Cyfoeth Naturiol Cymru
Natural Resources Wales

Natural Resources Wales Permitting Decisions

Castle Cement Limited (Padeswood Cement Works)

Decision Document

Application for a Substantial Variation to add a Carbon Dioxide Capture Plant to the Cement Kiln.

The application number is: PAN-026621

The permit variation number is: EPR/BL1096IB/V021

The applicant / operator is: Castle Cement Limited

The Installation is located at: Padeswood Cement Works, Padeswood, Mold, Flintshire, CH7 4HB

Our Decision

The installation operator, Castle Cement Limited, has applied to Natural Resources Wales to vary its Environmental Permitting Regulations (EPR) permit for Padeswood Cement Works, to add a carbon dioxide capture plant to the existing cement kiln. Natural Resources Wales has decided to issue the variation for the proposed changes. This decision document should be read in conjunction with the permit published with it.

The purpose of the proposed development is to remove carbon dioxide (CO_2) from the exhaust gas emissions from the kiln, instead sending these for geological storage. CO_2 is an important greenhouse gas, and carbon capture and storage (CCS) is a developing technology to enable carbon intensive processes to reduce their emissions. The permit determination is based solely on the application details and governing legislation, and is not influenced by broader climate change issues.

Purpose of this document

This decision document:

- explains how the application has been determined
- provides a record of the decision-making process
- shows how all relevant factors have been taken into account
- justifies the specific conditions in the permit other than those in our generic permit template.

Unless the decision document specifies otherwise, we have accepted the applicant's proposals.

Contents

1. Executive summary

1.1. Application summary

Castle Cement Limited already operate a cement manufacturing installation at Padeswood, with a rotary kiln for clinker production. They have applied to vary their environmental permit in order to add a carbon dioxide capture plant to the kiln. Further details of how this process will operate are given below. The variation also allows other associated changes to the installation, such as addition of an integrated combined heat and power plant, to provide the additional energy necessary for carbon dioxide separation / capture. Although emissions to atmosphere will be affected as described, the cement manufacturing process itself is largely unchanged by the variation.

1.2. Our decision

We are minded to issue the variation for Padeswood Cement Works, operated by Castle Cement Limited, for the reasons outlined below.

We consider in reaching that decision we have taken into account all relevant considerations and legal requirements and that the permit will ensure that the appropriate level of environmental protection is provided.

2. Application Details: The Installation and the variation applied for

2.1. The permitted activities

The regulated facility is an installation which comprises the following activities listed in Part 2 of Schedule 1 to the Environmental Permitting Regulations:

- S3.1 A(1)a: Producing cement clinker in a rotary kiln with a production capacity exceeding 500 tonnes per day *(existing activity, updated to reflect changes associated with the carbon capture activity).*

- S1.1 A(1)(a): Burning any fuel in an appliance with a rated thermal input of 50 or more megawatts *(new activity – integrated combined heat and power plant).*
- S6.10 A(1)(a): Capture of carbon dioxide streams from an installation for the purposes of geological storage pursuant to Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide *(new activity – CO_2 capture)*.
- S4.2 A(1)(a): Producing inorganic chemicals such as - (i)gases …(**hydrogen**) *(new activity – small scale hydrogen generation integral to captured CO_2 purification. (For removal of trace oxygen by reaction with hydrogen to produce water, followed by removal by pressure swing absorbtion dehydration).*
- S3.1 A(2)(a): Grinding cement clinker in cement mills 1, 2, 3, 4 & 5 *(existing activity).*
- S3.1 part B (a): Storing, loading or unloading cement or cement clinker in bulk prior to further transportation in bulk *(existing activity).*
- S3.1 part B (b): Blending cement in bulk or using cement in bulk other than at a construction site, including the bagging of cement and cement mixtures, the batching of ready-mixed concrete and the manufacture of concrete blocks and other cement products *(existing activity*).

The permitted activities are detailed in Table S1.1 of the Installation Permit. The regulated facility also includes installation "directly associated activities" which have been amended where necessary.

Together, these activities comprise the Installation. Section 10.1 of this document details specific limits/conditions on the activities which have been specified in the permit.

2.2. Changes to the installation

The existing installation activities will continue with only relatively minor changes as a result of this variation, as described in the application and this document. The main change arising from the variation is to add a carbon dioxide separation / capture plant to treat the exhaust gases from the kiln, and is described in section 2.3. In order to integrate the carbon dioxide capture plant into the existing activity, the following additional changes to the facility are required:

- Additional land to the south/south-west of the existing facility is added to the installation boundary; the carbon capture plant will be built on this additional area of land which is currently not used for industrial activity.
- A combined heat and power (CHP) plant is added to the facility, consisting of an approximately 130MW_{th} input maximum continuous rating natural gas boiler, equipped with a steam turbine generator to produce approximately 22 MW_e and approximately 100 MW_{th} steam output. This is not a standalone device, but utilises kiln waste gases as part of the combustion air demand, and in turn feeds its exhaust gases into the carbon dioxide capture plant. It is required, because the carbon dioxide separation process is endothermic (i.e. requires energy), principally in the form of steam, although electricity is also provided to the installation. As described in the application, "*A selective catalytic reduction and oxidation unit (SCR/O) will be integrated with the CHP to pre-treat the gases from the cement plant to reduce carbon monoxide (CO), ammonia (NH_3), oxides of nitrogen (NOx), and volatile organic compounds (VOC)".* This reduces emissions of these pollutants to air, but is principally to protect the downstream carbon capture process, which is sensitive to other contaminants in the waste gases.
- Connections, tie-ins, infrastructure and upgrades are provided as necessary. Principally, the existing waste gas ducting from the kiln will be modified and extended to transport waste gases to the new carbon capture plant. The existing waste gas bag filter will be upgraded with lime and activated carbon injection in order to further reduce trace pollutant levels (primarily sulphur dioxide, hydrogen chloride and mercury), to meet the enhanced inlet requirements of the capture plant, but also reducing production emissions to the environment. Waste heat recovery units (WHRU) will be added to kiln processes to recover heat that can be used in the capture plant. Other connections, such as utilities, reagents, waste effluent will be made between the carbon capture plant and existing assets.

2.3. Description of the carbon dioxide separation / capture process.

Separation of the global warming pollutant gas carbon dioxide (CO_2) from industrial process exhaust gases is relatively new, although it combines and further develops a range of existing, proven technologies. The application describes the carbon capture process in full, summarised in the non-technical summary. The key steps of the separation process are described below, taken from the operator's description:

BOX 1: Operators non-technical description of the carbon capture process:

"The Padeswood CCS project is a post-combustion carbon capture and compression (PCCC) plant with natural gas-fired combined heat and power (CHP) to supply the heat and power requirements of the PCCC plant. The carbon dioxide (CO2) arising from the CHP will be treated in the PCCC as well. In addition, waste heat recovery units (WHRU) are included in the scope to harvest waste heat from the cement process and complement the heat supply from the CHP.

…The combined gases from the cement kiln and CHP are cooled in a gas/gas heat exchanger and quencher, and then pass through the absorber. The absorber, which is the 'capture' part of the process, can be described as a giant washing machine that removes to CO_2 from the gas and traps it in the liquid. This liquid, is mixture of water and amines (like the detergent in the washing machine), grabs onto the CO_2 and holds it tight, removing it from the flue gas.

Amines are organic compounds derived from ammonia, that readily react with CO2. Amines are particularly effective for this purpose because they have a high affinity for CO_2, allowing for efficient absorption even at low concentrations. This technology is relatively mature in the petrochemical and gas industries, however, it is considered new technology for the cement industry. Amine based carbon capture can be integrated into existing industrial processes for large-scale CO_2 reduction. Amine solutions for the carbon capture process have been in development for many years and are ever evolving.

Heidelberg Materials have selected KS21TM amine developed by Mitsubishi solution for the Padeswood project. Compared with generic amines and its predecessors, KS-21 provides energy-saving performance, reduces operating costs, and lower amine emissions.

With the CO2 removed, the remaining gases pass through the wash tower to remove any carried-over amine droplets from the gas. The clean gas is then reheated at the gas/gas heat exchanger prior to being released at the stack. The emissions from the new stack will be reduced in comparison to the existing plant.

The amine solution combined with CO2 is transferred to the regenerator column, where it is heated to release the CO2. The amine is recycled back to the absorber. The CO2 is compressed, dried, and purified to meet the pipeline and storage specifications. The CO2 then flows through the CO2 pipeline to storage.

The carbon capture system requires clean water to operate and therefore requires a water treatment plant to produce demineralised water. The mineral-rich wastewater stream will be used in the cement plant for cooling purposes instead of borehole or surface water used at present. The overall scope of this project is for zero process liquid discharge.

Given the above, the proposed development aims to capture approximately 800,000 tonnes of carbon dioxide (CO2) per year from the cement works…

So the main new steps added to the kiln waste gas treatment, by introduction of carbon capture and in process order are as summarised below.

1. Upgrades to existing kiln bag filter plant to reduce levels of residual pollutants mercury, hydrogen chloride and sulphur dioxide entering the capture stage
2. Addition of Combined heat and power, with selective catalytic reduction, using a major portion of kiln gas as combustion air (with additional ambient air for oxygen content) to provide energy for the capture process while conserving gas volume and optimising energy/capture efficiency.
3. Gas-gas heat exchanger (*cooling – see [6])* to reduce the waste gas temperature for CO_2 capture
4. Gas wet alkali quenching and electrostatic precipitator to further reduce gas temperature, sulphur dioxide and particulate prior to CO_2 capture
5. (a)Counter-current amine CO_2 absorber tower, where CO_2 is "stripped" out of the flue gases and leaves in solution having reacted with the amine

   (b) complementary amine regenerator tower, where "rich" CO_2-containing amine is heated, driving off pure CO_2 and releasing amine solution for further use in the absorber

   (c) supporting processes – liquid-liquid heat exchanger to cool the amine entering the absorber while heating the amine entering the regenerator, steam reboiler to heat the regenerator, alkali reclaimer to maintain circulating solvent quality by breaking down heat-stable salts.
6. Exhaust gas wash tower and gas-gas heat exchanger *(warming – paired with [3]*) to finally clean and condition the gas prior to emission – main purpose being to reduce the emissions of amines and their by-products to environmentally acceptable levels.
7. New emission stack for "CO_2 depleted" gases emitted to atmosphere, with full pollutant monitoring provisions.
8. Captured CO_2 purification, compression and monitoring ready for injection into the pipeline network.

Further information is provided in the application (including in the main technical summary and also the process flow). Also in following sections of this document where specific technical and environmental issues are examined in appropriate detail.

3. Application & Determination Process: Administration

3.1. Receipt of the application

The application was first received on 09/08/2024. In order for us to be able to consider the application duly made, we needed more information, summarised as follows:

- Clarification of narrative descriptions of process / impacts, notably non-technical and technical summaries of new processes, air quality assessment, particularly for clarity on the public register to a non-specialist audience
- Further clarification and detail on the CO_2 absorption solvent(s), and possible environmental emissions arising (principally to air), including the tolerable environmental levels for specific substances
- Further information on Best Available Techniques (BAT) for key process steps and with reference to relevant guidance
- Further information on noise impact, principally via BS4142 assessment as required for EPR permitting (noting that required noise information was absent from the submitted application as explained in an accompanying noise covering note).
- Clarification of other important details; containment of liquids, passive (vent) emission point identification, directly associated activities, site condition report for additional land.

A letter requesting this information was sent to the applicant on 09/10/2024. Upon receipt of this information, on 17/02/2025, we were able to consider the application duly made. This means we considered it was in the correct form and contained sufficient information for us to begin our determination, but not that it necessarily contained all the information we would need to complete that determination. It is noted that by exception, a longer time was allowed by NRW for this provision of further information than is usual, reflecting the fact that the carbon capture technique and regulation is developing and that a longer period was reasonably required.

3.2. Confidential Information

A claim for commercial or industrial confidentiality has been made in respect of the proprietary carbon capture solvent proposed for the process. We have accepted the applicants claim for commercial confidentiality in full and the relevant information as identified in the claim has been excluded from the public register. Redacted, public

versions of two documents are available on the public register, where only part of the information was claimed as confidential. The decision was taken in accordance with our guidance on commercial confidentiality. A Notice confirming this was issued to the applicant on 18/02/2025. The commercial confidentiality claim did not include information relating to emissions, which must be included on the public register (EPR 51 (3)) and are discussed in section 8.

3.3. Consultation

3.3.1. Consultation on the Application

We have carried out consultation on the duly made application in accordance with the Environment Permitting Regulations (EPR), our statutory Public Participation Statement (PPS) and our Regulatory Guidance.

A copy of the application is available on the public register (PAN-026621)for anyone to view. We advertised the application to the public by a notice placed on our website directing people to the public register, advising them of how they could arrange for copies to be made if required and how they can provide comments.

We also consulted with the following bodies, which includes those with whom we have "Working Together Agreements":

- Flintshire County Council (the local authority – planning and public health)
- The Food Standards agency
- The Health and Safety Executive (HSE)
- Public Health Wales

These are bodies whose expertise, democratic accountability and/or local knowledge make it appropriate for us to seek their views directly.

The consultation started 25/02/2025 and ended on 26/03/2025.

A summary of consultation comments and our response to these representations can be found in Annex 1. We have taken all relevant representations into consideration in reaching our decision.

3.3.2. Draft Permit Consultation

We are carried out a public consultation on our draft decision. This consultation began on 09/09/2025 and ended on 09/10/2025. There were no public comments.

3.4. Requests for information

Further information was requested during determination by way of a Schedule 5 Notice requiring the applicant to provide further information relating to:

- Further information on air quality impacts – extending modelling scope of atmospheric reactions of amines to cover additional compounds where data had become available.
- Noise impact assessment – to include background sound levels in the absence of the existing cement plant operation, and modelling assessment of the installation noise including existing cement plant as well as the proposed new equipment
- Further information on secondary containment of potentially polluting liquids and conformance of containment arrangements with Ciria C736 requirements

The Schedule 5 Notice was sent on 06/05/25 with a deadline for response of 01/06/25.

The applicant's response to the Schedule 5 Notice was provided in parts by agreement with NRW, on 13/05/25 (air quality and Ciria C736 assessment), 22/05/25 (noise baseline measurement data only), 11/06/25 (additional Ciria C736 containment information), 23/06/25 (Revised noise impact assessment) and 27/06/25 (revised noise modelling files). The additional information first supplied was satisfactory on air quality but did not satisfy the requirements of the Schedule 5 Notice in respect of containment or noise. A meeting was held (27/05/25) with the operator via Teams to explain how the initial response was not sufficient. The deadline for response date was extended. The applicant provided further information as detailed below which we finally considered satisfied the request of the Schedule 5 Notice with submission of further revised noise impact assessment and modelling files on 08/08/25.

Several informal information requests were also made via email, and clarifications were sought via calls scheduled between the operator and determining officer. These related to numerous matters of detail (including those referred to in Schedule 5 notices and separate issues) pertaining to the determination, and reflect the complexity of the

application, and the evolving knowledge of the process, both within the operator and the regulator during the application. They took place to ensure that NRW fully understood the application, and its environmental implications, to inform their permitting decision. Where these were written requests, and/or resulted in a written update to the application, these are available on the public register for the determination.

4. Application & Determination Process: Relevant Legislation and matters outside of scope

4.1. The Legislation

The variation will be issued, under Regulation 20 of the EPR. The Environmental Permitting regime is a legal vehicle which delivers most of the relevant legal requirements for activities falling within its scope. In particular, the regulated facility is:

- an *installation* as described by the IED;
- subject to aspects of the Well-Being of Future Generations (Wales) Act 2015 and the Environment (Wales) Act 2016 which also have to be addressed.

4.2. NRW's decision making under the legislation

We address the legal requirements directly where relevant in the body of this document. NRW is satisfied that the decision on this application is consistent with its general purpose of pursuing the sustainable management of natural resources (SMNR) in relation to Wales and applying the principles of SMNR. In particular, NRW acknowledges that it is a principle of sustainable management to take action to prevent significant damage to ecosystems. We consider that, in issuing the variation a high level of protection will be delivered for the environment and human health through the operation of the Installation in accordance with the permit conditions.

As the EPR regulator in Wales, NRW are required to determine any duly made permit application. This means that we must decide either to grant, or to refuse the variation based upon an objective assessment of the proposals against the detailed legal requirements of EPR. Our public participation statement gives more information on what can, and cannot, be taken into account when making our permitting decision.

The application, and this decision document, only considers the permitting of the facility under EPR as described throughout the document.

4.3. Matters beyond the scope of our determination

We only assess the installation and its impacts as defined under the relevant legislation. We cannot take into consideration indirect impacts which are not as a direct result of activity within the installation boundary.

For information only, it is noted that the purpose of the proposed development is to remove carbon dioxide (CO_2) from the exhaust gas emissions from the kiln, instead sending these for geological storage. CO_2 is an important greenhouse gas, implicated in anthropogenic climate change (e.g. What Is Climate Change? | United Nations). Carbon capture and storage (CCS) is a developing technology to enable carbon intensive processes to reduce their emissions. The application under EPR is specifically for CO_2 capture for geological storage, and it is understood that CO_2 from Padeswood would be sent to the Hynet UK industrial cluster (About HyNet - HyNet) which is subject to UK government funding via the Department for Energy Security and Net Zero (DESNZ). NRW acknowledges the climate crisis, and importance of both mitigation and adaptation activities. However, this wider context does not materially affect our EPR determination process, which is based upon the application and installation, and the relevant EPR legislation only.

Furthermore, any proposed development and wider associated activities will be required to be compliant with all relevant and applicable law, for example, environmental law, health and safety law, planning law. This other legislation acts largely independently of EPR (although they may be inter-related). Such other matters are beyond both the scope of this document, and of our regulatory remit and expertise and are not relevant to our EPR permitting decision. Ensuring compliance with all other regulation and obtaining any required consents (such as planning permission) is the responsibility of those undertaking the development and is regulated by the relevant appropriate authority for each.

5. Our Determination: defining the site

5.1. Site Plan

The existing cement manufacturing activities are to a large extent unaltered by the proposed variation and addition of carbon capture plant. The capture plant will be built on available land to the South / South-West of the previously permitted installation, necessitating an update to the site plan and increase in installation boundary.

The applicant has provided an updated permitted boundary plan which we consider is satisfactory, showing the extent of the site of the facility. A separate block layout plan of the carbon capture plant (CCP) identifies the new air emission point, and CCP drainage plan shows the new water emission point. It is noted that a minor correction is made to the boundary at the northern tip of the site; this is not a change to boundary or surrender of land, but a correction to minor inaccuracy in previous plan.

The updated boundary plan is included in the permit and the operator will be required to carry on the permitted activities within the site boundary

5.2. Site Condition Report

The applicant has proposed to add land to the facility as part of this variation and has provided information on the condition of that land in a baseline summary and preliminary risk assessment documents. We have reviewed these and consider the description is broadly satisfactory. The decision was taken in accordance with our guidance on Site Condition Reports – Guidance and Templates (H5), noting that key information appears to be present, but that it does not fully follow the H5 recommended format, and contains both information about the existing site and land to be added for the CCP which can be confusing.

We have therefore added a pre-operational condition PO 03 to the permit, requiring the operator to review the site condition report information provided to NRW with the application, and either confirm that they are satisfied that it fully describes the baseline condition of the newly permitted area, or will provide any further information that they wish to submit, with reference to the H5 guidance and format. Noting that NRW will

consider there to be no existing contamination at the point of permit variation issue, unless demonstrated to us otherwise in writing ahead of operation of the new plant.

5.3. Site protection: potentially polluting substances and prevention measures

The operator has a duty to ensure that soil and groundwater are protected in order to meet the requirements of Articles 14 (1)(b), 14(1)(e) and 16(2) of the IED. The operator clearly stated (in technical summary) their intention of providing suitable and sufficient impermeable, sealed surfaces beneath the CCP process equipment, and secondary containment (bunding) for potentially polluting liquids in accordance with Ciria C736 guidance. This is discussed further in section 8.7. Furthermore, arrangements for the collection of uncontaminated surface water, holding in a balancing pond/storage lagoon, testing, and discharge to surface water or re-use in process were described and satisfactory (see section 8.3).

6. Our Determination: General operation of the installation

6.1. Operator competence

The applicant is the sole operator of the Installation. We are satisfied that the applicant is the person who will have control over the operation of the varied Installation; and that they will be able to operate the Installation so as to comply with the conditions included in the permit. The decision was taken in accordance with EPR RGN 1 Understanding the meaning of operator[1]. As the CCP process is an emerging industrial abatement technique, we have subjected the application to an enhanced level of scrutiny, and are satisfied that the operator is making sufficient provision to competently operate a new, and complex industrial plant.

The legal operator of the Installation is Castle Cement Limited. It is noted that broader public information on the Padeswood project is published under the Heidelberg Materials branding (e.g. Padeswood CCS | Padeswood CCS) and that the site has also been part of the Hanson Cement company (History of Padeswood cement works

[1] RGN 1 Understanding the meaning of 'operator' (naturalresources.wales)

| Padeswood CCS). Only the legal operator is relevant to NRW's determination, but this additional information is noted for public awareness.

6.2. Relevant Convictions

The applicant has declared they have relevant convictions as detailed in the application. These all relate to breaches by Castle Cement Limited of environmental consent requirements, and date from 1996 to 2010 at Padeswood and other UK manufacturing sites.

NRW's COLINS Database has been checked to confirm that all relevant convictions have been declared.

Relevant convictions were found which matched those declared in the application. We have considered relevant offences and the likelihood of re-offending. We have taken into consideration the post-conviction plan submitted by the operator as part of the application, and accept its contents. In particular we note the considerable remedial and improvement work undertaken on the site since conviction, and that recent permit compliance is improved (Band C compliance rating 2024). While noting environmental guidance makes clear that offences committed by corporate bodies are never considered "spent" under the rehabilitation of offenders act 1974, it is acknowledged that the most recent conviction is over 10 years ago, for offences from 2007 and before. We are satisfied that the operator has fully declared previous convictions, and have considered their relevance to the current application. However, we do not consider that these actions provide any reason to consider refusal of or specific conditions in the current variation application.

6.3. Financial Provision

The applicant has declared they have no current or past bankruptcy or insolvency proceeding against them.

There is no known reason to consider that the operator will not be financially able to comply with the permit. The decision was taken in accordance with EPR RGN 5 on Operator Competence.

6.4. Environmental Management System

The applicant has demonstrated in the application that they have already implemented an Environmental Management System (EMS) that meets the requirements for an EMS in our "How to comply with your environmental permit" guidance2 . This EMS is certified to ISO 14001 across multiple sites/operations.

We have reviewed the application and are satisfied that appropriate management systems and management structures will be in place for this Installation, and that sufficient resources are available to the Operator to ensure compliance with all the Permit conditions. The application states the EMS will be reviewed and updated in due course to cover operation of the CCP and associated changes detailed in this variation (it is not possible to develop and certify the EMS this far ahead of operation). An initial environmental aspects and impacts register has been submitted with the application. It is a pre-requisite of building the EMS, and is in a more advanced stage of development than we would normally see for a pre-construction permit variation application for a new plant. A pre-operational condition PO 04 has been included, requiring the operator to report on updates/changes to the EMS prior to the commencement of commissioning of the CCP and to include a Not Normal Operation (NNO) management plan. This plan is important to manage the process and its environmental impacts during non-normal operation, such as start-up, shut-down, and process perturbations. It is particularly important for the varied facility as NNO will be complex – potentially including NNO of each component part (Kiln, CHP, CCP), and may also be caused by external factors (e.g. non-availability of the CO_2 export pipeline). Some NNO scenarios will qualify as IED Chapter 4 "abnormal operation" and/or IED start-up/shut down, but not all. A complementary improvement condition IC19 has been included, requiring the operator to report on the implementation of the EMS within 12 months of completion of commissioning of the CCP.

