along the north edge of the railway. The westernmost part is now classified as Long Established Woodland of Plantation Origin (LEPO). The upright part of the 'L' shape is a belt trending generally north westwards, marking the western boundary of the site. These areas generally conform to parts of the current shelterbelt ring. The OS maps of 1898, 1907 and 1957 show little change except that the areas of woodland become rough grassland or marsh as tree cover dies out over time.

The OS map produced between 1976 and 1994 shows neither significant change to enclosures nor tree planting. However, modern mapping reveals that the burn has been diverted from a point located towards the south west around the northern periphery of the site. The central watercourse has largely disappeared along with various field boundaries and tracks in the centre of the site whilst significant woodland planting has taken place around the periphery.

Site inspection confirmed that the burn had been re-routed to the north, which has involved creation of a cutting to overcome topographical restrictions. A drain in the western centre of the site roughly follows the route of the former natural burn but flows south westwards back to the new route as compared to north eastwards. West Lothian Council staff advised that some re-grading work was carried out in the past as site preparation for a development that did not take place.

Tree growth and map information suggest that the burn was diverted and the site was re-graded sometime in the early to mid 1990s.

Aerial photography shows the route of the pre 1853 tracks including the north-eastward track entering the site from the south west. This track continues as a boundary as far as the crossroads with the north westward track, separating new planting of the mid 1990s from older natural regeneration to the south in the LEPO woodland area. The north eastward track then continues as a drain line boundary. Aerial photography also reveals that the wildlife reserve is located on old rigg and furr field ploughing that clearly continues across the pre 1853 railway and shows the 'S' form indicating a mediaeval period origin.

The Linhouse site is located within the 1km WIAT zone around Livingstone, immediately south of Murieston and the Livingstone South railway station. Murieston is relatively affluent. There are good path links with Murieston to the north and paths along the Linhouse Water towards the north east, and the woodlands within the site complement a significant network of woodlands of various ages and composition throughout the area and especially along the nearby river itself.

Woodland

The woodland located within the site boundary at Linhouse comprises c 15 year old mixed broadleaves and conifers planted on plough ridges on clay-based mineral soil in an intimate and group mix. The majority of the crop is broadleaved including Ash, Alder, Oak, Birch and Hazel. Hawthorn and Willow are found throughout the site, with natural regeneration appearing across the rough grazing both sparsely and in groups. The route of the old north-west trending track still exists as a ditch and field boundary except where disturbed by re-grading around the former burn. This route is bounded by gorse in places, which also occurs in the rough grazing towards the south and in the wildlife reserve area by the railway line.

The woodlands include a relatively small proportion of conifers in intimate and small groups, mostly Scots pine with some Hybrid larch and other conifers.

There are relatively few large or mature trees on the Linhouse site but those seen include several mature Oak on old field boundaries in the centre of the area, mature Beech lining the old track leading from the railway along the edge of the wildlife reserve in the south and various older mature broadleaves along old field boundaries, including the northern boundary of the wildlife reserve.

There is a small area of apparently naturally regenerated broadleaved woodland forming part of the encircling woodland ring in the south west, west of the original 'north westward' track and south of the 'north eastward' route. This appears to have developed over the last two or more decades.

A feature of the Linhouse site is that the boundary does not clearly differentiate between woodlands within the site and similar and slightly older neighbouring adjacent woodlands. As such it is likely that the surrounding areas are, or were, also owned by West Lothian Council. For example, the high quality grit path loop that encircles much of the site is partly within and partly just outside the actual boundary as given. The neighbouring woodlands include 15 - 20 year old mixed broadleaves with some pine that are very similar to those in the site. Stands of semi-mature c 30 year old pure conifers, predominantly Sitka spruce with some larch are located between the site and Murieston Road.

Open space

The open space at Linhouse can be described in two categories, the largest of which is the central are of former farmland now effectively rough grazing with developing Willow and Hawthorn natural regeneration and encroaching *Juncus* rushes. Aerial photography reveals that this area was cut in the past few years. However, this

maintenance regime appears to have stopped perhaps three or four years ago allowing scrub to start colonising.

The remaining open space is composed of internal clearings and space associated with the encircling ring of shelterbelts, and within the wildlife reserve, the latter of which appears to support a proportion of heather.

Soils

Geological maps suggest that the original surface deposits across the Linhouse site were of till (glacial clay). Cultivation before and after 1853 has worked the soils, that are now a light to mid brown clay to sandy clay loam. The high clay content has resulted in some areas of poor drainage and puddling, which is likely to have been exacerbated by re-grading activity when the burn was diverted.

