Best Available Techniques Assessment

Purpose: Best Available Techniques (BAT) Assessment for an organic chemical manufacturing plant to produce agarose based resin for pharmaceutical use. This supports an Environmental Permit application for a bespoke installation permit.

Operator: Purolite Ltd.

Site: Purolite Ltd. Unit C, Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff, CF72 8LF

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1 Introduction

1.1 Scope

This document comprising a Best Available Techniques (BAT) Assessment, was prepared by Shann Pitts Consulting Limited and Melbury Environmental Limited on behalf of the Operator Purolite Limited herein termed 'the Operator'. This supports an Environmental Permit application for a bespoke installation permit, for an organic chemical manufacturing plant, to produce agarose based resin for pharmaceutical use, at Unit C, Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff, CF72 8LF herein termed 'the Site'.

Under the EU Council Directive 2010/75/EU on industrial emissions (the 'Industrial Emissions Directive' or IED)[1], environmental permits must take into account the whole environmental performance of the plant covering e.g. emissions to air, water, land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure. The permit conditions include emission limit values, which are based on Best Available Techniques (BAT) and which are designed to limit the impact of the installation on the environment. At an EU level the Commission organises an exchange of information in order to define BAT, which results in BAT reference documents known as 'BREFs'. The IED requires that the BAT conclusions, contained in the BREFs are the reference for setting permit conditions.[2] These are implemented in the UK through the Environmental Permitting (England and Wales) Regulations 2016.

This document discusses the proposed operation in relation to published BAT detailed within the following document:

- How to comply with your environmental permit. Additional guidance for: Speciality Organic Chemicals Sector (EPR 4.02), Natural Resources Wales, September 2014 (herein referred to as the 'Organic Chemicals Sector BAT')[3]

All 'indicative BAT' references throughout this document, outlined in a black border, are lifted directly from the Organic Chemical Sector BAT, to make it easy for Natural Resources Wales (NRW) to assess how each BAT has been addressed. The standards within the Organic Chemicals Sector BAT document are derived primarily from the current IPPC BREF document (Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for the manufacture of Organic Fine Chemicals, European Commission, August 2006).

An updated version of the Speciality Organic Chemicals Sector BREF document is currently available in draft format, as well as other draft BREF's that will also have an impact on the organic chemical industry. The publication of revised BREF's will trigger a revision of the UK's Organic Chemicals Sector BAT. Once the revised BREF is adopted in the EU, NRW will have 4 years to implement any changes

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[1] The IED is the successor of the EU Directive 2008/1/EC concerning integrated pollution prevention and control (the IPPC Directive), although the Natural Resources Wales guidance still refers to the old IPPC regime.

[2] Summary of Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control). Available online: http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm (accessed 02.10.17).

[3] Available on-line: https://naturalresources.wales/media/2105/how-to-comply-with-your-environmental-permit-additional-guidance-for-speciality-organic-chemicals.pdf (accessed 04.10.17)

(although it is not yet certain what impact Brexit will have on this). The Operator must work towards meeting any new BAT standards wherever possible.

This BAT assessment applies to the production of organic chemicals by the Operator, who is regulated under the Environmental Permitting (England and Wales) Regulations 2016 under Schedule 1, Part 2, Section 4.1 Organic Chemicals, Part A(1). It also applies to any directly associated activities, which have a direct technical connection to the main activities and could also impact emission and pollution levels.

2 Managing Activities

2.1 Environmental performance indicators

Indicative BAT. You should where appropriate:

1. Monitor and benchmark your environmental performance, and review this at least once a year. Your plans for minimising environmental impacts should be incorporated into on-going Improvement programmes. Indicators can be derived using the Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1). It is suggested that indicators are based on tonnes of organics produced (tOP) as they provide a good basis for measuring performance within an installation or a single company year on year.

The Operator has in place an Environmental Management System (EMS) certified to ISO 14001:2015, which supports the business to meet and exceed environmental regulatory requirements and well as make day to day operations more sustainable. This is further underpinned by an environmental policy, which outlines a companywide commitment to ensure all products are developed in ways that:

- minimise any adverse environmental impacts;
- reduce use of energy, water, raw materials, wastes and emissions; and
- ensures through active engagement with the customer base, products are used wisely to further minimise their environmental impact.

As part of the EMS process, and to ensure indicative BAT is met for environmental performance indicators, the Operator will:

- **Continue to monitor and benchmark environmental performance** to enable the development of measurable targets and objectives as part of an on-going improvement programme. In accordance with the Horizontal Guidance Note H1 Environmental Risk Assessment[4] (GTBR Annex I), environmental activities that will be monitored and benchmarked, will include as a minimum:
    - Waste-stream data (both tank away and foul drain) including:
        - Volumes;
        - Characterisation/ chemical composition; and
        - Disposal or recovery routes.
    - Raw material usage;
    - Energy usage;
    - Water usage;
    - Controlled releases to air – planned and managed releases associated with plant activities (releases from the stack, hydrogen vent, storage of epichlorohydrin; and tank breather valves);
    - Fugitive emissions to air and water – noise, dust, odour, litter; and

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[4] Environment Agency (2011). Horizontal Guidance Note H1 Overview Document (withdrawn 01.02.16). Available on-line: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/496278/withdrawn_H1_overview_-_LIT_4975.pdf (accessed 23.11.17)

    - Uncontrolled releases such volatile organic compounds (VOCs) from pressure relief systems.
- **Continue to set environmental objectives and targets** for the following year during the annual management review for continued environmental performance. Targets will be set year upon year to reduce pollution normalising these to production figures (i.e. based on the tonnes of agarose based products manufactured). Normalising the data to production figures provides an intensity ratio that facilitates comparison over time, allowing Purolite to know their environmental impact relative to the amount of goods produced.

As per the current EMS process, the yearly management review ensures yearly top-level objectives and targets are set, which are measureable, legal, and consistent with the environmental policy and going forwards, this BAT assessment. All actions will be discussed with line managers and staff and recorded and followed up via a remedial action plan.

2.2 Accident management

The proposed agarose manufacturing plant falls under the threshold for regulation under the Control of Major Accident Hazards (COMAH) Regulations[5]. However, it has been deemed appropriate by the Operator to adopt a Major Accident Prevention Policy (MAPP), a requirement for establishments that fall under the COMAH Regulations.

The MAPP document is similar in approach to a health and safety policy document, but with two important additions: it deals specifically with major accident hazards; and it includes measures to protect the environment[5]. The Operator's MAPP will include: their policy setting out the aims and principles of action concerning the prevention of major accidents; and a description of their safety management system for achieving these aims.

The Operator has a safety management system in place, accredited to Occupational Health and Safety Standard OHSAS 18001: 2007. There is a target based system in place for Health and Safety performance with yearly management health and safety meetings held to ensure targets for a safe working environment have been met and new targets set for the following year. Monthly health and safety team meetings are held to ensure delivery of these targets and to prevent accidents wherever possible.

The Environmental Management System includes a site specific Emergency Plan, which will be kept updated as part of the EMS internal audit procedure.

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[5] Health and Safety Executive (HSE), 2013. Control of Major Accident Hazards, understanding COMAH – a guide for new entrants. (pdf) Available from < http://www.hse.gov.uk/comah/guidance/understanding-comah-new-entrants.pdf > (accessed 15.11.17)

2.3 Energy efficiency

Indicative BAT

You should where appropriate:

1. Assess the environmental impact of each process and choose the one with the lowest environmental impact. (We recognise that your choice may be constrained, for example, by the integration of processes on a complex site).

The Operator has fully quantified the electricity and steam requirement for the production plant. The process has been developed over four years through the operation of a pilot plant, to be as resource efficient as possible, with energy efficiency being a key component in plant design. Equipment has been selected to ensure it meets high health and safety standards, as well as being the most commercially and energy efficient.

Minimising energy requirements at the Purolite site is affected through:

- **Technology selection and design:** Process equipment has been selected that is highly energy efficient (such as the CERTUSS steam generator) and is sized appropriately to accommodate the usage and ranges of operation.
- **Operations:** Timed, low energy saving electrical systems are used for controlling light, heat and machines where possible. In order to ensure the on-going maximum efficiency of plant and equipment, a full preventative inspection and maintenance programme will be put in place in line with the technology provider’s recommendations. Vacuum pumps and processes that use a large amount of nitrogen are only used one at a time, which minimises the energy demand peaks across the operation.

Minimising heat loses at the Purolite site is affected through:

- **Technology and design:** Heat loss to the surrounding area is minimised by keeping the steam generator and temperature control unit (TCU) in close proximity to the plant area. All heat exchangers are sized correctly for their required duty. All pipework and vessels that are at elevated temperatures are insulated. The process follows a highly controlled recipe, with temperature being a key control parameter, which means prevention of heat loss is integral to plant design.
- **Operations:** In order to ensure the on-going maximum efficiency of the heat exchangers, heat transfer pipework, and insulation materials, a full preventative inspection and maintenance programme will be put in place in line with the technology provider’s recommendations.

Increasing energy recovery at the Purolite site is generally not possible due to the process being a batch process and because processes that produce recoverable heat (including pumps) are not used extensively across the site. This means heat is produced intermittently, making energy recovery problematic. Over time, even less heat will be released as the production team further reduce exothermic reactions through improving their control over the process. The multiple air-handling system does recover heat from warm rooms (such as the quality assurance lab and control room).

As a company, Purolite meets the qualification criteria for ESOS, which means the company applies the Energy Savings Opportunity Scheme (ESOS) Regulations 2014. Every four years, ESOS assessments are carried out to audit the energy used by buildings, industrial processes and transport to identify cost-effective energy saving measures. An ESOS assessment will be carried out on the new production plant before the next compliance period, being December 2019. This combined with the targets set through their EMS process, will enable more energy saving measures to be implemented as part of the company's strategic growth plan.

2.4 Efficient use of raw materials and water

2.4.1 Efficient use of raw materials

The ethos of the Purolite production facility is to produce relatively low quantities (up to 100 tonnes per year) of high-grade agarose based bead products, rather than focus on high yields. This means that high purity raw materials and solvents are required as well as inert gas and purified water to reduce the risk of impurities. Although the process is more or less fixed by the chemistry and chemical engineering design of the process, there have been opportunities to reduce the amount of raw materials and intermediates in the production process and ensure it is designed to produce the least amount of wastes. Once the plant comes on-line and the expertise in this new area of business for the operator grows, there will be opportunities for further improvements in line with the Environmental Performance Indicators in the EMS as described in Section 2.1.

Regarding raw material usage, the Operator has considered the following:

- **Sourcing raw materials from locations of close geographic proximity** using where possible, local or UK based suppliers. In the case of speciality fine chemicals, the geographically closer options were preferred;
- **Sourcing raw materials from suppliers accredited to ISO 14001;**
- **Identifying raw materials that posed a major health and safety implication** (such as cyanide and bromine) and where possible, replacing these with less harmful substances that could be more readily dealt with;
- **Reducing, where possible, the use of raw materials and intermediates in the production process** and ensuring the process is designed to produce the least amount of wastes. For example due to an improved washing process, approximately 1,500m^3 of Industrial Methylated Spirit (IMS) is projected to be saved per year, being an 85% saving per batch. In addition, the Operator is currently working on technology from their core business to adapt it to be suitable for agarose bead manufacture, which although not yet achieved, should eliminate the use of solvent from the bead forming stages; and
- **The fate of by-products and contaminants and their environmental impact has been assessed** by engaging early on with waste contractors and understanding how the wastes are dealt with once leaving the plant.

2.4.2 Efficient use of water

The Purolite process was designed over four years to make it as safe and resource efficient as possible and water efficiency was considered as part of this design process. The proposed site sources its water from a mains water connection (Welsh Water). A purified water tank is used to remove impurities making this water suitable for use in the production process where it is used as a raw material, for washing, separation, chilled water storage and the distribution system. The water supply for the boiler and glycol tank systems are supplied with mains water, not purified water. The largest water consumption in the process is screening (removing unwanted large and small particles). Through refinement of their process, the Operator is now working with improved rates and lower water consumption than at the outset of the project.

Water use will be monitored regularly through meter readings and recorded. Water saving techniques will be employed wherever possible and targets to reduce consumption, where possible, in line with the EMS will be undertaken.

Indicative BAT

You should where appropriate:

- Maximise heat transfer between process streams where water is needed for cooling. Use a recirculating system with indirect heat exchangers and a cooling tower in preference to a once-through cooling system.
- Where water is used in direct contact with process materials, recirculate the water after stripping out the absorbed substances.

2.4.3 Industrial cooling system

2.4.3.1 Overview

Following selection of the water-cooling system, the process designers consulted the Industrial Cooling Systems BREF[6] to ensure that BAT was met for this element of plant design.

The proposed cooling system is a recirculating chilled water system, consisting of an air-cooled chiller unit and a chilled water tank supplying chilled water at 5-7^{O}C to some reactors and condensers. It is baffled and has two compartments, one for normal purified water and the other for chilled water. The circulating medium in the cooling system is a solution of 25% “Flowcool IG” Inhibited Ethylene Glycol and Water. The 25% glycol has a biostatic effect, inhibiting the growth of microorganisms. The inhibitors are all Organic Acid (Additive) Technology (OAT) offering corrosion protection and, unlike with traditional coolants, negate the need for regular additions of supplemental coolant additives at scheduled service intervals. This will provide a reduction on raw material use[7].

The cooling system is a closed system, which doesn’t need to be topped up and has no routing discharge so there will be no emissions during normal operating conditions.