6.5. Accident management

The EMS is required to include an Accident Management Plan, and as noted above will need to be extended to include the CCP and other new equipment authorised by this variation. We have reviewed the Environmental Risk Assessment, and ENVID

[2] Natural Resources Wales / Guidance to help you comply with your environmental permit

submitted with the application, noting that these include accident/incident scenarios. We are satisfied that appropriate controls are already in place to help reduce the occurrence and impact of any accidents that occur on the installation, and that provisions will be extended and amended for the new and altered activities authorised by this variation.

In order to ensure that the management system proposed by the applicant sufficiently manages the residual risk of accidents, permit condition 1.1.1(a) requires the implementation of a written management system which addresses the pollution risks associated with, amongst other things, accidents. The EMS improvement condition mentioned above also provides Natural Resources Wales an opportunity to review accident management provisions.

6.6. Design uncertainty and operational envelope.

The EPR permit variation application for the CCS project was been submitted after the majority of the front end engineering design (FEED) has been completed. A great deal of design detail has been provided with the application and is on the public register, but there are still elements of design uncertainty, for example the exact specification of motors and pumps, and therefore their energy efficiency is noted as still awaiting final confirmation. In making our permitting decision, we consider that we have enough information to determine the application. In some cases this is based on "design intent" rather than full detail, and in these cases we accept the standard that the operator proposes to meet, rather than the exact configuration details. This is a standard issue that NRW as regulator routinely works with in the consenting pathway of complex projects, where it is impossible for full detail to be available at the point that consenting decisions are needed. For permitting requirements, the EMS (above) will act to ensure that the detail is established and documented. We have also included pre-operational condition PO 02 to ensure that the necessary detail is provided to NRW and as necessary agreed by us, in a timely manner, along with standard pre-operational condition PO 07 and improvement condition IC 14 to develop and have approved, a plan for commissioning and report on commissioning when it is complete. Together these will provide us with additional detail on final design and operation parameters, and ensure that as the new plant moves through the complex stages of

commissioning and early operation, there is the necessary exchange of information with NRW for adequate environmental control and scrutiny of performance.

7. Our Determination: Minimum Standards and Best Available Techniques (BAT) for Installation Operation

This chapter describes how the operator has demonstrated that the proposed variation meets the BAT standards and other guidance/requirements for installations. As noted in the industrial emissions directive, "'*techniques' includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned*" and we consider all these as relevant in determining whether the proposal is BAT.

7.1. Options Appraisal

One of the pre-requisites of comprehensive BAT assessment is to ensure that an appropriate set of techniques has been selected from available options. While BAT conclusions are neither prescriptive or exhaustive, BAT can only be achieved if a fundamentally suitable technology/approach has been selected. The operator has included an options appraisal in the application to show why post-combustion amine based CO_2 capture has been selected over other techniques including cryogenic and membrane separation, oxyfuel or oxycal kiln technology, and Leilac cement production with CCS. The decision is largely based on the ability to deploy the technology now, based on commercial availability and technology readiness level. We note that the "hot potassium carbonate" absorption process (mentioned e.g. in the evidence review for post-combustion capture techniques) is not included in the operator's review, but this technique is at lower technology readiness level, and does not offer sufficient advantage to justify us to request a further review of options. We agree that the operator has considered alternatives to the amine-based capture proposed, and justified their technology decision to be BAT based on appropriate criteria.

They have also provided justification via a separate report that proprietary amine technology is an appropriate BAT option, over generic designs (e.g. Monoethanolamine based). We accept the operator position that proprietary solvent can be a BAT option, based on current information. This does not preclude other

amine options also being accepted as BAT by the regulator, nor endorse a particular proprietary solution.

7.2. Variation application BAT assessment and determination

The applicant has described the proposed equipment and operating techniques and systematically compared these against the relevant minimum standards, guidance and Best Available Techniques conclusions (BATc) for the activities added or substantially changed by this variation. We have reviewed the techniques proposed and unless stated otherwise or discussed further below, we agree that the operator has shown the variation to meet BAT and other requirements for the varied installation, summarised in the Table below.

We consider that the kiln remains primarily under the Cement, Lime and Magnesium Oxide BATc, that the CHP is most closely aligned with the LCP BAT conclusions (although these are not directly relevant), and that the CCP is informed by the UK "Guidance on emerging techniques" for post-combustion carbon capture with amines, noting that it is indirectly relevant, and does not have the authoritative status of BATc. The operator has referenced several other BATc, and we agree that these are informative in determining BAT for the overall installation.

We have specified that the applicant must operate the permit in accordance with descriptions in the application. See section 10.4 of this document for more information on how we have incorporated the application/variation into the permit and section 10.5 for how emission limit values have been set.

Plant / Equipment	BATc, guidance or minimum standard	Operator assessment against requirements	Regulator assessment summary
Post combustion capture (PCC)plant *(all parts from additional inlet gas pre-treatment, to compression and export of CO_2 and emission of residual exhaust gases)*	UK Guidance - Post-combustion carbon dioxide capture: emerging techniques Indirectly relevant (informative) as aimed at combustion plant and energy from waste, emerging guidance without the authority of formal BAT conclusions	4E assessment against PCC emerging techniques – assessed as compliant by the operator with all relevant criteria 4a MHI_Tech_Selection_NRW specifically provides justification of the use of a proprietary solvent mix, rather than the reference monoethanolamine capture (part 3.2 of guidance)	Indirectly applicable and compliant, with notes as below
CHP Plant	Minimum Standard: IED chapter III	4D justification that Ch III LCP standards are not relevant	See below. Agreed during determination that these standards are not directly applicable, but informative to integrated Kiln-CHP-CCP arrangement
	LCP BATc	LCP BAT assessment (general) And 4c LCP BATc 40,41, & 44	Indirectly applicable; shown to be compliant with narrative and BAT-AEL performance as far as possible in an integrated system design as noted for minimum standards

Individual components of the flue gas treatment and PCC train	Various	4b justification of BAT for each process stage	Acceptable brief justification is provided for each process step. All technology steps (notwithstanding proprietary design elements) are recognised as BAT for abatement in other installation sectors etc, see below.
Whole variation application: original BAT assessment (prior to NRW requests for further information and provision of the additional reports above)	Various, including post combustion carbon capture guidance (evidence review), energy efficiency BATc, Common Waste Gas Treatment in the Chemical Sector BATc, Industrial Cooling BATc, Large Combustion Plant BATc, Waste Treatment BATc, Emissions from storage BATc, Waste Incineration BATc	C3-3a-01 BAT assessment	Comprehensive assessment of narrative BAT, but not including BAT-AEL performance, and certain other specific points. Hence additional information above, requested by NRW before the application was Duly Made. Much of this BAT assessment is informative, but goes beyond minimum determination requirements: For example the Waste Incineration BATc are not strictly relevant, so assessment against these is additional supporting information.

Cement Kiln plant (existing)	Cement, Lime and Magnesium Oxide BATc	No standalone assessment, but referenced in separate assessments above at various points	Kiln operations are largely unchanged, and NRW did not require a repeat BAT assessment as compliance had already been demonstrated and documented at BREF review. However, where BAT may have been affected by changes (e.g. modifications to main bag plant) NRW consider that the production process continues to be BAT, as detailed below where necessary.

7.3. Our approach to IED Minimum standards (Chapter III for large combustion plant, Chapter IV for waste incinerators and co-incinerators).

Minimum Standards specified in IED

The Padeswood Cement kiln is already regulated as a co-incinerator subject to Chapter IV of the Industrial Emissions Directive. This is standard regulatory practice for cement kilns that utilise waste as alternative fuels and ensures a very high level of environmental protection. In respect of emissions to air, the facility will still have to meet the Chapter IV minimum standards (and also any BAT-associated emission limit levels (AELs)) associated with the process. However, the removal of CO_2 from the exhaust gases will (if all other factors remain the same) increase the emission pollutant concentration, so we will allow the operator to make a further calculation adjustment of the reported emission concentrations, to normalise for the CO_2 captured. Noting that the overall pollutant mass release rate authorised will be unchanged from current situation.

The variation application included addition of a natural gas-fired combined heat and power plant (CHP) with a net thermal input of 132 MW. As a matter of routine, when we received the application, we asked the operator to demonstrate that IED Chapter III minimum standards for combustion plant, and Large Combustion Plant BAT, were met. Were the CHP a standalone unit, these requirements would need to be met in full.

For determination of the application, our initial assumption was that Chapter IV would continue to apply to the Cement plant, and Chapter III to the Combustion Plant (CHP). However, as described in the application and this document, there is a high degree of process integration, with kiln exhaust gases being further exploited as part of the combustion air for the CHP, before passing through to the carbon capture plant. The operators response(s) to BAT information on the CHP make it clear that while the boiler is expected to be effectively compliant with the Chapter III requirements, strict demonstration of conformity (particularly with standalone Chapter III emission limit values) would be extremely impractical, owing to the process integration.

After due consideration, we are of the view that this integration is an elegant technical, BAT-optimised solution. Amongst other features it conserves energy (heat from kiln gases and by use of CHP), minimises CCP treatment gas volume (and so maximises CO_2 concentration and minimises O_2, desirable to the separation process), and potentially reduces VOC from the kiln by providing in effect an "afterburner" solution. It would be highly counter-productive to require process separation purely for regulatory compliance demonstration purposes. However, because it is impossible to completely separate the production processes, it makes it inappropriate to effectively consider the kiln under Ch III, and the CHP under Ch IV. It is both impractical (owing to the similarity but contrasting details of the regulations) and unnecessary to apply Ch III and Ch IV requirements simultaneously.

Article 42 of IED (for incineration and co-incineration) states that "*For the purposes of this Chapter, waste incineration plants and waste co-incineration plants shall include all incineration lines or co-incineration lines, waste reception, storage, on site pretreatment facilities, waste-, fuel- and air-supply systems,* ***boilers****, facilities for the treatment of waste gases, on-site facilities for treatment or storage of residues and waste water, stacks, devices and systems for controlling incineration or co-incineration operations, recording and monitoring incineration or co-incineration conditions.*" Meanwhile Article 28 of IED (for Combustion plant) states that "*This Chapter shall apply to combustion plants, the total rated thermal input of which is equal to or greater than 50 MW, irrespective of the type of fuel used*", but makes specific exclusions (a-j), including *"(j) plants which use any solid or liquid waste as a fuel other than waste referred to in point (b) of point 31 of Article 3".* In simple terms, under IED, a "plant" which may be both is designated as either Chapter III, or Chapter IV, not both.

We have therefore decided to regulate the EPR Schedule 1, 1.1 combustion activity (CHP) as part of the kiln Chapter IV envelope (noting that this includes "boilers", with the CHP being a boiler) and includes auxiliary burners which would normally be exempt from additional regulation. This is in accordance with the chapter III exclusion for "plants" that burn waste, given that the Kiln and CHP complex is thereby considered as one plant. We also consider that it will provide a high degree of environmental protection, noting the following points:

- The majority of Chapter III concerns air pollutants and their monitoring. For Padeswood, pollutants arising from natural gas combustion (CO, NO_X, particulate matter) are already regulated and monitored rigorously under Chapter IV. There is no additional "allowance" in ELVs for pollutants arising from the CHP, so any pollutants generated from the natural gas combustion has to be within the ELVs set for the Kiln. While monitoring detail differs, it is broadly equivalent in purpose and rigour.
- The IED Article 36 requirement for CO_2 storage readiness would not apply to a unit under 300 MW_{th}, but is in any case superseded by the CCP at Padeswood.
- There are comparable (in fact more rigorous) breakdown/malfunction requirements and limits in Chapter IV (Article 46.6, 47) than in Ch III Article 37.

Finally this approach is indirectly supported by definitions in the Waste Incineration BATc (which are not themselves relevant to this plant), where incineration is defined as "The combustion of waste, either alone or in combination with fuels, in an incineration plant." – confirming the position that a (co)incineration plant can include the combustion of other fuels.

7.4. BAT determination comments for key plant process stages in the Variation

BAT for cement clinker production in a rotary kiln

We are satisfied that the modifications to the existing plant are BAT. Recovery of waste heat is recognised as BAT, and augmentation of bag filter abatement with activated carbon (for mercury) and lime (for SO_2 and HCl) addition for enhanced pollutant removal is recognised BAT both in the cement and lime BATc and more widely in a variety of BATc. It is established and proven technology which will both meet the process (CCP) requirements and further reduce emissions to air of these substances.

We are also satisfied that unless discussed further elsewhere in this document, existing compliance with the cement and lime BAT conclusions continues without material change. This has been previously assessed and documented by NRW. The following points are noted:

- CLM BAT 2 – noise – addressed elsewhere in this DD as further work has been required, including under improvement and pre-operational conditions as a result of the variation.

- CLM BAT 4 – as described elsewhere in the DD, we are satisfied that wastes from the CCP can be re-introduced to the kiln as proposed and are BAT.
- CLM BAT 5 – appropriate BAT monitoring is proposed as described; kiln pollutant monitoring requirements continue irrespective of CCP operation or emission point.
- CLM BAT 9 – cogeneration / CHP is relevant BAT and is described elsewhere within the BAT section.
- CLM BAT 11, 24-28– Waste QC for CCP residues returned to the process are specified in the permit and are considered BAT, having regard also for the volumes as well as the compositions of these materials.
- CLM BAT 12 – we are satisfied that BAT is applied in re-introducing CCP residues to appropriate points in the kiln, as detailed in section 10.9 of this decision document.
- CLM BAT 13, – Alongside other relevant comments in this document, it is expected that existing waste management processes will be extended to residues from the CCP as part of review of the EMS as noted elsewhere in this document.

It is noted that the application technical description and Air Quality Assessment (AQA) propose a reduction in ELV for SO_X as SO_2 from 200 mg/Nm^3 to 50 mg/Nm^3, reflecting the enhanced SO_2 abatement in the bag filter and subsequent gas treatment stages, which is calculated to correspond to a reduction of emissions to 29% of their current consent. In contrast, it is proposed to maintain the ELVs for HCl, HF and Hg at their current values (10, 1 and 0.05 mg/Nm^3 respectively) without further "Normalisation" (i.e. correction) of calculated gas volume. However, as noted in the technical description "*Combustion of natural gas with air in the CHP increases the volume of gas released at the CCS stack [compared to baseline] and when considering the worst-case scenario, it appears that the emissions will increase for those parameters maintaining the BAT-AELs. Although theoretically possible, the likelihood of emissions at the ELV are low due to the additional air emission abatement controls in place.*"

NRW has considered this submission, and has discussed it with the operator. We recognise that additional combustion air is necessary for the CHP, and that understanding pollutant and exhaust gas flows is complex. Where these values are used for impact modelling, we recognise that the operator has correctly used "worst case" presumptions for a precautionary approach – in this case assuming that additional combustion air, leading to an increase in total exhaust gas volume (from

66.3 m^3/s as-is to 91-97 m^3/s with CCP, additional air, and accounting for volume reduction by CO_2 removal). We are in agreement that this precautionary approach to impact modelling is appropriate.

We do not agree with an approach to the variation that allows an increase in overall mass-emissions of kiln-generated pollutants (e.g. HCl, HF), particularly with respect of BAT-AELS. Noting that the CHP-CCP itself should and could not be a source of these pollutants. Even if the likelihood of this in practice is low. Ater due consideration, we do not believe that the application is in fact proposing any true increase in emissions, but this is simply a function of the calculation assumptions. Any increase is unacceptable in terms of regulation and BAT, and we have therefore set the permit emissions limit values (ELVS) (at BAT-associated emission level, BAT-AEL) at the same level as before, unless the applicant has requested a lower limit, and placed a note in the permit table S3.1. This note requires the operator to "normalise" (correct) the emissions concentration to disregard any dilution by additional air added at the CHP for kiln pollutants. It also allows the operator to "back-correct" the concentration for CO_2 volume, such that the removal of CO_2 does not penalise the BAT-AEL, as otherwise effectively this further concentrates the emissions which would be an unfair penalty. Pre-operational condition PO 05 requires the operator to develop and submit the correction methodology to NRW for approval. It is anticipated that this correction may be done automatically within the Continuous Emissions Monitoring System (CEMS) data acquisition and handling system (DAHS) for continuously measured pollutants. It is expected that all emissions monitoring reports will reference / acknowledge this correction. The ELVs and requirement for CHP combustion air volume correction (where applicable) for different pollutants are summarised below:

Pollutant and BAT-AEL	**Padeswood Emission Limit Value (ELV) (mg/m^3)**	**Correction (normalisation) to discount CHP combustion / dilution air required?** Note 1	**Rationale**
Particulate matter (PM)	10	Yes	Current ELV is unchanged. Although the CCP could be a source of limited PM (e.g. ammonium

BAT 17 BAT-AEL 10mg/m^3 for bag filter abatement			sulphate aerosols), it is expected that kiln dust emissions will dominate and control must be demonstrated. No relaxation of current (corrected) ELV justified so calculation required to ensure that "whole system" performance at least matches current performance limits.
TOC (total organic carbon) No BAT-AEL but IED Chapter IV minimum standard of 50 mg/m^3	30	No	Operator proposes to reduce limit from 50 mg/m^3 to 30 mg/m^3 as part of variation which assures BAT and Chapter IV compliance of the kiln at the revised ELV and ensures no relaxation of current limits. The existing limit of 50 mg/m^3 is from IED Chapter IV – the BATc do not limit TOC further. Both the kiln and the CCP are potential sources of TOC so correction is meaningless. CHP natural gas burners and Selective Catalytic Reduction (SCR) are expected to reduce TOC from the kiln, amines and by-products from the CCP present a new and separate source.
Hydrogen chloride (HCl) BAT 25 BAT-AEL <10mg/m^3	10	Yes	ELV based on BAT-AEL, and continued demonstration of compliance with BAT-AEL is required. Additional gas cleaning is likely to reduce HCl emissions, but uncertainty of measurement exists at low levels which is likely reason why operator has not proposed ELV reduction. There is no source of HCl from the CCP, though it may affect emissions – e.g. via accumulation and release of Cl from wash waters etc.
CO No BAT-AEL	400	No	Operator proposes ELV reduction from 1200 mg/m^3 to 400 mg/m^3 as part of variation. General BAT compliance and no relaxation of current limit by "dilution" is assured, noting that CO from the Chapter IV "envelope" (both the kiln and CCP) is included – both are potential CO sources though the natural gas combustion may reduce kiln CO by oxidation to CO_2.
SO_X as SO_2	50	No	Operator proposes ELV reduction from 200 mg/m^3 to 50 mg/m^3 as part of variation. BAT compliance and no relaxation of current limit by "dilution" is assured. Note separate

BAT 21 BAT-AEL <50-400 mg/m^3			measurement of SO_3 is introduced, owing to new risks around formation in SCR, and possible impact on aerosol formation and consequent amine emission if not controlled.
Oxides of Nitrogen (as NO and NO_2 as NO_2) NO_X BAT 19 BAT-AEL <200 – 450 mg/m^3	200	No	Operator proposes ELV reduction from 450 mg/m^3 to 200 mg/m^3 as part of variation. BAT compliance and no relaxation of current limit by "dilution" is assured by new limit without need for correction.
NH_3 BAT 20 BAT-AEL <30 – 50 mg/m^3 with SNCR	30	No	Operator proposes ELV reduction from 70 mg/m^3 to 30 mg/m^3 as part of variation. BAT-AEL compliance and no relaxation of current limit by "dilution" is assured by new limit without need for correction. Note the 2016 BATc decision document explains the old limit of 70 mg/m^3, which was a function of kiln and SNCR slip NH_3. No such calculation is now needed, the limit is for the whole process at end-of-pipe and is BAT.
HF BAT 26 BAT-AEL <1 mg/m^3	1	Yes	ELV based on BAT-AEL, and continued demonstration of compliance with BAT-AEL is required. Additional gas cleaning is likely to reduce HF emissions, but uncertainty of measurement exists at low levels which is likely reason why operator has not proposed ELV reduction. There is no source of HF from the CCP, though it may affect emissions – e.g. via accumulation and release from wash waters etc.
Cadmium (Cd) + Thallium (Tl) BAT 28 BAT-AEL <0.05 mg/m^3	0.05	Yes	ELV based on respective BAT-AEL, which is also IED Ch IV "minimum standard" performance. Correction to ensure compliance demonstration without dilution / reduction in plant performance. Additional gas cleaning is likely to reduce emissions of all metals, notably Hg, (noting use of activated carbon), but as the operator has not proposed ELV reduction so correction is necessary.
Mercury (Hg)	0.05	Yes	

BAT 28 BAT-AEL <0.05 mg/m^3			
Metals (Sum Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V)) BAT 28 BAT-AEL <0.5 mg/m^3	0.5	Yes	
Dioxins and furans (I-TEQ) BAT 27 BAT-AEL <0.05 – 0.1 ng I-TEQ PCDD/F /m^3	0.1 ng/m^3	Yes	ELV based on BAT-AEL (BAT27), which is also IED Ch IV “minimum standard” performance. Correction to ensure compliance demonstration without dilution / reduction in plant performance. Additional gas cleaning (activated carbon, SCR), is very likely to reduce emissions of dioxins and furans, but as the operator has not proposed ELV reduction so correction is necessary.
New pollutants associated with CCP and new abatement: SO_3, amines, N-amines, formaldehyde, acetaldehyde.	As specified in permit	No	These pollutants are not associated with Kiln operations and do not require correction for kiln gas volumes / parameters for compliance. The limits set in the permit are those proposed by the operator and are site-specific BAT as also informed by impact modelling.

Note 1: For pollutants marked “no” although correction of ELVs to kiln volume is not required, NRW will accept a volume correction and concurrent increase in numerical ELV via permit variation, if this simplifies reporting and compliance assessment, given that we do require correction for some pollutants. Such a change would be technical in nature, and although the ELV number would be adjusted, the actual emissions performance will be unaffected. For all pollutants, correction to account for CO2 volume removed is permissible if relevant.

BAT for large combustion plant as applied to the CHP

Complementary to the approach to minimum standards outlined above, we have similarly determined that the LCP BAT conclusions are not directly relevant, as the combustion is taking place within a co-incineration plant (cement kiln), not in a “combustion plant” as per the scope of the BATc: *“1.1: Combustion of fuels in installations with a total rated thermal input of 50 MW or more, only when this activity takes place in combustion plants with a total rated thermal input of 50 MW or more”.* However, as neither the cement & lime BATc nor other relevant guidance cover BAT for the CHP, we consider the LCP BATc as indirectly relevant in determining BAT, and to be followed as far as possible. The application BAT assessments also reflect this. In general terms, we agree that the proposals for the CHP are BAT, noting the following:

- LCP BAT2 – The requirement to measure net total fuel utilisation (“energy efficiency”) is acknowledged and is required through permit Table S3.5 – process monitoring (net total fuel utilisation). It shall be completed as a requirement of IC 18.
- LCP BAT3 – while there are no normal operation emissions from the CHP, it is expected that the BAT ancillary measurements of Flow, O_2, temperature, pressure, and water vapour will be measured or calculated for the CHP outlet / CCP inlet, unless otherwise agreed in writing by Natural Resources Wales.
- LCP BAT7 – SCR optimisation – this requirement is acknowledged and is addressed through improvement condition IC 21.
- LCP BAT9 – Natural Gas composition is well characterised and consistent. Requirements are minimal compared with less consistent or more polluting fuels.
- LCP BAT16 – waste management is discussed for the new plant as a whole, below. Within this, we are satisfied that waste management from the CHP component is satisfactory.