At least some of the soils in the area of the former central burn and the diversion route up to the northern boundary are likely to comprise disturbed re-graded soils with consequent compaction and dilution with subsoil.

Terrain & Water Environment

The whole area of land at Linhouse is located on a plateau that lies north west of the escarpment, followed by the railway, that is the north west bank of the Linhouse Water.

The terrain is generally level, although there is a slight fall from the southern trending boundary across to the north eastern trending boundary, and to some extent dipping towards the central burn and the burn that forms the extreme northern boundary.

The site was formerly traversed from south west to north east by a burn that discharged into the Murieston Water just to the north of the site. However, this watercourse was re-routed through a new cutting to run along and just outside the northern boundary before re-joining its natural route. This appears to have taken place in the mid 1990s.

No ponds or wetlands were seen on the site visit, maps or aerial photography but parts of the site are relatively poorly drained, including parts of the central rough grazing and the woodland just north of the wildlife reserve. No evidence of subsurface field drainage was seen although there may still be some limited effective field drainage in the areas undisturbed by the site re-grading and woodland planting.

Biodiversity

The most likely area of higher biodiversity value is the Linhouse Glen Wildlife Reserve which is located on historically undisturbed land, including what is likely to be

mediaeval rig and furr field strips that were cut by the railway. This site includes a substantial area of gorse that has been burned within the last season or so, and is marked on the National Inventory of Woodlands and Trees record of pre 2006 as being planted conifers at that time. The conifer crop is presumed to have failed, possibly due to competing whin vegetation. Note that the land from the southern side of the railway to the Linhouse Water, just along the south of but outside the site boundary, is designated as the Linhouse Valley SSSI.

There are a few large older broadleaves that may be suited to bat roosting and what is assumed to be natural regeneration in the 'LEPO' woodland in the south west. The routes of the old tracks are marked by ditches and old field boundaries together with mature broadleaves in places and there are areas of gorse along the north westward track.

The mixed woodland planted in the mid 1990s and its internal open space is of some biodiversity interest.

It is likely that the rough grazing in the centre of the site includes at least some semi-improved and possibly some unimproved neutral grassland, which in some cases is a priority habitat.

The presence or absence of priority local or national biodiversity action plan habitats or species would require confirmation by ecological survey.

External Access

There are two clear external access routes open to the Linhouse site, both of which involve crossing land bounding the property, but which may be the subject of rights of access and may even remain in council ownership.

The unclassified Murieston Road lies less than 100m from the northern boundary along an unmade track that is also used for public access. Limited entrance improvement would be advisable should HGV access be regularly required. Although Murieston Road partly comprises a residential area it gives onto the A71 in Livingstone less than a mile away.

The second main external access point comprises a partly made aggregate road bed leading c 250m from an industrial estate to the north east boundary of the site. The industrial estate road is designed for HGVs and gives onto the A71. The uncompleted road route would require extending to cross into the site boundary over the burn that exists at that point, so some upgrading would be required prior to any HGV access being feasible.

Internal Access

Internal access is very limited and comprises the c 2.0m wide grit surfaced public path that winds through the encircling woodland both within and just outside the boundary of the site. This route is suitable at the most for very limited light vehicle use in dry weather. In addition, the 'north western' trending track route still exists in places but is not directly connected to the northern entrance track onto Murieston Road. This route would be suitable for limited 4WD use if re-connected.

Despite the present lack of useable internal access tracks, any development within the central rough grazing area could readily be provided with integral ride or track access.

Constraints

Several wood-pole electricity power lines traverse the site and the presence of buried services cannot be discounted.

The central area includes ground that has been re-graded, probably in the mid 1990s. Although this land may have been degraded in respect of plant growth it is likely still to be suited to forestry planting with suitable cultivation.

Any operations on site would need to ensure protection of the Wellhead Burn and the Linhouse Water nearby.

There area various areas of biodiversity interest, including the Linhouse Glen Wildlife Reserve and there may also be areas of open space habitat such as neutral grassland that would not be suitable for afforestation.

Discussion

Suitability for forestry using AD / CLO

The majority of Linhouse is effectively undisturbed natural soils and so is not likely to justify use of soil amendments other than limited fertilisation to bring nutrient levels up to ideal levels, albeit that this may not be necessary nor economic. In particular, levels of nitrogen in the soils are not likely to justify significant addition.

The re-graded part of the central area is not likely to differ significantly from the undisturbed areas in respect of use of AD / CLO.

Suitability for woodfuel production

The central rough grazing area of the Linhouse site is very suited to large scale SRF or SRC production.