Prior to commissioning, the fluid system will be flushed and sanitised using proprietary flushing and sanitising mixtures. A fluid sample will be taken on completion and the analysis results kept on file for reference. Fluid testing will be carried out at least twice a year as part of the planned preventative maintenance programme. Depending on the initial fluid analysis results, a full fluid sample analysis may be ordered.

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[6] European Commission (December, 2001). Integrated Pollution Prevention and Control (IPPC) Reference Document on the application of Best Available Techniques to Industrial Cooling Systems. Available on-line: http://eippcb.jrc.ec.europa.eu/reference/BREF/cvs_bref_1201.pdf (accessed 20.11.17)

[7] http://www.coolantexperts.com/coolant_overview/oat_coolant (accessed 13.12.17)

The refrigeration circuit is charged with HFC refrigerants R410A. This circuit has been pressure tested and sealed during manufacture.

2.4.3.2 Re-circulating water following contact with process materials

Due to high purity products Purolite are creating, it is not possible to recirculate any water that has come into direct contact with process materials after stripping out the absorbed substances. Effluent is tested in-line for pH and total organic carbon and if appropriate, discharged to the foul sewer in accordance with the Welsh Water trade effluent consent. If the monitoring shows that the quality requirements are not met, it is diverted to a holding tank, where it is removed off-site by authorised waste contractors (tankers) and managed as per the best environmental option with regards to the waste hierarchy.

2.4.3.3 Steam generation and use

With regards to steam, this is generated on-site by a CERTUSS stream generator and piped to various points of use. This is a rapid steam-raising boiler, which is highly efficient on water and energy use due to its triple outer casing construction and patented air circulation and pre-heated combustion feature, delivering a minimum thermal efficiency above 93%[8]. It has also been sized by to its required duty. Processes that use steam are equipped with Temperature Control Units (TCU) for more accurate and efficient process control.

2.5 Avoidance, recovery and disposal of wastes

The Operator has designed the process over four years, involving a hazard and operability study (HAZOP) and hazard identification (HAZID) (see section 3.1) to make it as safe and resource efficient as possible. The avoidance, recovery and disposal of wastes were considered as part of this process.

The operator’s production process produces five key waste-streams, known as A, C, D, E and F as outlined by Table 1 below. This section should also be read in combination with:

- Appendix A: Process waste-stream analysis – which shows where waste streams arise in the production process.

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[8] CERTUSS Steam Generators website. Available from: http://www.certuss.co.uk (accessed 04.12.17).

Table 1: Waste-stream composition

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Waste management has been considered as follows:

- **Reducing, where possible, the use of raw materials and intermediates in the production process to ensure the process is designed to produce the least amount of wastes.** For example:

  - Waste stream A was significantly reduced - due to an improved re-design of the washing process saving approximately 1,500m^3 of Industrial Methylated Spirit (IMS) per year, being an 85% saving on IMS per batch; and
  - An entire waste-stream (known as 'waste stream B') was removed altogether at the early design stage, by diverting this waste more effectively. This meant the more concentrated IMS wash was sent to waste-stream A and the less polluted wash was sent to waste stream E (foul sewer);
  - When the process comes on-line the operator would like to explore the feasibility of reducing waste-stream D; and
  - When the process comes on line, the operator would like to see if they can bring technology from their core business to eliminate the use of solvent from the agarose bead forming stages, thus further reducing the pollutants found in the wastes;
- **All potential waste releases were identified and fully characterised** to ensure they are segregated properly and routes for recovery or disposal represent the best environmental option. This also meant vacuum design was developed to keep the waste-streams separate and prevent cross contamination (see below);
- **Waste contractors were identified and approached at the early design phase** to ensure wastes could be recovered or disposed of representing the best environmental option;
- **Safe storage locations of all wastes were carefully designed**– including the construction of a bunded 'tank farm' (see section 3.4 describing procedures for containment of spills). Safe procedures for removal are covered by on-site operating procedures and were reviewed carefully during the HAZOP.

Indicative BAT for waste recovery

You should where appropriate:

1. Demonstrate that the chosen routes for recovery or disposal represent the best environmental option. Consider avenues for recycling back into the process or reworking for another process wherever possible.
2. Provide a detailed assessment identifying the best environmental options for waste disposal where you cannot avoid disposing of waste.

- **Treatment of waste streams at source** – wastes cannot be treated or recycled back into the process on-site due to the complex nature of the treatment processes required and the high purity of raw materials needed in production. Purolite considered using reverse osmosis to remove the sodium sulphate from Waste stream C, but this was not technically feasible due the concentrations being too high. Instead wastes will continue to be characterised to ensure routes for recovery or disposal represent the best environmental option.
- **Segregation of all releases (dedicated vacuum system)** – to maximise their routes for recovery or disposal, the vacuum filtration, liquid removal and transfer systems are provided by three separate vacuum sets. There will be a dedicated vacuum system for waste stream A and waste stream C and a combined vacuum system for waste stream D, E and F. This is to allow proper waste segregation and enable optimum recovery of the solvent in the waste stream by the waste contractors.

- **Best environmental options for disposal or recovery of each waste stream** has been handled as follows (currently Tradebe has been identified as the authorised waste contractor):
    - **Waste stream A** – recovery via distillation. Ideally the solvent will be sold back to Purolite as a raw material input, although it is unlikely the purity will be high enough. In this instance it will be sold on by Tradebe for use at other sites;
    - **Waste stream C** – this has been routed for physiochemical treatment, although the waste contractor would like to see more representative samples from the operational plant. If the waste stream proves to be unsuitable for treatment it will be taken to Fawley Hazardous Waste Incinerator in Southampton for disposal via incineration. Recovery via incineration is not possible due to its low calorific value;
    - **Waste stream D** - this has been routed for physiochemical treatment, although the waste contractor would like to see more representative samples from the operational plant. If the waste stream proves to be unsuitable for treatment it will be taken to Fawley Hazardous Waste Incinerator in Southampton for disposal via incineration. Recovery via incineration is not possible due to its low calorific value;
    - **Waste stream E (to foul drain)** - this effluent is tested for pH and TOC using automated in-line process monitoring, before being discharged to sewer in accordance with a Welsh Water trade effluent consent. In the event of an exceedance, flows are retained within a holding tank (see section 3.4 describing procedures for containment of spills) and an alarm system alerts operators of the issue. The waste is removed by specialist waste contractors and disposed of or recovered as per the best environmental option; and
    - **Waste stream F** – this will go to Fawley Hazardous Waste Incinerator for disposal via incineration. Recovery via incineration is not possible due to its low calorific value.

3 Operations

3.1 Design of a new process

Indicative BAT

You should where appropriate:

1. Consider all potential environmental impacts from the outset in any new project for manufacturing chemicals.
2. Undertake the appropriate stages of a formal HAZOP study as the project progresses through the process design and plant design phases. The HAZOP studies should consider amongst other things the points noted above *(note: these 'points' have been covered by the ensuing section).*

The operator's production process was designed over four years and is a new area of business for the company, with only one other company worldwide making these products. In the early stages of process design, a hazard identification (HAZID) study was conducted, involving Purolite, civils and process engineers, as a qualitative technique to identify any potential hazards and threats affecting people, the environment, assets or reputation. In 2016, this was formalised through a hazard and operability study (HAZOP), this being a more detailed quantitative risk assessment technique to assess hazards, once the design process was complete.

Due to the nature of the hazards associated with the process, the HAZID and HAZOP were primarily focussed on identifying and evaluating problems that may represent risks to personnel or equipment. Environmental and commercial aspects were also considered, in part due to the fact that there is a high degree of cross-over. However, the health and safety aspects of the plant were prioritised in the chemical engineering design of the process.

Although a preliminary environmental statement was not drawn up at the outset of the project, the points covered by BAT were addressed through the HAZID and HAZOP assessment. These assessments formally reviewed and refined the production plant and process. The points outlined in the BAT have been addressed as follows (see the Emissions Management Plan[9] for more detail):

3.2 Identifying and characterising all potential releases

All potential releases have been identified and fully characterised with an emissions monitoring and management plan[9] in place to continue to monitor and characterise these emissions.

Essentially potential releases from the plant include:

- **Four key waste-streams**, known as A, C, D and F (waste-stream B was removed altogether in the early stages of process design). These are removed by vacuum from collection vessels in the processing areas, and moved to an outdoor bunded 'tank farm' (see below). Authorised waste contractors tanker these off-site and either recover them via physiochemical treatment or dispose of them via incineration. All road tanker filling and emptying is done under a closed

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[9] Melbury Environmental Ltd and Shann Pitts Consulting Ltd (December 2017). Emissions Management Plan (EMP) for an organic chemical manufacturing plant to manufacture agarose based resin for pharmaceutical use. This supports an Environmental Permit application for a bespoke installation permit. Doc ref: SPC0055_ ME17.11.23_Emissions_Management_Plan_December 17

loop vapour return system, to prevent vapour and odour releases during this process. These wastes will continue to be characterised to ensure routes for recovery or disposal represent the best environmental option with respect to the waste hierarchy;

- **An effluent (to foul drain)** known as 'waste stream E' which is monitored prior to being discharged to sewer in line with a Welsh Water trade effluent consent;
- **Air emissions released via the stack -** these are captured from a number of chemical storage tank vents and process steps and vented via a single elevated stack (12.7m) at a required discharge velocity (15m/s). These emissions have been fully characterised by Briggs of Burton PLC (see Appendix B) and detailed air dispersion modelling has been conducted by Ricardo (se Appendix C) to ensure these can be released to atmosphere without posing risk of harm to human health or the environment or posing an odour risk. A quantitative risk assessment using the H1 tool supports the air dispersion modelling report (also submitted as part of the Environmental Permit application)[10].
- **Hydrogen generated during one of the reaction phases** is dispersed directly to atmosphere, heavily diluted with nitrogen, from the north-east face of the building (i.e. the back of the building with the least human occupancy). Due to its high flammability, it was concluded it was safer to release this directly, rather than divert through the pipe-work to the stack[9];
- **Emissions from storage tanks that breathe directly to atmosphere** - some bulk chemical and waste storage tanks don't connect to the main stack to reduce the risk of the vacuum pulling too much vapour off, so some exclusively use a breather valve instead such as IMS (this tank is stored outside in the tank farm). Losses are minimal with venting only occurring when the weather is warm enough for some liquid to evaporate and build up headspace pressure high enough to overcome the breather valve;
- **Extract air from storage of epichlorohydrin**. As this is a highly flammable liquid, it was deemed safer to release this directly to air following filtration via a carbon filter. It is released from the side of the building and vented to a high level. This is very low volume material with a maximum working capacity of 100 litres.
- **Fugitive emissions** including:
    - **Extract air from powder handling rooms** – losses are minimal with all air from these areas filtered by two filters (the second one installed as a back-up if the primary one fails). This is vented through the side of the building, but it is not expected it will contain any emissions, other than warmed air;
    - **Losses from leaking pipes or other equipment** - leak detections are monitored manually and through sensors (for example if there is an unexpected pressure/ level drop) and through vapour detection. If the SCADA system picks up any abnormalities, an alarm is sounded to alert the plant operators to take the correct action.
    - **Vapour losses from tanker loading/ unloading** is expected to be nil as the tanker off-loading/ loading procedures are in place to prevent this and there is a closed loop system for vapour return to ensure that no vapour is released.
    - **Noise** impacts are expected to be minimal. The chemical manufacturing process will be carried out inside the building; air compressors are within the building. The compressor room is designed for high noise levels and will be suitably insulated for

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[10] Melbury Environmental Ltd and Shann Pitts Consulting Ltd (December 2017). Environmental Risk Assessment (EMP) for an organic chemical manufacturing plant to manufacture agarose based resin for pharmaceutical use. This supports an Environmental Permit application for a bespoke installation permit. Doc ref: SPC0055_ ME17.11.23_Environmental_Risk_Assessment_December 17

sound. The building is constructed of steel sheets with a Rockwool core giving a good level of sound insulation. The air-handling unit is located outside the building but is not anticipated to be a source of noise. Noise from vehicle movements will be minimal, as it is not anticipated that there will be any more than four tanker movements per week.

- **Odour** – odour is primarily controlled through plant design, for example the use of condensers, which enable a reduction in loss of VOCs. Emissions from the main/ common stack have undergone an odour impact assessment by Ricardo, who confirmed a stack height of 12.7m to ensure dispersion of any residual odourous compounds. Venting of the most odorous raw materials and wastes stored on-site are vented via this stack system. Tank breather valves not connected to the stack are for chemicals with a low odour potential. Loss of vapour from these is controlled through tank design; tall tanks with low surface area and appropriate pressure rating to reduce vapour loss. Tank breather valves will not open under normal operating conditions. There is no odour potential from the hydrogen vents as this and nitrogen are odourless gases. During tanker loading/ off-loading activities, the closed loop system/ vapour return line reduces vapour loss and minimise odour emissions;
- **Dust -** the proposed manufacturing process will be carried out within a building under highly controlled conditions. Ancillary activities outside the building will not be a source of dust or particulates. Vehicles moving in and out of the site for deliveries and collections will move over concreted / tarmacked areas.
- **Litter** - There is a low potential for litter associated with the proposed chemical manufacturing process. Liquid raw materials are supplied in bulk via tankers, IBC's or sealed drums. Solid raw materials are delivered in sealed containers to the inside of the building. There is an external undercover bin area. There is potential for some litter arising from the staff welfare facilities, but the residual risk of this is low, through management of the site.

