Nutrient neutrality assessment and mitigation strategy (NNAMS) for a proposed Anaerobic Digestion plant at Three Maids Hill, Winchester

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Abbreviations

AD	Anaerobic Digester
AEL	Associated Emissions Limits
AMP	Accident Management Plan
BAT	Best Available Techniques
CH_4	Methane
CO_2	Carbon Dioxide
CHP	Combined heat and power engine
Defra	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
EMS	Environmental Management System
EU	European Union
FRfW	Farming Rules for Water
K	Potassium
N	Nitrogen
NE	Natural England
NGR	National Grid Reference
NH_3	Ammonia
Nm3	Normal cubic metre of natural gas
NVZ	Nitrate vulnerable Zone
NMP	Nutrient Management Plan
Mg	Magnesium
P	Phosphorus
S	Sulphur
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest

1. Introduction

1.1 Appointment

This nutrient neutrality and mitigation assessment report has been prepared by Earthcare Technical Ltd at the request of Acorn Bioenergy Ltd to support a planning application to Winchester City Council Ref: 22/02037/FUL, for *"*the construction and operation of an anaerobic digestion facility, ancillary infrastructure, landscape planting and the construction of a new access road and access from the A272*"* on land at Three Maids Hill, Winchester SO21 2QG. The site is referred to as 'Three Maids' within this report.

Earthcare Technical Ltd is a member of the Anaerobic Digestion and Bioresources Association (ADBA), the Renewable Energy Association (REA), and holds National Farmers Union (NFU) Professional membership.

This report is produced by Anna Becvar BSc (Hons), MI Soil Sci, C Sci, MBPR FACTS RFE/414. Anna is a Chartered Scientist and Member of the British Society of Soil Science. She has had 30 years of experience across the agricultural, waste, and environmental sectors and has worked on government-funded projects on behalf of WRAP and Natural England during her career. She maintains continued professional development activities to meet the requirements of the Fertiliser Advisory Certification Training Scheme (FACTS) and Chartered Scientist status and is a BASIS-approved trainer for certain advanced modules. She is also past Chair of the Professional Practice Committee and Board Trustee for the British Society of Soil Science, and a current member of the Green Gas Steering Group within the Renewable Energy Association.

1.1 Nutrient neutrality

Natural England has released guidance and advice for development proposals with the potential to affect water quality resulting in adverse nutrient impacts on habitat sites in certain catchments. Habitat sites are protected by the Conservation of Habitats and Species Regulations 2017 (as amended)[1] (referred to as the 'Habitats Regulations'). These include Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Any development proposals that could affect them require a Habitats Regulations Assessment (HRA). Ramsar sites are also included as these are protected as a matter of government policy.

The latest Natural England advice (released on 16 March 2022)[2] identifies that the Solent region is at risk from high levels of nitrogen (N) input to the protected water environment and in the case of the Itchen river catchment (within which the proposed development is located) phosphorus (P) and nitrogen (N) are causing detrimental environmental effects.

Currently these nutrient inputs mostly come either from agricultural sources or from waste water from existing housing and other developments. The presence of excessive nutrients can cause eutrophication, which impacts on protected habitats and species. There is uncertainty as to whether new development will cause further deterioration in designated sites, and/or will make them appreciably more difficult to restore.

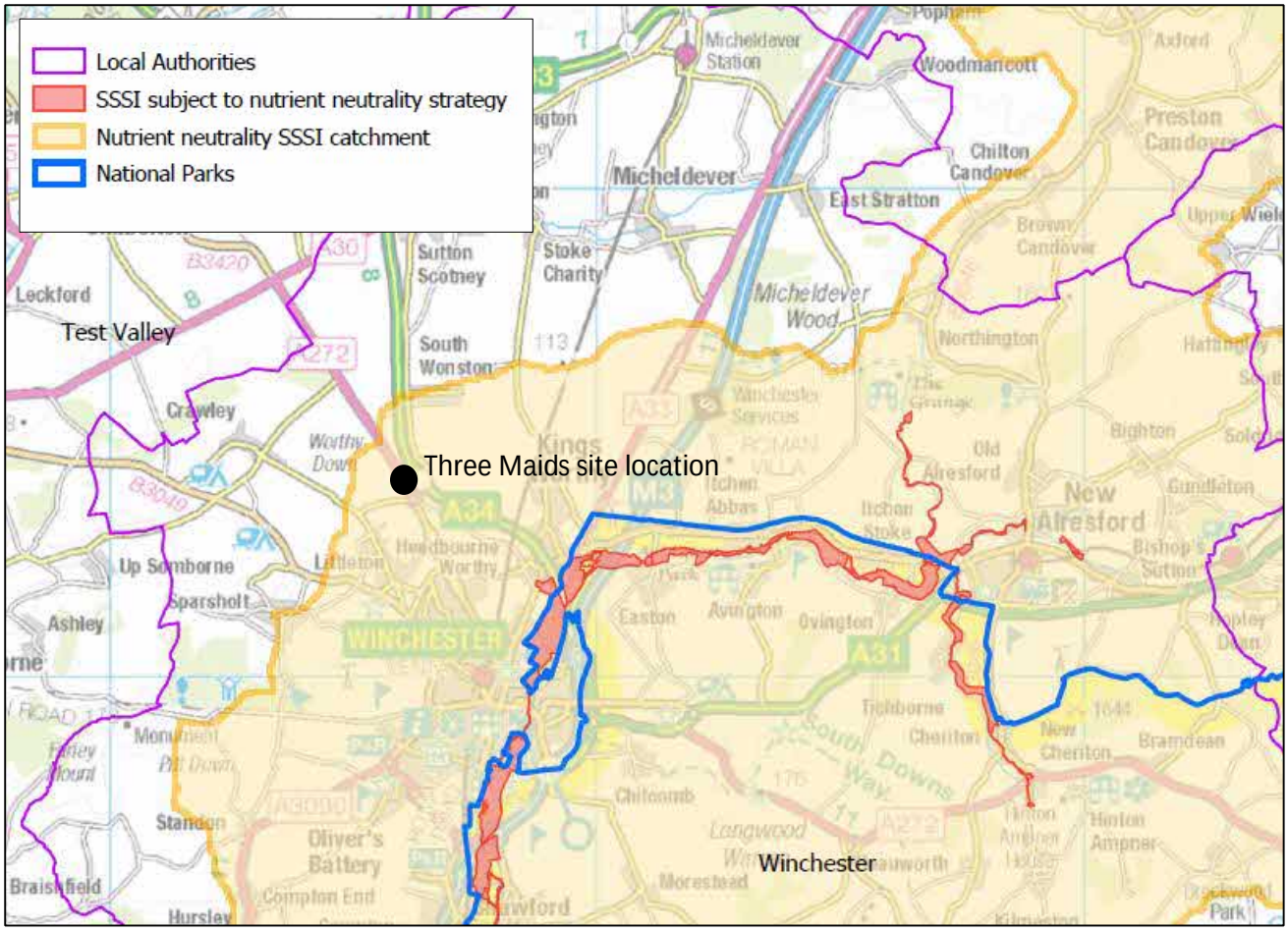
[1] Conservation of Habitats and Species Regulations 2017 (as amended) (https://www.legislation.gov.uk/uksi/2017/1012/contents/made)