- LCP BAT17 – noise is discussed for the plant as a whole, below. Within this, we are satisfied that noise minimisation and management from the CHP component is satisfactory.
- LCP BAT40 – a net total fuel utilisation of 78-95% is required for this plant. An efficiency of 80-85% is expected, and will be measured as specified in LCP BAT2, reportable under IC 18 and according to the performance monitoring specified in the permit.
- LCP BAT41 – in addition to Cement & Lime BAT performance for NO_X, the application states that the net NO_X emissions will not increase as a result of the CHP unit. Furthermore, the identification of various relevant primary NO_X control techniques for the CHP confirm that combustion performance in respect of NO_X generation and subsequent abatement from the CHP will be BAT, and that emissions performance will not be excessively reliant on end-of-pipe abatement (i.e. SCR only). This will be confirmed via LCP BAT7 and IC21.
- LCP BAT44 – as per BAT41 for NO_X, the application states that the net CO emissions will not increase as a result of the CHP unit. Furthermore, the burner management system referred to in the BAT assessment, along with optimisation under BAT7 confirm that combustion performance in respect of CO will be BAT for the CHP.
- Finally, while not a specific requirement of the LCP BATc, we recognise the implicit selection of a steam-raising boiler with back-pressure turbine for steam and electricity production as a technology selection step, with natural gas as the fuel, and carbon dioxide capture from the exhaust gases (as integrated with kiln operations). We agree that natural gas combustion for additional power demand, using a steam generator, is BAT for the site-specific energy requirements (i.e. majority heat from steam and minor electricity proportion).

Carbon dioxide capture

Carbon dioxide separation from exhaust gas emissions is still an emerging technology undergoing rapid development. Therefore, there is not the formal and established BAT guidance for the technique that there is for other processes. In this situation, regulations require NRW to set permit conditions on the basis of BAT that we determine to be appropriate, after consultation with the operator. In anticipation of this need, UK regulators have been working with industry, academics and other leading experts to inform initial BAT for this application. A summary of work done can be found on the UKCCSRC website. In their initial permit application BAT C3-3a-01 BAT assessment the operator sought to demonstrate BAT against the full technical

evidence review for post-combustion CO_2 capture. Note that this document has been published for several years, and the 2024 date is the latest update. The BAT assessment provides strong evidence that the carbon dioxide capture process is likely to be BAT, and we are satisfied with the operators submission. However, in addition to the full evidence review, UK regulators have published formal "Guidance on emerging techniques – Post combustion carbon dioxide capture" which is informed by the wider technical review. It is in general terms, shorter and more specific as to requirements. Before the application was duly made, we therefore also asked the operator to assess their proposals against this guidance, with their response being report 4E assessment against PCC emerging techniques. As noted in the guidance, it is intended for power plant and energy from waste plant, so in the absence of sector specific guidance, we consider it relevant to cement production, but will allow a greater degree of site-specific flexibility if required. Having considered the operators BAT assessment against the PCC guidance, we agree that the proposal is BAT, noting the following key points:

Ref	Requirement	Comment
2.1	Power plant integration and energy efficiency	Addressed above and throughout operators BAT assessment. The CHP component will meet the LCP BAT-AEEL net fuel utilisation. A high degree of energy efficiency and integration is noted throughout the whole project, with recovered heat from the kiln being used in the PCC, heat exchangers used where appropriate in the PCC, and energy efficiency is acknowledged as a key choice in equipment selection etc, see below. The cement process differs from a power or EFW plant in that the PCC is not solely a further energy penalty on generation capacity and "parasitic load", but requires a bespoke CHP to provide sufficient energy for the PCC reaction process.
2.2	Dispatchable operation	As noted, N/A as the cement plant is not dispatchable, and any scenarios other than cement kiln, CHP and PCC plant all operating fully would be NNO for the installation. Normal fluctuation in cement manufacturing (raw mill and other ancillary processes on or off is regarded as part of normal operation envelope, as is any duty load of CHP between minimum stable load and maximum continuous rating).
2.3	Heat and power for PCC	A new, dedicated CHP *("ancillary plant")* is proposed and appropriately sized to provide heat and power to the CCP. This is appropriate to the cement operation where additional external heat is required. A back-pressure turbine

		is appropriate to the relative requirement for electricity and steam/heat. CO_2 emissions will be captured from the additional generation plant.
3.1	PCC plant design purpose	The application as a whole demonstrates that the requirements are met, including acceptable environmental risk in respect of air emissions, suitable preparation/specification of captured CO_2 for transmission into the storage network. A key requirement is the intent to achieve 95% carbon dioxide capture (as an annual average over all normal operation). The operator has indicated that this is the case.
3.2	Solvent selection	The operator has provided brief justification of selection of a proprietary solvent mixture which includes secondary amines and has the potential for nitrosamine and other breakdown formation. Stated advantages include lower absorption reaction energy consumption and lower solvent flow for effective capture, lower volatility, lower thermal and oxidative breakdown. We accept that this option can be BAT, while not precluding other approaches, noting that the application addresses the potential concerns associated with the solvent selected in terms of impact control. The air emissions risk assessment demonstrates very low process contributions for breakdown products of concern (see below) through a series of measures, both to mitigate against solvent breakdown (and hence release of solvent by-products), and to prevent solvent /by-product escape, which is indicative of BAT. The solvent reclaim process is proprietary, and matched to solvent (i.e. provided by the same supplier). It does however contain the solvent reclaim processes expected by BAT, including thermal and alkali steps to treat heat solvent salts and separate useable solvents from breakdown products/impurities. However, we do note limited information on the expected performance of the solvent system, the degradation / regenerator & reclaim control (temperature, other monitoring) / consumption rate, and limited evidence provided of previous performance data from other applications, when compared with "BAT" expectations. Given the commercially nascent development of the technique, this is unsurprising. We have therefore included pre-operational condition PO 06 and improvement condition IC 14 to provide us with further information on the key operational parameters to be monitored to ensure system stability, efficacy, and efficiency, to demonstrate that the plant is operating optimally with no adverse performance indicators such as excessive solvent consumption. We will monitor these during commissioning and early years of operation (including as a requirement of IC20), and this in turn will inform future BAT. The permit also requires monitoring and reporting of key process parameters to ensure BAT in respect of solvent performance, some

		of which are already specified in the permit Schedules, and some which will be added to as a result of operator information provided in respect of the PO/ICs above.
3.3	Minimisation of emissions	The application, including the BAT assessment, confirms that the proposed design is in accordance with Guidance on Emerging Techniques (GET) requirements, and is considered site-specific BAT: • Extensive "polishing" of inlet gas (NO_X, SO_X, HCl), and control of NH_3 which will serve to minimise solvent breakdown with appropriate techniques as required, including specifically for SO_3 to control risk of solvent loss via aerosol formation, and to address issues of ammonium sulphate formation with ammonia. Lower ELVs are proposed for these kiln-arising pollutants, reflecting the enhanced gas cleaning (as well as any further removal in the CCP itself). • Effective abatement of amine emissions via 3-stage wash tower (including acid wash) and with proprietary demisters to address aerosol risks. IC 20 (full commissioning report) specifically requires information to confirm control of aerosols, given that they may be critical to solvent loss, and that detailed information in the application is limited, although stated emissions performance is satisfactory (proprietary demister units in the wash tower, wet Electro Static Precipitator ([W]ESP) after the quench, to reduce aerosol carry-over into the capture plant, upstream). It is expected that response to IC 14 (preliminary commissioning report) will also cover this matter. • The application demonstrates a clear understanding of the implications of trace pollutants from the kiln on CCP performance and emissions. For example, mercury removal is enhanced primarily to protect the CCP structural integrity. It is evident that all other components of the influent gas to the CCP have been considered for their possible effects on the process. • As noted in 3.2 above, information on operating temperatures of the reclaim and recovery units, and on solvent degradation is limited. The application demonstrates that BAT is expected to be achieved, but the PO / ICs above will provide evidence to the regulator, and allow us to require further optimisation if necessary. • The amine wash tower meets the GET requirements, having 3 stages, each of which has a proprietary demister, and the last stage of which may function as an acid wash if required. Combined with abatement, flue gas reheating and stack height ensure that (as

		dispersion modelling shows), the environmental impact of pollutants from the PCC are acceptable, as detailed later in this documents. Furthermore, we are satisfied that the operator has provided suitable (reasonable worst case) information on the credible emissions from the process arising from the carbon capture plant / solvent, as summarised in Table 1 of the application. Further information provided under a confidentiality claim has allowed NRW to correlate emitted substances with supplied solvent composition, and to be satisfied that further chemical substances have been considered and/or tested for emission, but have been shown not to be present (at levels at least an order of magnitude lower than those in Table 1 for substances with comparable structures).
3.4	Monitoring	The operator has demonstrated commitment to BAT by confirming that appropriate monitoring will be in place, including emissions to air (kiln pollutants and CCP pollutants), CO_2 metering and monitoring [to enable mass balance approach], and process control monitoring for both solvent/absorber condition and efficacy (including breakdown products), and wash tower efficacy. All emissions to air will be monitored at the final stack, unlike some operators who propose to demonstrate production plant compliance upstream of the CCP – but we currently consider that either may be BAT. The BAT assessment (and GET guidance) refers to further work being required, to develop methods for CCP emissions monitoring, and to establish the best framework of monitoring for process control of the amine absorber. Many key parameters are listed and understood, but the CCP technology is still developing, and it is recognised that further refinement of approach will occur, not least as a result of learning from operational plant. The application makes reference to Brevik, a CCP project by the same company, which will commission first, and will inform details of the Padeswood approach). This uncertainty is not ideal at the permitting stage, but reflects an emerging industry. The operator has committed to implementing whatever monitoring and process control is necessary to effectively operate and manage the plant. We agree that the operator understands the basic BAT requirements of process monitoring, and is continuing to work to substantiate the detail. We have imposed a series of rigorous, detailed pre-operational and improvement conditions (PO 02, 06, IC 11, 14, 15) to require the operator to fully identify and agree with NRW suitable emissions and process monitoring before commissioning commences, and to share operational information and learning once the process is running, to justify ongoing process monitoring arrangements that show the plant to be operating optimally. This work will

		include, as necessary, active participation in efforts to develop monitoring techniques for amines and nitrosamines, where this is still required across the sector (PO 08, IC22). Furthermore, the emissions monitoring requirements specify increased frequency of monitoring during early operations, do demonstrate process control until full operational stability and performance is established.
3.5	Unplanned emissions	The operator has committed to a preventive maintenance programme (which will form part of the EMS) to minimise risk of unplanned emissions. The main BAT assessment makes limited reference to a leak detection and repair programme and a pre-operational condition PO 04 requires this to be fully developed. The application environmental risk assessment and EnvID detail risks including unplanned emissions from the CCP, and show risks to be adequately controlled for the pre-construction phase. Further detail will be developed in the EMS. Specifically, the EnvID recognises that the actual composition of waste (and circulating) solvent needs to be considered when assessing risk, a point specifically noted in the GET guidance, and one which we require to be addressed via PO 06.
3.6	Capture level, flexible operation, start-up and shut down	See 2.2 and 3.1 above. The design is expected to achieve 95% capture as an annual average over all normal operation of the installation, excluding NNO of any part of the system. Capture rate for all operational time including NNO will also be monitored. A NNO management plan is a requirement of PO 04 and will be reviewed within 12 months of operation under IC 19. A cement plant is not intended to operate intermittently or be “dispatchable”, and we would in fact consider BAT to include minimising start-up and shut-down events (which is a reason why conditions 2.3.14 and 2.3.15 of the permit allow limited abnormal kiln operation; to minimise the environmental impact of avoidable start-up and shut-down events). BAT is demonstrated for the capture rate intention; the other requirements are N/A.
3.7	CO_2 compression	The operator has acknowledged BAT requirements, but has not finalised compressor details. In terms of overall BAT, this is a relatively minor point relating to energy efficiency and heat recovery. PO 02 requires the operator to confirm the design detail and to demonstrate, for our agreement, that the design is BAT. However we consider that any reasonable design is capable of being BAT, and lack of detail on this matter does not prevent us making our permit determination decision. Noise from compression is largely a separate BAT issue as noise must be considered holistically, and performance is dependent on mitigation (enclosure) as well as equipment selection, meaning that our decision is not dependent on compressor selection in respect of noise (below).

3.8	Noise and odour	Noise impact is dealt with in a separate section of this document. Noting the applicant's statement that "*Noise sources have been identified, mitigation proposed and modelled*" – with the detail in the noise impact assessment, we accept that the design is BAT based upon equipment and techniques employed, and resultant impact predicted. The operators noise impact assessment (section 9) includes a BAT assessment for noise sources relating to the proposed variation (CCP) and references relevant BAT conclusions other than the CCP guidance. We are satisfied that BAT is demonstrated for the individual items of equipment within the CCP as listed in Table 9.2, in so far as appropriate techniques are identified and proposed to achieve the noise impact described in their report. However, owing to outstanding uncertainties in noise impact of the installation (principally relating to noise from existing activities) this BAT assessment must remain under review, and further measures be implemented if it is found that the new sources could cause or contribute to significant adverse effect at receptors. Pre-operational condition PO 10 therefore requires review of the BAT assessment alongside other noise work. BAT as documented for new equipment in the application represents the minimum that NRW will accept for the variation, and further improvement may be required to these sources to demonstrate continued/updated BAT upon completion of the PO/IC's. The operator has submitted an odour risk assessment with the application, covering the existing and new proposed facilities. It assesses that the risk of complaints from odour is negligible. For the new facilities, we agree that this is the case, given the need to control emissions of potentially odorous emissions (amines, ammonia) for other reasons – i.e. human health protection, ELVs and leak detection and repair. We accept that measures to control odour, , are BAT and we consider that permit conditions 3.3.1 and 3.3.2 are sufficiently protective.
3.9	Hot potassium carbonate	N/A as amine based CO_2 capture has been selected and justified.
4	Cooling	Cooling is addressed in the original BAT assessment against "industrial cooling" horizontal BATc. As summarised in the PCC submission, a combination of many techniques for cooling/heating is evident. We are satisfied that BAT is demonstrated.
5	Discharge to water	N/A – zero discharge design of new plant.

6	Other – gas conditioning & drying	The application (technical summary) describes that oxygen removal and drying is required for the captured compressed CO_2 before it can be exported from site. The oxygen removal is via oxidation of hydrogen to produce water, as described. Hydrogen is generated in-situ at relatively small scale, using an electrolyser for use solely within the process but although the activity is minor in relation to the scale of the CCP, regulations require that it is listed as a separate permitted activity. We are completely confident that based on preliminary information, the scale of H_2 production is BAT within the total project envelope. Nevertheless, regulatory GET guidance on H2 production by electrolysis identifies specific typical best practice requirements. We have therefore required the operator to confirm electrolyser design parameters against GET requirements as a pre-operational condition PO 02.

Individual process stages

Given the complexity of the multi-stage flue gas processing plant for carbon capture, and noting the numerous discrete steps of gas treatment, we asked the operator to explain the individual steps and their integration, and to justify that each step in turn was BAT. They did this via the updated Technical Description of the process and the 4b justification of BAT for each process stage. This has enabled us and the public to better understand the overall process configuration, for example the benefits of integrating the CHP into the kiln exhaust gas stream, and of SO_3 removal to prevent subsequent issues with ammonium sulphates or SO_3 either on the CCP process (e.g. leading to excessive solvent consumption) or as a contributary factor in amine emissions. This is particularly important for emerging commercial technology, which may be less well understood than is typical in installation permit applications.

We are satisfied with the coherence of the overall post-kiln CCP design described in the application, based on numerous sequential treatment stages and supporting processes. We consider that each step individually, and the overall process collectively, is BAT, as described in the application. NRW observe that while individual components may be viewed as unfamiliar or novel to the non-specialist, or within the cement industry, each of the fundamental technologies is well known from other processes and industries. For example, quench-based Flue gas desulphurisation (FGD) with slaked lime is commonplace in coal-fired power plant (as well as recognised in cement & lime BATc), and Wet ESPs for particulate control in saturated gases are noted in several industry sector BAT conclusions. It is further noted that

enhanced measures (e.g. more advanced techniques, proprietary technology) is employed at critical process stages, such as where carry-over into the next process stage is detrimental. Examples include the use of Wet ESP in the quench, where more simple mist elimination may have been proposed, and proprietary demisters are used in the amine wash tower, where droplet removal is recognised as critical to process control. This further demonstration of BAT is particularly important given the emergence of carbon dioxide capture from exhaust gasses as a new approach, and provides strong assurance that the techniques applied, all of which are already deployed commercially across a range of applications and industry, are BAT for this new application. As noted above, IC 20, 21 will allow us to monitor progress of the installation, both to continue to assure that BAT is demonstrated, but also to inform BAT for future facilities.

Horizontal BAT – energy efficiency, industrial cooling, and storage.

The operator's application in respect of horizontal (cross cutting) BAT – which applies across different industries/sectors, is described above.

During duly making, we asked the operator to compile a full list of secondary (passive etc) emission points and their abatement, particularly with regard to storage tank breathers, overpressure valves etc, recognising that these would typically be minor emission sources. The operator responded accordingly. Subsequently, we have determined that provided it is clear that appropriate measures will be in place (inventory of emissions points, identification of appropriate controls, fugitive emission plan / leak detection and repair / preventive maintenance for passive abatement), then the detail could be finalised in response to a pre-operational condition 02. However, from this information, we did note the operator's statement that [for passive vents, pressure relief valves etc] *"an estimate of composition and release volume will be made to determine if abatement is required. With appropriate abatement installed, any residual emissions will be negligible of particulates and chemicals*", and cross referenced this with respect to their BAT assessment for Emissions from Storage (EFS) horizontal BAT conclusions, particularly BAT5 and BAT11, also BAT 39. These state that "*BAT is to abate emissions from tank storage, transfer and handling that have a significant negative environmental effect*" and that vapour treatment (for emissions to air) is BAT for storage of more harmful substances, with BAT 39 providing

further detail for the valves associated with storage. The response to BAT 11 indicated that it was not applicable. Given the information in the SDS on the solvent hazards identification *(including the full version of the SDS accepted as confidential)*, we were of the view that the enhanced requirements of BAT11, 5, and 39 (i.e. a vapour treatment unit and consideration of BAT39 (d) additional measures for valves such as diaphragms, bellows or double walled valves, may be relevant. We asked the operator for clarification of this during the determination, and they have confirmed that the BAT applies, and that such BAT measures will be adopted in the design.

With this one matter resolved, We are satisfied that BAT has been demonstrated for cross-cutting issues as identified.

Note that the EFS numbering above is as adopted by the operator: the 2006 BATc did not adopt formal numbering.

Other potentially relevant BAT

We note the comprehensive set of BAT assessments in respect of other secondary BAT conclusions. We are satisfied that BAT is demonstrated for the proposed new activities, and have in our determination referred to these as necessary. However, these generally represent additional information, and while we are in general agreement with the conclusions, we have not audited responses to every point, where this goes beyond what is necessary for determination. Specific points of agreement (or disagreement/clarification) are as noted above.

7.5. Other BAT determination comments

Efficient use of raw materials, water and energy

Having considered the information submitted in the application, we are satisfied that the applicant will ensure that raw materials, water and energy are used as efficiently as possible as also required by permit conditions 1.2 and 1.3. Natural gas will be combusted efficiently in the CHP, the solvent system has been selected with reference to its lower CO_2 separation energy requirements, and there is evidence of significant energy integration within the design envelope. There is evidence of considerable water efficiency efforts leading to a zero waste discharge outcome, and numerous measures are in place (which will be monitored by NRW via the permit including Pre-operational and improvement conditions as already identified) to ensure the efficient

use of solvent mixture via measures to prevent both irreversible loss to breakdown products, or emission from the system.

The operator will be required to report energy usage and resource efficiency performance parameters under condition 4.2 and Schedule 4 of the permit (Table S4.2). This will enable us to monitor energy recovery efficiency at the Installation.

Avoidance, recovery or disposal of wastes produced by the activities

Having considered the information submitted in the application, we are satisfied that the waste hierarchy referred to in Article 4 of the WFD will be applied to the generation of waste and that any waste generated will be treated in accordance with this Article.

We are satisfied that waste from the Installation that cannot be recovered will be disposed of on or offsite using a method that minimises any impact on the environment. Permit condition 1.4.1 of the permit will ensure that this position is maintained.

Flue gas Treatment changes and products of incomplete combustion.

NRW have considered whether the proposed changes to the Kiln flue gas treatment could, holistically, present a risk of altering the emission profile for persistent products of incomplete combustion such as dioxins and furans. Specifically, whether any of the temperature gradients in the flue gas path risked de-novo synthesis of dioxins. We have briefly examined this question and are satisfied that there is no likely risk. The de-novo synthesis occurs at a temperature range of ~200-400 °C, i.e. upstream of the existing bag filter in the Kiln which is unchanged. Heating by the CHP burners and subsequent cooling by the boiler will inevitably lead to this temperature window, but the residence time will be comparable to that in other (co)incinerator heat recovery systems. Furthermore, it is anticipated that the gas burners may to an extent act as an “afterburner” further reducing VOC content from the kiln. It is expected that the SCR catalyst will result in further dioxin destruction in the section of the plant where the temperature (stated for SCR in application as ~300-400 °C) could otherwise lead to dioxin formation . The application Technical summary refers to reduction of TOC (Total organic carbon, equivalent to VOC) from the SCR, and a detailed US EPA report on SCR confirms that although the same question has been raised previously for other plant, SCR is in fact known to reduce dioxin concentrations. This is also reported

elsewhere for (co)incineration and it is noted in the waste incineration BATc (30) that SCR is a technique for dioxin reduction. Once flue gases enter the pre-CCP quench, the potential for further dioxin formation is negligible.

8. Our Determination: The Application Environmental Impact Risk Assessment

Regulated activities can present different types of risk to the environment, these include noise and vibration, accidents, odour, fugitive emissions to air and water; as well as point source releases to air, water, sewer and discharges to ground or groundwater, global warming potential and generation of waste. All these factors have been considered during our determination and the relevant risks from this proposal are discussed in this and other sections of this document.

The next sections explain how we have approached the critical issue of assessing the likely impact of emissions from the Installation on human health and the environment and what measures we are requiring ensuring a high level of protection.

In line with our guidance, the applicant has provided an environmental risk assessment with the application which identifies the sources of key risks from the variation, possible pathways and receptors. This risk assessment and further assessments provided by the applicant and/or completed by NRW are summarised here and will be discussed in further detail below:

- Over-arching risk assessment.
- Supplementary EnvID assessment
- Odour risk assessment
- Application noise assessment (dated 03/01/2025)
- Air quality assessment
- Air quality assessment – supplementary work for atmospheric reaction N-amine formation (initial, application)
- Schedule 5 response 1 (PART), [13/05/25]further N-amine atmospheric formation information for AQA, further information and Ciria C736 assessment of secondary containment (partial response) .

- Schedule 5 response 2 (PART), [22/05/25] noise baseline survey (including with existing plant "off").
- Schedule 5 response 3 (PART), [11/06/25] further information and explanation of secondary containment to support Ciria report already submitted.
- Schedule 5 response 4 (PART, "Final") [23/06/25]– Updated noise impact assessment (supporting modelling files submitted by separate cover).
- Further updated Noise Impact Assessment [08/08/25] following dialogue with NRW regarding deficiencies in previous Schedule 5 noise response.