3.3 Non-routine or unplanned releases and disposals

- **Start-ups and shutdowns** – as the process is a batch process made up of discreet reaction stages, this is not particularly relevant. Peak emission concentrations have been predicted and modelled to ensure risk of harm to human health or the environment has been properly managed[9];
- **Off-specification products** – in most cases the product can be re-worked back into production. If this is not possible then the off specification product will be removed via the contracted waste contractor to an appropriate regulated facility and managed as per the best environmental option;
- **Non-routine releases** – continuous process monitoring means any issues that could cause an unplanned release will be picked up early and alarms sounded. The stack has two fans to ensure air emissions from the main/common stack can still be released at the required velocity even if one fan fails. If one fails, the Operator is alerted via the SCADA and the plant put into a controlled 'hold state' whilst this is rectified. Most reactors are fitted with condensers to enable good process control. If the condensers fail (chilled water circulation), the plant will go into a controlled 'hold state', with operations being limited until the process

is safe to start again. At worst, mains water can be flowed through the condensers at ambient rather than chilled temperature.

- **Spillages** (see section 3.4); and
- **Pressure relief for emergency situations -** the storage tanks in the tank farm as well as process vessels are all fitted with pressure relief. The process vessels within the building production area have pressure relief valves and/or bursting discs with pipework sized to route the pressure relief vents to the external of the building. Pressure relief valves and /or bursting discs will only be triggered with significant pressure increases caused by scenarios such as external fires that cause the contents to boil and vaporise. Higher-pressure ratings are fitted to vessels, where process explosions are most likely, to contain explosions within the vessels. Explosions and pressure bursts are considered in the structural design of the building.

See Section 2.2 for more detail on how health and safety procedures will be covered.

3.4 Containment of spills

Containment of spills has been a major health and safety and environmental consideration in plant design. The following measures have been undertaken to minimise these risks:

- **Construction of a bunded 'tank farm'** – this is an external tank holding area designed for storage tanks that hold raw materials and wastes that pose a spillage risk (the crash tank, see below, works as an overflow if ever required). The tanks themselves are fit for purpose and subject to frequent visual checks, which form part of the site EMS. All tanks have continuous level monitoring. The tank farm itself was designed in consultation with CD Gray, Natural Resources Wales (NRW) and DCWW (Welsh Water)[11]. Full details of the tank farm can be viewed in the CD Gray 'Drainage Philosophy' report (full report included in Appendix D). The bund is equipped with flammable vapour detectors (% Lower Explosive Limit) that will alarm and notify personnel if a spillage occurs. In the event of vessel rupture within the tank farm, liquid will be held within the above ground bund (wall height approximately 1.2m). The bund has been designed in accordance with CIRIA report C736 – containment systems for the prevention of pollution, with appropriate allowances for rainfall events in the containment capacity. The bund has been water tested prior to commissioning. Surface water, contaminated water or stagnant water collected within this bunded area is tested and pumped out periodically. It is either disposed to sewer, in line with the trade effluent discharge consent or removed off-site by authorised waste contractors if outside acceptable limits. Operational management procedures will be in place to manage the tank farm. As an additional health and safety precaution, foam cannons are in place to cover the bunded area and crash tank simultaneously in a foam blanket if required to prevent the risk of fire or escape of chemicals/ vapours into the environment.[12]
- **Construction of a secondary 'crash tank'** (see CD Gray drainage philosophy Appendix D) located below ground. This caters for emergency spillages within the building or during tanker offloading activity**.** This has been sized based on the same principals as the tank farm bund, to CIRIA C736, as the largest of 25% complete volume or 110% of the largest tank, providing a

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[11] CD Gray and Purolite met with Mark McLoughlin, an Environment Officer at NRW and Heather Pepper, a Trade Effluent Officer at DCWW (Welsh Water) on 21/04/16 and 12/05/16 where design principals were agreed.

[12] CD Gray Associates Ltd (December 2017). Drainage Philosophy Purolite. CDGA-9021-REPO1-R4. (Appendix D).

minimum storage of 31m^3. From this location, the operator can pump spillages to holding tanks within the bunded tank farm before off-site removal by an authorised waste contractor or discharge to the foul sewer if within the discharge consent limits[12].

- **Construction of a tanker off-load area** (see CD Gray drainage philosophy Appendix D) located directly above the crash tank. This enables any spillage from tankers to be contained within the below ground crash tank. The tanker off-load area has been designed with a high level/ ridged crown line on its outside edge with falls created to direct run-off within this area towards the crash tank inlet holes. The containment volume of the crash-tank caters for deliveries with a maximum load of 28,000 litres. Ordinarily, the penstock within the crash tank's receiving chamber will direct run-off to the surface water network. Operational management procedures are in place to ensure this penstock valve is closed before tanker off-loading to ensure spillages are diverted into the crash tank.
- **Alarms on reactors to prevent overfilling –** this is to prevent loss of containment to the local area. In addition, reactants cannot be added until the operator has confirmed the hopper is in place and connected before the next step can be initiated. For highly dangerous chemicals (such as IMS), high-level detection would close off valves and shut the pump, providing the air emission with an open path to the common/ main stack, with any discharges drained to the crash tank.
- **Use of enclosed hoppers for transferring higher-risk reactants into reaction vessels –** for example, agarose and ethyl cellulose are brought into the production area in enclosed hoppers, from which powders cannot escape to atmosphere, as a spillage would release flammable dust to the atmosphere. Filling is carried out in a dedicated area.
- **Site spillage procedures are in place –** enabling, for example, minor spillages to be picked up during walk arounds with the appropriate equipment and PPE available if they do occur.
- **Appropriate material handling procedures** prevents the overfilling of IBC containers, due to it being necessary for the operator to be in place during this activity. IBC containers are also placed on portable bunds, to collect any accidental spillage.
- **Procedures in place to ensure wash-down substances are correct** – for example most spillages can be washed down with cold water, but for substances such as sodium sulphate, this would result in solid precipitation causing blockages in the drain. Hot wash down facilities will be made available to prevent this occurrence.
- **Waste-streams with a risk of solids settling/crashing out have been addressed:**
    - Waste stream C is moved into a separate IBC container, due to this risk of it crashing out and will be stored either in the bin store or warehouse. This liquid is pumped into an IBC with trace heating and followed by purified water as a flush to minimise sulphate blockage risk. Breaks are available to rod if required;
    - Agarose solution can be discharged, via trace heated pipework, into an IBC if required; and
    - Solid resin less than 20 microns does not pose a blockage risk as they are so fine they cannot settle.

3.5 Provision for effluent flow equalisation and emergency discharges

Provision for effluent flow equalisation (i.e. flow or velocity to sewer network) and for emergency discharges has been made. It is not feasible for effluent to be treated on-site. CD Gray[12] were commissioned to conduct a drainage philosophy, to ensure proper management of effluent to foul drain and Purolite have integrated their proposals into the final design:

- **Waste stream E (foul drain)** is tested for pH and toxicity using in-pipe process monitoring for pH and TOC parameters, before discharge to sewer in line with a Welsh Water trade effluent consent. There are two tanks for waste stream E enabling one tank to be receiving and the other to be testing and discharging. In the event of an exceedance detected via the in-pipe monitoring instruments, effluent is instead diverted to a dedicated storage tank and removed by specialist waste contractors for disposal or recovery as per the best environmental option.
- **Run-off** – only run-off generated by low risk areas associated with the building, car park, access road and service yard will be conveyed to the surface water system. Conveyance of surface water run-off from external areas designated ‘high risk’ has been avoided as far as practical. Design measures have included the covering of the bin store and IBC waste storage area, removing positive drainage provision to the bunded tank farm and operationally managing the tanker off-loading area so that ordinarily the area drains to the surface water network unless a tanker is loading/off-loading, when it is discharged to the foul drain.
- **Emergency effluent storage** – is accommodated through the crash tank and bunded tank farm. The tank farm/ crash tank is sized to accommodate the foam from the foam cannon system, covering the area inside the bunds in a foam blanket to prevent the risk of fire or escape of chemicals/ vapours into the environment. As per the CD Gray report[12], the pump house, IBC storage tanks, foam pumps and sprinkler tanks are all higher than their relative surroundings with respect to flood risk – the bunded tank farm, would remain protected from inundation in the most extreme of flood events.

3.6 Main/ common stack control system reliability

Air emissions that pose risk of harm to human health or the environment are diverted to the main/ common stack. Using data produced by Briggs of Burton PLC during development of the pilot plant, detailed air dispersion modelling was subsequently conducted by Ricardo (see Appendix C) who concluded at a stack height of 12.7m and a velocity of 15m/s, these emissions can be released to atmosphere without posing risk of harm to human health or the environment or posing an odour risk. It was therefore determined that additional process abatement would not be necessary. A quantitative risk assessment using the H1 tool further supports the air dispersion modelling report[10].

Most reactors are fitted with condensers to allow solvent recovery and to enable good process control. As recovery of solvents is feasible, abatement on the residual very low concentration of VOCs released is not deemed to be proportionate to the benefit that would be achieved by having abatement.

If condensers fail, which would be due to a failure of the chilled water circulation system, the plant will go into a controlled ‘hold state’, with operations being limited until the process is safe to start again. As a contingency if necessary mains water can be flowed through the condensers at ambient rather than chilled temperature.

The heat exchangers on the condensers will be fitted with instrumentation to detect failures. There will be a temperature transmitter on the vent route, which will alarm if the temperature rises. This will be set on commissioning. Alarms are handled by the SCADA automation system and will be raised in the control room for the operator to handle. The heat exchangers will be part of the planned maintenance procedure.

During the HAZOP it was decided to provide two standby fans on the main/ common vent stack (with the process switching equally between each fan), to ensure a back-up is in place if one fan fails. If a fan does fail, the SCADA system puts the plant into a controlled hold, alerting the operator to the issue so it can be rectified, before the process is safe to start again.

3.7 Storage and handling of raw materials, products and wastes

All reactive chemicals are stored as per the manufacturer and supplier recommendations. This includes, the container type, their proximity to other reactive chemicals, flammability, the need for storage under a steady gas stream where necessary and environmental considerations. Most bulk storage tanks connect to the vent stack, especially if there is an odour risk. However, some bulk storage tanks do not connect to the vent stack as there is a risk the vacuum could end up pulling too much vapour off, so some exclusively use a breather valve instead such as IMS (this tank is stored outside in the tank farm). Losses are minimal with venting only occurring when the weather is warm enough for some liquid to evaporate and build up headspace pressure high enough to overcome the breather valve. All storage tanks and breather valves are regularly checked as part of planned maintenance programme.

Indicative BAT

You should where appropriate:

- Store reactive chemicals in such a way that they remain stable, such as under a steady gas stream, for example. If chemical additions are necessary then tests should be carried out to ensure the required chemical composition is maintained. Inhibitors may also be added to prevent reactions.
- Vent storage tanks to a safe location.
- Use measures to reduce the risk of contamination from large storage tanks. In addition to sealed bunds, use double-walled tanks and leak detection channels.
- Use HAZOP studies to identify risks to the environment for all operations involving the storage and handling of chemicals and wastes. Where the risks are identified as significant, plans and timetables for improvements should be in place.

The following has also been undertaken to ensure risks related to the storage and handling of raw materials and wastes has been minimised:

- Construction of a bunded ‘tank farm’;
- Construction of a secondary ‘crash tank’; and
- Construction of a tanker off-load area (see section 3.4 Containment of spillages).

A HAZOP study has been conducted to identify health and safety and environmental risks for all operations involving the storage and handling of chemicals and wastes. Any risk that has been identified as significant has a plan and timetable in place for completion before the plant comes on-line.

Table 2: Raw material description, tonnages and storage locations

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]					
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]					
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]					
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]					
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Table 3: Storage location of wastes

Waste Stream	Storage Location	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

** Waste stream C contains sodium sulphate at levels that pose a risk of it crashing out. Therefore it is not appropriate to store on the tank farm.*

3.8 Plant systems and equipment

This section requires the discussion of any waste streams or fugitive emissions that are released from ancillary equipment across the plant.

Indicative BAT

You should where appropriate:

1. Formally consider potential emissions from plant systems and equipment and have plans and timetables for improvements, where the potential for substance or noise pollution from plant systems and equipment has been identified.

Purolite have in the design of their process formally considered potential fugitive emissions from plant systems and equipment and put plans and timetables in place for improvement where any issues have been identified. Please refer to section 3.2 for more detail.

A systematic HAZOP study on all plant systems and equipment, including valve performance, vessel and piping selection has been conducted to identify potential health and safety and environmental impacts. Through appropriate design, in addition to the operation being under an accredited Environmental Management System incorporating a planned preventative maintenance programme, fugitive emissions will be minimised across the plant.

Indicative BAT

You should where appropriate:

3. Choose vacuum systems that are designed for the load and keep them well maintained. Install sufficient instrumentation to detect reduced performance and to warn that remedial action should be taken.

All vacuums are designed for the load and a planned preventative maintenance programme will be in place to ensure all equipment is inspected and maintained in accordance with the manufacturer's recommendations. The inspection and maintenance programme will also account for frequency of use considerations and the criticality of equipment in process management. Furthermore, operational procedures dictate that before every transfer a vacuum test is conducted, which pulls on every bit of equipment and holds for a set amount of time. If the pressure drops, this suggests a leak or failure and an alarm is raised via the SCADA system.