[2] Nutrient update statement March 2022, https://www.winchester.gov.uk/assets/attach/32142/Nutrients-up-date-statement-March-2022-ES-v3-002-.docx

There is a generic methodology in place for assessing new development, which contributes to overnight accommodation. This methodology calculates the mitigation which may be required to achieve nutrient neutrality. Nutrient neutrality is a means of ensuring that development does not add to existing nutrient burdens, and this provides certainty that the whole of the scheme is deliverable in line with the requirements of the Habitats Regulations described in section 2.1 of this report. This methodology is not applicable to agricultural and industrial development.

The proposed development is within the River Itchen catchment as shown in Figure 1 below. The National Park shown is the South Downs National Park which lies to the south east of the blue line.

Figure 1 Site Location within the River Itchen Catchment[3]



In addition, farms which may be used to grow energy crops, provide livestock manures, and receive digestate (as biofertiliser) from the proposed AD facility may fall within the wider Test Valley catchment to the west and north of the site which may affect component SSSIs of the Solent: including. These include Chichester and Langstone Harbours SPA/Ramsar, Solent and Southampton Water SPA/Ramsar, Solent Maritime SAC and Portsmouth Harbour SPA/Ramsar, the entire catchment map[4] is provided in Figure 2 below.

[3] Defra Spatial Sciences (2021) European protected sites requiring nutrient neutrality strategic solutions (https://www.winchester.gov.uk/assets/attach/32136/NN_map_River-Itchen-SAC.pdf) Accessed October 2022

[4] https://www.winchester.gov.uk/assets/attach/32137/NN_map_Solent.pdf

Figure 2 The Solent catchments nutrient neutrality map

1.2 Proposed development

The proposed development is for "The construction and operation of an anaerobic digestion facility, ancillary infrastructure, landscape planting and the construction of a new access road and access from the A272" on land at Three Maids Hill, Winchester SO21 2QG.

The proposed anaerobic digestion (AD) facility will treat around 83,600 tonnes (t) per annum of livestock waste (poultry, cattle slurry, and farm yard manures), energy crops and crop residues from local farms and potentially other local biodegradable wastes such as those from the dairy products or brewing industries. The materials termed 'feedstocks' will be treated by the natural process of AD within the proposed facility. The AD process is carefully controlled to optimise the biological break down of the feedstocks to generate biogas, digestate, heat and power. The carbon that the feedstocks contain is biogenic as it has been taken from the atmosphere, stored within soil, taken up by crops and used by animals to generate organic matter in manures. This contrasts with fossil fuels which, when burnt, release non-biogenic carbon that has been locked up for millions of years.

Biogas is a mixture of gases, primarily methane (CH_4) and carbon dioxide (CO_2). It is collected and upgraded on site into biomethane which can be used to replace fossil fuel natural gas within the National Gas Grid. Upgraded biomethane will be transported offsite for injection at a central gas to grid injection point or may be used within a combined heat and power (CHP) engine on site to supply the heat and electricity required to run and maintain the AD process. In addition, CO_2 from the biogas will be captured and purified for replacing fossil fuel-derived CO_2. The AD facility would have the capacity to produce approximately 19,864,629 Nm^3 of biogas per annum, which may produce 9,753,000 Nm^3 of biomethane and around 13,673 tonnes (t) of captured CO_2 per year as a natural by-product. The proposed AD facility would be fitted with equipment to upgrade the CO_2 to 99.9% purity, which is suitable for almost all industrial and commercial applications in the UK. Upgraded CO_2 would be liquefied and transported by road to end users within the market area.