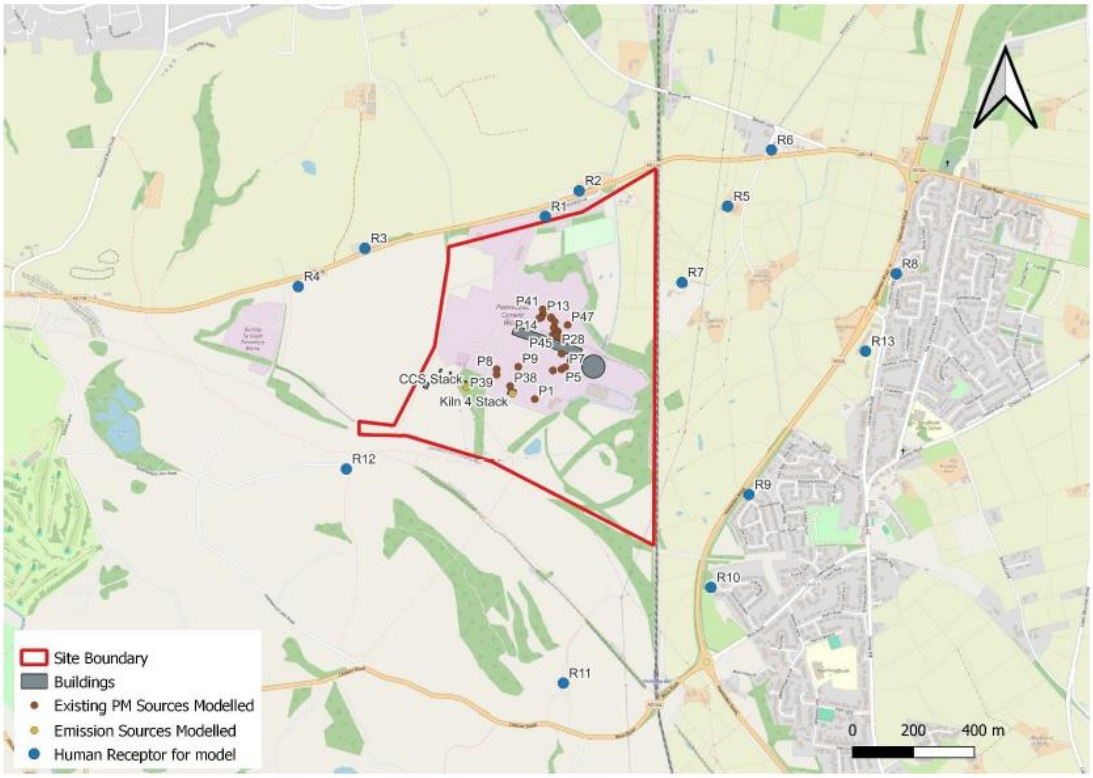
There are no emissions to sewer, nor other emissions of process effluent arising from the variation. Uncontaminated water discharge is addressed below.

8.1. Sensitive environmental receptors

For relevant pollutants, notably noise, air quality and secondary containment of potentially polluting substances, the operators topic-specific risk assessments identify specific sensitive receptors that may be affected. Typically but not always, the highest impacts are close to, (and for air pollutants, often downwind), of the installation. As shown below, 13 specific (residential) receptors were identified for the air dispersion modelling. No specific receptor classifications (e.g. hospital, nursing home, school or air quality management area [AQMA]) were noted in the vicinity.

There are no AQMA's in North Wales, and the closest to the site is >10km away (Chester). NRW did note that it was approximately 3.7 km to A494 at Deeside which is noted in the Clean Air Plan for Wales for NO_X concerns and we will have regard for this in our determination in respect of NO_X.

Figure A2: Human Receptors included in the Dispersion Modelling Assessment



For noise, the specialist consultants identified 32 nearby and representative noise sensitive receptors as illustrated below and shown in full in their report, with the closest being <200m from the site.

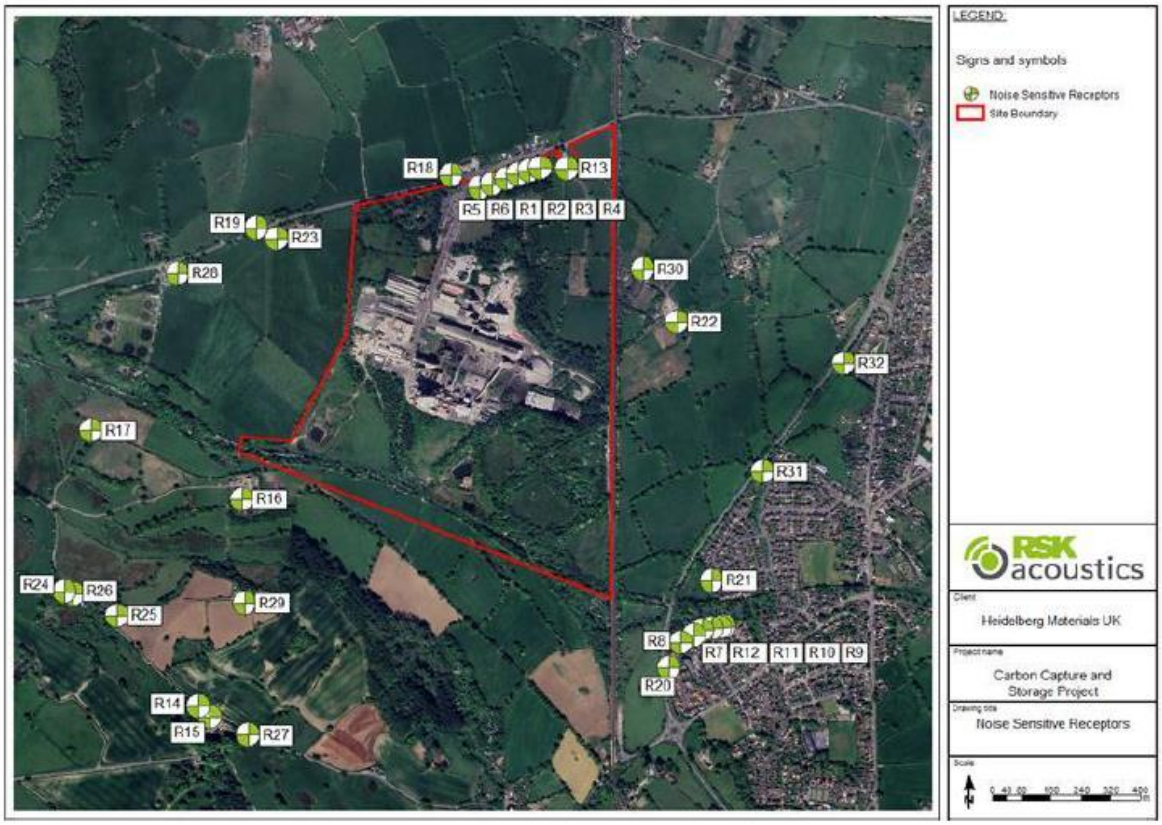


Figure 1. 1 Site location and sensitive receptors

For loss of containment of liquids risks, both local (e.g. stream/watercourse) and sensitive (e.g. designated habitat) receptor risks were considered.

We are satisfied that the operator had due regard for most sensitive/impacted receptors in their topic-specific risk assessments.

8.2. Assessment of impact on air quality

This section of the decision document deals primarily with the dispersion modelling of emissions to air from the stack and its impact on local air quality for human health. Impact on ecological / protected sites is detailed in section 9 although the approach to impact modelling is the same. Links to the reports provided by the applicant can be found in section 8 above.

Identification of emissions to air

Air emissions from the cement industry are well characterised, and the Padeswood permit already contains emission limit values (ELVs) for those pollutants:

- Particulates,
- Total Organic Carbon [TOC],
- Hydrogen Chloride,

- Carbon Monoxide,
- Oxides of Sulphur (as SO_2),
- Oxides of Nitrogen (NO and NO_2 as NO_2),
- Ammonia,
- Hydrogen Fluoride,
- Cadmium and Thallium & their compounds,
- Mercury and its compounds, and;
- the sum of specified toxic / heavy metals: antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, and vanadium (and their compounds)
- Dioxins and furans

Addition of the CCP has the potential to change the emissions of these pollutants. The operator has proposed lower limits for TOC, CO, SO_2, NO_X and ammonia, recognising that the CCP train will necessarily reduce emissions of these compounds as explained in the application and the BAT assessment above. Specifically for NO_X (and CO) these pollutants are also potentially generated by combustion in the CHP, but any additional loading is more than offset by improved abatement. Furthermore, the CHP and integral SCR is expected to decrease levels of other pollutants including TOC, dioxins & furans. This is in addition to specific abatement introduced to prepare the gas for the CCP, such as mercury and SO_2 removal in the main bag filter, and further SO_2 removal in the wash/quench stage prior to the CCP.

However, addition of the CCP also has the effect of introducing new potential emission substances, which are those associated with the carbon dioxide separation process, namely the amines used for CO_2 separation/capture, and breakdown products arising from those materials. These are detailed in the air dispersion modelling reports mentioned above, and listed in Table 1 of the application.

Amines are carbon-containing molecules that are derivatives of ammonia (NH_3), i.e. they contain the :Nitrogen (N) functional group, with 1 or more Hydrogen (H) substituted with a hydrocarbon chain. Amine chemicals are widespread; some are naturally occurring, while others are anthropogenic. Amines are encountered in a wide range of applications including cosmetics and personal care products, as pharmaceutical agents, and as industrial intermediates in the manufacture of final

products. Naturally occurring amines occur in all living systems, the most notable of which are alpha amino acids, the building blocks of proteins which form the basis of living organisms.

The majority of amines used in carbon capture are anthropogenic, with the properties of different amines being engineered to facilitate rapid, effective, and reversible CO_2 capture at high efficiency (capture rate and energy penalty) while aiming for minimal amine loss, breakdown or other (non-target) reactions in the carbon capture plant. Nevertheless, unwanted side and breakdown reactions are inevitable in any system, typically leading to lower molecular weight hydrocarbons etc. Of note for amines are well-known reactions with other N-containing molecules, such as reaction of secondary amine with nitrogen oxide (NO) to produce Nitrosamine (R_2N-NO) and nitramine (R_2N-NO_2). These have been noted in other sectors for many years (with nitrosamines tightly controlled in, for example, foods and pharmaceuticals, where concern over exposure has been documented). Nitrosamines are primarily of concern because some are known, suspected, or potential carcinogens, as their chemical structure and reactivity means that they can interact with DNA. It is therefore imperative that their emission and formation in CCP is tightly controlled.

It is beyond the scope of this document to discuss all of the specific amines, their characteristics, and potential breakdown products, but as detailed in section 7.4, we are satisfied that Table 1 represents the full range and concentration limits of additional pollutant emissions arising from the carbon capture process and that, as below, their potential environmental impact has been adequately assessed based on the properties of each individual substance emitted or formed. More background information on the amines relevant to the application, and associated breakdown products, is given in the operators “amine” AQA and Schedule 5 response referenced above.

Dispersion Modelling undertaken

The applicant has assessed the Installation’s potential emissions to air against the relevant air quality standards, and the potential impact upon human health in line with relevant guidance. These assessments predict the potential effects on local air quality from the Installation’s stack emissions.

The air impact assessments, and the dispersion modelling have considered two scenarios. Baseline modelling is completed for the existing permitted scenario, of the cement kiln operating continuously without CCP, i.e. 8760 hours per year with all ancillary equipment and gas flows also operational. The modelling for the proposed variation with CCP also assumes that the kiln will operate continuously, comprising of a number of different components as follows:

- For 8276 hours per year the CCP will be operational (94.5% availability) and treating kiln exhaust gases. 4 separate sub-modes of operation are included in the modelling, which affect the volume of kiln gas flowing into the CCP (and hence emissions volumes):
    - all parts of the kiln and ancillary equipment operating (65% of time),
    - kiln and raw mill operating but coal mill off (25% of time),
    - kiln and coal mill operating but raw mill off (9% of time), and
    - kiln on but both mills off (1% of time)

This level of detail is greater than for the baseline model, but NRW accept the difference in approach.

- For 484 hours of the year, it is assumed that the CCP will not be available, and emissions will be at existing "baseline" limits, i.e. the cement plant is operating as consented before the variation without carbon capture.
- Other existing sources of particulate matter only (e.g. mills) are also included in both modelled scenarios.

It is inevitable that actual plant availability will mean that operating hours are below the 8760 hours modelled for either scenario. It is also assumed that emissions are at the relevant long-term or short-term emission limit values (actual for baseline, proposed ELVs for CCP), i.e. the maximum proposed/permitted emission rate – actual emissions will be below this value, typically by a considerable margin. For these reasons, the model input parameters are precautionary (worst-case) and we are in agreement with this approach.

The dispersion model was been developed using ADMS (version 6.0.0.1) and covered a 6 x 6 km domain with a 50m grid resolution (*10 x 10km and 50m resolution for N-*

amines and habitats impact). 13 nearby and representative potentially impacted human receptors were identified, and 61 ecological receptor points. As explained below, for human health impact, NRW have generally considered the highest impact "on the grid" (outside the installation) irrespective of receptor presence, as a precautionary approach, unless specific issues require further consideration.

The way in which the applicant used dispersion models, its selection of input data, use of background data and the assumptions it made have been reviewed by Natural Resources Wales modelling specialists to establish the robustness of the applicant's air impact assessment and to ensure that the approach aligns with regulatory guidance for dispersion modelling. We have concluded that the detailed assumptions underpinning the model are reasonably precautionary – the detail of which is available in the operator's application reports. The output from the model is therefore suitable to be used to inform further assessment of health impacts.

Model inputs vs BAT

As noted in section 7.4 (BAT) and above, the operator's AQA has been developed on a precautionary basis. Specifically it assumes an increase in emissions mass flow rate (m^3/second) owing to additional air required for combustion in the CHP. For the purposes of dispersion modelling, it is assumed that this total flow may have pollutant loadings (g/s) up to the ELV / BAT-AEL for cement production. While this approach is precautionary in terms of impact modelling and therefore acceptable in terms of understanding maximum impact at receptors, it represents an over-estimate as we will not accept any increase in pollutant loading from the kiln (e.g. for particulate matter, HCl, HF) as we explained in section 7.4. As stated, NRW will require volume calculation/normalisation methodology to demonstrate that emissions from kiln-arising pollutants are as a minimum not increasing as a result of the CCP project. Any apparent increase in dispersion model mass flows (g/s) of kiln pollutants (e.g. HCl, HF) is entirely a facet of precautionary calculations, and does not represent an increase in authorised emissions as the additional air volume associated with the CHP would not contain or generate these pollutants.

Impact assessment – summary of approach per pollutant

For each pollutant emitted from the process, the applicant has identified the environmental standards (ES) relevant to that substance, as defined in regulatory

guidance. This specifies the maximum concentration of the substance in the environment, over a specific averaging period. For example NO_2 has a maximum ES of 200 µg/m^3 as an hourly average, and 40 µg/m^3 as an annual average. The operator has also identified the "background" concentration of the pollutant already in the environment, where relevant.

The operator has then calculated the process contribution (PC) from the installation (in µg/m^3) with and without the variation and calculated the predicted environmental concentration (PEC) by adding the PC to the background, at receptor locations within the immediate vicinity. At our request (prior to duly making) they have also calculated the maximum impact from the facility (PC) within the modelled grid, outside of the installation boundary and assessed the PEC at that point. This represents a worst-case impact scenario for initial assessment purposes.

For convenient comparison, the operator has also presented PC and PEC as a percentage of the ES. They have described the PC as insignificant if it is less than 1% of a long term ES, or less than 10% of a short term ES. We are in agreement with this approach. Similarly, if the PC exceeds these thresholds, but the PEC is less than the ES, they refer to the pollution as not being significant. We agree with this approach, noting that the operator gives additional justification if the PC is >70% of the ES, i.e. the limit is being approached.

At our request, where relevant the operator has compared the maximum PC from the varied installation with the maximum currently consented (baseline). If the PC goes down, it represents an environmental improvement. Irrespective of the PC/PEC above, we would normally consider that the impact is acceptable if there is a reduction from the variation compared to the current consented operation, subject to the details of the specific scenario. The modelling results for each pollutant will be summarised and discussed below with reference to this general approach.

Impact assessment – Environmental Standards for different substances

As described in the application, and in regulatory guidance, there is a hierarchy of environmental standards. The most important are Air Quality Standard limit values (AQS or EQS, environmental quality standards) – which are set in legislation for

substances including CO, NO_2, SO_2 and particulate matter. Below these are Target values and objectives for substances including cadmium and nickel. If a pollutant has none of these, then an Environmental Assessment Level (EAL) is set, a level below which it is considered that significant pollution or harm to human health is unlikely to occur. UK regulators have set EALs for a wide range of substances which are emitted from industrial processes, including some amines and nitrosamine breakdown products such as N-nitrosodimethylamine (NDMA) and monoethanolamine. There are also some regulator led EALs which were proposed and subject to consultation during our determination, and now adopted by UK environmental regulators. We accept the use of these values in parallel to their adoption.

However, there are some emitted substances identified in this variation for which the UK regulators have not set or consulted on EALs. Given the large number of chemical substances which could be emitted from industry, this is not surprising, and air emissions guidance instructs that in this circumstance, operators should propose an EAL according to a specified methodology. For this variation, given the number of amines and by-products associated with the proprietary carbon separation process, the operator (and their supplier) have proposed EALs in their application for a number of emitted substances.

Development of robust EALs is complex, and based upon a thorough chemical and toxicological understanding of the substances involved. We have consulted with Public Health Wales [PHW] *(who in turn have liaised with the UK Health Security Agency)* in determining whether the EALs are appropriate. It is evident that while the operator-set EALs have been justified, they do not have the full rigor of those set by the regulator. Based on our review and the PHW input, we have determined that the EALs proposed are sufficiently precautionary for a case-specific determination, given the PCs predicted, and the considerable margin of error below the EAL that the PC's are. Even though we may not agree in full with the rationale behind the EAL values selected. We therefore consider the EALs suitable on a site-specific and case-specific basis, but do not automatically endorse their wider adoption without further examination of the supporting data. Full detail is available in the PHW response per EAL proposed.

It is noted that there are a number of minor anomalies between the EAL document and the amine modelling document, as the operator was preparing these in parallel. Therefore for some substances, the final EAL was not available when the air quality report was written and a precautionary (lower) substitute EAL was used. While this is not mechanistically justified it is a reasonable preliminary assessment, if the PC / PEC is demonstrated to be acceptable, NRW does not require further work as the risk is shown to be low. Re-calculation of the PC with the proposed EAL is straightforward with the provided data, and would lead to a lower %PC than reported.

Additional impact modelling – atmospheric chemistry reactions

As noted above, nitrosamines and (and related nitramines) are pollutants of particular concern owing to their chemical hazard, that may arise from amine breakdown, and reaction with NO/NO_2 (etc). For this reason, process control in the CCP, removal of NO_X prior to the CCP (i.e. SCR in this case) etc. as well as abatement are essential to controlling nitrosamine formation in the process, as well as preventing emission. However it is also of note that nitrosamines may form in the atmosphere from amines as a result atmospheric chemistry reactions. Work in this area is still developing, but UK regulators have decided to ask CCP applicants to undertake additional impact modelling to understand the possible impact of N-amines arising from the process but forming once the emissions have left the installation. This level of scrutiny goes beyond what would normally be required in permit determination and reflects both the possible hazard, and the additional scrutiny for a developing sector.

The operator has followed regulatory recommendations developed by the Environment Agency to model atmospheric N-amine formation arising from the installation emissions and has submitted this work in the separate volume of the air quality assessment concerning amines etc. During our duly making and determination, we worked with the operator to understand the risks around formation of N-amines in the atmosphere as well as emitted from the stack, and the work that they had completed. The submission for the duly made application considered atmospheric N-amine formation from Monoethanolamine (MEA), Dimethylamine (DMA) and Ethylamine (EA) only, because these were the only substances for which the detailed thermodynamic data (reaction constants etc) was published that is necessary to complete the atmospheric model. Noting that this modelling requirement

is new for permitting and the results subject to considerable uncertainty, we audited this work and were satisfied that it follows the guidance and provides a suitable methodology for possible magnitude of total N-amines arising from the process.

However, we also noted that although different amines will have different tendencies to form N-amines (notably whether they are primary, secondary or tertiary amines, i.e. have 1, 2 or 3 organic groups substituting H in the amine), MEA and DMA were predicted only as small components of emission (<0.1 mg/Nm^3). Although EA was a higher concentration emission substance (1mg/m^3), other components such as ethylmethylamine, ethylethanolamine, ethyldiethanolamine and piperazine were present at potentially higher concentrations than MEA or DMA, and should be considered for atmospheric reaction potential, if data allowed. We therefore agreed with the operator that the work submitted for determination could and should be extended to additional substances, where data was available. The technology provider worked during our determination to make such data available as far as possible, and in response to our schedule 5 notice, the operator provided further N-amine formation information as required. This was provided in the first part of the Operator's Schedule 5 response (link above) as a separate, updated N-amine modelling report, with accompanying modelling files. In this, all amines identified in Table 1 as being potentially emitted from the CCP were modelled for atmospheric N-amine reactions to the principle nitrosamine/nitramine, as detailed in the report. We are satisfied that this approach fully assessed the possible risk of secondary N-amine formation in the atmosphere from amines directly emitted from the CCP process. Full details of the modelling are available in the applicants report.

Impact assessment – summary of results (human health & ecological receptors)

The operators air quality assessment presents detailed impact results for all relevant pollutants, at numerous receptor locations, using the methodology described above. From the extensive information available, the key results can be summarised in the following 4 tables, with supporting explanatory notes below. For all tables, the process contribution is shown at the maximum point on the modelled grid outside of the installation (manufacturing plant) boundary – impact at defined receptors (e.g. residences) is always lower than this value. Considerable further detail is available within the operators application reports.

Already regulated (kiln) pollutant summary – EQS for the protection of human health:

Pollutant	EQS / EAL		Process Contribution (PC) Baseline- Kiln only		Process Contribution (PC) with CCP		Process Contribution (PC) - Difference		Back-ground	Predicted Environmental Concentration (PEC)				
	µg/m³		µg/m³	% of EAL	µg/m³	% of EAL	µg/m³	% of EAL	µg/m³	µg/m³	% of EAL	Screens out?	Criteria	Comment
NO_2	40	1	1.16	2.9	0.49	1.2	-0.67	-1.7	7.46	8.0	19.9	Yes (PEC, absolute)	CCP [& baseline] PEC <100% ES	PEC not a breach risk at any location, irrespective of background. As shown in main report, PEC insignificant at all receptor locations (<1%) even though max on grid is marginally above and hence PEC considered and shown to be unlikely to cause breach of EQS
	200	2	8.47	4.2	6.19	3.1	-2.28	-1.1	14.92	21.1	10.6	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not a breach risk at any location, irrespective of background
PM_{10}	40	1	0.03	0.1	0.03	0.1	0.01	0.0	10.13	12.1	30.2	Yes (PC, absolute)	CCP [& baseline] PC <1% ES	PEC not a breach risk at any location, irrespective of background
	50	3	0.1	0.2	0.14	0.3	0.04	0.1	20.26	25.4	50.8	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not a breach risk at any location, irrespective of background
$PM_{2.5}$	20	1	0.03	0.2	0.03	0.2	0.01	0.1	6.3	6.3	31.7	Yes (PC, absolute)	CCP [& baseline] PC <1% ES	PEC not a breach risk at any location, irrespective of background
SO_2	266	4	25.59	9.6	14.66	5.5	-10.93	-4.1	9.2	23.9	9.0	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not a breach risk at any location, irrespective of background
	350	5	10.48	3.0	4.08	1.2	-6.4	-1.8	9.2	13.3	3.8	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not a breach risk at any location, irrespective of background
	125	6	4.74	3.8	1.27	1.0	-3.47	-2.8	9.2	10.5	8.4	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not a breach risk at any location, irrespective of background
HCl	750	7	0.9	0.1	2.07	0.3	1.17	0.2	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not provided, but unnecessary as PC insignificant.
HF	16	8	*0.03*	*0.2*	*0.07*	*0.4*	*0.04*	*0.3*	*NA*	*NA*	*NA*	*Yes (PC, absolute)*	*CCP [& baseline] PC <1% ES*	*NRW estimate supports Note 1 in 4.1.1. of operator AQA*
	160	7	0.09	0.1	0.21	0.1	0.12	0.1	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not provided, but unnecessary as PC insignificant.
CO	10000	9	57.9	0.6	25.6	0.3	-32.29	-0.3	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not provided, but unnecessary as PC insignificant.
	30000	10	108	0.4	83	0.3	-25	-0.1	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not provided, but unnecessary as PC insignificant.
TOC (as benzene)	5	1	0.13	2.6	0.1	2.0	-0.03	-0.6	0.26	0.4	7.2	Yes, PEC, absolute	CCP [& baseline] PEC <100% ES	PEC not a breach risk at any location, irrespective of background. Consideration of total VOC "as benzene" (with very low EAL) is a highly precuatuinary (unrealistic) approach - no pollution antiicipated.
	30	11	1.92	6.4	0.96	3.2	-0.96	-3.2	0.52	1.5	4.9	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not a breach risk at any location, irrespective of background. Consideration of total VOC "as benzene" (with very low EAL) is a highly precuatuinary (unrealistic) approach - no pollution antiicipated.
NH_3	180	1	0.18	0.1	0.1	0.1	-0.08	0.0	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	PEC not provided, but unnecessary as PC insignificant.
	2500	10	6.31	0.3	6.21	0.2	-0.1	0.0	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <1% ES	PEC not provided, but unnecessary as PC insignificant.
Dioxins			2.59E-07		3.30E-07		7.10E-08					-	-	See explanatory note below

Key: relevant EQS as per legislation / guidance per substance, i.e. 1 – annual mean, 2 – 99.79th %ile of 1-hour mean, 3 – 90.41st %ile of 24-hour means, 4 – 99.9th %ile of15-minute means, 5 – 99.73rd %ile of 1-hour means, 6 – 99.18th %ile of 24-hour means, 7 – 1 hour mean, 8 – monthly mean, 9 – maximum daily running 8-hour mean, 10 – 1 hour maximum, 11 – 24 hour mean.