3.9 Over-pressure protection systems

Indicative BAT

You should where appropriate:
1. Carry out a systematic HAZOP study for all relief systems, to identify and quantify significant risks to the environment from the technique chosen.

A systematic HAZOP study for all pressure relief systems has been carried out to identify and quantify significant health and safety and environment risks from chosen systems. The HAZOP team have addressed any element of the over-pressure protection system that has been identified as not having adequate operator or independent safeguards.

The identification of all conceivable over-pressure situations, calculation of relief rates, selection of relief methods and design of the vent system were undertaken by Briggs of Burton PLC in collaboration with experts on the Purolite team. The careful design means the team are confident intrinsic protection against all conceivable over-pressure scenarios have been addressed, so relief systems and their consequential emissions can be avoided.

Key points to note regarding the over-pressure protection system:

- **Each process vessel is equipped with a relief system sized for the fire case** (tank contents boiling and vaporising). This means they either have a relief valve, bursting disc or both. Briggs of Burton PLC were commissioned to calculate relief vent sizes ensuring tanks can be safety vented if there is an external tank fire in the process area. The pressure relief valves are only in use when required.
- **All pressure relief is routed to north-east face of building** as this is the easiest path outside of the building and there are no people on that side so it is safest.
- **Hydrogen-gas generation phase of reaction is routed to north-east face of building.** During one part of the reaction phase, hydrogen is generated and due to its flammability it is deemed safer to release this directly from the building (diluted with large amounts of nitrogen) rather than to the vent stack.
- **All pressure relief valves will be subject to routine inspections as per the preventive maintenance plan.** The content and frequency of checks will be derived from: frequency of use considerations; criticality of equipment; and manufacturer's recommendations. These checks will form part of the EMS.
- **The nitrogen purging system is designed to act as a fail-safe**, in place for blanketing and inerting the tanks at approximately 100-300 mbar. This helps prevent over-pressure. As part of the standard operating procedures, at least 125% of the required purge will be carried out and manually monitored at regular intervals. A pressure swing method will be used, with the atmosphere quality verified by an oxygen analyser. Pressure monitoring will also be deployed during the purge cycle using a watchdog timer.

Indicative BAT

3. Maintain in a state of readiness all equipment installed in the venting system even though the system is rarely used.

- **All equipment installed in the venting system is maintained in a state of readiness** even though the system is rarely used. No operator action is required in order for the pressure relief systems to operate. Pressure relief valves are not used as a routine part of the process, rather provided as safety systems to mitigate external tank fires. The vent path for the hydrogen generation phase is unobstructed, with automatic values that open at the right phase of the process. All equipment related to over pressure protection is subject to a planned preventative maintenance programme, which forms part of the EMS.

3.10 Heat exchangers and cooling systems

Indicative BAT

You should where appropriate:

1. Consider leak detection, corrosion monitoring and materials of construction, preferably in a formal HAZOP study. Plans and timetables for improved procedures or replacement by higher integrity designs should be in place where the risks are identified as significant.

2. If corrosion is likely, ensure methods for rapid detection of leaks are in place and a regime of corrosion monitoring in operation at critical points. Alternatively, use materials of construction that are inert to the process and heating/cooling fluids under the conditions of operation.

As there is potential for the process streams to leak into the heat/ cooling system or vice versa, the materials of construction of both these systems has been selected based on chemical compatibility and stability, during the design phase and HAZOP. Briggs of Burton PLC have advised on what systems to select. Corrosion is minimised by ensuring that:

- The correct quality of water is supplied to both the heating and cooling systems (purified water) as specified by system manufacturers;
- By ensuring that a planned preventative maintenance programme is in place to monitor these systems; and
- By ensuring that every effort has been made at the design stage to minimise corrosion risk through optimum material selection and pipework design.

Leak detection is monitored manually and through sensors (for example if there is an unexpected pressure/ level drop) and through vapour detection. Drip trays are placed strategically around the process equipment with level monitoring equipment that will raise an alarm if liquid is present. Fully welded pipework is used. The only flanges in the plant are near process vessel and storage containers, therefore leak detection will be picked up through daily checks, which form part of the EMS. If the SCADA system picks up any abnormalities, an alarm is sounded to alert the plant operators to take the correct action.

Indicative BAT

You should where appropriate:

3. For cooling water systems, use techniques that compare favourably with relevant techniques described in the Industrial Cooling Systems BREF.

See section 2.4 for more detail.

Indicative BAT

You should where appropriate:

1. Assess the potential for the release to air of VOCs and other pollutants along with discharged purge gas and use abatement where necessary.

3.11 Purging facilities

Multiple process vessels are purged with nitrogen as a technique for inerting and blanketing. The inerting cycle is calculated to give sufficient nitrogen to complete inerting with minimal wastage. All venting is routed through the hydrogen vent. Using peak pollution emissions estimates provided by Briggs of Burton PLC and Purolite (see Appendix B) an air quality and odour impact assessment was subsequently conducted by Ricardo (see Appendix C) and an H1 assessment by Shann Pitts Consulting and Melbury Environmental[10], both concluding the long and short impacts of air emissions would not result in exceedances of Environmental Assessment Levels in ambient air around the facility or at any sensitive receptor sites.

3.12 Reaction stage

Indicative BAT

You should where appropriate:

1. With a clear understanding of the physical chemistry, evaluate options for suitable reactor types using chemical engineering principles.
2. Select the reactor system from a number of potentially suitable reactor designs - conventional STR, process-intensive or novel-technology - by formal comparison of costs and business risks against the assessment of raw material efficiencies and environmental impacts for each of the options.
3. Undertake studies to review reactor design options based on process- optimisation where the activity is an existing activity and achieved raw material efficiencies and waste generation suggest there is significant potential for improvement. The studies should formally compare the costs and business risks, and raw material efficiencies and environmental impacts of the alternative systems with those of the existing system. The scope and depth of the studies should be in proportion to the potential for environmental improvement over the existing reaction system.
4. Maximise process yields from the selected reactor design, and minimise losses and emissions, by the formalised use of optimised process control and management procedures (both manual and computerised where appropriate).
5. Minimise the potential for the release of vapours to air from pressure relief systems and the potential for emissions of organic solvents into air or water, by formal consideration at the design stage - or formal review of the existing arrangements if that stage has passed.

The Purolite agarose production process was designed over four years to be as safe and resource efficient as possible, and design of the reaction stages was considered in detail, including formally through both a HAZID and HAZOP assessment. This process is new to Purolite and is carried out in only one other company worldwide on a similar scale. Processes were evaluated and developed on an R&D and pilot scale. The operation very much focuses on producing high purity products rather than high yields, which impacts how the process is designed.

The process is a batch process and, as such, requires lengthy process steps to carry out the reactions. This limits the types of reactors available for the plant. The reactors and vessels selected have been optimised for heat transfer and agitation to ensure the process steps do not need to be repeated. In some cases, the reactions can be carried out in a combination filter reactor. This minimises waste and cleaning chemicals as, to some extent, the product and vessel can be washed simultaneously. Heating and cooling is only carried out where necessary for the process. Process vessels, specifically those that could be at risk of an explosion, have been designed to an 8 bar pressure rating (to contain explosions within), based on HAZOP outcomes and discussion.

The team have found ways to optimise parts the process, for example during washing of the resin beads. By changing the washing process, approximately 1,500m^3 of Industrial Methylated Spirit (IMS) will be saved per year, being an 85% saving per batch. Although not yet achieved, the operator is currently working on technology from their core business to adapt it to be suitable for agarose bead manufacture, to eliminate the use of solvent from the bead forming stages.

The potential for the release of vapours to air is minimised through the recovery of volatile organic compounds in the condensers integral to most process vessels. In addition the loss of vapour from all tanks is controlled through tank design i.e. tall tanks with a low surface area and appropriate pressure rating to reduce vapour loss. The tank breather valves and pressure relief systems will not be used during normal operating conditions; they are in place as a safety feature.

Solvent loss is minimised through process design. It is in the interest of the Operator from a financial, operational, environmental and health and safety perspective to minimise raw material use and losses, minimise all losses to air and minimise waste production.

As the team develop their expertise in this area, it is part of the company's strategic growth plan to continue to optimise and improve the production process.

3.13 Minimisation of liquid losses from reaction systems

Purolite have addressed minimisation of liquid loses through the system particularly during clean-out as follows:

Indicative BAT

You should where appropriate:

Use the following features that contribute to a reduction in waste arisings from clean-outs:

- Low-inventory continuous throughput reactors with minimum surface area for cleaning
- Minimum internals such as baffles and coils in the reactor
- Smooth reactor walls, no crevices
- Flush bottom outlet on reaction vessels
- All associated piping to slope back to the reactor or to a drain point
- Sufficient headroom under the reactor for collection of all concentrated drainings in drums or other suitable vessel, if necessary
- Minimal pipework, designed to eliminate hold-up and to assist drainage
- Pipework designed to allow air or nitrogen blowing
- System kept warm during emptying to facilitate draining
- HAZOP studies used to assess the potential for the choking of lines by high- melting-point material
- Campaigns sequenced so that cleaning between batches is minimised
- Campaigns made as long as possible to reduce the number of product change- overs
- Where a complete clean is necessary, use cleaning methods that minimise the use of cleaning agents, (e.g. steam-cleaning, rotating spray jets or high-pressure cleaning) or use a solvent which can be re-used
- Carry out HAZOP studies to minimise the generation of wastes and to examine their treatment/disposal
- Consider use of disposable plastic pipe-liners
- Eliminate or minimise locations for solids to settle-out
- Consider duplicate or dedicated equipment where it can reduce the need for cleaning that is difficult.

- **Overall process design:** The process cannot be carried out on a continuous basis, although the company is looking at transferring existing technology from the core business to the agarose resin production to make the process semi-continuous. All process vessels are jacketed and have smooth inside surfaces. In most cases, these vessels do not have baffles, making the cleaning process more efficient. Baffles are only used when the agitator needs additional mixing power.
- **Design of valves and pipework to prevent blockages:**
    - All reaction vessels have fully draining hygienic valves.
    - All bulk storage tanks have bottom outlet valves to minimise hold up.
    - The pipework and manifolds have been optimised using block valves, to minimise hold up of waste and product within the system.
    - Pipework has been modelled to give falls to correct locations (either the next process vessel or to drain).
    - Pipework runs have been reduced as far as possible and allowances have been made to flush the pipework if necessary.
    - All vessels are connected to process drains, where waste liquids can be directed to the appropriate waste stream.
    - Some waste streams have insulated and trace heated pipework to prevent chemicals precipitating in pipework and causing blockages.
    - The HAZOP process assessed and then addressed the risks of blockages occurring in pipework.
    - Allowances have been made for discharging agarose solution (which sets at 40 °C and melts at 80 °C). There is a trace heated pipework section from reactor RE01 to a local IBC if this solution needs to be discharged. There is a hand valve as well and this will require authorisation to carry out. This was all covered in the HAZOP.
- **Water cleaning processes** are part of the operating procedures and have formally been considered by the HAZOP. Cleaning across the plant is mostly carried out with water. Water is delivered into the process vessels by a spray ball to give maximum surface coverage with minimal water usage.
- **IMS cleaning processes** are part of the operating procedures and have formally been considered by the HAZOP. Reactor RE02 specifically is cleaned using IMS. The initial cleaning rinses are discharged to the next step in the process, being DV03. The IMS is delivered into RE02 with two impact cleaning heads.
- **Designing out the need for cleaning -** some process vessels (SV7A, SV7B RE08, RE09, C10A, C10B) have multiple purposes, which minimises the amount of down time in each vessel. In other words occupancy or utilisation of these vessels is very high, so cleaning is done just once between batches, rather than leaving vessels dormant for some time requiring further cleaning before start-up.
- **Minimisation of waste-streams from cleaning activities:**
    - Waste stream A had the volume significantly reduced through optimising the washing process by moving from sedimentation washing to column washing. Approximately 1,500m^3 of Industrial Methylated Spirit (IMS) was saved per year, being an 85% saving on IMS per batch;
    - Waste-stream B was eliminated in the early design phase of the process.

- **Waste streams with a risk of solids settling/crashing out have been addressed:**
    - Waste stream C is moved into a separate IBC container, due to this risk of it crashing out. It contains high levels of sodium sulphate making further processing or treatment very difficult. This liquid is pumped into an IBC with trace heating and followed by purified water as a flush to minimise sulphate blockage risk An authorised waste contractor as per the best environmental option removes this waste from site.
    - Agarose solution can be discharged, via trace heated pipework, into an IBC if required.
    - Solid resin less than 20 microns does not pose a blockage risk as they are so fine they cannot settle.

3.14 Minimisation of vapour losses

Indicative BAT

You should where appropriate:

1. Review your operating practices and review vent flows to see if improvements need to be made.
2. Consider opportunities to enhance the performance of abatement systems.

To ensure minimal vapour loses across the plant:

- **Dip pipes are used for all solvents** to minimise air entrainment, static build up as well as for hygiene reasons.
- **Process vessels are fitted with condensers** to ensure that the reaction composition remains constant throughout the process (required for successful processes). This reduces the amount of vapour that can pass into the vent stack. The performance of the condenser has been assessed by Briggs of Burton PLC as well as during the HAZOP. All vapours (apart from during the hydrogen generation phase – see section 3.2) are released through the stack. These have fully assessed to ensure they do not pose risk of harm to human health and the environment[10].
- **Opportunities to enhance the performance of the stack system** have been made formally through the HAZOP assessment and it was decided two fans were needed to ensure emissions would be released at the required velocity, with contingency in place if one fan fails. The plant goes into a controlled 'hold' if a fan does fail, alerting the operators to the issue so it can be resolved. Year on year through the EMS process, the operator will continue to improve performance, where possible, so overall emission releases are reduced.
- **Organic solvents processed at elevated temperatures have been minimised where possible.** Reactor RE02 contains toluene that is heated for the process. This is the only example of heating an organic solvent.
- **A systematic HAZOP study, which has considered vapour losses across the plant has been carried out** to ensure any element of the system that has been identified as not having adequate operator or independent safeguards be put in place.