Whole digestate from the AD process will be further processed to separate it into approximately 35,000 tonnes per annum (tpa) of digestate liquor and 65,000 tpa of digestate fibre. The separated liquor will be an excellent biofertiliser, containing major plant nutrients such as N, P, potassium (K), magnesium, (Mg) sulphur (S), and trace elements which can be used to replace manufactured and mined fertilisers needed to grow crops. The solid fibre fraction, as well as being a useful fertiliser, will contain useful quantities of organic matter, and when applied to soils will improve soil structure, soil resilience during heavy rainfall or drought periods and will improve the ability of the soil to cycle and retain nutrients. By applying fibre digestate to improve soils, the risk of soil erosion and runoff are reduced, mitigating risk of soil and nutrient losses to the wider environment.

Farmers are currently facing shortages in manufactured fertiliser supply as well as significantly increased costs, given that fertiliser supply is heavily linked to natural gas prices and partly dependent on overseas imports. They are proactively seeking to use sustainably produced digestate to replace manufactured fertiliser both in the short and longer term. Anaerobically digested livestock manures are sanitised and enhanced by the AD process, which converts some of the nutrients into more readily available forms that crops can take up more efficiently. Local farmers will therefore gain more direct fertiliser replacement value from the digestate than they would have from untreated slurries and manures. In addition, the AD process captures methane and carbon dioxide that may otherwise be released as green house gases if stored and used untreated on farm, thereby assisting farms with meeting the objectives of the Clean Air Strategy.

It was confirmed through initial discussion with Natural England that a Habitats Risk Assessment for nutrient neutrality is required for the proposed Three Maids AD facility to consider the potential (for the site itself and/or from associated activities) to release additional N and/or P load into the identified catchments and thus affect water quality.

1.3 Report structure

This report forms an assessment of elements of the proposed design and operation of the Three Maids AD facility which could affect water quality in the vicinity. It describes the relevant legislation and guidance for N and P management and the mitigation measures which will be employed to ensure the development does not add to existing nutrient burdens on habitat sites.

2 Legislation and Guidance

The legislation and guidance relevant to this nutrient neutrality assessment are summarised below.

2.1 The Conservation of Habitats and Species Regulations (2017 as amended)

The Conservation of Habitats and Species Regulations (2017 as amended), referred to as the 'Habitats Regulations' are the UK's transposition of European Union Directive 92/43/EEC on the 'Conservation of natural habitats and of wild fauna and flora' (the Habitats Directive)[5].

A Court of Justice of the European Union decision, Coöperatie Mobilisation for the Environment and Vereniging Leefmilieu (Case C0293/17) which is referred to at the 'Dutch case' (7 November 2018) considered EU and other law. The Habitats Directive states *"*Whereas an appropriate assessment must be made of any plan or programme likely to have a significant effect on the conservation objectives of a site which has been designated or is designated in future.*"*

The judgement is a material planning consideration and an assessment on N, (and P when applicable), and the effect that it/they may have on the quality of habitat types being negatively affected by their release and deposition must be undertaken. The judgement sets out the requirement that any plan or programme likely to have a significant effect on the conservation objectives of a site which has been designated or is designated in the future requires an appropriate assessment and that a plan or project likely to have a significant effect on the site concerned cannot be authorised without a prior assessment of its implications (judgement of 12 April 2019, People Over Wind and Sweetman, C0323/17, EU: C:2018:244).

2.2 Environmental Permitting (England and Wales) Regulations 2016

The proposed facility requires a Bespoke Installations environmental permit to operate under the Environmental Permitting (England and Wales) Regulations 2016[6]. The Environment Agency (EA) is the competent authority which will regulate the facility. The site operations must comply with best available techniques (BAT) conclusions and BAT Associated Emissions Limits (AEL). These are laid out in the Best Available Techniques Reference Document (BREF) for Waste Treatment: Industrial Emission Directive 2010/75/EU) Integrated pollution Prevention and control) 2018.[7] Chapter 6 stipulates the BAT conclusions for waste operations in general, and specifically for biological treatment of waste.

The site must be operated in accordance with a written management system that identifies and minimises risks of pollution, so far as is reasonably practicable, including those risks arising from operations, maintenance, accidents, incidents, non-conformances, closure, and those drawn to the attention of the

[5] The Conservation of Habitats and Species Regulations 2017 (https://www.legislation.gov.uk/uksi/2017/1012/contents/made)

[6] The Environmental Permitting (England and Wales) Regulations 2016 (https://www.legislation.gov.uk/uksi/2016/1154/contents/made)

[7] European IPPC Bureau (2018) Best Available Techniques (BAT) Reference Document for Waste Treatment: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control).

operator as a result of complaints. The site must be operated using sufficient competent persons and resources and records demonstrating compliance must be kept.

The permit requires that energy and raw materials are used efficiently, and that disposal of any wastes generated from activities on site is avoided.

2.3 CIRIA 736

CIRIA 736[8] Containment systems for the prevention of pollution: secondary, tertiary, and other measures for industrial and commercial premises guidance was developed to assist operators of industrial and commercial facilities storing substances (inventories) that may be hazardous to the environment. It provides guidance on identifying the hazards, assessing the risks, and mitigating the potential consequences of a failure of the primary storage facility and/or the combustion of its contents. Guidance is provided on the design, and construction of new secondary containment systems and the inspection, maintenance, repair, extension and upgrading of existing installations. The Three Maids AD Facility will be designed and constructed in accordance with CIRIA 736.

2.4 Nitrate Vulnerable Zone Regulations

The Action Programme for Nitrate Vulnerable Zones (England and Wales) Regulations 1998[9] covers areas designated as being at risk from agricultural nitrate pollution. The NVZ areas include about 55% of land in England. The land surrounding the Three Maids AD facility is within an NVZ. Farmers must follow NVZ rules if their land is within an NVZ. The EA enforces the NVZ Regulations.