As shown, for all pollutants in the table above other than NO_X (annual) and TOC (annual) the process contribution of the CCP enabled kiln is insignificant, as the PC is less than 1% of long-term limits and less than 10% of short-term limits. For Annual NOX and TOC (as benzene), PEC is unlikely to cause significant pollution as it is considerably below the relevant Environmental standard, and for NOX pollution is insignificant at receptors. Furthermore, for all pollutants other than HCl and HF, the process contribution is decreasing as a result of the variation – i.e. the change represents an improvement to impact. As explained in section 7.4, we do not expect nor allow the mass emission of HCl or HF to increase, and do not expect any change in impact (which is as a result of changed dispersion only) to be significant either.

Already regulated (kiln) pollutant summary – EQS for the protection of designated sites (SAC, SPA, Ramsar, SSSI):

Pollutant	Ecological EQS / EAL		Process Contribution (PC) Baseline- Kiln only		Process Contribution (PC) with CCP		Process Contribution (PC) - Difference		Back-ground	Predicted Environmental Concentration (PEC)					
	Pollutant critical levels, atmospheric concentration														
	µg/m³		µg/m³	% of EAL	**µg/m³**	**% of EAL**	µg/m³	% of EAL	**µg/m³**	**µg/m³**	**% of EAL**	**Screens out?**	**Criteria**	**Most impacted ecological site**	**Comment**
NO_2	30	1	0.73	2.4	0.5	**1.7**	-0.23	-0.8	11.06	11.6	38.5	Yes (PEC, absolute)	CCP [& baseline] PEC <100% ES	E3 + E4 - Deeside and Buckley Newt Sites SAC, comprising Buckley Claypits & commons and Maes Y Grug SSSI's respectively	PEC not a breach risk at any European / SSSI ecological receptor location, irrespective of background. PC also reducing (environmental improvement) as result of variation
	75	2	5.26	7.0	3.23	4.3	-2.03	-2.7	22.12	25.4	33.8	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	E3 point withn Deeside and Buckley Newt Sites SAC, Buckley Claypits & commons SSSI.	PEC not a breach risk at any European / SSSI ecological receptor location, irrespective of background
SO_2	10	1,3	0.32	3.2	0.13	**1.3**	-0.19	-1.9	1.96	2.1	20.9	Yes (PEC, absolute)	CCP [& baseline] PEC <100% ES	E3 point withn Deeside and Buckley Newt Sites SAC, Buckley Claypits & commons SSSI.	PEC not a breach risk at any European / SSSI ecological receptor location, irrespective of background. PC insignificant (<1%) at all other European / SSSI receptors other than E3. PC also reducing (environmental improvement) as result of variation
	20	1,3	0.08	0.4	0.03	0.2	-0.05	-0.3	1.4	1.4	7.2	Yes (PC, absolute)	CCP [& baseline] PC <1% ES	E17, E18 - Llay Bog SSSI and Chwarel Singret SSSI respectively - each have similar PC	PEC not a breach risk at any European / SSSI ecological receptor location, irrespective of background. PC insignificant (<1%) at all European / SSSI receptors with EQS of 20 ug/m3
HF	0.5	4	0.02	4.0	0.05	**10**	0.03	6.0	*~0*	*~0.05*	*~10*	Yes (PEC, absolute)	CCP [& baseline] PEC <100% ES	*E1 point withn Deeside and Buckley Newt Sites SAC, Buckley Claypits & commons SSSI.*	*Operator makes a standard assumption that HF background is zero. NRW is satisfied that the ES is unlikely to be breached with any credible background HF concentration*
	5	2	0.03	0.6	0.09	1.8	0.06	1.2	*~0*	~0.1	~2	Yes (PC, absolute)	CCP [& baseline] PC <10% ES	E1 point E3 point withn Deeside and Buckley Newt Sites SAC, Buckley Claypits & commons SSSI.	
NH_3	1	1,5	0.11	11.0	0.08	**8.0**	**-0.03**	**-3.0**	***1.56***	*1.6*	*164.0*	Yes (PC, improvement)	OGN 200 guidance: considered insignificant (no LSE) if improvement on current consented impact	E3 point withn Deeside and Buckley Newt Sites SAC, Buckley Claypits & commons SSSI. Exceeding background at most receptors, many where PC not insignificant, but reducing or static at all assessed points	Proposed variation demonstrates a clear and signficant reduction (improvement) in impact compared to existing operations. Therefore considered acceptable as per NRW guidance, even though the future PC cannot of itself be considered insignifcant and impacting on an exceeding background, only in view of reduction achieved
	3	1,5	0.03	1.0	0.02	0.7	-0.01	-0.3	***3.06***	*3.1*	*102.7*	Yes (PC, absolute)	CCP PC <1% ES	E18 Chwarel Singret SSSI	PC insignificant at all receptors where ammonia ES is 3 µg/m³ owing to higher limit, and distance from source. PC also improving (or low and static) at all receptors compared to existing impact.
	Pollutant critical loads, deposition factor														
	KgN/ha/yr		KgN/ha/yr	% of EAL	**KgN/ha/yr**	**% of EAL**	KgN/ha/yr	% of EAL	**KgN/ha/yr**	**KgN/ha/yr**	**% of EAL**	**Screens out?**	**Criteria**	**Most impacted ecological site**	**Comment**
N-deposition	10	1	*1.028*	*10.3*	*0.74*	***7.4***	***-0.288***	***-2.9***	***32.582***	*33.3*	*333.2*	Yes (PC, improvement)	OGN 200 guidance: considered insignificant (no LSE) if improvement on current consented impact	E3 point withn Deeside and Buckley Newt Sites SAC, Buckley Claypits & commons SSSI. Exceeding background at most receptors, many where PC not insignificant, but installation PC reducing or static at all assessed points	Proposed variation demonstrates a clear and signficant reduction (improvement) in impact compared to existing operations. Therefore considered acceptable as per NRW guidance, even though the future PC cannot of itself be considered insignifcant and impacting on an exceeding background, only in view of reduction achieved
	5	1	0.092	1.8	0.072	**1.4**	**-0.02**	**-0.4**	**18.966**	*19.0*	*380.8*	Yes (PC, improvement)	OGN 200 guidance: considered insignificant (no LSE) if improvement on current consented impact	E20 - Halkyn Mountain / Mynydd Helygain SAC. Exceeding backgrounds at most receptors with a Clo of 5, but PC reducing at all points	
	Kg_{eq}/ha/yr		Kg_{eq}/ha/yr	% of EAL	**Kg_{eq}/ha/yr**	**% of EAL**	Kg_{eq}/ha/yr	% of EAL	**Kg_{eq}/ha/yr**	**Kg_{eq}/ha/yr**	**% of EAL**	**Insignificant?**	**Criteria**	**Most impacted ecological site**	**Comment**
Acid deposition	0.519	1	0.03	5.8	0.017	**3.3**	**-0.013**	**-2.5**	**2.83**	*2.8*	*548.6*	Yes (PC, improvement)	OGN 200 guidance: considered insignificant (no LSE) if improvement on current consented impact	E23 Vicarage Moss SSSI/Ramsar. All receptor points show a reduction of both N and S deposition as a result of the proposed CCP variation	Proposed variation demonstrates a clear and signficant reduction (improvement) in impact compared to existing operations. Therefore considered acceptable as per NRW guidance, even though the future PC cannot of itself be considered insignifcant and impacting on an exceeding background, only in view of reduction achieved

Key: relevant EQS as per legislation / guidance per substance, i.e. 1 – annual mean, 2 –max 24-hour mean, 3 – site relevant SO_2 limit of 20 or 10 µg/m^3 as specified on APIS, 4 – max weekly mean, 5 -site relevant NH_3 limit as specified on APIS, 1 µg/m^3 if lichens or bryophytes present, otherwise 3 µg/m^3. Green highlight indicates the criteria upon which significant pollution is unlikely to be caused or impact determined to be insignificant.

Already regulated (kiln) pollutant summary – EALs for the protection of other ecological sites (Local Wildlife sites, Ancient Woodland)):

Pollutant	Ecological EQS / EAL		Process Contribution (PC) Baseline- Kiln only		Process Contribution (PC) with CCP		Process Contribution (PC) - Difference		Back-ground	Predicted Environmental Concentration (PEC)					
	Pollutant critical levels, atmospheric concentration														
	µg/m³		µg/m³	% of EAL	**µg/m³**	**% of EAL**	µg/m³	% of EAL	**µg/m³**	**µg/m³**	**% of EAL**	**Screens out?**	**Criteria**	**Most impacted ecological site**	**Comment**
NO_2	30	1	0.6	**2.0**	0.34	1.1	-0.26	-0.9	10.02	10.4	34.5	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E24 Price's Hill Wood Ancient Woodland/ Flintshire Wildlife Site. PC is higher at E39 un-named ancient woodland (2.2%, 0.66 µg/m3) but neither PC nor PEC breach significance criteria at either receptor or others listed	PEC not a breach risk at any Local designation ecological receptor location, irrespective of background
	75	2	8.44	11.3	4.19	5.6	-4.25	-5.7	20.04	24.2	32.3	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E24 Price's Hill Wood Ancient Woodland/ Flintshire Wildlife Site. PC is higher at E39 un-named ancient woodland (6.8%, 5.12 µg/m3) but neither PC nor PEC breach significance criteria at either receptor or others listed	For LWS and AW, PC considered acceptable under permitting guidance if <100% of ES. Noting also that impact is significantly reducing (improving) as a result of proposed variation
SO_2	10	1,3	0.27	2.7	0.09	0.9	-0.18	-1.8	1.66	1.8	17.5	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E24 Price's Hill Wood Ancient Woodland/ Flintshire Wildlife Site. PC is higher at E39 un-named ancient woodland (1.8%, 0.18 µg/m3) but neither PC nor PEC breach significance criteria at either receptor or others listed	
HF	0.5	4	0.02	4.0	0.04	8.0	0.02	4.0	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E26 Black Pool Plantation, Flintshire Wildlife Site. PC is higher at E55 un-named ancient woodland (12.4%, 0.06 µg/m3) but neither PC nor PEC breach significance criteria at either receptor or others listed	
	5	2	0.03	0.6	0.08	1.6	0.05	1.0	NA	NA	NA	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E26 Black Pool Plantation, Flintshire Wildlife Site. PC is higher at E55 un-named ancient woodland (2.4%, 0.12 µg/m3) but neither PC nor PEC breach significance criteria at either receptor or others listed	
NH_3	1	1,5	0.09	9.0	0.05	5.0	-0.04	-4.0	2.31	2.4	236.0	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E24 Price's Hill Wood Ancient Woodland/ Flintshire Wildlife Site. PC is higher at E39 un-named ancient woodland (9.9%, 0.1 µg/m3) but neither PC nor PEC breach significance criteria at either receptor or others listed	For LWS and AW, PC considered acceptable under permitting guidance if <100% of ES. Noting also that impact is significantly reducing (improving) as a result of proposed variation
	Pollutant critical loads, deposition factor														
N-deposition	**KgN/ha/yr**		KgN/ha/yr	% of EAL	**KgN/ha/yr**	**% of EAL**	KgN/ha/yr	% of EAL	**KgN/ha/yr**	KgN/ha/yr	**% of EAL**	**Screens out?**	**Criteria**	**Most impacted ecological site**	**Comment**
	20	1	**0.311**	1.6	0.2036	1.0	-0.1074	-0.5	**20.53**	20.7	103.7	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	E30 Padeswood Pasture, Flintshire Wildlife site	As well as PC <100% of ES at all receptors, improvement in impact noted for all impact points
	10	1	0.855	8.6	0.505	5.1	-0.35	-3.5	35.87	36.4	363.8	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E24 Price's Hill Wood Ancient Woodland/ Flintshire Wildlife Site. PC is higher at E39 un-named ancient woodland (9.1%, 0.91 kgN/ha/yr) but neither PC nor PEC breach significance criteria at either receptor or others listed	
	5	1	0.181	3.6	0.114	2.3	-0.067	-1.3	21.09	21.2	424.1	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	E26, Black Pool Plantation, Flintshire Wildlife site	
Acid deposition	**Kg_{eq}/ha/yr**		Kg_{eq}/ha/yr	% of EAL	**Kg_{eq}/ha/yr**	**% of EAL**	Kg_{eq}/ha/yr	% of EAL	Kg_{eq}/ha/yr	Kg_{eq}/ha/yr	**% of EAL**	**Insignificant?**	**Criteria**	**Most impacted ecological site**	**Comment**
	3	1	*0.131*	*4.4*	*0.063*	*2.1*	*-0.068*	*-2.3*	*2.76*	2.8	94.1	Yes (PC, absolute)	CCP [& baseline] PC <100% ES	Data for E24 Price's Hill Wood Ancient Woodland/ Flintshire Wildlife Site. PC is higher at E39 un-named ancient woodland (4.1%, 0.122 kgEQ/ha/yr) but neither PC nor PEC breach significance criteria at either receptor or others listed	As well as PC <100% of ES at all receptors, improvement in impact noted for all impact points

Key: relevant EQS as per legislation / guidance per substance, i.e. 1 – annual mean, 2 –max 24-hour mean, 3 – site relevant SO_2 limit of 20 or 10 µg/m^3 as specified on APIS, 4 – max weekly mean, 5 -site relevant NH_3 limit as specified on APIS, 1 µg/m^3 if lichens or bryophytes present, otherwise 3 µg/m^3. Green highlight indicates the criteria upon which significant pollution is unlikely to be caused or impact determined to be insignificant.

Impacts on specific designated ecological receptors are discussed further in section 9, below.

Already regulated (Kiln arising) pollutants – EALs for metal emissions:

In addition to the main pollutants described above, the cement manufacturing process may emit a range of potentially harmful metals at trace levels or lower. Process contributions for these for the varied (CCP) process are shown below. PCs are generally so low that PECs are not shown in the table as emissions are shown to be insignificant (<1% of long term average and/or <10% of short term average), with the notes at the end of the section, below:

Pollutant	EQS / EAL		Process Contribution (PC) with CCP	
	µg/m^3		µg/m^3	% of EAL
Cd	0.005	1	*0.00002*	0.4
	0.03	3	0.0012	4.0
Hg	0.6	2	0.0103	1.72
	0.06	3	0.0012	2.00
Sb	5	1	2.60E-05	0.00
	150	2	1.60E-03	0.00
Pb	0.25	1	1.70E-04	0.07
Co	0.2	1	1.84E-05	0.01
	6	2	1.10E-03	0.02
Cu	0.05	3	0.0067	***13.4***
Mn	0.15	1	3.93E-04	0.26
	1500	2	0.0246	0.00
V	1	3	2.14E-04	0.02
As	0.003	1	1.50E-05	0.50
Cr (II)(III)	2	3	1.70E-03	0.09
Ni	0.02	1	0.0002	0.76
	0.7	2	0.0090	1.29

Key: relevant EQS as per legislation / guidance per substance, i.e. 1 – annual mean, 2 – 1-hour maximum mean, 3 – maximum 24-hour mean. Cd = cadmium, Hg = mercury, Sb = antimony, Pb = lead, Co = cobalt, Cu = copper, Mn = manganese, V = vanadium, As = arsenic, Cr = chromium (in oxidation state ii or iii), Ni = nickel.

Carbon Dioxide Capture Plant pollutant summary – EALs for the protection of human health for newly emitted substances (amines, nitrosamines, nitramines):
The table below summarises the additional pollutants that may be emitted (amines and their breakdown products, etc), as a result of addition of the CCP to the cement plant. As shown, the PC of the majority of individual substances assessed are insignificant (<1% of long term limit, <10% of short term limit). Where the PC cannot be assumed to be insignificant (shown in Bold in the table), it is not expected that exceedences of the EALs (and hence significant pollution) would occur. For specific speciated amines, nitrosamines, and nitramines, it is currently a reasonable simplification to consider that the background is zero, so for all emitted substances where the PC is over the "insignificance" threshold, it remains unlikely that significant pollution would occur as the PEC is not at risk of breach:

Pollutant		**EQS / EAL**		**Process Contribution**	
Name	**CAS registry number / unique identifier**	**µg/m^3**		**µg/m^3**	**% of EAL**
Methylamine	74-89-5	15	1	0.0032	0.02
		1900	2	0.2068	0.01
Ethylamine	75-04-7	22	1	0.0032	0.01
		2800	2	0.2068	0.01
Dimethylamine	124-40-3	22	1	0.0032	0.01
		2800	2	0.2068	0.01
Diethylamine	109-89-7	33	3, 4	0.032	0.10
		330	2, 4	0.2068	0.06
Ethylmethylamine	624-78-2	28.6	1, 5	0.0032	0.01
		3640	2, 5, 6	0.2068	0.01
Monoethanolamine	141-43-5	100	3	0.032	0.03
		400	2	0.2068	0.05
Diethanolamine	111-42-2	3	3, 4	0.032	**1.07**
N,N-dimethylethylenediamine	108-00-9	*104*	3	0.032	*0.03*
		417	2	0.2068	*0.05*
N-(2-hydroxyethyl)acetamide	142-26-7	0.085	1	0.0032	**3.76**
N-(2-hydroxyethyl)formamide	693-06-1	*86*	1	0.0032	*0.004*
Formaldehyde	50-00-0	5	1	0.0066	0.13
		100	7	0.5645	0.56
Acetaldehyde	75-07-0	370	1	0.0313	0.01
		9200	2	2.0472	0.02
Ethylethanolamine	110-73-6	50	1, 5	0.0066	0.01
		300	2, 5	*<0.2068*	*<0.07*
Ethyldiethanolamine	139-87-7	440	1, 5	0.0009	0.00
		3	3, 8	*<0.032*	**<1.07%**
Piperazine	110-85-0	15	3, 4	0.006	0.04
Nitrosamines and Nitramines	sum of all emissions	0.0002	1, 9	0.0001527	**76.35**

Key: relevant EQS as per legislation / guidance per substance, i.e. 1 – annual mean, 2 – 1-hour maximum mean, 3 – maximum 24-hour mean. 4, 5. Minor inconsistency in application re EAL. Value used in summary table is from Environment Agency

consultation, not application (calculated by NRW), 6. Hourly PC is inferred from other amines modelling (same basis) as not provided by the applicant, 7. 30-minute maximum mean, 8. Operator used derived annual EAL of 440ug/m3. PHW advised that comparison to diethanolamine EAL is also considered, with an EAL of 3 ug/m3. This row generated by NRW and illustrates the likely PC order-of-magnitude – still unlikely to cause significant pollution even with far more precautionary EAL. 9 Comparing the sum of all N-amine emissions with the published EAL for NDMA, see notes below.

Notes on tables (human health standards):

- Short term PECs (where relevant) are calculated using annual average background pollution according to regulatory guidance "*When you calculate background concentration, you can assume that the short term background concentration of a substance is twice its long term concentration*."
- For NO_X, from the data presented and the low process contribution compared to short and long term limits, we are satisfied that the impact will be insignificant at the NO_X focus area along the A494 at Deeside which is noted in the Clean Air Plan for Wales for NO_X concerns, ~3.7km from the site.
- For particulate matter, there is an additional site-based particulate matter contribution (1.92 µg/m^3 annual average, 5 µg/m^3 daily average) from other sources (e.g. mills) which are unchanged by the Kiln/CCP modifications and are not shown in the summary table. These are included in the PEC's quoted, therefore the PEC is not the simple sum of the PC + background for these two rows – the detail is in the application document.
- For the purposes of establishing an EAL, it is assumed that all TOC is emitted as benzene, which is a standard precautionary approach. This is an assessment convention; it does not suggest or imply that benzene is the substance emitted from the process – it is simply a very low EAL which is used to demonstrate that, even on a precautionary basis, the emission of TOC is unlikely to cause significant pollution (and noting numerous individual organic compounds, including amines and nitrosamines are considered separately, and will contribute to the total TOC).
- As a result of the gas volume assumptions described above, the dioxin / furan PC is predicted to increase by ~30% at point of maximum impact. As described already, we do not consider this a genuine increase in pollution emission and with reference to BAT would not allow an increase. In fact as we explained in Section 7.5 we actually expect normalised dioxin concentrations in emissions to reduce. Therefore for the purposes of impact assessment, we consider that as a reasonable worst case assumption there is no significant change in dioxin emission or impact as a result of the CCP. We have therefore not required a human health risk assessment (HHRA)

to be updated as it would be an administrative exercise only – the existing HHRA remains precautionary. We also agree with the applicant's statement that even with the c.30% modelled increase, *the change would not "significantly alter the conclusions of the previous HHRA*". The same principles would apply to any other similar products of incomplete combustion such as polychlorinated biphenyls (PCBs) or polycyclic aromatic hydrocarbons (PAH) which are not subject to specific emissions limits.

- The operator calculated the hourly, but not monthly average for HF for human health impacts, noting DEFRA guidance that indicates breach of the monthly value is unlikely if the 1-hour limit is not breached. NRW has applied the "rule of thumb" conversion in the AERA guidance to convert an hourly mean to a weekly mean (multiply by 0.31), a precautionary approach as a monthly conversion is not provided to provide indicative confirmation that the monthly HF emission is acceptable. We are confident that the HF emission from the CCP is insignificant (<1% of the monthly mean) but note that the figures in the table (*in italics*) above for HF monthly are entirely indicative.
- NRW does not routinely apply an EAL for cobalt, but acknowledges the annual and hourly screening values (of 0.2 and 6 µg/m^3 respectively) adopted by the applicant. We agree that the low PC compared to these precautionary values indicates that pollution is unlikely to be significant.
- The operator calculated the 24-hourly, but not the annual average for Cadmium (compared with an annual EAL of 0.005 µg/m^3). Simple NRW check calculation (in italics) shows that the PC is insignificant (<1%). Calculation is based upon the operators annual:24-hour emission ratio for Sb, Co and Mn, and taking a precautionary (worst case) value.
- As shown in the table above, the daily mean PC for copper cannot be automatically assumed to be insignificant, being 13% of the ES (>10%). However, the operator also presents PC at 13 individual receptor locations (residences), all of which are insignificant (<10%) so we are satisfied that the PC is insignificant at receptors. Furthermore, given the background metal concentrations presented by the operator in table 6.5 of their air quality assessment, we do not consider that significant pollution is likely, as the PEC is unlikely to breach the ES at any point as a result of the cement manufacturing operation plus background.
- As shown in the last row of the table for emissions from the CCP, the sum of direct and indirect nitrosamines and nitramines is relatively high, at 76% of the ES. This is dominated by atmospheric reactions and secondary pollutant generation. NRW regard this as highly precautionary worst case modelling, with numerous layers of over-assumption. It is also work which goes beyond what we normally would ask for

in determination impact assessment. After considerable review, we are satisfied that this robustly demonstrates that the emissions (and subsequent generation) of N-amines is unlikely to cause pollution or human health risk, for reasons (both unique to this work, and common to much dispersion modelling), and including but not limited to:

- It is improbable that that all the emissions would be at the ELV throughout the impact averaging period
- The maximum impact is the worst of 5 years of meteorological data
- Numerous precautionary assumptions are made both in the general underlying dispersion modelling, but also in the atmospheric chemistry modelling.
- It is precautionary to compare the sum of N-amines against the published EAL for NDMA, which is generally regarded as one of the most harmful nitrosamines (*noting one or two N-amines including NDEA are reported as even more harmful but also that NDEA is only a very minor component of the expected emission profile for N-amines*). Although a minor component of the sum of N-amines from the process, it is noted for information that a separate EAL has been proposed by the Environment agency for N-nitrosomorpholine which is 25 times higher than the NDMA EAL, indicating the range of harm values assigned. Considering the sum of all of the N-amines against the NDMA EAL is a reasonable and precautionary approach.
- As noted above, the quoted impact is the maximum on the modelled grid; at sensitive receptors (e.g. residential buildings) the impact will always be below this figure.