3.15 Separation stages

3.15.1 Overview

Liquid-vapour and liquid-liquid separations are not used in any of the Purolite plant processes so have not been reviewed as part of this BAT.

3.15.2 Solid-liquid separations

Indicative BAT

You should where appropriate:

1. Use the techniques to minimise, re-use and/or recycle rinse water, and to prevent breakthrough of solids.
2. Install instrumentation or other means of detecting malfunction as all of the techniques are vulnerable to solids breakthrough.
3. Consider installing "guard" filters of smaller capacity downstream, which, in the event of breakthrough, rapidly 'clog' and prevent further losses.
4. Have good management procedures to minimise loss of solids, escape of volatiles to air and excessive production of waste water.

To optimise solid-liquid separations across the plant the operator will:

- **Include a washing step at the end of each process** - to remove the process liquors and wash the agarose beads. This washing step takes place in a filter with a 20 micron stainless steel sintered filter.
- **Reduce the amount of solvent (typically water) used for washing** through developments made in the R&D and pilot plant. For example:
    - Waste stream A had the volume significantly reduced through optimising the washing process by moving from sedimentation washing to column washing. Approximately 1,500m^3 of Industrial Methylated Spirit (IMS) was saved per year, being an 85% saving on IMS per batch;
    - Waste-stream B was eliminated in the early design phase of the process.
- **Collect waste run off samples periodically for analysis -** to look at the efficiency of the washing process and determine the amount of contamination remaining. It will also aid detection of solid particles.
- **Make use of a sight-glass to observe resin passing through –** specifically during WC4A and WC4B, which are processes carried out under gravity. In the event of a large failure, the sight-glass would also allow detection.
- **Locate an effluent buffer tank to collect the waste downstream of each filter -** before transferring the waste to the bulk effluent tanks.
- **Conduct periodic inspections and cleaning of the filter plates** to allow early detection of damage that may result in solids passing through.

- **Install an appropriate stainless steel sintered mesh inside filters** - which is made up of 5 layers of stainless steel mesh ranging from 20 micron to 2000 micron. This gives the filter good strength and protection for passing solids.

3.16 Purification stage

Purification of chemicals of wastes, such as by distillation, is not carried out in this plant so has not been addressed further by this BAT.

3.17 Chemical process control

Indicative BAT

You should where appropriate:

1. Monitor the relevant process controls and set with alarms to ensure they do not go out of the required range.

The process is entirely recipe driven, making this a highly controllable process. The Operator can only carry out the next process step, when the previous series of actions (most automated) have been through the correct sequence. The operator interfaces will all equipment through the Supervisory Control and Data Acquisition (SCADA) control system, which is a type of industrial control system, designed to automatically supervise the plant. This uses multiple means to interface with the plant including computers, networked data communications, programme logic controllers (PLCs) and proportional integral derivative controllers (PIDs). Unless an operator has supervisory access, the operator cannot simply over-ride the SCADA system and add in or remove process steps.

For process vessels (by way of example), the SCADA monitors and displays information on the temperature, pressure, agitation speed, flow and time. These are all displayed and set to predetermined ranges. Alarms will sound if the parameter is out of range or has been exceeded. There are literally hundreds of control loops (i.e. a fundamental building block of the SCADA system) across the plant. These are marked on the internal Piping and Instrumentation Diagrams (P&IDs) with step by step controls covered by the internal the User Requirement Specification (URS) and Functional Design Specification (FDS). The HAZOP has systematically reviewed these controls to ensure they provide adequate health and safety protection, prevent emission breakthroughs and where these occur minimise risk of harm to human health and the environment.

These internal documents are confidential as they contain the recipe for the process and therefore cannot be shared in full with NRW during the permit determination period, as they are commercially sensitive. The Emission Management Plan[9], also submitted during the permit application, provides an overview of these key process controls.

3.18 Analysis

Indicative BAT

You should where appropriate:

1. Analyse the components and concentrations of by products and waste streams to ensure correct decisions are made regarding onward treatment or disposal. Keep detailed records of decisions based on this analysis in accordance with management systems.

This BAT has been met by the operator as follows:

- **All waste streams will be subject to sampling procedures** and analysis by the operator and/or the waste contractor to ensure each waste is handled with regards to the best environmental option[9].
- **Waste stream E (for discharge to foul sewer**) is automatically tested to ensure it meets the requirements of a Welsh Water trade effluent consent. Logging information about this discharge will be maintained including: start and finish time of the discharge; date; volume discharged; flow rate; TOC; COD; ph. Initially, Welsh Water will be notified of the operators intent to discharge and will be issued with measurements as specified in the consent letter (see Appendix E).
- **Logs and records of all wastes leaving site through tank away** will also be maintained. If samples are taken (please refer to the Emissions Management Plan) [9]the log will record the results of testing.
- **Refer to section 2.1 regarding other environmental performance** indicators that will be measured across the plant and improved through the EMS process.

3.19 Run-away reaction potential

Run-away reaction potential was not addressed by the NRW BAT[3], but as this is a risk at the proposed site, it was felt necessary to include this section for completeness.

Reaction vessels using sodium hydroxide (including vessels RE5A, RE5B, RE08, RE09, CR1A & CR1B, which are better outlined in the EMP) are at risk from a runaway reaction due to exotherm. All remaining vessels do not undergo a chemical reaction. To help manage this, all vessels that use sodium hydroxide are controlled by Temperature Control Units (TCU), which react to any fluctuations in temperature.

For completeness, there are specific in-house procedures for dealing with runaway reaction potential, summarised below:

- **The addition of sodium hydroxide is carefully controlled and monitored**, depending on the reactor and what is happening within it. In some reactors, sodium hydroxide is added in two portions. In others over a lengthy time period. In some cases a site glass sits on the side of the vessel to enable the operator to check the mixing is sufficient.

- **Before sodium hydroxide is added, the TCU is sent into cooling mode** to pre-empt any rise in temperature from the exotherm.
- **Pressure relief valves** form part of the safety feature of these vessels to the nitrogen blanket.
- **A series of alarms and actions are proposed for the control system** to ensure the operator can monitor any problems.
- **If the temperature exceeds a threshold an alarm will sound.** Sodium hydroxide dosing will be paused until the temperature recovers to within normal parameters.
- **Once a threshold temperature has been exceeded and if the temperature is rising at a rate that is faster than expected but the TCU can stabilise the temperature an alarm will sound.** Sodium hydroxide dosing will be paused until the temperature recovers to within normal parameters.
- **Once a threshold temperature has been exceeded and if the temperature is rising at a rate that is faster than expected and the TCU cannot stabilise the temperature an alarm will sound.** This alarm will override any other activity and all screens will show this alarm. The response to this alarm will be to dump a quench tank of cold water to fill the headspace of the vessel. The quench tank will be filled and verified before the process commences.

It has been deemed that all processes where there is a risk of an exothermic runaway reaction have been thoroughly evaluated and safe processes implemented. Further control measures have also been put in place to remove the possibility of a runaway exothermic reaction.

4 Emissions and Monitoring

4.1 Emissions to air monitoring

4.1.1 Overview

This section should be read in conjunction with the Emissions Management Plan (EMP), written by Melbury Environmental Ltd and Shann Pitts Consulting Ltd and submitted as part of the permit application (document reference: SPC0055/ME17.11.23/Emissions Management Plan/December 17).

Point source emissions to air from the site are marked on the Emission Point Plan (see Figure 8 of the EMP). They arise from:

- Tank breather valves:
    - EP01: IMS Tank vent;
    - EP02: Waste Tank A vent;
    - EP03: Toluene Tank vent;
- EP04: Common (or Main) Vent Stack;
- EP05: Hydrogen Vent Routing; and
- EP06: Epichlorohydrin tank venting.

The EMP includes a full description of each of these point source emissions, as well as methods for controlling these. The following provides a brief overview.

4.1.2 Description of each point Source emission to air

4.1.2.1 Tank breather valves (EP01, EP02, EP03)

The tank breather valves (TBVs) will not release vapour under normal operating conditions. Losses only occur when the weather is warm enough for some liquid to evaporate and build up headspace pressure high enough to overcome the breather valve. The tanks also breathe in (usually overnight) when the pressure drops. The TBVs for tanks containing odourous compounds are connected directly to the Common/ Main Stack to aid odour dispersion. TBVs not connected to the stack are for tanks containing chemicals with a lower odour potential. The loss of vapour from all tanks is controlled through tank design; tall tanks with a low surface area and appropriate pressure rating to reduce vapour loss.

The losses of VOCs from TBVs not connected to the Main Stack are not considered to be significant and have therefore not been assessed further.

4.1.2.2 Common or main stack (EP04)

During the process, various process vessels release vapours and these are in almost all instances diverted to the stack (except for health and safety reasons during the hydrogen generation phase – see section 3.1.3 of the EMP). Vapours are also sent to the stack where they arise from storage of wastes or raw materials that do not pose a flammability risk. The following storage tanks vent directly to the stack:

- Waste stream D
- Waste stream F
- Allyl glycidyl Ether (AGE); and
- Glycidyl-trimethyl-ammonium chloride (GMAC).

During the four years it took the operator to develop the process on an R&D and pilot scale, they were able to understand the likely emissions that would be released during the process, based on chemical engineering principles.

Briggs of Burton PLC quantified emissions from the process vessels and tank breather valves connected to the stack (Appendix B).

This data has been used to carry out a quantitative (H1) risk assessment through which the need for detailed dispersion modelling has been screened out. This has been detailed in an H1 environmental risk assessment submitted as part of the permit application[13].

Emissions to air from the organic chemical manufacturing plant will be regulated by NRW through an Environmental Permit issued under the permitting regulations and in accordance with the IED.

4.1.2.3 Hydrogen route venting (EP05)

During a particular reaction phase, hydrogen is generated – this occurs in six vessels. Due to its flammability, it is diverted out of the building via the shortest exit route, using unobstructed pipework. It is heavily diluted with nitrogen (nitrogen being used as an inerting gas during the process) to remove/ reduce the chances of ignition.

No other vapours are expected to be generated in this phase.

Hydrogen and nitrogen are naturally in the atmosphere and are not considered to be pollutants. This emission point has been included in the H1 risk assessment[13], which has determined no further assessment is required. Furthermore there is no potential odour from this vent as these are odourless gases.

The hydrogen venting has been included as a point source emission due to its potential flammability.

4.1.2.4 Extract air from storage of epichlorohydrin (EP06)

Very small amounts of Epichlorohydrin are required for the manufacturing process; the tank has a maximum working capacity of 100 litres and is located within the flammable store within the building.

As epichlorohydrin is a highly flammable liquid, it was deemed safer to discharge any vapours released during storage, directly to air following filtration via a carbon filter, rather than up the main stack.

It will be released from the side of the building and vented at the building apex (approximately 9m). The tank will only vent infrequently, during filling of the tank, due to a closed loop system that is used during emptying/ filling of the container drum. Only one drum is connected at a time

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[13] Submitted as part of the Permit Application. Doc reference: SPC0055/ME17.11.23/Environmental Risk Assessment/Purolite/December17

The carbon filter will be highly effective at removing organic chemicals. It will be replaced based on the manufacturer's recommendation.

4.1.3 Emissions to air summary and BAT requirements

Emissions to air from point source EP01, EP02, EP03, EP05 and EP06 have been screened out from further assessment via the H1 Environmental Risk Assessment[13].

Therefore the remainder of this section focuses on how BAT has been met for EP04 (i.e. the Common/ Main Stack).

To understand how benchmark values for this emission has been achieved, as per Annex 1 of the Organic Chemical Sector BAT[14], please refer to Chapter 9 of the EMP[15].

4.1.3.5 Particulate matter

This is not expected to be released from the Purolite process.

4.1.3.6 Control of emissions of VOCs

Indicative BAT

You should where appropriate:

1. Formally consider the information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector as part of the assessment of BAT for point- source releases to air, in addition to the information in this note.
2. Identify the main chemical constituents of the emissions, including VOC speciation where practicable.
3. Assess vent and chimney heights for dispersion capability and assess the fate of the substances emitted to the environment.
4. Use the following measures to minimise emissions to air:
   - recover emissions rich in organics by fractionation and then recycle
   - recover and reuse solvents
   - continuously monitor off-gas concentration from reaction vessels, dryers, condensers, evaporators and scrubbers where off-gases are shown to be environmentally significant

Briggs of Burton PLC have quantified the chemical constituents of the emission, including VOC speciation, from process vessels and tank breather valves connected to the main/ common stack (this dataset is provided in Appendix B). These calculations have worked out the amount of each chemical directed to the vent stack, based on temperature, hours of operation, pressure and consideration for condensers.

Using earlier Briggs data, Ricardo were commissioned to conduct an Air and Odour Impact Assessment of the emissions released via EP04 (see Appendix C). This work confirmed a stack height of 12.7m would be required to ensure dispersion of any residual odourous compounds.