NVZ rules govern the use of fertiliser and organic manures (such as digestate) within the catchment. Key relevant points are described here. No more than 250 kg of total N from all organic manures may be applied in any 12-month period to any single hectare (ha) of land. This limit (the field limit) ensures that total organic N is not over-applied.

All applications of fertiliser and organic manures must be planned before they are carried out. The plan comprises four steps to calculate:

1. The amount of N in the soil (soil N supply) that is likely to be available for the crop to use during the growing season.
2. The optimum amount of N that should be applied to the crop, considering the amount of N that is likely to be available from the soil.
3. The amount of N from any planned applications of organic manure, (such as digestate), likely to be available to the crop in the growing season in which it is to be spread.
4. The remaining amount of manufactured N fertiliser required.

[8] Containment systems for the prevention of pollution (C736F) (2014) ((https://www.ciria.org/ItemDetail?iProductCode=C736F&Category=FREEPUBS)

[9] Using nitrogen fertilisers in nitrate vulnerable zones (Published 10 August 2015, Last updated 15 August 2022) (https://www.gov.uk/guidance/using-nitrogen-fertilisers-in-nitrate-vulnerable-zones) Accessed October 2022.

The quantity of crop-available N supplied from digestate will be calculated based on analysis of the digestate to be spread, the crop type, timing of application, soil type and rainfall within the catchment.

It is an offence to allow fertiliser or any type of organic manure to enter surface waters such as ponds and rivers. Fields must be inspected to assess the risk of N runoff or leaching prior to an application taking place. The farm must keep a 'spread risk map' identifying risks associated with fields that may be spread. The spread risk map must include "no spread areas" to the field to mitigate a risk where present e.g., the creation of 6-10 m wide '"no spread' buffer strips" alongside streams to protect them from potential runoff.

Within NVZs, there are periods of the year in late autumn and winter which are closed for spreading of high readily available nitrogen (RAN) organic manures and fertilisers to reduce the risk of runoff and leaching and to ensure applications are made when crops have a need for the N applied and will actively take it up. Liquid digestates are typically high in RAN, as are certain fibre digestates: they are therefore subject to NVZ 'closed' periods.

2.5 The Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018

The Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018[10] are referred to as the Farming Rules for Water (FRfW). The EA enforces the FRfW.

The FRfW were introduced to reduce and prevent diffuse water pollution from agricultural sources, within England and Wales. They cover the application and storage of fertilisers and organic manures and the management of soil and livestock. The rules consider both P and N and are relevant to the control of diffuse pollution from both nutrients within the Itchen catchment. The most pertinent requirements are described below.

Applications of fertilisers and organic manures, (such as digestate) must be planned. A nutrient management plan must be in place prior to an application being carried out. The plan must:

1. Show a crop nutrient requirement for each field, informed by AHDBs nutrient management guide (RB209)[11] suitable farm software, and/or a suitably qualified adviser.
2. Take into account the results of up-to-date soil sampling and analysis (to include P, K, Mg and pH).
3. Consider the nutrients provided by organic manures and fertilisers when they are to be applied.

Farmers should avoid applying organic manures that raise the Soil P Index above target levels for soil and crop on land over a crop rotation.

To reduce the risk of nitrate leaching and surface runoff, there are certain time periods when high RAN organic manure applications should either not be made or are restricted in terms of the quantity that may be spread to land. Farmers must not apply more N than any crop needs over the annual crop cycle. These restrictions are similar to those of NVZs but time periods of application are more restricted for certain crops.

[10] https://www.legislation.gov.uk/uksi/2018/151/contents/made

[11] AHDB Nutrient Management Guide (RB209) (https://ahdb.org.uk/nutrient-management-guide-rb209)

The FRfW state that farmers should plan to establish a cover crop by 15 October in any year as a reasonable precaution to help prevent diffuse pollution unless they are delaying drilling to enable activities to control persistent weeds, such as blackgrass or plan to leave medium and heavy soils to weather before a spring root crop.

2.6 Codes of Good Agricultural Practice

Protecting our Water, Soil and Air: A Code of Good Agricultural Practice for farmers, growers, and land managers[12] (the 'CoGAP') provides a practical interpretation of legislation and provides advice on best practice. "Good agricultural practice", in this context, means a practice that minimises the risk of causing pollution while protecting natural resources and allowing economic agriculture to continue. It was written by technical specialists from Defra and Natural England (NE), published 2011 and last updated in 2018.

The additional guidance Nitrates and phosphates: plan organic fertiliser and manufactured fertiliser use[13] was published in 2016 which specifically applies to land managers with an Environmental or Countryside Stewardship agri-environmental agreement on land that is outside of an NVZ.

The Code of Good Agricultural Practice for reducing ammonia emissions[14] provides best practice guidance for reducing ammonia emissions from farms in England. It is included here for completeness, although this nutrient neutrality assessment primarily considers potential emissions to land and water of N and P which might affect water quality.

[12] Defra Guidance: Protecting our water, soil and air: A Code of Good Agricultural Practice for farmers, growers and land managers (2009) (https://www.gov.uk/government/publications/protecting-our-water-soil-and-air)

[13] Defra (Published 22 December 2016) Use organic manures and manufactured fertilisers on farmland (https://www.gov.uk/government/publications/nitrates-and-phosphates-plan-organic-fertiliser-and-manufactured-fertiliser-use) accessed October 2022.