Notes on tables (ecological standards/receptors):

- NRW note that Table 8.27 of the operator's AQA – annual average NO_X for ecological receptors – final column (PEC as % of ES) is in error, and appears to have been calculated using the daily mean ES of 75 µg/m^3 rather than the 30 µg/m^3 which is relevant. The penultimate column (NO_X PEC in µg/m^3) is also inconsistent with other (validated) data presented, though its origin is not evident. . The figures above have been re-calculated by NRW using the correct ES. The conclusions remain valid – that no breach of the ES is predicted at any receptor, and that PC is only potentially significant at E3 and E5 (Deeside and Buckley Newt sites SAC, comprising of (*Buckley Claypits and Commons and Maes Y Grug SSSI's respectively*) – being <1% insignificant at all other SAC/SPA/Ramsars, and <100% at locally designated sites.

Such minor anomalies in submitted reports are not unusual, noting their length and complexity and are often identified during NRW determination.

- Similarly in Table 8.28 of operator's AQA – maximum daily average NO_X for ecological receptors – as above there is an anomaly in the final two columns. The % PEC does correspond to the stated PEC in µg/m^3, but the PEC is based on the existing PC, not the lower PC with addition of the CCP. Again, the figures above have been re-calculated by NRW from the operators data, with the same conclusions of insignificance as the operator.
- HF for ecological receptors – as per section 6.6 of the operator's AQA, background is considered by them to be zero, and allowing the conclusion that significant pollution is unlikely, in addition to the low PC's calculated. Zero HF background is not an unusual assumption and simplification made by applicants for HF owing to its reactivity / localised impact, and relatively few point sources (*the nearest on national inventory being Pilkington Greengate Works in St Helens, approx. 38km from Padeswood*). This is also reflected in our regulatory knowledge, where very few installations have HF emissions. While it is a simplification to assume zero background, we agree with the operator that significant HF pollution is unlikely; it is improbable that the PEC would breach any HF ES for ecological receptors. Furthermore, our analysis in section 7.4 above is pertinent – that the actual emissions are not permitted to increase, so change in modelled impact is expected to be small and a function of alteration to dispersion characteristics (not mass emission) only – the majority of the reported increase in HF impact is a result of a precautionary modelling approach regarding ELV and flue gas volume.

  For designated ecological receptors, the HF PCs can in any case be regarded as insignificant (10% of weekly ES and 1.8% of daily ES at most impacted receptor point – both short term limits). For non-statutory sites (Local Wildlife Sites, Ancient Woodland), different screening criteria are used, and it is considered that significant pollution is unlikely if PCs do not breach the ES. For HF this is also true – at the most impacted (non-statutory) ecological receptor, the weekly PC is maximum 12.4% of the ES (on ancient woodland) and daily is maximum 1.6% on the same receptor location.
- N deposition values are adjusted by NRW to account for N arising from amine degradation, as reported separately by the operator in their final (schedule 5 response) "amine" AQA. This is a precautionary approach, as it assumes that all amines (etc) break down to N-depositing substances, with reasonable worst-case deposition velocities assumed. As shown, the CCP plant and associated abatement still reduces the N deposition PC, although the additional impact from amine (modelled

using reasonable worst case assumptions) lowers the benefit slightly. However, without summation, the values in DD will not correspond directly to those in the applicant AQA or Amine AQA

Emission limits

We have decided that emission limits should be set for the parameters listed in the permit. These limits are in agreement with the proposals made by the operator in their application for all existing kiln pollutants (noting our comment in section 7.4 regarding flue gas normalisation requirements post CHP). For by-products from the CCP Emissions Limit Values (ELV) are in accordance with the technical specification by the operator in the application. The format of the limits (e.g. specification of sum limit based on sum of all speciated amines) has been proposed by NRW based on current best practice and agreed with the operator during determination. It is noted that the standardised specification of such limits may in future be changed, owing to the stage of development of CCP deployment, and associated regulatory framework maturity.

ELVs maintained at previous value following CCP variation

The following substances have been identified as continuing to be being emitted in significant quantities from the kiln and Emission Limit Values (ELVs) based on BAT have been maintained for those substances when emitted via the CCP: Particulate matter, Hydrogen Chloride (HCl), Hydrogen Fluoride (HF), mercury (Hg), Cadmium + Thallium (Cd + Tl), Metals*, Dioxins (as I-TEQ).

Metals = the sum of nine prescribed metals and their compounds: Antimony (Sb) + Arsenic (As) + Lead (Pb) + Chromium (Cr) + Cobalt (Co) + copper (Cu) + Manganese (Mn) + Nickel (Ni) + Vanadium (V).

It is considered that the ELVs will ensure that significant pollution of the environment is prevented and a high level of protection for the environment secured. It is anticipated that the changes to the flue gas treatment train are likely to further reduce emissions of all of these substances, but there is insufficient data to propose further ELV reduction given the low limits already in place. Operational data from the plant may justify a further reduction in ELV in future, via standard permit review processes.

As noted already (section 7.4), the normalised emission volume shall be corrected such that additional combustion air for the CHP does not constitute dilution in respect of the ELV where existing values are maintained. This ensures that BAT-AEL performance continues to be demonstrated. Further, we have decided to allow the operator to make a correction to ELVs (derived from minimum standards and/or BAT-AELS) to account for the attendant reduction in flue gas volume (and hence pollutant concentration) arising from CO_2 removal. CO2 in the flue gas is a significant proportion before removal, at ~10-20%. Where kiln pollutants are measured after the CCP, a correction factor is applied to "back-calculate" the effective concentration of pollutant if the CO_2 had been present (as well as to account for combustion air), to ensure consistency and fairness with other operators. This aligns with the principles of good regulation, and also with the concepts of standardisation in IED and BAT, for example routine oxygen standardisation (10% for cement kilns). It is noted that IED Annex VI Part 6, 2.7 (monitoring details for incinerators and co-incinerators) allows for specific volume correction for oxygen-enriched combustion. While CO_2-depletion is not the same, the text "reflecting the special circumstances of the individual case" confirms that such CO_2 correction is similarly technically appropriate to this case, where carbon capture has developed subsequently. The approach is aligned with the requirements of Article 15 (1) and (3) of the Industrial Emissions Directive. Given that the detail of this calculation has yet to be set out, we have included a pre-operational condition (PO 05) requiring the operator to provide an appropriate methodology for this correction, prior to operation of the CHP and CCP. It is anticipated that such a methodology may be incorporated automatically into the Data Acquisition and Handling System (DAHS) associated with the CEMs, for automatic and variable correction according to flue gas conditions. A note in Table S3.1 requires the operator to review in their annual report to NRW whether requirements of Article 15(3) continue to be met, and our obligations under that article will be met through our review of the operator monitoring data and annual report.

ELVs reduced as a result of the CCP variation

We have imposed a stricter ELV than those defined as BAT for cement production and/or already set for the Padeswood kiln in respect of Total organic Carbon (TOC), Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_X), and ammonia (NH_3). This is as a result of the application by the operator, who proposed

these lower limits, reflecting the expected improvements in emissions performance associated with the additional abatement of conventional kiln pollutants associated with the implementation of carbon capture. These changes in ELV are primarily for the purpose of protecting the CCP operation, but have the additional benefit of constituting considerable environmental impact improvement when compared with the existing kiln impact. Furthermore, this approach has allowed the operator to demonstrate that certain pollutant impacts (e.g. nutrient nitrogen and acid deposition) are reducing overall and are therefore acceptable, even though the CCP may otherwise slightly increase pollutant loadings, if a reduction in "baseline" were not considered.

Note that any additional NO_X load generated by the CHP (compared to the kiln alone) is included within the overall ELV, so any additional NO_X generated by Natural Gas combustion is offset by the pollutant destruction associated with the SCR, in achieving an ELV that is well below the previously consented limit. Unlike the ELVs above which are unaltered, we have not required the operator to normalise the results with respect to combustion air and/or CO_2 depletion as attainment of BAT-AEL performance is in any case assured owing to the reduction in ELV value. However, should the operator wish to normalise all results in the same way, and therefore amend the ELV proportionately for this group of pollutants, we would consider this a minor technical change to the permit that did not require technical assessment.

ELVs when the CCP is not operational

It is inevitable that the CCP will not have 100% availability, and it is expected that there will be periods when the CCP is offline, but that the cement kiln continues to operate. In this instance, the cement plant will operate in "standalone" mode, with kiln exhaust gases being emitted either via the existing kiln stack (A8), or via a bypass damper arrangement through the new CCP stack (A17). For cement kilns, ELVs are set as daily averages, and it is foreseeable that there will be days of kiln operation that comprise some hours of CCP operation, and some hours without CCP. As noted as a footnote to Table S3.1 in the permit, in this circumstance the daily ELV is taken to be a weighted average of the ELVs for CCP and kiln-only modes, for continuously monitored pollutants, and where the ELVs differ (e.g. NO_X, SO_X). The weighted

average shall be based on the number of valid half-hourly operational periods in CCP mode and kiln-only mode, as defined in the permit conditions .

New ELVs associated with the CCP variation

Formal BAT has yet to be established for amine carbon capture and storage, and nor does the guidance on emerging techniques prescribe ELVs. We have therefore set ELVs for emitted substances associated with the CCP in accordance with legislative requirements, having regard for the operators application information, site-specific BAT (*as determined by NRW with input from the operator*), and the impact of pollutants on the environment.

We have set new limits for total amines, total nitrosamines, and total nitramines. Each of these are as the sum of all identified compounds in each class, as given in the application "Table 1" of all anticipated emissions arising from the CCP and as detailed in the permit. We have also set separate speciated limits for formaldehyde and acetaldehyde as principal non-amine breakdown products.

Based upon the information in the application and the measures (ELVs) that will be imposed by the permit we are satisfied that the appropriate measures will be in place to protect air quality for the environment and human health.

As we have explained above, we are satisfied that Table 1 represents the full extent of emissions from the CCP/solvent. Nevertheless, owing to the considerable public and regulatory interest in this emerging technique, and for the avoidance of uncertainty, we have placed an improvement condition IC 22 in the permit, requiring the operator to undertake a campaign of additional emissions testing, once commissioning is complete, to demonstrate that the speciated emissions in table 1 represent the full extent of significant organic breakdown products emitted from the CCP and that the concentration of different speciated primary, secondary and tertiary amine monitored is in agreement with the application specification. The methodology for this work is to be agreed between the operator and NRW in due course, but it may for example include comparison of emissions with analysis data for the circulating solvent composition, or be based upon a mass-balance of TOC and speciated emissions, between the inlet and outlet of the CCP (*noting that the speciated*

emissions, if all at their respective ELV, constitute over half of the total VOC emissions limit, including any arising from the kiln meaning that the scope for significant additional emissions is very small). It is intended that this is a one-off exercise rather than an ongoing emissions exercise, it may be research based, and with the objective of confirming design expectations, rather than providing additional or ongoing regulatory burden.

Additional emission points to air

The application has also identified that there will be a number of additional minor release points to air, such as breather vents on storage tanks and silos and steam pressure release valves, often referred to by NRW as "passive vents". For a complex site, it is normal that such points exist, and it is required that emissions from these be negligible, if necessary via abatement (e.g. activated carbon filter) or by routing vapours back into the process. We are satisfied that these emission points are capable of effective environmental control, but that the exact details have yet to be finalised pre-FEED. Building on the approach already used in the permit for Padeswood (Table S3.2) for vents that are "small sources of particulate matter", Pre-operational condition PO 02 & 04 require the operator to develop a full inventory of new passive vents. See section 8.4 below for more information on fugitive and diffuse emissions management controls.

Venting of captured carbon dioxide

One potential consequence of CCP operation is the separation of CO_2, followed by the need to release ("vent") captured gas in the short-term, if for example it does not meet specification for transport and storage, or if the CO_2 export line becomes unavailable. CO_2 does not have an EAL, and while there are health risks associated with high-concentration exposure, the risk is predominantly one of asphyxiation in the short-term. For some CCP applications, venting scenarios are an important part of determination, where high-volume low-level release may occur. The application reports that for Padeswood, the only significant venting scenario is one in which CO_2 is re-mixed with combustion gases from the kiln etc, and is emitted via the 117m CCP stack. The operator has explained that dispersion from this scenario is satisfactory, and that there is minimal risk. We accept from this assessment that the risk "screens

out" as insignificant and have not required further information or model auditing to be undertaken.

8.3. Assessment of impact to surface and ground water and to ground

The proposal includes a direct discharge to surface water of uncontaminated surface water (rainwater) as described in the application technical summary, with further detail of the site drainage arrangements provided in the drainage philosophy and drainage technical note. Discharge would be periodic, from a holding pond of capacity 3700 m^3, and there is also the option to re-route recovered water back for process use.

There are some unsurfaced areas within the additional permitted land added at this variation for the CCP, where contamination is improbable and rainwater infiltration will occur. All other areas will be impermeable. Areas where process contamination is not expected (such as roads) will drain to the attenuation / holding pond via an inlet oil and silt interceptor. Bunded areas (etc.) where process fluid contamination is possible, will have sealed containment, where rainwater will accumulate. After confirmatory checking that there is no appreciable contamination (visual inspection and suitable instantaneous analysis), uncontaminated water will be removed from these areas periodically, by active pumping, and discharge to the uncontaminated surface water system. In the event of contamination, such water would be taken off site for disposal/treatment. All elements of this drainage design intent are standard practice for industrial installations. See section 8.7 for details of secondary containment for the prevention of loss of potentially polluting liquids.

As such, it is expected that water in the attenuation pond will be uncontaminated, and suitable for discharge as rainwater. The operator has proposed the following testing of water prior to / during discharge, to confirm negligible contamination. The proposed parameters / limits are based on arrangements for their existing discharge W1 as listed in the table, which is a comparable arrangement on the main site. For W4 it is proposed to add chemical oxygen demand (COD) testing as an indicator of presence of organic substances.

Release Point	Name	Parameter	Current limit (W1)	Proposed limit (W4)	Proposed Reference Period	Proposed Monitoring Standard	Proposed Monitoring Frequency
W4	Surface water drainage via settlement lagoon	TSS	50 mg/l	50 mg/l	Spot Sample	BS EN 872	Monthly / when discharging
		pH	6 min 9 max	6 min 9 max	Instantaneous	MCERTS approved instrumentation	Continuous
		Temperature	23 °C	23 °C	Instantaneous	MCERTS approved instrumentation	Continuous
		Oil/Grease	None visible	None visible	Spot Sample	Visual check	Weekly
		COD	N/A	500 mg/l	Spot Sample	ISO 15705	Monthly / when discharging

Note: continuous monitoring in the table above means continuous during discharge.

We are in agreement with this approach, with appropriate confirmatory testing to confirm that discharged water is free from contamination. However, we do not consider that the proposed COD limit is sufficiently stringent to demonstrate that the water is free from contamination. In agreement with the operator, we have set an interim limit of 50 mg/l above the influent water COD in addition to the other limits proposed above to ensure that the discharged water is free from organic contamination, particularly by ammoniacal materials including amines. We have set an improvement condition IC12 for the operator to propose the most suitable final limit for COD (or other suitable parameter) for amine/organic contamination control for NRW agreement.

As discharge is only consented for uncontaminated rainwater, with appropriate controls to ensure that this is the case, no further impact assessment is necessary. We have determined that the temperature limit is unnecessary as there is no direct thermal load from the CCP in the emitted water.

Based upon the information in the application and limits in the permit, we are satisfied that the appropriate measures will be in place to prevent pollution of ground and surface water.

8.4. Diffuse and Fugitive emissions

Cement production processes already present a risk of fugitive dust emissions, which are controlled via a dust management plan (IMS procedure PG10, V13, 13/12/24). The applicant has identified further operations in the CCP variation that have some potential for fugitive emissions, such as storage and use of activated carbon, lime, slaked lime and bag filter dust (with new silos, breather vents etc). They have indicated that a preventative maintenance programme is a key part of fugitive emission control, and we agree. Furthermore, the variation introduces the potential for a new type of fugitive and diffuse emission, that of organic substances such as amines (VOC), ammonia (SCR reagent), and hydrogen (from CO_2 oxygen removal), and CO_2 itself once separated.

The application addresses the need both for preventative maintenance, and for a leak detection and repair programme, which would also include fugitive emissions monitoring and minimisation. However, the plans are not fully developed, reflecting the early design stage of the project.

Based upon the information in the application we are satisfied that the operator understands the risks and necessary control measures for fugitive and diffuse emissions, and of the appropriate measures that will need to be in place to prevent or where that is not practicable to minimise them and to prevent pollution. We are satisfied that standard control and management techniques are capable of controlling the risks. However, further work will be required by the operator before the CCP is commissioned and operated, to extend the scope of the existing dust management plan to include additional dust sources, and to develop a separate plan to cover other non-dust fugitive and diffuse emissions, and to integrate these plans with the appropriate preventative maintenance regimes. We have therefore included pre-operational condition PO 04 to require these plans to be developed and approved by NRW ahead of commissioning. This will include demonstration that appropriate abatement and monitoring are in place if required, including for passive vents referred to above.

Permit condition 3.2.1 requires that emissions of substances not controlled by emission limits (i.e., fugitive emissions) shall not cause pollution. The measures

outlined above will ensure that additional fugitive / diffuse risks are controlled as described.

8.5. Assessment of odour impact

There are sensitive receptors within the close vicinity of the installation and CCP. Various residential and farming (etc.) receptors are identified in the application. The operator has provided an odour risk assessment with the application.

The operator has identified potential sources of odour, both from the existing installation and the CCP variation including:

- Alternative fuels and raw materials such as meat and bone meal in the Kiln operations
- Ammonia and amine solvent KS-21 in the CCP.

The variation application details measures which will be in place for preventing and minimising emissions which could give rise to odour pollution, such as containment of solvent and ammonia within the operational equipment, and use of abatement on breather vents etc. to prevent release. NRW note that a very high degree of control of odorous materials associated with the variation is necessary owing to their chemistry and hazard. This means that the required air pollutant emissions controls for human health ensure that odour risk is, in any case, controlled, and that additional measures are unnecessary. We therefore agree that the overall risk, as stated in the odour risk assessment, from new odorous substances introduced by the variation, are insignificant in all cases. We have not reviewed the measures associated with already consented plant/operations, which are beyond the scope of the variation process.

We have reviewed the control techniques proposed for the variation and are satisfied the techniques represent appropriate measures.

Based upon the information in the application we are satisfied that the appropriate measures will be in place to prevent or where not practicable to minimise the effects of odour from the CCP and associated changes.

Condition 3.3.1 in the permit also requires that emissions from the activities are free from odour at levels likely to cause pollution outside the site. We are satisfied that this will be sufficiently protective in conjunction with the measures described by the

operator for minimising odour at the varied installation. Condition 3.3.2 however does allow us to require an odour management plan to be written, approved, and implemented if we notify the operator that pollution by odour is in fact occurring.

8.6. Noise and vibration assessment

Overview of noise information submitted

The potential for pollution by noise and vibration from the installation has been a significant consideration in our variation determination, and noise is one of the key concerns for the local community. Padeswood cement plant is located in a predominantly rural area. There are no other major industrial/manufacturing sites in the immediate vicinity, but there are busy ("A-classification) roads and railway lines and farming activity which will contribute to local environmental noise. There are nearby receptors which may be affected by noise from the installation: isolated dwellings, farms etc to the South and West, and residential properties to the north and East (Penymynydd / Penyffordd),. The town of Buckley is further north of the site. Padeswood cement works has been operational since 1949, so is an established part of the local sound environment, but has also been the subject of sporadic noise complaints and regulatory action in respect of noise over more recent years.

Our requirements for noise / vibration information are described in our regulatory guidance and NRW have met with the operator through the application process with the aim of explaining technical questions and ensuring clarity of information requests to ensure that responses are comprehensive. Key submissions are described above, but to summarise, when the application was originally submitted (August 2024) it did not contain a full Noise Impact Assessment (NIA) meeting EPR permitting requirements, but instead contained a technical note "noise assessment methodology" indicating that further work needed to be completed (*including environmental monitoring work which NRW notes may take a considerable amount of time to undertake*). Noise information was the last Schedule 5 response to be received from the operator during the determination.

The principal requirement for permit determination in respect of noise and vibration is a Noise Impact Assessment. This must meet the requirements of BS 4142:2014

+A1:2019, "*Methods for rating and assessing industrial and commercial sound*", and the regulators Method Implementation Document (MID) for BS 4142. Our initial assessment of the application identified that this was absent and we subsequently requested its submission. A Noise Impact Assessment was received on 06/01/25 and found to be substantially complete, after which the application was Duly Made. However, on full review, it was found that the report did not consider the variation noise impact along with noise from the existing permitted installation, as required in our guidance:

> "*When you apply for a variation, do not include noise from the existing site (before changes) as part of the background or the residual sound levels. Your noise impact assessment must consider all the noise resulting from the proposed variation – the existing site and the variation together. Show both components clearly and then add them together to give a new total for site noise at the receptors. The impact assessment will be based on this new value, known as the 'specific level' in BS 4142*".

A schedule 5 notice was subsequently issued requiring this approach and related additional information. A final BS 4142 noise impact assessment was received on 08/08/25, prepared by a specialist consultant. This assessment includes:

- Noise monitoring both with the existing cement plant operational (2 weeks), and for limited periods non operational (2 nights). For noise impact assessment purposes NRW guidance considers that the background sound is without plant operations, but that existing ambient sound levels (with cement manufacturing) may be informative. The operator has used "plant off" background data (night-time only as plant was only fully off at night) as the basis of comparison for their assessment.
- Older source measurements (2021) of existing cement plant made by a different consultancy, imported directly to the sound propagation model, and without additional validation beyond a simple "sense check".
- Source measurements (2025) for 8 items of existing cement plant sources, where the equipment had been added/changed since previous surveys and hence not included in the 2021 dataset. Also source terms for equipment already consented (V020) but not yet operational – Solid recovered fuel (SRF) equipment.
- Comprehensive list of expected sound sources and locations from the proposed variation (capture plant, CHP and associated equipment), including proposed mitigation (Table 5.2).

- Computational sound propagation modelling (SoundPLAN) to calculate anticipated sound pressure levels at nearby sensitive receptors, based upon the inputs above (including measured source data for existing plant, modelled source/mitigation data for proposed CCP equipment).
- Comment upon results (including context, uncertainty etc), largely as required by the BS 4142 standard and MID.
- BAT assessment for the new equipment, dealt with separately in section 7, above.