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[14] Natural Resources Wales (2014). How to comply with your environmental permit. Additional guidance for: specialty organic chemicals sector (EPR 4.02). Available on-line (https://naturalresources.wales/media/2105/how-to-comply-with-your-environmental-permit-additional-guidance-for-speciality-organic-chemicals.pdf (accessed 02/11/17).

[15] Submitted as part of the Permit Application. Document reference: SPC0055_ ME17.11.23_Emissions_Management_Plan_December 17

Using the most up-to-date emission data provided by Briggs of Burton PLC, a further quantitative environmental H1 risk assessment was undertaken[13]. This confirmed that with a stack height of 12.7m and a velocity release of 15m/s the long and short term impacts of predicted air emissions would not result in exceedances of Environmental Assessment Limits in ambient air around the facility or at any sensitive receptor sites, including at ecological receptors.

In accordance with BAT Document on Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector[16] it is BAT to remove VOCs from waste gas streams. The control technique of choice for the Operator is condensation as this technique allows the recovery of raw material and / or solvent.

In the Purolite process, condensation is used as a recovery technique not an abatement technique. Most reactors are fitted with condensers to enable good process control.

The efficacy of condensation depends on the vapour pressure of the contaminants at condensation temperature and therefore substances with higher vapour pressure are less suited to condensation.

Where applicable condensers have been incorporated as part of the vessel designs (RE01, RE02, DV03, RE5A, RE5B, RE08 and C10A). The condensers used in the Purolite manufacturing process are operated with conventional water cooled tube in tube heat exchangers; the chilled water arriving at the condenser is around 5^0C rising to approximately 12^0C on the return. There is not sufficient heat released from the process to consider reuse of heat.

In accordance with BAT[16] Document on Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector[16]:

- The use of indirect cooling in order to cool or condense vapours is preferable to the direct use of water for cooling as the later produces large amounts of waste-water (Section 3.3.1.3).
- Indirect condensation is preferred because direct condensation needs an additional separation stage (Section 3.5.1.2).

The efficiency of the condensers has not been quantified at this stage.

As recovery of solvents is feasible, abatement on the residual very low concentration of VOCs is not deemed to be proportionate to the benefit that would be achieved.

The heat exchangers will be fitted with instrumentation to detect failures. There will be a temperature transmitter on the vent route, which will alarm if the temperature rises. This will be set on commissioning. Alarms are handled by the automation SCADA system and will be raised in the control room for the operator to handle. The heat exchangers will be subject to part of a planned maintenance procedure.

If the condensers fail which would be due to a failure of the chilled water circulation system, the plant will go into a controlled ‘hold state’, with operations being limited until the process is safe to start again. As a contingency if necessary mains water can be flowed through the condensers at ambient rather than chilled temperature.

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[16] Integrated Pollution Prevention and Control, Reference Document on Best Available Techniques in Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector, European Commission, February 2003

4.2 Point source emissions to water

There are no point source emissions to water arising from the Purolite process.

4.3 Point source emissions to land

There are no point source emissions to land arising from the Purolite process.

4.4 Fugitive emissions

Indicative BAT

You should where appropriate:

1. Identify all potential sources and develop and maintain procedures for monitoring and eliminating or minimising leaks and releases of VOCs from all non-process stream sources.
2. Choose vent systems to minimise breathing emissions (for example pressure/ vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment.
3. Use the following techniques (together or in any combination) to reduce losses from storage tanks at atmospheric pressure:
    - maintenance of bulk storage temperatures as low as practicable, taking into account changes due to solar heating etc.
    - tank paint with low solar absorbency
    - temperature control
    - tank insulation
    - inventory management
    - floating roof
    - bladder roof tanks
    - pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations
    - specific release treatment (such as adsorption condensation).

Please refer to the EMP[15] for a full description of fugitive emissions released from the plant and how these are controlled. This includes information on how the process is monitored to eliminate or minimise leaks and releases of VOCs from all non-process stream sources.

All vent systems for tanks have been designed by Briggs of Burton PLC. Breather values are used with back-up pressure relief and anti-vac valves. All bulk tanks are designed in line with current standards.

All reactive chemicals are stored as per the manufacturer and supplier recommendations. This includes, the container type, pressure rating, their proximity to other reactive chemicals, flammability, the need for storage under a steady gas stream or at a specific temperature where necessary and environmental considerations. Most bulk storage tanks connect to the vent stack, especially if there is an odour risk. However, some bulk storage tanks do not connect to the vent stack as there are various concerns that it could result in mixing of vapours which could pose a health and safety risk. For more information on this refer to section 4.1.2.1 on tank breather valves.

4.5 Fugitive emissions to surface water, sewer and groundwater

Indicative BAT

You should where appropriate:
1. Provide hard surfacing in areas where accidental spillage or leakage may occur, e.g. beneath prime movers, pumps, in storage areas, and in handling, loading and unloading areas. The surfacing should be impermeable to process liquors.
2. Drain hard surfacing of areas subject to potential contamination so that potentially contaminated surface run-off does not discharge to ground.
3. Hold stocks of suitable absorbents at appropriate locations for use in mopping up minor leaks and spills, and dispose of to leak-proof containers.
4. Take particular care in areas of inherent sensitivity to groundwater pollution. Poorly maintained drainage systems are known to be the main cause of groundwater contamination and surface/above-ground drains are preferred to facilitate leak detection (and to reduce explosion risks).
5. Additional measures could be justified in locations of particular environmental sensitivity. Decisions on the measures to be taken should take account of the risk to groundwater, taking into consideration the factors outlined in the Agency document, Policy and Practice for the Protection of Groundwater, including groundwater vulnerability and the presence of groundwater protection zones.
6. Surveys of plant that may continue to contribute to leakage should also be considered, as part of an overall environmental management system. In particular, you should consider undertaking leakage tests and/or integrity surveys to confirm the containment of underground drains and tanks.

All production activities are carried out in the production building. The entire production area, some plant rooms and warehouses are connected to the external crash tank drain to collect any liquid in the event of loss of containment. The drains, floor and pipes are chemically resistant. Any filling of IBC's is done on drip-trays, which are bunded and connected to pumps. All areas of plant will be subject to frequent walk around inspections to identify leaks, faulty equipment or other environmental issues.

The design of external areas, to prevent fugitive emissions to surface water, sewer and groundwater are covered by a drainage philosophy written by CD Gray (see Appendix D).

There is hard standing across the external areas of the site, with drainage directed to the surface water drains. The bunded tank farm, tanker off-loading area and crash tank are designed to capture any spillages that may occur both in and outside the production building (see section 3.4 on containment of spillages). The surfaces and drains are all designed for the chemicals handled.

Site procedures are in place to ensure all activities that pose a risk of leak/ spillages are carried out in designated areas. Spillage kits, including drain covers will be on-site in strategic locations. The manufacturing personnel will be trained to handle a variety of spillages on multiple scales and will have drills at certain frequencies. Drains will be subject to regular flushing to prevent the accumulation of any chemicals in the pipes and this will be documented in the operational procedures.

Drainage infrastructure is suitably designed to cope with expected rainfall events including surface water flooding the main yard. The design and profiling of the site ensures that if a storm event of a significant magnitude were to occur, flows would be directed around the main building affording the building adequate protection. All other external infrastructure has been raised with this flood risk in mind, protecting it from inundation in the most extreme of flood events.

An external bin store and IBC/ drum store have been designated as ‘high risk’ in that run-off could become polluted if rainwater were to come into contact with these areas. It was therefore deemed to make these into undercover areas, placing them on an impermeable surface, with a sealed drainage system which all runs into the crash tank. As per the section 3.4 Containment of spillages, crash tank waters are tested and released to the sewer network, provided they are in-line with the Trade Effluent consent. If not, they are removed from site by an authorised waste contractor and managed as per the best environmental option.

In their report, CD Gray have assessed the suitability of the existing drainage network for foul water and surface water to determine its suitability for re-use by the operator and where necessary, what modifications would be required prior to start-up.

With regards to groundwater, the proposed site is not located in a groundwater source protection zone (see Figure 2 Aquifer Designation Map appending the EMP[15]). The aquifer under the site is designated as ‘Secondary A’ and is comprised of the following ‘sand and gravel’ permeable layers: Hughes Member; and glaciofluvial deposits. It is classed as a minor sand and gravel aquifer.

4.6 Odour

Indicative BAT

You should where appropriate:

1. Manage the operations to prevent release of odour at all times.
2. Where odour releases are expected to be acknowledged in the permit, (i.e. contained and treated prior to discharge or discharged for atmospheric dispersion):
    - for existing installations, the releases should be modelled to demonstrate the odour impact at sensitive receptors. The target should be to minimise the frequency of exposure to ground level concentrations that are likely to cause annoyance.
    - for new installations, or for significant changes, the releases should be modelled and it is expected that you will achieve the highest level of protection that is achievable with BAT from the outset.
    - where there is no history of odour problems then modelling may not be required although it should be remembered that there can still be an underlying level of annoyance without complaints being made.
    - where, despite all reasonable steps in the design of the plant, extreme weather or other incidents are liable, in our view, to increase the odour impact at receptors, you should take appropriate and timely action, as agreed with us, to prevent further annoyance (these agreed actions will be defined either in the permit or in an odour management statement).
3. Where odour-generating activities take place in the open, or potentially odorous materials are stored outside, a high level of management control and use of best practice will be expected.
4. Where an installation releases odours but has a low environmental impact by virtue of its remoteness from sensitive receptors, it is expected that you will work towards achieving the standards described in this guidance note, but the timescales allowed to achieve this might be adjusted according to the perceived risk.
5. Where further guidance is needed to meet local needs, refer to Horizontal Guidance Note H4 Odour (see GTBR).

The operations are managed to prevent the release of odour at all times and this is covered in detail in the emissions management plan[15]. Odour is primarily controlled through plant design and the design of storage tanks to prevent release of emissions that could pose an odour nuisance. Where odour releases are expected the Operator has:

- **Conducted detail air dispersion modelling** to ensure dispersion of any residual odourous compounds on sensitive receptors from the main/ common stack (EP04) (Appendix C). It was determined a stack height of 12.7m would be required to achieve BAT;
- **Put in place operational procedures to conduct at least daily checks** on external areas where odour is most likely, including on the tank farm and tanker off-loading area. Operational procedures and training on the use of the vapour return system during tanker loading/ off-loading will form part of the Environment Management System and Standard Operating Procedures.
- **Put in place process, management and maintenance controls to ensure condensers on process vessels are working at all times.** Condensers on the outlets of reaction vessels enable a reduction in loss of VOCs as well as reduction in odour potential. Therefore their performance is of upmost importance in odour management.
- **Put in place a maintenance plan to ensure the** epichlorohydrin vent functions, as it should. This release is expected to be very small and is put through a carbon filtration system before release to atmosphere, however due to odour and human health risk, controls are in place to prevent this causing a nuisance by odour.

If odour is an amenity issue then an Odour Management Plan as per Horizontal Guidance Note H4 on Odour, will be developed in consultation with Natural Resources Wales.

4.7 Noise and vibration

Indicative BAT

You should where appropriate:
1. Install particularly noisy machines such as compactors and pelletisers in a noise control booth or encapsulate the noise source.
2. Where possible without compromising safety, fit suitable silencers on safety valves.
3. Minimise the blow-off from boilers and air compressors, for example during start up, and provide silencers.

The chemical manufacturing process will be carried out within the building; air compressors are within the building. The compressor room is designed for high noise levels and will be suitably insulated for sound. Operators will wear suitable PPE (ear protection) in this area. The building is constructed of steel sheets with a Rockwool core giving a good level of sound insulation.

The air-handling unit is located outside the building but is not anticipated to be a source of noise.

There is a preventative maintenance programme for all equipment.

Daily checks for noise will be carried out in accordance with operational procedures.

Noise from vehicle movements will be minimal, as it is not anticipated that there will be any more than four tanker movements per week.

If noise is an amenity issue then a noise and vibration management plan will be developed in consultation with Natural Resources Wales.

4.8 Monitoring and reporting of emissions to air and water

There are no emissions released to water from the Purolite process.

Indicative BAT

You should where appropriate:
1. Carry out an analysis covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits. The need to repeat such a test will depend upon the potential variability in the process and, for example, the potential for contamination of raw materials. Where there is such potential, tests may be appropriate.
2. Monitor more regularly any substances found to be of concern, or any other individual substances to which the local environment may be susceptible and upon which the operations may impact. This would particularly apply to the common pesticides and heavy metals. Using composite samples is the technique most likely to be appropriate where the concentration does not vary excessively.
3. If there are releases of substances that are more difficult to measure and whose capacity for harm is uncertain, particularly when combined with other substances, then "whole effluent toxicity" monitoring techniques can be appropriate to provide direct measurements of harm, for example, direct toxicity assessment.

The EMP (document reference: SPC0055/ME17.11.23/EMP/V1/Purolite/ December 17) covers emissions to sewer and how these are monitored to be in line with the Trade Effluent consent issued by Welsh Water.

Emissions to air and a proposed monitoring approach are also covered by the EMP[15].

4.9 Monitoring and reporting of waste emissions

Indicative BAT
You should where appropriate:
1. Monitor and record:
    - the physical and chemical composition of the waste
    - its hazard characteristics
    - handling precautions and substances with which it cannot be mixed

During the operation of the pilot plant detailed chemical analysis of all of the waste streams was carried out. This sample analysis data was used to fully characterise the waste streams and to determine the most appropriate option in terms of recovery or disposal.