[14] Defra (2018) Code of Good Agricultural Practice (COGAP) for Reducing Ammonia Emissions (https://www.gov.uk/government/publications/code-of-good-agricultural-practice-for-reducing-ammonia-emissions)

3 Nutrient neutrality assessment

The proposed Three Maids AD facility could have the potential to impact N and P levels within the Itchen and wider Solent catchments. The following section comprises a series of nutrient neutrality assessments of key areas of the proposed AD operation given that there is no generic methodology for AD facilities currently available.

3.1 Site location and drainage design

The site is centred at NGR SU 46069 33921 and is approximately 4.2 hectares of arable land to the north of Winchester, immediately east of the A272 Andover Road and north of the Three Maids Hill roundabout.

SLR Consulting Ltd have produced a Flood and Surface Water Drainage Strategy [15] to support the Three Maids planning application. The site does not lie within an area considered to be at risk of fluvial or tidal flooding. Flood risk from all potential sources of flooding is low.

The surrounding area is used principally for arable farming and grassland and contains pockets of protected ancient woodland. The soil type is classified as freely draining, shallow lime-rich soils over chalk and limestone (Seaford Chalk Formation – Chalk with Stockbridge Rock Member – Limestone within the eastern part of the Site)[16], with a loamy texture. The site is currently an arable field above a principal aquifer at medium to high risk for groundwater vulnerability according to the SLR report[14], and so there is little potential for attenuation if a potentially polluting loss or spillage occurs there. The site is not within a designated groundwater source protection zone (SPZ) or within a Drinking Water Safeguard Zone (DWSZ) but is within an NVZ.

There are no surface waters shown on Ordnance Survey 1:25,000 scale mapping but there is a small surface water ditch adjacent to the eastern boundary of the site. The AD facility will be sited over 10 metres (as a minimum) from this surface water in order to mitigate risk.

The site infrastructure primary and secondary containment systems and sealed drainage system will be designed to mitigate risk of pollution to the environment from a spillage, accident, or incident on site and will comply with CIRIA 736. All surface water runoff will be managed to prevent pollution and uncontrolled release of N and P to the wider environment. It is a statutory requirement of the site environmental permit that all solids, liquids, and sludges on site are stored securely.

Effective primary containment or storage is the most important means of preventing major incidents involving losses of potentially polluting substance. All equipment is designed and built to BAT with additional safety measures. For example, all tanks will be fitted with high-level sensors linked to management control systems and will be regularly inspected and maintained. Secondary containment on the AD facility will comprise a large, impermeable concrete bund which will minimise the consequences of failure of primary containment on site. The secondary containment is appropriately sized to fully contain a tank integrity

[15] PROPOSED ANAEROBIC DIGESTION FACILITY AT THREE MAIDS HILL, WINCHESTER, Flood Risk Assessment and Surface Water Drainage. SLR Ref: 404.11923.00004.0004 Version No: 01 August 2022
[16] BGS Geological viewer accessed October 2022

failure on site, should one occur. Any underground tanks will benefit from secondary containment and leak detection.

There will be two drainage systems, including:

a 'clean water system', which will collect rainfall and surface runoff from clean areas of the site such as roofs and hardstanding areas free of any contamination. The harvested clean water will be used within the AD process and may only be positively released to the environment if deemed clean and free of contamination.

A 'dirty water system', which will collect water from areas such as the silage effluent from the silage clamps and the areas around the feed hoppers. This system will capture dirty water containing N and P for re-use within the AD process and recover these nutrients within the biofertiliser. Any containment waters contaminated through process residues will be held within the dirty water system and used within the AD process, they will not be released to the environment.

The site infrastructure and design will be implemented in accordance with BAT and the EA will assess that these requirements are met prior to issue of a permit to operate the AD facility. A written Environmental Management System (EMS) and Accident Management Plan (AMP) will be in place. The AMP will provide clear instructions within standard operating procedures on how to contain and deal with spillages should they occur, in order to mitigate risks to the wider environment.

The site environmental permit will not allow any point source emission to land, surface waters or groundwater under control of the permit. The site infrastructure is specifically designed to ensure this requirement is met and therefore operation of the Three Maids AD facility should not result in the release of additional N and P load to the Itchen Catchment. It will thus achieve nutrient neutrality.

3.2 Production and use of feedstocks

The proposed AD facility will treat around 83,600 tonnes per annum of feedstocks, typically comprising:

- livestock manures such as poultry litter, dairy slurry and other farm yard manures;
- Purpose purpose-grown energy crops such as rye, maize and grass which will be harvested and preserved for use as silage;
- crop residues such as straw; and
- production residues, such as those from the dairy or drinks industry, (These may replace a proportion of the purpose-grown energy crops used).

The availability of different feedstocks can fluctuate because of local, national, and international economic conditions and due to the seasonal nature of supplies. A full nutrient mass balance cannot be calculated without feedstock types and quantities having been secured. However, the principles of nutrient management are discussed below.

3.2.1 Livestock manures

There are many advantages to sending livestock manures to a central AD facility for treatment. The AD process sanitises manures, reduces the risk of transfer of pests, pathogens and weed seeds and increases the

crop-availability of the nutrients that manures contain, thereby making them into more effective fertiliser replacement materials. Arable farms are also reluctant to import untreated manures for fear of introducing pernicious weeds (such as blackgrass), pests and diseases.

In many cases, livestock farms import more P and N in the form of animal feeds and protein than they export in terms of finished products such as meat and milk. Some of the imported nutrients are captured as manures which can be used effectively by neighbouring arable farms or returned to the farm's own fields. The NVZ regulations provide controls on the levels of N applied to fields and the more recent FRfW effect controls on P. However, historic repeated applications of manures may have resulted in a build-up of P on certain fields, leading to an increased risk of losses to the wider environment.