Readers should refer to the full submitted report for full information. However as described below, it left NRW with some concerns and uncertainty over the noise impact from the existing site, and proposed future operations, leading us to the actions which we describe. Table 7.1 is reproduced below from the applicant's full report, as it contains a summary of the calculated impact both of existing operations and proposed new operations:

ID Number	Receptor Address	Period	Background Noise Level, dB(A) $L_{90,T}$ (Site Shutdown)	Existing Noise Level, dB(A) $L_{Aeq,T}$	Rated Predicted Noise Level, dB(A) $L_{ar,Tr}$	Excess Over Background Proposed Sources dB(A)	Excess Over Background Existing Plus Proposed Sources dB(A)	Ambient Level at Receptor dB (A)	Change in Ambient Noise Level, dB(A)
R1	2 Padeswood Drive	Night-time	30	51	39	+9	+21	56	0
R2	3 Padeswood Drive	Night-time	30	51	39	+9	+21	56	0
R3	6 Padeswood Drive	Night-time	30	50	39	+9	+20	56	0
R4	7 Padeswood Drive	Night-time	30	50	38	+8	+20	56	0
R5	10 Padeswood Drive	Night-time	30	51	41	+11	+21	56	0
R6	11 Padeswood Drive	Night-time	30	51	40	+10	+21	56	0
R7	14 Ffordd Derwyn	Night-time	23	41	31	+8	+18	48	0
R8	33 Ffordd Derwyn	Night-time	23	41	31	+8	+18	48	0
R9	34 Plas Yn Rhos	Night-time	23	40	31	+8	+18	48	0
R10	38 Plas Yn Rhos	Night-time	23	40	31	+8	+18	48	0
R11	40 Plas Yn Rhos	Night-time	23	40	31	+8	+18	48	0
R12	44 Plas Yn Rhos	Night-time	23	41	31	+8	+18	48	0
R13	Bannel Farm	Night-time	30	49	35	+5	+19	56	0
R14	Beudy Coch, Padeswood Lake Road	Night-time	30	46	33	+3	+16	47	0
R15	Camfa Rheinallt Farm, Padeswood Lake Road	Night-time	30	46	33	+3	+16	47	0
R16	Dyke Farm, Padeswood Lake Road	Night-time	30	50	37	+7	+20	47	0
R17	Hendy Cottage, Padeswood Lake Road	Night-time	30	52	34	+4	+22	47	0
R18	Homelea	Night-time	30	51	41	+11	+21	56	0
R19	Laburnam Cottage	Night-time	30	46	41	+11	+17	56	0
R20	Brook Meadow Housing Estate	Night-time	23	42	32	+9	+19	48	0
R21	Oak Drive	Night-time	23	44	32	+9	+21	48	0
R22	Oak Tree Farm, Bannel Lane	Night-time	27	48	31	+4	+21	50	0

R23	Oak Tree Farm	Night-time	30	47	42	+12	+18	50	1
R24	Pen-Yr-Allt Farm, Padeswood Lake Road	Night-time	30	47	32	+2	+17	47	0
R25	The Gables, Padeswood Lake Road	Night-time	30	47	32	+2	+17	47	0
R26	The Old Barn, Padeswood Lake Road	Night-time	30	47	32	+2	+17	47	0
R27	Toll Bar Cottage, Chester Road	Night-time	30	46	33	+3	+16	47	0
R28	Ty Gwyn Farm	Night-time	30	46	39	+9	+17	56	0
R29	Well House Farm, Padeswood Lake Road	Night-time	30	51	37	+7	+21	47	0
R30	Springfield	Night-time	27	49	30	+3	+22	50	0
R31	Pine Way Residences	Night-time	23	41	33	+10	+19	48	0
R32	Hawthorn Way Residences	Night-time	27	48	27	+0	+21	50	0

Table 7.1 Operational predicted sound levels

Columns 1-3 identify and reference different potentially sensitive receptors, and show that the figures are for night-time impact. As shown in column 4, this table indicates a night time background level at sensitive receptors of between 23-30 dB(A) without the cement plant operating. Column 5 indicates a calculated existing sound level (from the cement plant) of 41-52 dB(A) at receptors and column 6 a further calculated contribution from the proposed CCP variation of 27-42 dB(A). Column 7 shows the increase from the variation only over the night-time background sound of +0 to +12 dB(A) at receptors (but note that this is a theoretical prediction; in reality the CCP could not operate without the cement plant). Column 8 shows the cumulative impact of varied cement plant with CCP, ranging from +16-22 dB(A) at receptors, *(note that as calculated, this impact is dominated by existing site noise sources).* Column 9

indicates the average measured Ambient ("actual") sound level at receptors, *[including the cement works, plus other natural and artificial noise at the location such as traffic, other businesses, and animals/birds],* and column 10 depicts the calculated change in ambient level at receptors owing to the variation to add the carbon capture plant.

Based upon this data, the applicant makes a number of observations / conclusions, including on the context of sound from the cement works. In particular NRW note that the report states that:

"*With consideration to significance of impact, there is a potential for the site to cause an adverse impact in terms of noise, subject to context*"

And:

"*The existing operational site generates noise levels that are +18 dB(A) above the derived background levels [NRW: at R23, Oak Tree Farm, see below]. The proposed plant items are predicted to result in a +1 dB(A) marginal increase in ambient noise levels at Oak Tree Farm receptor. Although this is not the highest change in comparison to background noise levels, this receptor predicts the worst-case change in ambient noise level. A change of this magnitude would not be distinguishable above the existing noise environment*".

Our findings in respect of submitted noise impact assessment

Having carefully considered the content of this report, NRW has reached the following conclusions in respect of the noise submission to inform our determination:

- The background levels used in the assessment have been derived using a statistical method that is relatively precautionary. The background levels used in the assessment are derived from measurements undertaken without the existing plant operating and are considered to be low and generally representative of the rural location.
- The calculated existing sound levels (from the cement plant) are high when compared to background sound levels without the existing site. This is not surprising given the scale of industrial activity and identified noise emitting equipment, and is consistent with ongoing NRW regulation of the site. The calculated difference above background is very likely indicative of a significant adverse impact at receptors (being >10dB(A) above background – the maximum at most impacted receptor is +22dB(A) for the existing site alone). This is above the "adverse" descriptor used by the applicant, although these figures do not take account of context as described in the standard

(see below). There is also reason to believe that these existing impacts may have been over-estimated, and the difference above background may not be as large as calculated *(this includes uncertainty in existing site source terms; possible double-counting of sources; potentially not accounting for all recent noise improvements. This position is supported by the observation that calculated levels (L_{Aeq})due to the existing plant at receptors are in some cases higher than measured ambient levels (L_{Aeq}) at MP1-4 with the cement plant operating (as reported in application noise report Figure C1-C4 in Appendix C). It also aligns with qualitative regulatory observations regarding existing site impact / complaints*.

- Like the cement production facility, the proposed CCP is a significant industrial facility, and contains various equipment which could be expected to bring noise risk (fans and blowers, motors, pumps, and CO_2 compressor) The basis of design of the CCP in respect of noise is in effect to select sufficiently low noise equipment in the first place, and employ mitigation (such as acoustic enclosure or lagging) to ensure that, as stated in the report, the additional equipment from the variation will "*not be distinguishable above the existing noise environment".* There is inherent uncertainty in the modelled noise from new sources, as actual performance cannot be verified ahead of operation. This is normal for proposed new equipment and there is no specific reason to believe that stated noise performance will not be achieved.
- In Section 7.3, the report makes observations upon the noise context, including that the cement works is a long-standing established noise source, and that "*receptors are unlikely to experience a significant change in their soundscape [NRW: as a result of the proposed variation]*.
- The submitted NIA raises a number of detailed technical questions which would merit separate clarification / justification to NRW, by the operator.
- Because of the uncertainties in the existing source terms, the relative impact of the proposed CCP changes may have been underestimated. They also do not take into account any future changes to the existing site, which may be required to mitigate existing noise impact, meaning that the relative impact of the new plant may be under-stated (in simple terms, as the existing site gets quieter, the .proposed CCP equipment may become more noticeable).
- Nevertheless, the report does contain information on the existing plant and proposed variation that allows NRW to make a permitting decision on the variation as described below.

Our web guidance linked above states that

Unacceptable level of audible or detectable noise

This level of noise means that significant pollution is being, or is likely to be, caused at a receptor (regardless of whether you are taking appropriate measures).

You must take further action or you may have to reduce or stop operations. The environment agencies will not issue a permit if you are likely to be operating at this level.

The closest corresponding BS 4142 descriptor is 'significant adverse impact' (following consideration of the context).

The submitted report clearly indicates a calculated impact (at R17, Hendy Cottage, Padeswood Lake road) and R30, Springfield of +22 dB(A) which (subject to context) would likely be a significant adverse impact, whether or not the variation was issued, as the noise is at that level from the existing plant. At all representative receptors listed (R1-R32), the calculated impact of existing operations is >10dB(A), indicative of significant adverse impact (subject to context), being in the range +16 dB(A) to +22 dB(A).

The biggest calculated change in sound as a result of the variation alone is at R23, Oak Tree Farm, where the new equipment has a calculated +12 dB(A) above background (indicative of significant adverse impact, subject to context but incapable of operating alone as it serves the cement manufacturing plant), a combined impact of +18dB(A) with existing cement production operations. At other representative receptors, the calculated impact of the new (variation) equipment alone is in the range +0 dB(A) to +12 dB(A), with 12 of the 32 assessed locations being +9 dB or above.

NRW Decision on actions as a result of noise information provided

On the basis of the submitted report and NRW review, we have made the following principal conclusions and decided that the following actions are appropriate.

- The report provides a strong indication that significant adverse impact at receptors is likely from existing site operational noise, but contains uncertainties which should be reduced. We will require the operator to investigate / substantiate this further via improved BS4142 surveys, and to take corrective action as necessary to reduce noise emissions from the site. In itself, despite the guidance quoted above, this is not a reason to refuse the proposed variation, as the issue comes from the existing operations, and refusal would not make any difference to that situation.

- The report concludes that noise from the proposed variation would not be distinguishable from the existing site noise, but we do not consider this to be certain. Based on the applicant's derived background levels with the existing site operating (Column 5, Table 3.10) and presented predictions for the variation in isolation (Column 6, Table 7.1), the predicted sound levels are +6 dB(A) (calculated) above background, without any character correction. This is at R23, Oak Tree farm, where the variation is predicted to have the largest change from existing operations (NRW note the figure quoted by the operator is incorrect). This is a reason to require more work to be done prior to operation of the CCP to determine what more can be done to reduce new noise impacts. New noise sources must not cause significant adverse impact (even after cement plant improvements required above). We can assess the impact of new noise sources, and appropriate mitigations better when the work now required (above) has been done on the existing site.
- We are confident that if we vary the permit to allow the CCP, NRW can require and verify further work to be undertaken by the operator, (via pre-operational and improvement conditions) to ensure that existing noise issues are reduced, and that the "as built" carbon capture plant does not cause significant pollution.
- Because we anticipate the need for material reductions in noise from the existing site, the relative impact of the proposed new equipment may increase and therefore the noise specification of new kit must remain under review (for possible reduction only) while improvements to existing permitted noise sources are undertaken and assessed.

We have therefore decided to issue the proposed variation, with the following specific actions:

- We can only vary the permit in respect of an operator application for things that they have asked to change. We have therefore imposed an "NRW led" variation element to the variation requiring the operator to review and update their noise impact assessment for existing site noise as an improvement condition (IC 16) to refine the estimate of impact of existing site noise on receptors.
- As a result of the reported impact from existing site sound sources, we have imposed an NRW-led pre-operational condition (PO 09) prior to operation of the

carbon capture plant development, requiring physical improvements to existing site noise to either reduce the impact to “adverse” or below, or if this is not possible, demonstrate that BAT measures have been applied to prevent or minimise polluting noise emissions. Improvements must be completed before the carbon capture plant is operated and contributes to regulated sound sources.

- We have imposed a pre-operational condition (PO 10) in respect of the variation. This requires the operator to update their noise impact assessment in respect of existing and new sources, and to review new noise source terms, in order to demonstrate that with all of the above changes, the variation (neither causes nor contributes to a significant adverse impact at receptors, and that BAT measures have been applied to prevent or minimise polluting noise emissions, taking into account the fact that the existing operations sound performance must improve. In this way, we have developed robust measures that allow the proposed variation to proceed, but ensure that it will not cause significant noise pollution.

  The wording “cause or contribute” reflects the requirement that where a significant adverse impact is indicated from the existing site, then the rating level from the variation sources (V021) will not increase the total site rating level. Where the existing site rating level is found to be an indication of adverse impact or lower, then the total site rating level (including variation sources V021) should not result in an indication of a significant adverse impact.
- Finally, because there is always some uncertainty with future noise modelling predictions, we have imposed an improvement condition (IC17) to measure new and existing noise sources and determine actual noise impact following existing site improvements and carbon capture plant operation. This work must demonstrate a material improvement in noise levels from those currently predicted, confirm the performance expected via the IC’s / PO’s listed above, and propose any further practicable measures if total noise is still considered to have a “significant adverse” impact or is above predicted levels. Such additional measures must be implemented if NRW requires them.

This approach in respect of noise is not taken in isolation; there has been significant regulatory and operator activity to reduce noise impact over many years. While a limited number of complaints still occur, this regulatory approach continues on an existing trajectory to improve site performance and reduce impacts further while allowing the proposed variation to proceed. The operator has proposed within the application significant mitigation measures to reduce impact from the CCP, with the clear design intent that noise from the proposed variation does not significantly adversely impact local receptors, and our permit conditions ensure this will be the case.

NRW has enforcement powers with regard to permit conditions. We are satisfied that pre-operational conditions PO 09 and PO 10, together with improvement conditions IC16 and IC17 provide an enforcement mechanism designed to reduce overall noise levels from the installation. As these conditions are enforceable, we will take the appropriate action if they are not complied with, in accordance with our powers and duties.

In reaching our decision on noise, we believe that we have balanced the requirements to deal with an apparent existing noise pollution issue that has been identified (through new information provided in support of the variation application), the needs and expectations of the local community, and to allow further development provided that it is robustly demonstrated through operator response to the conditions imposed that it does not cause significant noise pollution.

8.7. Loss of Containment risk assessment for potentially polluting substances

As summarised in section 5.3 above, the operator has a duty to ensure that soil and groundwater are protected in order to meet requirements of the IED. In practice, this means ensuring appropriate measures for containment (i.e. preventing release) of potentially polluting liquids which could otherwise leak from the site. Such loss of containment can either be gradual (e.g. drips from valves and flanges, and during maintenance), or sudden (e.g. storage tank major leak or catastrophic failure). Effective containment is reliant on at least two layers of protection: (1) effective

primary containment (tanks, sumps, pipework, fittings & controls) through appropriate design, equipment specification, selection and materials, maintenance and inspection etc, and (2) additional protection in the event of loss of primary containment, i.e. secondary containment, also known as bunding and as necessary further “stacked” containment, i.e. tertiary, quaternary.

The generic requirement for bunds is often summarised that they hold 110% of the brim-full capacity of the largest tank, or [for collective bunds], 25% of all the tanks bunded together, whichever is the greatest. However, Ciria C736 guidance lays out far more detail on appropriate risk-assessed containment for the prevention of pollution and for sites such as the Padeswood CCP with significant substance inventories, NRW expects the Ciria approach to be used.

The operator clearly stated (in technical summary) their intention of providing suitable and sufficient impermeable, sealed surfaces beneath the CCP process equipment, and secondary containment (bunding) for potentially polluting liquids in accordance with Ciria C736 guidance. Furthermore, arrangements for the collection of uncontaminated surface water, holding in a balancing pond/storage lagoon, testing, and discharge to surface water or re-use in process were described and satisfactory, and included emptying of collected uncontaminated water from bunds and transfer to the surface water system (see section 8.3).

The application (technical summary and plans) listed in detail the tanks / vessels required, and provided detailed indication of the general tank specification standard and other engineering specification for primary containment, which is seen to be to a high standard and protective against losses of contents in the first place. The application did not however fully specify the secondary containment detail. Based upon the information in the application we were satisfied of the design intent to provide appropriate measures to protect the site and its surroundings from polluting substances. However, we did not consider that sufficient detail had been made available to confirm the specific containment arrangements, given the complexity of the process plant and storage, and the potential hazard presented by the amine-based carbon capture agents and other reagents (sulphuric acid, ammonia, etc). We therefore requested further information at the duly making stage (containment class

for different liquids, inventory of secondary (and tertiary) containment areas, validation of design, etc). The operator proposed to provide further detailed information within the determination period, noting that full design criteria were not available at the point of submission. We agreed to this approach, noting that we had sufficient evidence of intent and layout to begin determination, and received further detailed information on 13/05/2025 in response to our Schedule 5 notice (as the provision of information from the operator had been delayed).

The additional information received demonstrated a high-quality approach to secondary containment. It identified that Ciria C736 Class 2 containment was appropriate for the site, based on a source, pathway, impact model that referred to relevant local receptors. It considered in detail possible scenarios for loss of containment, even with the 110%/25% bunding in place, such as jetting leaks and catastrophic tank failure modelling, where the momentum of fluid loss ("sloshing") can lead to containment loss nevertheless. However, it was also clear that some more basic information (e.g. bund location, dimensions, collective contents, rationale for excluding some vessels) was either absent from the submitted information, or disperse and difficult to identify. We therefore held a call with the operator on 27th May 2025, and explained what further information/clarification was needed. This information was provided on 11/06/2025 comprising of the email text, a powerpoint presentation indicating principal storage tank areas and layouts within the site, a spreadsheet summarising all tanks, their contents, and containment volumes, and a PDF explanation of purpose and construction of "sump tanks".

It is noted that in addition to technical updates and provision of further information to the regulator, following dialogue with us the operator changed their proposals in regard of tank 720-TK-012 (Quencher FGD Section Drain Tank). In the Ciria report received 13/05/25, it was identified that this tank did not have full secondary containment. The case was put forward, on the basis of environmental hazard of the contents and chance of loss, that residual risk was "As low as reasonably practicable, ALARP" for secondary containment other than 110% of full volume). Following dialogue with the regulator, during which we explained that further evidence would be required to demonstrate that ALARP was achieved, the operator instead amended their plans

(11/06/25) to include full 110% containment, and engineer out this residual risk. We accept this approach to the issue.

With regard for all of the information submitted in respect of secondary containment and Ciria C736 risk assessment, we are satisfied that the operator will implement measures which in all reasonable scenarios, prevent the loss of potentially polluting liquids from the installation. Noting the following key points:

- Tanks 740-TK-001, 002, 003, 004 and 009 are justified as not requiring secondary containment as the contents is low or no environmental risk – being water of various grades (raw water, demin water, flue gas condensate, Reverse Osmosis (RO) reject water and fire system raw water respectively). We accept that "clean" water has negligible risk; and also that RO reject and "clean" flue gas condensate (prior to further treatment e.g. gypsum) present a low environmental risk. These tanks are in a kerbed area, and loss of containment of these tanks would not risk impacting bund volume for other tanks by co-location).
- There are several sumps (referred to as sump tanks, 720-TK-002, 008, 013, 014 and 720-TU-002) that are not bunded – it is impractical to provide secondary containment to a sump. Typically sumps are constructed of reinforced concrete, and it is then typically accepted that loss of inventory is unlikely provided systematic management (e.g. inspection, testing) is in place. In this application, several sumps were referred to as "sump tanks" and indicated material of construction other than concrete – including carbon steel and stainless steel. We therefore sought further explanation and the supplementary PDF document (11/06/25) provides this detail.

  In essence, these are intermittent use low-lying tanks to enable the complete gravitational emptying of other process/storage vessels and pipework, for maintenance etc. They will be used after the main content has been pumped out elsewhere to lowest operational pumping point. The contents of the sump tank is subsequently pumped to appropriate tank storage. The material of construction is impermeable to the intended contents. For all other than 720-TU-002, this involves an impermeable metal liner set within concrete walls and base that will provide mechanical strength/protection. They are also small tanks (all 6.8 m^3 working volume, although with considerable headspace design of 21.2 m^3 brim-full) compared to the main operational infrastructure, reflecting their intended use. 720-TU-002 is larger at 56 m^3 working volume, 64 m3 brim-full, but this reflects the size of the supported

infrastructure (with the main drain tank 720-TK-012 being 462 m^3 working volume). It is of concrete construction with resin lining resistant to the intended content.

We are satisfied that these sump-tanks are fit for purpose and that measures are in place (suitable physical and mechanical design, inspection, maintenance, level alarms) to minimise the risk of loss of process fluids from these intermittent use vessels.

- For the remainder of the tanks (720-TK-001, 003, 004, 005, 006, 007, 009, 010, 011, 012, 015, and 740-TK-010, the spreadsheet provided 11/06/25 shows that the tanks will be provided with bunding of at least 110% of their brim-full volume, and where collective bunding, that this is at least 25% of the volume of all the co-located tanks. The powerpoint of the same date/email shows visually where these tanks are located within the site, and the general arrangement of the secondary containment bunds. We are satisfied that the main design engineering requirements for secondary containment are provided for these vessels.
- The Ciria assessment (13/05/25) identifies possible scenarios in which the proposed containment may not be fully effective, and through use of source-pathway-receptor modelling of reasonable worst case impacts and probability of events, develops an overall site risk rating, which concludes that Class 2 containment is required. The only containment below class 2 when the report was written was 720-TK-012, but this has since been amended to achieve class 2 provision by implementation of a larger bund.

  The assessment also considers scenarios where the class 2 containment (110% / 25% etc), nevertheless leaves a residual risk of partial loss of inventory. These scenarios are tank over-fill, catastrophic failure (and “sloshing” over the bund wall), and a hole in the tank wall (leading to “jetting” beyond the bund). It is typical that within a design, such extreme scenarios, even with the required containment, could lead to some material loss, and such events are estimated as less than 1 in a million probability per year. We regard that the scenarios of tank overfill, catastrophic failure, and penetration “jetting” while recognised risks, will be managed to minimise probability of occurrence, through design, operational control and maintenance. Furthermore, the operator has committed to undertaking additional design refinement to further minimise the risk of jetting leaks, by repositioning tanks within bunds, and potentially also by providing baffles etc, subject to final design decisions. We are satisfied that the proposals at least meet our requirements for secondary containment, and go beyond the detail seen in many applications. Where residual risk is identified,

further reasonable work will be done to minimise such risk, meaning that loss of inventory is only expected in exceptional disaster/emergency scenarios.

- The application makes reference to further engineering and operational controls that we would routinely expect to be in place, but does not provide full detail. Matters such as level alarms and leak detection, planned preventative maintenance and testing, etc are all expected to be in place to achieve a high degree of control. We consider that we have sufficient information on such measures to determine the permit, but expect further detail via e.g. EMS and leak detection and repair programme to be available as the project engineering continues. Relevant parts of pre-operational condition 02 and 04 will ensure that this detail is provided in a timely manner
- The majority of pipework is above ground, with only drainage and sump connections being below ground. While pipes will run outside of bunded areas, it is expected that engineering and operational controls (including inspection, testing, leak detection by flow metering etc) will minimise the risk of loss of inventory outside of bunded areas.

Finally It is noted that in the event of a significant emergency on site, the rainwater attenuation pond (also known as balancing pond) may act as a significant tertiary containment structure for process liquids or firewater. This is referred to briefly in the email 11/06/25 However, this containment role is not covered in the application (e.g. with demonstration of flow from site to the pond via modelling, prevention of infiltration, etc), and our decision is not dependent on the role of the pond, which in effect may provide an additional but un-validated layer of environmental protection. This is because we are satisfied that the described secondary containment alone is sufficient for our decision. In the unlikely case of contamination of the pond in an emergency scenario where secondary containment was not fully effective, it would further reduce the potential off-site impacts, but formal determination assessment of utility is not necessary. Were the pond to fulfil a containment role in practice, it would probably be necessary to tanker the water offsite for appropriate treatment, but such matters are beyond the scope of our determination.

Upon receipt of the information detailed above, we were satisfied that there was sufficient evidence that in addition to effective primary containment, there is robust secondary containment of all potentially polluting liquids in order to minimise the risk of loss, in all reasonably foreseeable scenarios in accordance with Ciria C736 risk assessment principles. Given the likelihood of some degree of design updates

between our determination and construction in respect of containment/bunding we have included a requirement in pre-operational condition PO 02 to provide NRW with any minor final details of containment arrangements which may be amended or finalised following our determination.