The remaining woodland on the site is capable of yielding small quantities of firewood or biomass from thinnings but this will not be economic in its own right.

Results

Potential for forestry using AD / CLO

The Potential for use of AD / CLO on the site has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of doing so. The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The overall site is classified as **Low Potential** for AD / CLO use:

		Requirement		
	Potential	High	Medium	Low
Feas-ibility	High	High	Medium	**Low**
	Medium	Medium	Medium	Low
	Low	Low	Low	Low

Requirement is a subjective assessment of the degree to which soils require improvement, if any, by addition of organic amendments in order to support sustained healthy tree growth. This is likely to be linked to soil organic matter and Nitrogen content. High Requirement 'soils' will be man-made soils and soil forming material including overburden, shale, spoil and other parent material having very low organic matter and nutrient content. Low Requirement soils will be partially disturbed or undisturbed soils with compaction or other poor soil structure issues, low organic matter content and slight deficiency in one or more major nutrients. Natural soils of reasonable soil structure and fertility and moderate to high organic matter content are likely to have a nil requirement and are not included. Restored but forested soils are likely to have either a Low or nil requirement by virtue of their raised organic matter and nitrogen status.

Feasibility is an objective assessment of the degree to which application and mixing of AD / CLO into soils at the site is constrained by physical and social factors including external access, internal access, utilities, neighbouring communities and land uses, community use, biodiversity, water environment and tree cover.

Potential is a subjective assessment of the combination of Requirement and Feasibility.

The assessment of Potential for new forestry on unplanted land using AD / CLO is shown on the map shown as:
Blue (Medium Potential)= 0 ha
Yellow (Low Potential) = 49 ha.

Suitability for woodfuel production in an AD / CLO system

The Potential for producing woodfuel on the site by Short Rotation Forestry (SRF) or Short Rotation Coppice (SRC) within a sustainable system using AD / CLO as a soil amendment has been categorized using two factors: the Requirement for AD / CLO and the Feasibility of growing and harvesting SRF / SRC on the site.

The assessment applies to unplanted areas (other than internal open space) and to specific forested areas if identified as a re-restoration opportunity.

The overall site is classified as **High** Potential for SRF / SRC within and AD / CLO system:

	Potential	Requirement for AD / CLO		
		High, Medium, Low	Medium	Nil
Feasibility of SRF/SRC	High	**High**	Medium	Low
	Medium	Medium	Medium	Low
	Low	Low	Low	Low

Conclusions

Linhouse provides a good opportunity for temporary or permanent SRF or SRC production with limited investment in infrastructure. This may provide the opportunity for limited fertilisation using AD / CLO but in reality this is likely to be of marginal quantities.

Recommendations

Options for short to medium term management of Linhouse as an 'Industrial Safeguard' site prior to eventual development include:

- Retain existing woodland, wildlife reserve and farmed improved grazing in current use.
- Scope as a potential major biomass production site.

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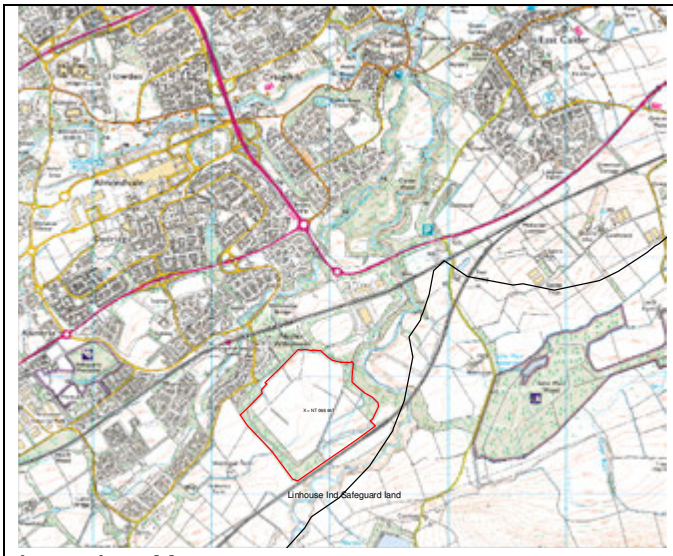
The list of products/manufacturers in this report is not comprehensive, other manufacturers may be able to provide products with equivalent characteristics. Reference to a particular manufacturer or product does not imply endorsement or recommendation of that manufacturer or product by Forest Research.