Livestock farms are currently very vulnerable to high feed and energy costs and low meat prices. The collection of cattle manures for export to other farms or to the AD plant in question is likely only to relate to winter housing periods. Pig and poultry manures also tend to be available at set times of year and/or at the end of each production cycle. The tonnages of locally available livestock manures are therefore likely to be variable during the year and will need to be balanced with energy crop supply in order to provide an appropriate feedstock mix for the AD plant.

The Three Maids AD facility will be a biofertiliser producer. The digestate liquor and fibre produced will replace the use of fossil fuel derived and mined fertilisers within the catchment and will allow the effective redistribution of nutrients to where they are needed. Given that digestate applications must be planned to meet (and not to exceed) crop requirements, no additional load of N and P should be introduced to the catchment from the use of livestock manure feedstocks; biofertiliser will replace some of the manufactured fertilisers currently used.

3.2.2 Energy crops

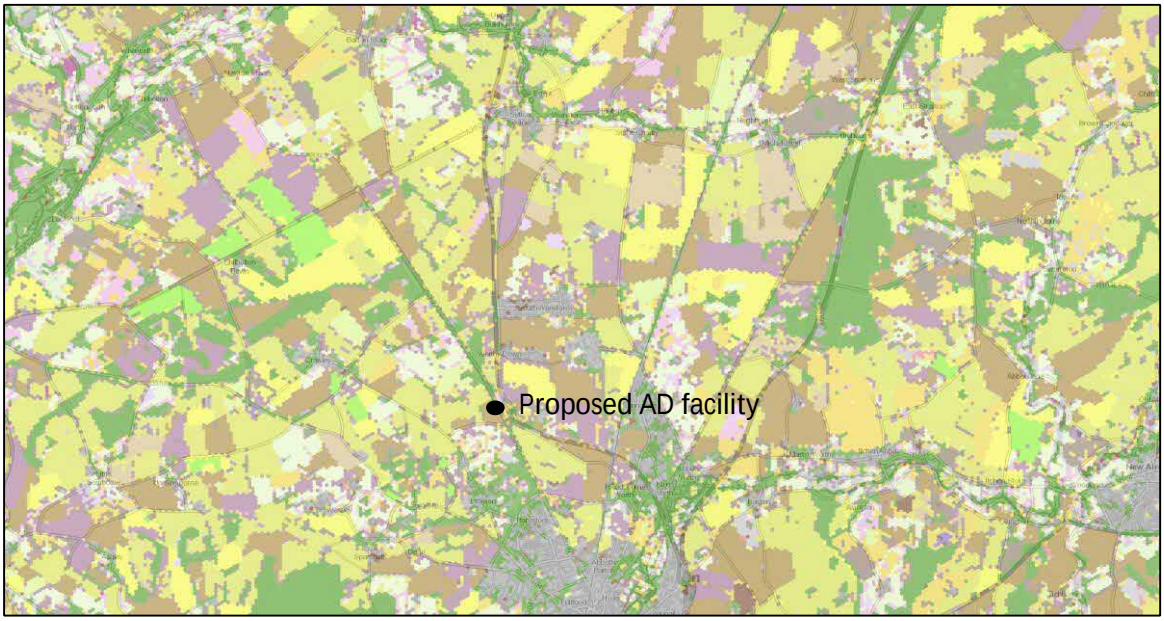
Energy crops such as maize and rye will be used to supplement feedstock supply. Their use will help to maintain a stable AD process and a consistent local supply of feedstocks.

Energy crops grow rapidly over a short growing season, absorbing and storing energy and CO_2 from the atmosphere (termed 'biogenic carbon') as a natural result of their life cycle. The AD process creates digestate, a rich source of nutrients and some carbon within organic matter which is then recycled to land.

The land that surrounds Three Maids is principally used to grow winter and spring cereals, oilseeds, grass, and maize (Figure 2). The requirements for energy crops at the proposed Three Maids AD facility will integrate well into the existing arable and grass crop rotations and will not result in land use change within the catchment.

For example, maize will be grown from April to October, within a 3 to 4-year crop rotation. This provides an opportunity for double cropping in one year; whereby maize under-sown with grass may be grazed, or the land may be drilled to a winter cereal or cover crop following harvest. Energy crops can be incorporated into existing crop rotations and management regimes, and do not require land to be taken out of food production in the long term. They can serve as break crops within arable rotations by providing pest and diseases breaks. Suitable crop rotations, alongside regular digestate applications can help to enhance overall crop yields.

Figure 2 Defra Crop Map of England 2020 Hampshire[17]



Crop type Key:

[17] Defra Spatial Data Download (https://environment.data.gov.uk/DefraDataDownload/?mapService=RPA/CropMapOfEngland2020HAM&mode=spatial) (Screenshot captured 4 October 2022)

The soil types around Three Maids are principally free draining Andover Series soils, shown as yellow in Figure 3 below with isolated areas of slightly acid clay-with-flints and plateau drift.

Figure 3 Soilscapes Map [18])

These free draining soils are susceptible to leaching of nitrates and pesticides to groundwater, and surface capping in areas of clay-with-flints, which could lead to erosion of chalk soils to sensitive chalk stream receptors. These risks can be mitigated by significantly reducing soil particulate run-off and thereby colloidal phosphates entering surface waters by ensuring NVZ and FRfW legislation and good practice guidance is followed.