Purolite have appointed Tradebe to manage waste streams going forward once the plant is fully operational. Initially Purolite will take frequent samples of all of the waste streams for removal off site (A, C, D and F). These samples will be sent to Tradebe for analysis.

It is anticipated that the sampling frequency will be significantly reduced once the plant is fully operational as the manufacturing process is highly controlled and there should be very little variability in the waste stream constituents. However, it is recognised that it is important to undertake regular e.g. annual sampling to ascertain if there are any changes and also to regularly reassess the optimum recovery or disposal route in line with the waste hierarchy.

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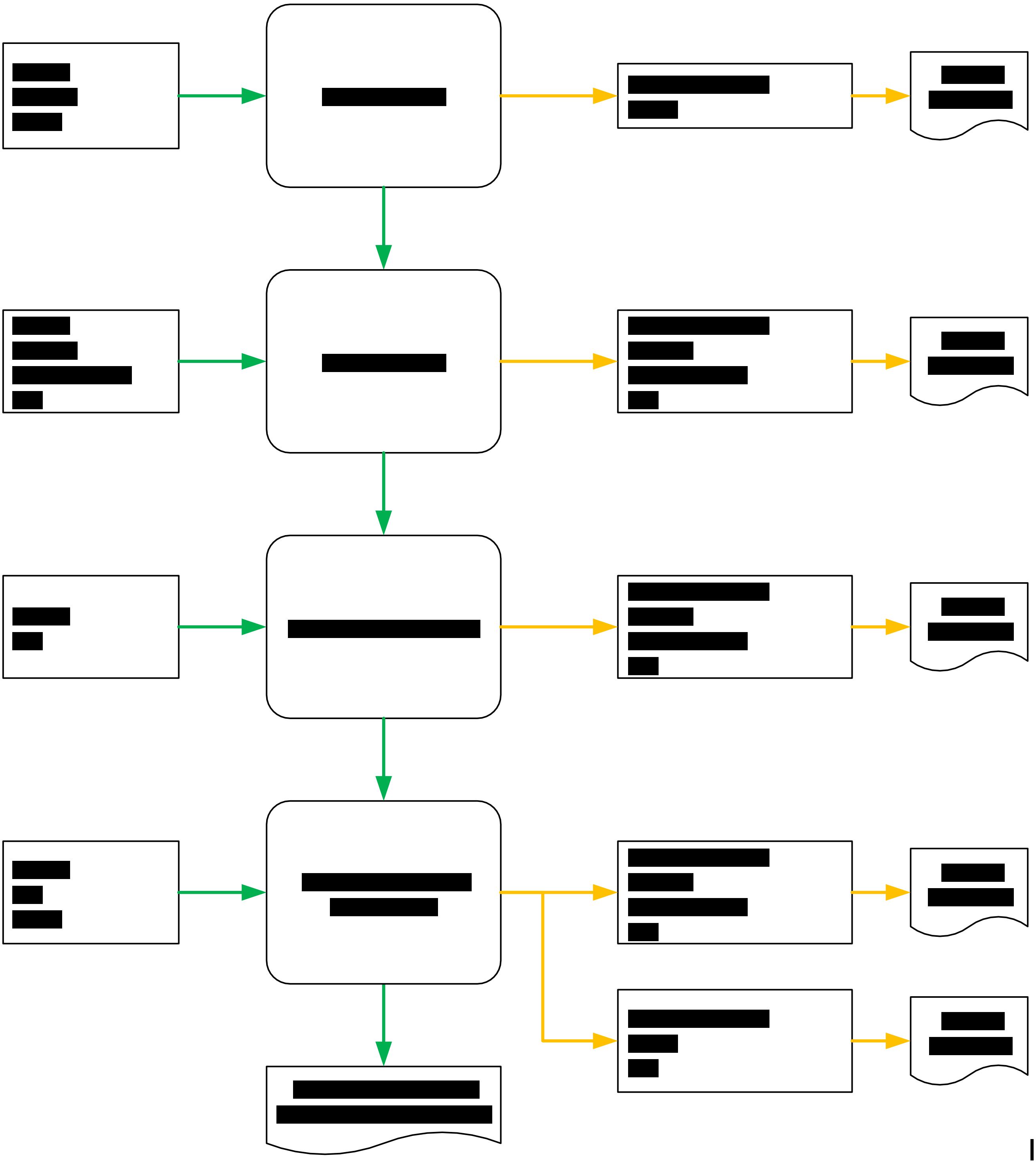

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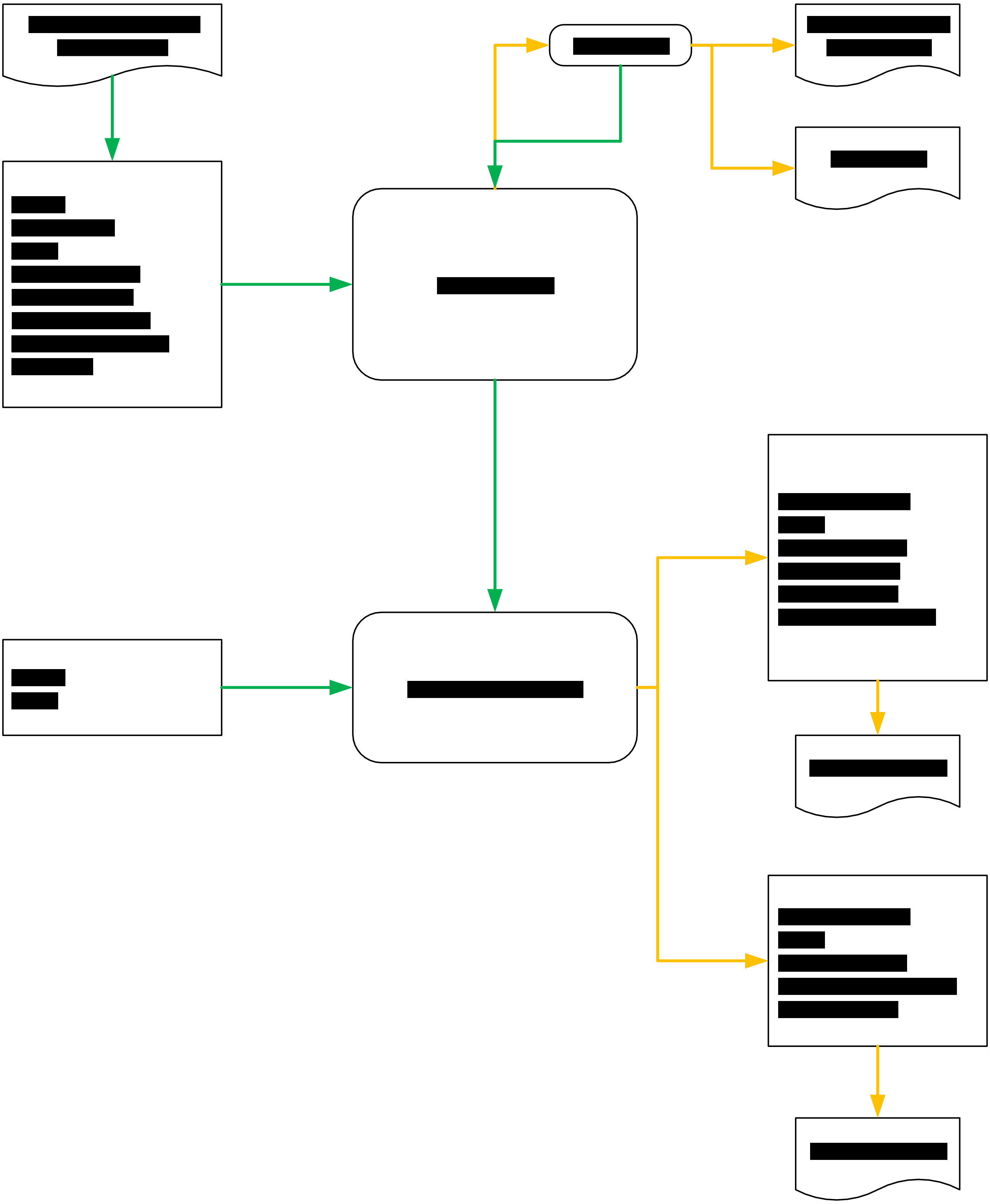
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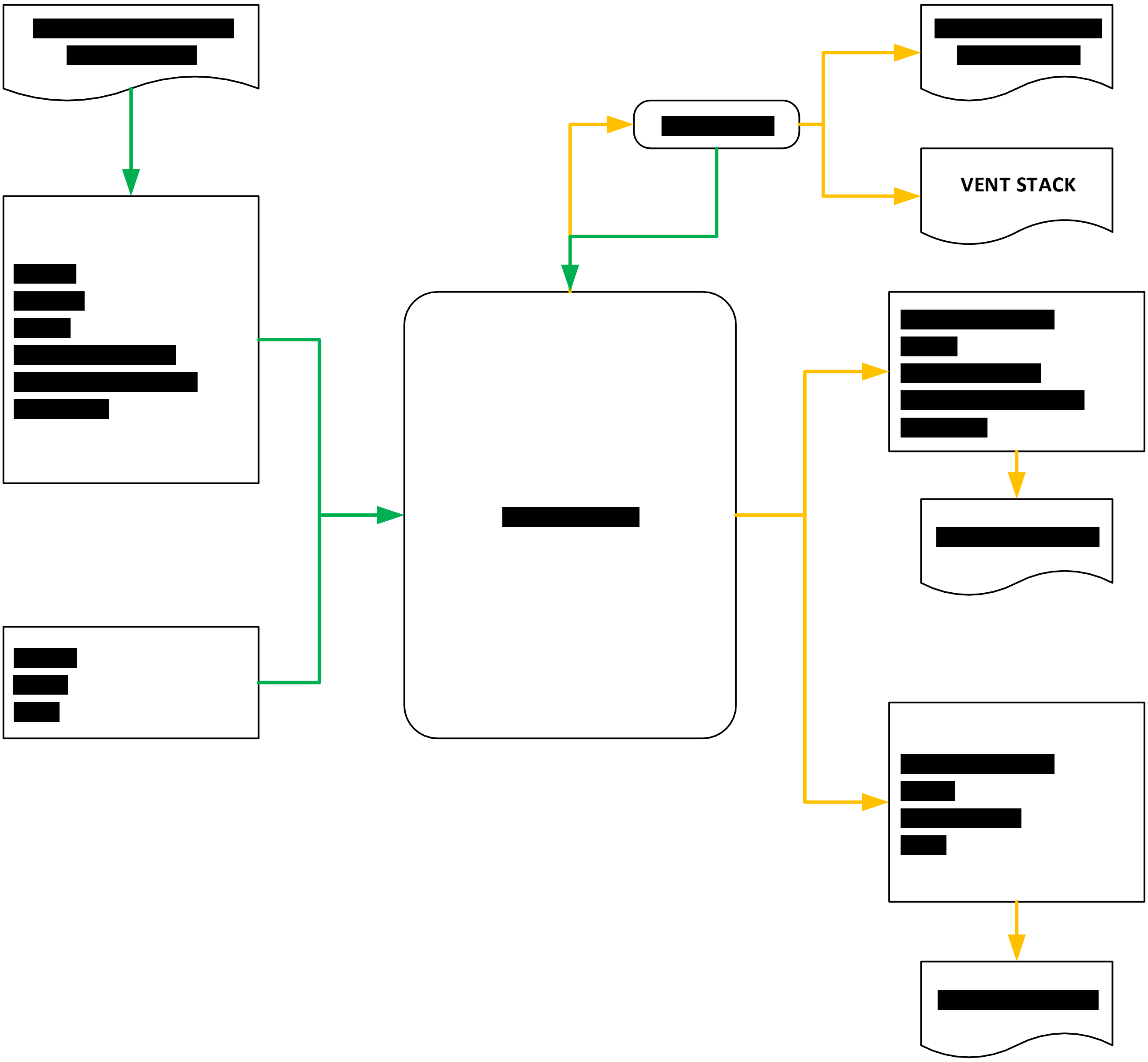
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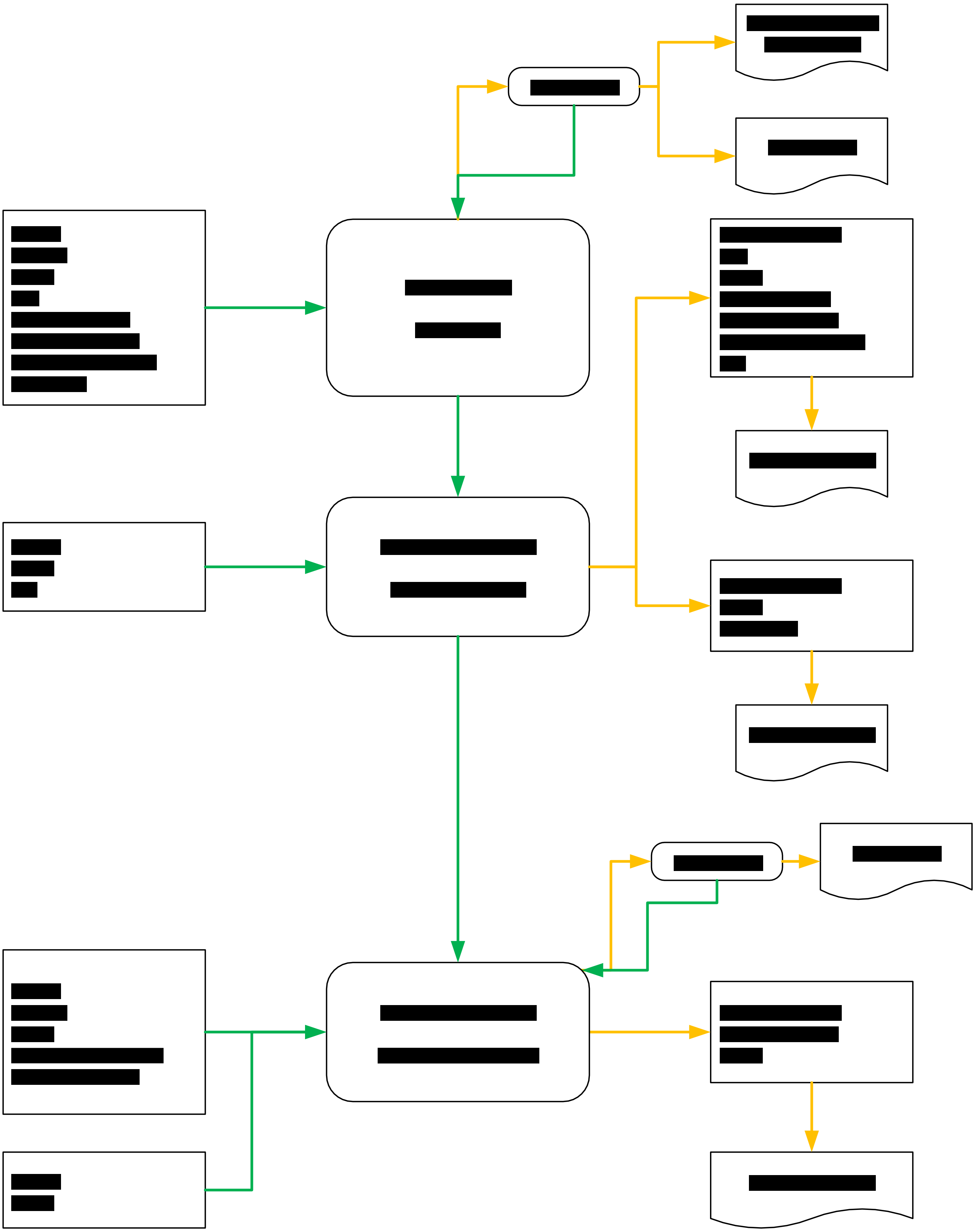
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Appendix B Briggs Emission Estimations