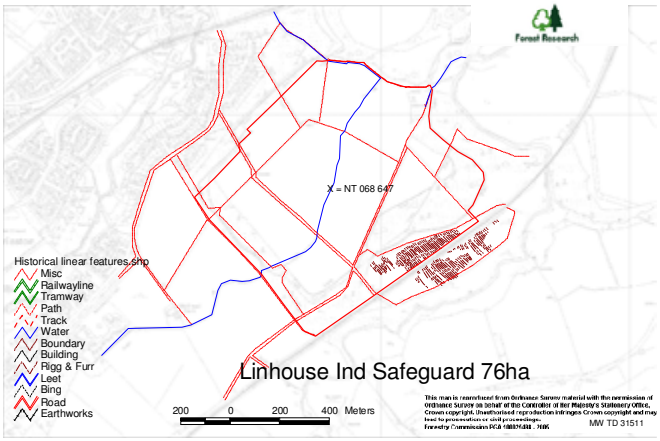
Appendices

Location Map
Historical Features Map
Constraints Map
Land Use Map
Potential for forestry restoration using AD / CLO Map

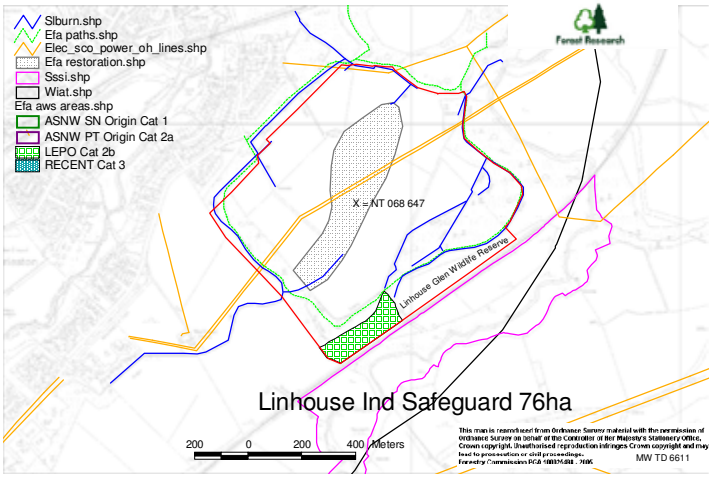
SITE REPORT B10 MAPS, LINHOUSE



Location Map



Historical Features



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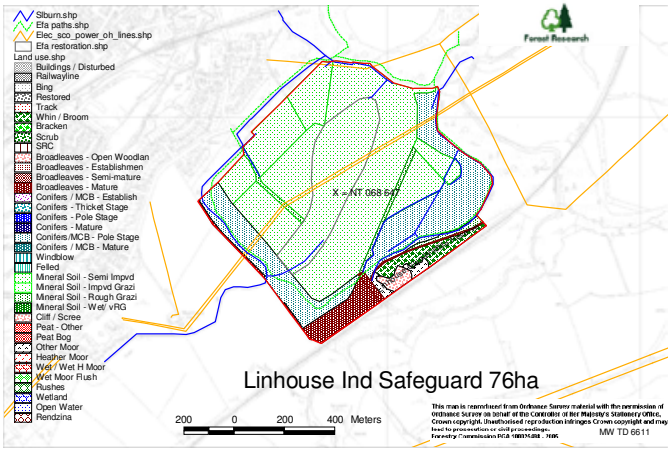
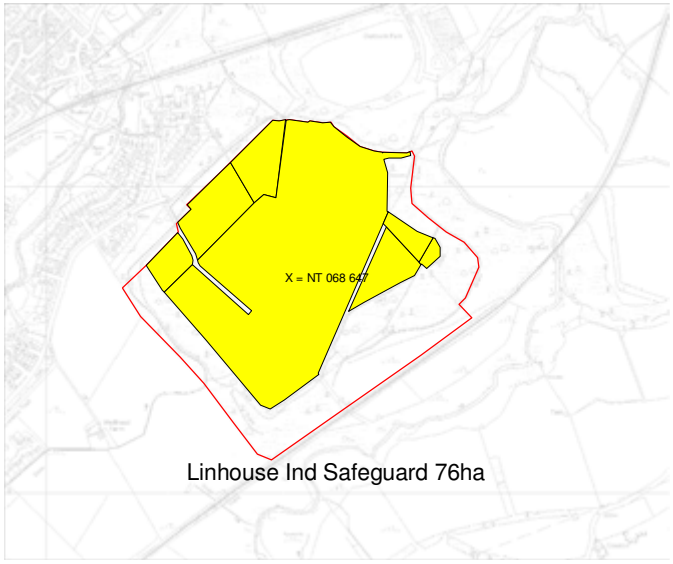


Land Use



Forestry restoration potential using AD/CLO