[18] Soilscapes map (Landis.org.uk/Soilscapes) Image captured 4 October 2022

Acorn Bioenergy Ltd have team members who are both BASIS fertiliser advisers certification and training scheme (FACTS) qualified and Registered BASIS Environmental Advisers. The following measures will be recommended specifically to those farmers growing maize:

Field locations used to grow maize will be selected for their suitability. North-facing and exposed fields are considered less suitable, as maturity will be achieved more slowly. Heavier soils will be avoided both due to an increased risk of soil erosion and difficulties in achieving a good seedbed for maize. Steeply sloping fields will not be used for growing maize and the proximity of fields to surface waters and environmentally sensitive receptors will be considered. Hampshire is a southern county and is therefore considered to be a good area to grow maize in terms of sunlight and warmth.

A nutrient management plan will be prepared to ensure that crop nutrient requirement is accurately calculated and not exceeded. This will be based on information in RB209, taking into account recent (within 3-4 years) soil analysis and any applications of nutrients from digestate or fertiliser. The risk of nutrient losses to the wider environment will therefore be reduced.

Early maturing maize varieties will be chosen which require a short growing season to reach target maturity in good time in September, and in accordance with SW5[19] harvest before 1 October.

Maize can be drilled from mid-April onwards (past 15 April to avoid frost damage) in Hampshire, as soils reach the required 8ºC earlier as they are so far south in the country. This allows an earlier harvest date, as suitable maturity is achieved earlier.

The maize can be under-sown with grass using specific inter-row sowing machinery between the maize rows or the seed can be broadcast 6-7 weeks post maize drilling. Italian rye grass can be used which will scavenge nutrients effectively. The benefits of under sowing maize are to stabilise soil and retain nutrients as they are taken up and held by the grass. This approach will help to increase N retention which might otherwise be leached from uncropped overwinter stubbles.

The under-sown grass may either produce forage for livestock for grazing or silage or the biogenic carbon that has been grown can be incorporated back into soils to improve them. During the maize harvest the grass will hold soils in place and will reduce the risk of soil erosion and mud on roads.

Fields should be harvested swiftly as soon as target dry matter has been reached by 1 October. In 2022, dry conditions saw maize being harvested in August. Contractors will be co-ordinated to harvest fields in order of maturity.

If soil compaction has occurred, fields will be cultivated to create an open soil structure with uneven surface to allow interception and infiltration of rainfall thus helping to avoid runoff. If crops are not under-sown, then in accordance with SW5, a fast-growing cover crop will be established by 15 October.

[19] Rural Payments Agency and Natural England (Published 2 April 2015, last updated 20 September 2022) SW5: Enhanced management of maize crops (https://www.gov.uk/countryside-stewardship-grants/enhanced-management-of-maize-crops-sw5)

Fields next to watercourses will be avoided or "no-spread buffer strips" will be in place, with grass margins to capture any sediment or organic material that may run off.

Maize is drilled in the spring and is fast growing. Different types of 'energy' crops may be grown within the rotation, such as varieties of lucerne (a deep-rooted, perennial pasture legume crop). Over-wintering cover crops such as oats and vetch may also be harvested in southern England where excess growth under mild temperate conditions leaves too much green material to be simply soil incorporated. Grass and rye are also effective energy crops. All crops will only receive digestate or fertiliser applications following the preparation of written nutrient management plans based on legislative requirements and accepted guidance with regards to nutrient neutrality. The nutrients supplied by the digestate will replace those which would be supplied from manufactured fertiliser.

3.2.3 Production residues

Production residues containing valuable nutrients may be more effectively treated and recovered through the AD process than where they are applied direct to land. (Certain liquid dairy and brewery production residues may currently be spread to land directly with no further treatment or may be taken to a waste water treatment works for treatment prior to discharge). By using these materials as feedstocks for AD, their nutrients are likely to become more crop-available and will be captured and for use in a more controlled manner in order to supply crop nutrient demand.

3.3 Digestate management and use

Farmers are navigating some exceptional challenges as they try to secure sufficient supplies of manufactured and mined fertilisers to sustain crop yields amid potential shortages of grain production across the world. Digestate is seen as a viable and now sought-after alternative nutrient source to directly replace these fertilisers.

The N supplied from digestate is the most critical major nutrient to sustain crop growth, alongside a balance of additionally valuable P, K, Mg, S and trace elements. Digestate should be used at the optimum times when crops are able to take up the supplied nutrients most effectively, thus realising the maximum financial value, particularly with regards to N use efficiency.

The FRfW guidance and NVZ rules for England require farmers to demonstrate that they have a written NMP in place prior to an application taking place. The NMP needs to demonstrate how significant risks of agricultural diffuse pollution from nitrate leaching and phosphorus runoff are avoided, taking account of the RAN content of the digestate. Recent representative laboratory analysis of the digestate will be supplied to all farmers planning to use it. The digestate liquor will be high in RAN and potential pollution risk must be considered, given the timing of each application. Single applications will be kept to around 30m^3/ha to allow good infiltration, unless they are to be soil incorporated ahead of drilling a crop which has a need for N at that time for establishment. In that case, there must be no repeat application within 21 days.

Crops such as oilseed rape have a small crop need to take up N to get well established in the autumn, followed by a rigorous spring requirement. Most cereal crops, such as winter wheat will establish effectively from the N held within the soil (soil N supply) in autumn and only additional N in the spring to sustain rapid growth and attain yield.