8.8. Global warming potential

Emissions of carbon dioxide (CO_2) and other greenhouse gases differ from those of other pollutants in that, except at gross levels, they have no localised environmental impact. Their impact is at a global level and in terms of climate change.

Global Warming Potential (GWP100) emissions as carbon dioxide equivalents (CO2e) have been estimated for the proposed facility by the applicant in accordance the relevant permitting guidance and in accordance with requirements of planning for Environmental Impact Assessment (EIA). As such, although supporting information (e.g. calculation methodology, explanation of approaches) was directly submitted for the permit application, the main GWP assessment was made available for permitting via reference to the public register portal for the associated planning application and EIA. We accept this approach to submission of information, noting the additional data /energy costs (and workload) of hosting the same report on two different repositories. The key GWP summary document is Chapter 7 of the EIA. At the time of permit determination, planning consent had already been granted, so in terms of GWP, there was no need for NRW to repeat / reconfirm work already reviewed by the planning authority (PEDW).

In summary, the applicant has assessed the 100-year global warming potential of the variation (carbon capture plant) compared to a baseline of assuming that the facility would continue to operate "as is" and without CO_2 mitigation, for a 25 year operational life. The impact is dominated by operational phase (i.e. emissions from production), but emissions from construction and decommissioning are also included in the 25 year model, although insignificant (<1% of total) emissions are omitted to simplify calculation. Full detail is given in the referenced report.

Unsurprisingly, for a carbon capture project, the impacts of the proposal (*i.e. implement CCS*) are lower than the baseline of unabated operation. From the calculations provided, the applicant estimates that "as is" emissions would be 16,251,000 tonnes of CO_2e over 25 years, whereas total emissions with the proposed CCP would be 2,208,000 tonnes of CO_2e, including decommissioning. Also taking into account carbon capture from biomass (not normally included in GWP assessments as "*neutral*") the net total impact of the CCP project is calculates as minus 15,624,000 tonnes of CO_2e over 25 years, i.e. emissions reduction of over 15.6 million tonnes. NRW agree that the applicant has suitably assessed the GWP impacts of the project, using reasonable assumptions and justifications. The approach to emissions reduction is also reasonable (e.g. CCP abatement of additional Natural Gas combustion, use of energy integration and CHP, continued use of alternative/secondary fuels and biomass – all of which we anticipate may increase future during the operational lifetime of the plant). We are satisfied that the GWP of the variation is acceptable, i.e. a significant reduction in greenhouse gas emissions, while maintaining industrial production capacity.

9. Our Determination: Impact on the Environment - National Site Network, SSSIs and non-statutory sites

The applicant has used the relevant screening distance criteria to identify relevant protected conservation sites which could be at risk from the proposal. As the predominant mode of potential impact on the environment is via air emissions (there are no process water emissions), screening distances were obtained from air emissions risk assessment guidance. In accordance with the guidance for larger emitters and certain fuel types, they have used the extended screening distances of 15km for SAC, SPA and Ramsar, 10km for SSSI's and 2km for local wildlife sites and ancient woodland We are in agreement with the screening distances used, reflecting the tall stack and wide dispersion area.

A full assessment of the variation application and its potential to affect the identified sites has been carried out as part of the permit determination process. National Site

Network sites, Sites of Special Scientific Interest (SSSI) and non-statutory conservation sites will be discussed separately below this overview.

Other than air emissions, other mechanisms of impact can be disregarded (no credible impact pathway). As noted above, there are no process emissions to water and the risk from accidents / incidents (including loss of containment) is well controlled as already discussed, so as to remove any credible impact pathway. Other impact pathways (such as disturbance, direct physical habitat damage) can be dismissed, noting that the installation is not within a protected site and the closest protected ecological receptor site is >100m from the site (1km for SAC, SPA , Ramsar), meaning that direct impact pathways can be ruled out.

For pollutants which were already emitted from the cement kiln production process (e.g. NO_X, SO_X, particulate, metals, HCl, HF), mass emission rates (grams per second) are either unchanged, or in some cases will reduce significantly with the CCP, owing to enhanced pollution abatement implemented (noting NRW analysis in section 7.4 above). Coupled with the change in pollutant dispersion arising from the CCP which is a factor of gas composition (CO_2, H_2O) and velocity, etc, the impact at all ecological receptors is either not significantly changed or has reduced. The same is true for nutrient nitrogen and acid deposition impact, which is a function of NO_X and NH_3, and NO_X, SO_X and NH_3 emissions respectively, of which are all reducing. No adverse effects from these conventional pollutants is therefore predicted, simplifying the ecological assessments considerably. NRW is satisfied that the “baseline” for proper assessment of impacts is against the presumption of the plant otherwise continuing to operate unabated, as already consented.

For newly emitted pollutants (amines, N-amines etc) there are no established ecological EALs, and relevant guidance states that “*The [assessment] process for protected conservation areas is limited to the emissions and emission periods in these [listed] environmental standards for protected conservation areas*” (gov.uk guidance). The main impact pathway for consideration from these substances on ecological receptors is therefore via any change to ammonia concentration, or via breakdown of organic amines (etc) contributing to nitrogen deposition.

9.1. The National Site Network

The following National Site Network sites are located within screening distance of the installation:

- Deeside and Buckley Newt Sites SAC UK0030132 1.7km
- Afon Dyfrdwy a Llyn Tegid SAC UK0030252 7.2km

(River Dee & Bala Lake – England & Wales)

- Dee Estuary / Aber Dyfrdwy SAC SPA Ramsar UK0030131 7.5km
- Alyn Valley Woods / Coedwigoedd Dyffryn Alun SAC UK0030078 8.3km
- Halkyn Mountain / Mynydd Helygain SAC UK0030163 9.7km
- Berwyn a Mynyddoedd De Clwyd SAC UK0012926 9.3km

(Berwyn and South Clwyd Mountains)

- Midland Meres and Mosses Ramsar (vicarage moss) UK11080 10.3km

Note – the distances quoted are by the applicant, and are to the protected site from the new proposed carbon capture plant. Distance to the existing installation boundary are somewhat lower, with the closest (Deeside and Buckley Newt Site) being ~1km from the existing installation boundary).

A Habitat Regulations Assessment (HRA) was completed to assess the potential to affect any of the sites identified. The project was screened for likelihood of significant effects and, taking account of the informal advice received from NRW's protected sites advisors who agreed with the proposed draft conclusion, it is considered not likely to have a significant effect (alone or in combination) on any National Site Network site (as documented in section 3.2 of OGN 200 Form 1, or section 5 if applicable). The full screening assessment is available to view on the public register, see here: PAN-026621 HRA – No LSE (OGN 200 Form 1). In summary, it is recognised that other than air emissions, there is no credible impact pathway owing to distance from project to receptors. For air emissions, for relevant emitted substances (NO_X, SO_X, NH_3, Nutrient Nitrogen Deposition and Acid Deposition), emissions impacts are either static, or decreasing compared to the baseline of unabated kiln operation (which has previously been subject to HRA). For all pollutants other than HF, impact is decreasing. For HF, impacts are insignificant (<10% of a short-term critical level). Therefore in accordance with our OGN200 guidance, impacts can be screened out as "no likely significant effect".

9.2. Sites of Special Scientific Interest (SSSI)

The following SSSIs are located within screening distance of the installation:

- Buckley Claypits and Commons 1.7km
- Maes Y Grug 4.9km
- Connah's Quay ponds and woodland 5.1 km
- River Dee 8.9km
- Dee Estuary 7.5km
- Shotton Lagoons and Reedbeds 8.7km
- Mynydd Y Fflint / Flint Mountain 9.8km
- Coed Talon Marsh 4km
- Chwarel Cambrian / Cambrian Quarry, Gwernymynydd 7.4km
- Alyn Valley Woods and Alyn Gorge Caves 8.3km
- Bryn Alyn 9.1km
- Glaswelltiroedd Eryrys (Eryrys Grasslands) 9.3km
- Llay bog 7.2km
- Chwarel Singret 7.9km
- Marford Quarry 8.8km
- Halkyn Mountain/ Mynydd Helygain 9.7km
- Berwyn a Mynyddoedd De Clwyd / Berwyn and South Clwyd Mountains 9.3km

Note – the distances quoted are by the applicant, and are to the protected site from the new proposed carbon capture plant. Distance to the existing installation boundary are somewhat lower, with the closest (Buckley Claypits and Commons) being ~1km from the existing installation boundary).

As a Section 28G Authority as defined in the Countryside Rights of Way Act 2000 permitting teams within NRW has a legal duty, under Section 28I of the Wildlife and Countryside Act 2981, to consult with NRW for formal advice when permitting an activity which has been determined to be likely to damage the features of a SSSI.

To determine if consultation is required, a SSSI Assessment was completed. The assessment concluded that the proposed permission is not likely to damage any of the

flora, fauna or geological or physiological features which are of special interest. Therefore, no consultation with NRW's protected sites advisors is required.

A copy of the assessment is available to view on the public register, here: PAN-026621 SSSI Appendix 4 Not Likely to Damage. A robust conclusion of "not likely to damage" can be drawn for similar reasons to those explained for the European sites covered by the HRA: There is no credible impact pathway owing to distance from project to receptors other than for air emissions, and for these, for relevant emitted substances, emissions impacts are either static, or decreasing compared to the baseline of unabated kiln operation for all pollutants other than HF, which has an insignificant impact at <10% of short-term critical levels. A decrease in pollution loading necessarily means that damage from the variation is unlikely, irrespective of process contribution significance criteria or predicted environmental concentration (*noting that some pollutants have "exceeding backgrounds" owing to sources other than this industrial facility*) .

9.3. Non-statutory conservation sites

The following relevant non-statutory sites are located within 2 km of the installation, with the operator identifying the closest as being 0.5km from the development envelope:

- Flintshire Wildlife Site (Prices Hill Wood, Bistre Wood, Black pool plantation, Hartsheath, Pontblyddyn Marsh and Coppa Wood, Padeswood Pool, Padeswood Pasture)
- Marleyfield Meadow,
- Padeswood Marsh,
- Etna Road Pools
- Plas Newydd Farm Lake
- Riding School wood and grassland
- Garth wood and hartsheath
- Warren Dingle
- 24 discrete areas of designated ancient woodland, which are not named in the application.

Based upon the information in the application we are satisfied that there will be no liklihood of significant pollution of the non-statutory conservation sites identified. In the same manner as SAC/SPA/Ramsar and SSSI, above, mechanisms of harm other than air quality impacts can be disregarded (including assessing the disturbance potential from change to noise impact as low, and *noting that for nearby non-statutory sites, the conclusion is contingent on containment risk from potentially polluting substances being as low as reasonably practicable to dismiss risks of water contamination from accidental release – see section 8.7 on Ciria C736 secondary containment)*). For air quality pollutants, as already described above, emissions impacts from the variation (CCP addition) are either static or decreasing compared to the baseline of unabated kiln operation, therefore damage is improbable, other than for HF. Furthermore, for all assessed air pollutants including HF, the PC is <100% of the environmental standard, a level regarded as unlikely to cause significant pollution of non-statutory sites.

10. Our Determination: The Permit Conditions

10.1. Changes to the permitted activities

The permit has been updated to reflect the variation that we have decided to grant. Principally, Table S1.1. has been updated for the new activities, and amended for existing authorised activities subject to change. This is summarised in section 2.1 and 2.2 of this document. The following further points are noted, where the descriptions and limits of the activities form specific permit conditions:

- The cement kiln S3.1 activity is amended to now include a waste disposal activity "D10 Incineration on land". The cement kiln was already authorised to undertake recovery ("R") activities associated with using waste as a fuel or alternative raw material. The kiln now also operates as a disposal facility, only for wastes arising on site from the carbon dioxide capture facility (once operational) and as described in the permit. We are satisfied that no other changes to permit conditions are required as a result of this change, noting that the Chapter IV activity clearly still remains co-incineration as the disposal is incidental to cement production which is the primary purpose of the plant. Were wider authorisation sought for additional waste disposal (e.g. external imports), this may change, and additional requirements for waste incineration may arise…

- As described above, The S1.1 combustion activity is considered part of the IED Chapter IV co-incineration plant, so is not separately regulated under IED Chapter III, but is nevertheless listed in Table S1.1. It is not permitted to operate as a standalone generation plant
- The S6.10 CCP activity includes all parts of the carbon capture process, including pre-treatment of flue gases, solvent re-generation and reclaim, etc, as described in the permit.
- The S4.2 Production of Hydrogen activity is incidental – use of an electrolyser to produce hydrogen is required for deoxygenation of the captured CO2 for meeting pipeline/injection specifications. This again is not a standalone process, but as an EPR schedule 1 activity, is noted in its own right as there is no de-minimus to the activity description in regulations..

10.2. Updating permit conditions during consolidation

Various minor updates have been made to permit conditions and a reference has been added, under operating techniques, to the existing Dust Management Plan. All with agreement by the operator

10.3. Use of bespoke permit conditions

Only one bespoke permit condition has been used – the new carbon capture process is to a very great extent regulated under existing permitting conventions, and with reference to appropriate existing regimes (e.g. cement, Large combustion plant, chemicals, materials handling).

The only bespoke condition added is 4.2.2 (d) [reporting] – requiring the operator to include in their annual report of operations, a report on the operation of the CCP. This is particularly important in early years of operation as information is gathered on the new facility.

Bespoke improvement and pre-operational conditions are used in several places, as documented.

10.4. Incorporating the variation

We have specified that the applicant must operate the permit in accordance with descriptions in the application, including additional information received as part of the determination process.

These descriptions have been specified in the Operating Techniques table in the permit.

10.5. Emission Limits

Article 14(3) of IED states that BAT conclusions shall be the reference for permit conditions. Article 15(3) further requires that under normal operating conditions; emissions do not exceed the emission levels associated with the best available techniques as laid down in the decisions on BAT conclusions. BAT is discussed extensively in section 7, above. BAT for cement and lime production is unchanged, and the plant will continue to at least meet BAT-associated emission levels (e.g. HCl, HF) as described.

For a number of kiln pollutants (e.g. NO_X, SO_X), implementation of the CCP means that there will be a marked reduction in emissions, and the operator has in several instances proposed (and modelled dispersion based upon) lower emission limits. We regard these as site-specific BAT when the cement plant is integrated with the specific amine-solvent CCP proposed. As the CHP combustion is considered to be within the Chapter IV “envelope”, any emissions arising from this must be within the prescribed ELVs (e.g. NO_X, CO).

BAT has yet to be established for CCP, and GET does not prescribe ELVs. Emissions limits associated with the carbon capture process / solvent are therefore set as site-specific BAT, and with regard for impact assessment that demonstrates that dispersion concentrations are at a level unlikely to cause significant pollution, or lower. Our qualitative assessment of the abatement techniques proposed (3-stage washing, acid wash capability, proprietary mist eliminators etc) indicate that resultant ELV control-points are BAT.

10.6. Monitoring

We have decided that monitoring should be carried out for the parameters listed in Schedule 3 of the permit using the methods and to the frequencies specified in those tables. These monitoring requirements have been imposed in order to demonstrate compliance with the emissions limits in the permit.

For emissions to air, the methods for continuous and/or periodic monitoring are in accordance with general regulatory guidance (Monitoring stack emissions: environmental permits - GOV.UK), guidance for carbon capture plant (Monitoring stack emissions: carbon capture plants with solvent-based abatement - GOV.UK) and/or in line with BAT requirements set out for the cement and lime sector. Monitoring requirements for existing kiln pollutants are unaltered, although limits and monitoring locations will change. Pre-operational condition PO 02 and improvement condition IC11 is set to ensure that the new CCP monitoring location is suitable to achieve representative sampling, and IC 13 will ensure that NRW is provided with appropriate information on the continuous monitors calibration. It is acknowledged that monitoring methods and approaches for carbon capture plant pollutants (aldehydes, amines, nitrosamines etc) are still developing, as is knowledge about the nature and variability of emissions from carbon capture activities. Further refinement / adjustment to monitoring arrangements is provided for in the permit. Specifically, an improvement condition (IC 15) is included which references Table S3.1 monitoring, and requires monthly sampling of these substances for at least six months, and until emissions results are shown to be low and stable. This is to ensure enhanced emissions data during early operation, and can be re-imposed by notice by NRW. The monitoring frequency requirements (monthly, dropping to 6-monthly provided certain criteria are met) is based upon the principles of the established “dioxin protocol”, which is used in the energy from waste sector for other trace-level pollutants which have similar monitoring / quantification challenges.

Based on the information in the application and the requirements set in the conditions of the permit we are satisfied that the monitoring techniques, personnel and equipment employed by the Operator will have either MCERTS certification or MCERTS accreditation as appropriate and where available. This is the case for all existing pollutants. For emerging pollutants from carbon capture (amines, nitrosamines and nitramines, aldehydes), it is widely recognised that further development of more

sensitive (and possibly continuous) methods of detection will be required. A collaborative, industry-led approach is required to drive innovation and improvement. We have therefore set a pre-operational condition PO 08 and improvement condition IC 22 (already referenced above), within the remit of environmental permitting, requiring the operator to initiate, support and encourage (so far as it is within their control) any initiatives to improve the availability of robust (and ultimately standardised) testing methods for the detection and quantification of emerging pollutants from carbon capture.

10.7. Reporting

We have specified the reporting requirements in Schedule 4 of the Permit to ensure data is reported to enable timely review by Natural Resources Wales to ensure compliance with permit conditions and to monitor the efficiency of material use and waste recovery at the installation. The format and frequency of monitoring data reporting (Table S4.1) is unaffected by the variation, though new emissions points and determinands (for air) are added. For the CCP, carbon capture (% as annual average), availability, energy efficiency (including CHP) and material efficiency (solvent use and waste arising) are key performance indicators, reflected in updated performance parameters reporting in Table S4.2 as necessary.

10.8. Process monitoring

In addition to the formally regulator-reported performance parameters identified in Schedule 4, Table S3.5 lists process monitoring which shall be made available to NRW. The operator will undertake a great deal of process monitoring throughout the cement and carbon capture plant, to ensure that it is operating properly. For the new CCP, this monitoring is especially important. We have specified a number of process monitoring parameters associated with the variation, as documented in the permit. We recognise that key process monitoring parameters for CCP are still developing, so have specified that the operator must agree appropriate measures with us as a pre-operational condition 06. These are likely to include, for example, rate of fresh solvent top-up, analysis of breakdown product in circulating solvent, rate of waste transfer to the kiln, but a degree of flexibility is allowed via the Pre-operational condition for the operator to agree with the regulator on the most effective and informative monitoring

parameters. These will be made available to NRW, but will not be routinely reported like measurements covered in 10.7 above.

10.9. Waste Types

We have updated the permitted waste types, descriptions and quantities, which can be accepted at the regulated facility. This is to include waste arisings from the CCP which will be returned to process for recovery, or for disposal. The additional EWC codes included are those in the variation application. Flue gas desulphurisation plant water (condensate, upstream of amine absorber) is used as an alternative low-risk process water source. Other wastes (reclaimer waste, acid wash waste water, filtration unit waste, dehydration unit waste) are considered hazardous or potentially hazardous and are disposed of via the calciner. The operator has confirmed that the injection point means that the temperature and residence time is appropriate to ensure complete destruction of organic constituents of the waste and we are therefore satisfied that the operator can accept these wastes and to the points in the process detailed in the application, but note that acceptance of these wastes sits outside of the Mineral Products Association Code of Practice for Waste Derived Fuels and Alternative raw materials, and therefore their suitability has been assessed on an individual basis during determination. Pre-operational condition PO 06 requires that the operator agree with NRW suitable specifications to ensure that the wastes remain suitable for use in the kiln, and parameters are reviewed under improvement condition IC 14. Specifically for the FGD waste water, one parameter shall be waste volume, i.e. that the volume of water returned to process is required operationally, to demonstrate alternative raw material status. PO 02 requires that information on the calciner point of injection and injector design be provided, with demonstration that the proposal assures the residence time and temperature referred to above.

10.10. Pre-operational conditions

Based on the information in the application, we consider that we need to impose pre-operational conditions. These are as listed in the permit. The requirement for them is explained above in this decision document, or is largely self-explanatory (e.g. the need for a commissioning plan for the new equipment).

10.11. Improvement conditions

Based on the information on the application, we consider that we need to impose improvement conditions. These are as listed in the permit. The requirement for them is explained above in this decision document, or is self-explanatory (e.g. the need for a report on the outcomes of commissioning of the new equipment).

11. OPRA

The OPRA score will change as a result of this variation. The current OPRA score is 116. It has been agreed by NRW that the current OPRA score will remain in force, and the appropriate, increased OPRA score will be implemented a suitable time before the CCP changes begin. This is likely to be approximately 1 year before the start of commissioning, when work is required on pre-operational and improvement conditions and in preparation for regulation of the additional facilities.

The OPRA score will form the basis for ongoing subsistence fees while this charging scheme remains in force. It is noted that NRW intend to review/update compliance charging approaches, which is likely to be in place before the CCP is commissioned. Specifically, it is anticipated that by then, NRW will specifically charge for assessment of completion of pre-operational and improvement conditions, which it currently does not. This may be of note to the operator.

ANNEX 1: Consultation Reponses

1. Advertising and consultation on the Application

The application has been advertised and consulted upon in accordance with Natural Resources Wales Public Participation Statement. Responses to this consultation and how we have taken consultation responses into account in reaching our decision is summarised in this Annex.

Consultation Responses from Statutory and Non-Statutory Bodies

Response Received from Flintshire County Council (Planning)	
Brief summary of issues raised:	**Summary of action taken / how this has been covered**
Standard pro-forma response in respect of noise – no specific noise issues raised (though NRW is aware of some noise complaints directly and via the operator)	See DD section 8.5 Noise – council input and other factors considered in deciding our approach to Noise and Vibration.

Response Received from Public Health Wales (Environmental Public Health Service)	
Brief summary of issues raised:	**Summary of action taken / how this has been covered**
Detailed response, as required /requested by NRW, given the expert support needed on assessing suitability of operator-proposed EALs for amines and their by-products. See the response. Noting the overall conclusion however, that "*Subject to the Regulator being satisfied that the applicant's assumptions, impact assessments and measures to control emissions, including to air, of noise, vibration and odour represent Best Available Techniques, we have no public health concerns associated with the proposed development*" In respect of noise, PHW have stated that "We recommend that the Regulator is satisfied that this approach *[NRW: design specification*	NRW has had regard for PHW's advice in respect of EALs for amines and their breakdown products and highly values their input – we are in agreement with their comment. See DD section 8.1 air quality impact assessment. NRW has also considered PHW responses to other issues during our determination, i.e. noise and vibration, odour, and containment / spillages. Subject to the comments above in relevant sections of the DD, we are satisfied with the operators proposals, and agree with PHWs comments. In respect of noise, we have outlined a three-part strategy of requiring improvement to noise impact assessment via permit

and additional mitigation] is achievable to limit noise impact at sensitive receptors. Ideally noise levels should be reduced where practicable from existing levels at sensitive receptors.	conditions, improvements to current site operational noise impacts through additional mitigation, and design of new equipment to (as a minimum and in line with PHW comment) to ensure that total noise from the regulated facility at receptors is reduced where practicable from existing levels at sensitive receptors as a result of the variation.

Consultation Responses from Others

No other comments were received during our consultation on the duly made application, including from members of the public and community organisations, or representatives such as Local MP, Member of the Senedd (MS), Councillors and Parish / Town / Community Councils. During our determination, we were made aware of concerns from a local individual over the proposed development that had been raised to the local council planning department. We took steps to understand these concerns, and to ensure that where relevant to permit determination, these concerns were listened to and considered, as relevant, in our decision.

2. Advertising and consultation on the draft decision

The application has been advertised and consulted upon in accordance with Natural Resources Wales Public Participation Statement. There were no public responses. Following the public consultation process, minor drafting changes were made in accordance with internal NRW and operator feedback to correct typos etc.