Fibre digestate, in addition to its fertiliser nutrient content, has the added advantage of being a soil improver, supplying good quantities of organic matter. It is typically applied to soils around the time crops are sown, both for practical reasons and as it is typically low in RAN and therefore the N is less likely to be lost through nitrate leaching. High RAN fibre digestate is best applied to crops with a need for N in the autumn or ahead of drilling spring crops, when the RAN will be rapidly taken up by crops, rather than lost.

FRfW require that farmers should avoid applying organic manures that raise the Soil P Index above target levels for soil and crop over a crop rotation. Soils will be sampled and tested for existing concentrations of crop-available P. The results will inform the strategy for phosphate and potash use. This will either involve building up concentrations which are low, maintaining levels to maintain crop productivity or running down the concentrations by applying less P and/pr K than will be removed within the rotation. The Nutrient Management Guide (RB209)[11] or suitable farming software will be used to calculate appropriate digestate application rates to achieve the chosen strategy.

The rules and regulations controlling the quality and safety of digestate use are well established. They have been outlined in Section 2 of this report. When these rules and regulations are followed, along with the correct adopted strategy for each individual field, the risk of nutrient losses to the wider environment will be effectively mitigated.

Logistics must be optimised when using digestate. This means getting the material applied to the right crop, at the right time to meet crop demand to attain economic yields of crops of a suitably high quality. The Three Maids AD facility will have 10,000 m^3 of digestate liquid storage onsite. It will have additional offsite storage in the form of storage tanks and lagoons distributed around receiving farms. This will allow digestate to be delivered and stored ready to apply during the short application windows when crops are actively growing and able to take up applied nutrients effectively. These arrangements will be presented in a written Digestate Management Plan, which will match digestate supply to demand and ensure the provision of at least 6 months storage for digestate when it is not required for crops.

A spreading team will complete spreading operations, using precision application equipment to reduce the potential for nutrient losses to the wider environment. All applications will be recorded such that each farmer can effectively calculate the balance of fertiliser required to meet crop need.

Digestate should provide a sustainable source of nutrients which, when used on farms surrounding the AD plant, will have a lower carbon footprint than manufactured or mined fertilisers. Adherence to effective nutrient management plans and adherence to good agricultural practices should not result in an increased N and P load to the wider catchments. The nutrients supplied by the digestate will replace those from fertilisers rather than increase overall nutrient use.

3.4 Sustainability

Acorn Bioenergy Ltd will also have statutory obligations to grow and use feedstocks and digestate in a sustainable manner as they will receive a tariff from the Renewable Heat Incentive (RHI) Scheme and will be regulated under the Renewable Transport Fuel Obligation.

During each scheme year, participants must submit a sustainability audit report to demonstrate they have complied with scheme rules. Operators will have to report and provide evidence on land use and

greenhouse gas (GHG) emissions for crop feedstocks and demonstrate compliance with the limits set by the Department for Business Energy and Industrial Strategy (BEIS) and the Office of Gas and Electricity Markets (OFGEM). This encourages efficient farming of crop-based feedstocks in order to optimise crop yields. It also encourages good practice, which includes minimising the use of herbicides, pesticides, fossil-fuel derived fertilisers and fuels used to cultivate.

4 Summary and conclusions

There is a generic methodology in place for assessing nutrient neutrality for overnight accommodation. This methodology is not applicable to agricultural and industrial development.

An assessment of elements of the design and operation of the Three Maids AD facility which could affect water quality in the vicinity and consideration of measures that will be in place to mitigate potential impact has been carried out.

The site will require a Bespoke Environmental Permit to operate and will be regulated by the EA. Dirty water will be captured and used within the process and not discharged, only captured clean water (e.g., from roofs) may be released. The site infrastructure is specifically designed to ensure this requirement is met and therefore the Three Maids AD facility should not result in the release of additional N and P load to the River Itchen catchment.

Livestock and poultry manures will be used as feedstocks and once treated within the AD process they will be sanitised and transformed into digestate, which is a more effective fertiliser replacement material.

The land that surrounds Three Maids is principally used to grow winter and spring cereals, oilseeds, grass, and maize. Energy crop requirements for the AD plant will be integrated into the existing arable and grass crop rotations and will not result in land use change or an increase in N and P load from land over the whole period of the rotation.

Acorn Bioenergy Ltd have in-house properly qualified expertise and fully intend to grow energy crops such as maize in a safe, legally compliant, and environmentally sustainable appropriate manner. They also have statutory obligation to grow and use feedstocks and digestate in a sustainable manner as they will receive a tariff from the Renewable Heat Incentive Scheme and will be regulated under the Renewable Transport Fuel Obligation.

Production residues containing valuable nutrients may be more effectively treated and recovered through the AD process. Some of these can currently be spread to land directly with no further treatment or may be taken to a wastewater treatment works for treatment prior to discharge. By using these materials as feedstocks for AD, their nutrients can be captured and used in a more controlled manner resulting in reduced risk of nutrient losses to the wider environment.

Digestate (biofertiliser) is a sustainable source of crop nutrients which can be used effectively on the land surrounding the facility with a lower carbon footprint than manufactured or mined fertilisers. All crops will only receive nutrients (in the form of digestate and manufactured/mined fertilisers) once it is established that the farmer has produced a written Nutrient Management Plan based on legislative requirements and accepted good practice guidance. Digestate use should not result in an increased N and P load to the wider catchments. N and P supplied by digestate used in the manner stated in this report will be effectively used and should not result in an increased N and P load from land within the Test Valley, the Itchen Catchments or further afield.

It is considered that the proposed development of the Three Maids AD facility should not add to existing nutrient burdens, and the whole of the scheme is deliverable in line with the requirements of the Habitats Regulations.