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Information used by Ricardo, provided by Briggs previously - 11Oct16

Material	CAS	Concentration (w/w)	Estimated Emissions (annually)	Estimated Peak Emissions (hourly)	Estimated Peak Gas Flow (hourly)	Temperature	Pressure	Target (**tbc**)	Comments
Acetic Acid	64-19-7	60%	**0.3 kg/yr**	0.21 kg/hr	4.0 m^3/hr	50 °C	Atmos.	**25 mg/m^3**	
Allyl glycidyl ether (AGE)	106-92-3	100%	**0.9 kg/yr**	1.35 kg/hr	60.0 m^3/hr	45 °C	Atmos.	**23 mg/m^3**	
Epichlorhydrin	106-89-8	100%	**3.6 kg/yr**	**0.46 kg/hr**	5.4 m^3/hr	50 °C	Atmos.	**2 mg/m^3**	
Ethanol	64-17-5	100%	**5.8 kg/yr**	**0.25 kg/hr**	4.0 m^3/hr	35 °C	Atmos.	**1920 mg/m^3**	
Ethanol (as IMS - Industrial Methylated Spirits)	64-17-5	96%	**177.6 kg/yr**	3.89 kg/hr	60.0 m^3/hr	70 °C	Atmos.	**1920 mg/m^3**	
Glycidyltri-methyl-ammonium chloride (GMAC)	3033-77-0	100%	0.0 kg/yr	0.00 kg/hr	0.0 m^3/hr	35 °C	Atmos.	**n/a**	Trace amounts only anticipated
Hydrogen	133-74-0	100%	**67.0 kg/yr**	**3.18 kg/hr**	42.4 m^3/hr	50 °C	Atmos.	**n/a**	
Methanol (as IMS - Industrial Methylated Spirits)	67-56-0	4%	**14.9 kg/yr**	8.02 kg/hr	60.0 m^3/hr	70 °C	Atmos.	**266 mg/m^3**	
Toluene	108-88-3	100%	**40.8 kg/yr**	4.12 kg/hr	60.0 m^3/hr	70 °C	Atmos.	**191 mg/m^3**	

Appendix C Air Quality and Odour Impact Assessment

Air quality and odour impact assessment

Report for Purolite Ltd

Order No. 88850, Reference. BG/DJ/SH

ED 62380131 | Issue Number 1 | Date 28/11/2016

Ricardo in Confidence

Customer:

Purolite Ltd

Customer reference:

Order No. 88850, Reference. BG/DJ/SH

Confidentiality, copyright & reproduction:

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Ricardo-AEA Ltd is certificated to ISO9001 and ISO14001

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Dr Nigel Gibson

Date:

28 November 2016

Ricardo Energy & Environment reference:

Ref: ED62380131- Issue Number 1

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Appendices

Appendix 1 Pollutant and odour concentrations at sensitive receptors

1 Introduction

Ricardo Energy & Environment have been commissioned to carry out an atmospheric dispersion modelling study to assess the impact of emissions on ambient concentrations of applicable pollutants and odour from a proposed fine chemical manufacturing facility. The objectives of the study were:

- To forecast pollutant concentrations against short-term and long-term environmental assessment limits, as set out in the guidance on *'Air emissions risk assessment for your environmental permit'*, provided by the Environment Agency and the Department for Environment, Food & Rural Affairs[1].
- To forecast odour concentrations against the applicable odour benchmark, as per the Environment Agency's "H4 Odour Management" document[2].

This report draws on the results of emission estimations provided by the plant design consultants; Briggs of Burton Plc. This estimate provided emission concentrations for a number of volatile organic compounds (VOCs) emitted from the process. This data was used to calculate concentrations, and the relative odour impact, in ambient air at sensitive receptor sites in the local area, using the atmospheric dispersion model ADMS v5.1, run using meteorological data representative of the location.

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[1] Environment Agency and Department for Environment, Food & Rural Affairs (2016) *Air emissions risk assessment for your environmental permit* via https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions2

[2] Environment Agency (2011) *H4 Odour Management – How to comply with your environmental permit* via https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296737/geho0411btqm-e-e.pdf

2 Methodology

2.1 Preamble

Once released to the atmosphere, the direction of spread of pollutants is totally dependent upon the direction of the wind. The rate of dispersion depends mainly on the wind speed, but other meteorological parameters, such as air temperature, also influence dispersion rates. The stability of the atmosphere also plays an important role in atmospheric dispersion.

There are also non-meteorological factors which influence downwind pollutant concentrations:

- Distance from source: The closer a receptor is to the emission source; the greater the likely pollutant concentration at that location and the greater the probability of impact or complaint.
- The height of release: Generally, the higher the point of release; the lower the pollutant concentration in the vicinity of the source.
- Emission characteristics: Higher concentrations can be expected to affect a larger area than lower concentrations.
- Building downwash: Pollutant emissions may be subject to highly turbulent wind flows in the wake of buildings.

The combined effect of these factors will influence the impact of the emissions from the proposed facility.

2.2 Modelling

2.2.1 Model description

Ground level concentrations of released substances have been modelled using the dispersion model ADMS V5.1. ADMS is an advanced dispersion model in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and heat flux at the surface. The model represents the concentration distributions as Gaussian in stable and neutral conditions, but the vertical distribution is non-Gaussian in convective conditions to take account of the skewed structure of the vertical component of turbulence. The model contains a meteorological pre-processor which calculates the required boundary layer parameters from surface heat flux, wind speed and boundary layer height data. Complex modules within the model allow for the effects of plume rise and the presence of buildings.

ADMS has been chosen because it is ‘fitted for the purpose of the modelling procedure’ as defined by the guidelines published by the Royal Meteorological Society (R Met Soc. 1995) and Guidelines for the Preparation of Dispersion Modelling Assessments for Compliance with Regulatory Requirements; an Update to the 1995 Royal Meteorological Society Guidance.

2.2.2 Meteorology

A statistical dispersion modelling run requires a minimum of five years of hourly meteorological records.

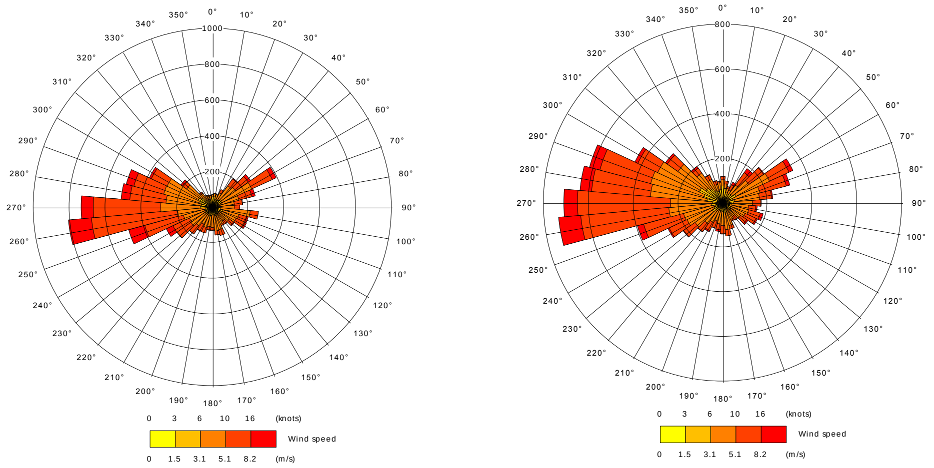
There is a meteorological station at Cardiff Airport, approximately 17 km south of the site. Due to the proximity and similarity of exposure of Cardiff Airport and the Llantrisant Business Park we consider that the records from Cardiff Airport will provide a reasonable illustration of the situation at the site and consequently they have been used in the modelling study.

Meteorological data was sourced from the NOAA surface observations archive and processed into hourly sequential ADMS format. Data filling was carried out where necessary according to the methodology provided by the USEPA in their “Meteorological Monitoring Guidance for Regulatory Modelling Applications” guidance document. The recommended filling procedure is based on the persistence method, where a missing value is replaced by the use of data from the previous hour(s). The data capture for wind direction and wind speed at the Cardiff Airport meteorological station was found to be good (>90 % data capture). Missing cloud cover data is quite common in meteorological data sets, and data for Cardiff Airport was found to have cloud cover data for ~85-90 % of hourly observations. As a result, in order to ensure data capture for all meteorological parameters was >90%, cloud cover data from nearby St Athan Airport was used to gap-fill.

The wind rose for the weather files, derived from data from Cardiff Airport (2011- 2015) is shown in Figure 1. This illustrates the relative frequency of wind directions and wind speeds used in the modelling study.

Figure 1: Wind rose reflecting meteorological data recorded at Cardiff Airport (2011-2015)

2011 2012



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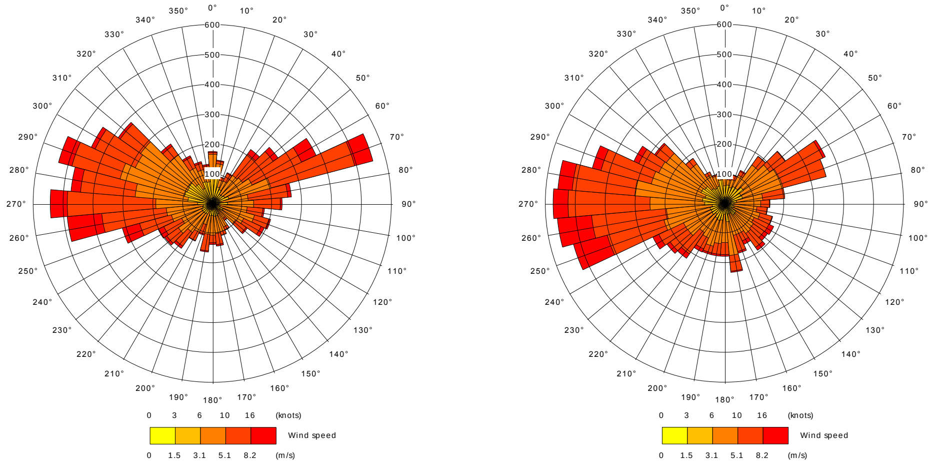
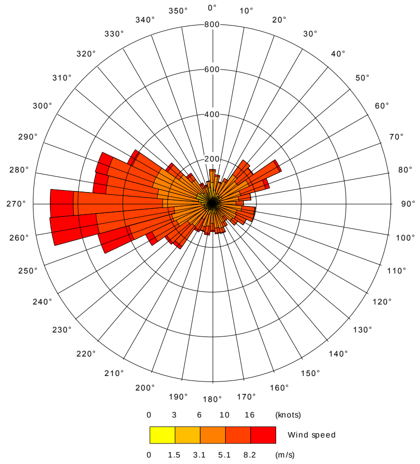


2015



2.2.3 Process information

This dispersion modelling exercise has been undertaken using discharge characteristics for the site provided by Purolite Ltd and Briggs, as shown in Table 1.

Table 1: Discharge characteristics

Stack parameters	Coordinates		Stack height (m)	Stack diameter (m)	Volumetric flow rate (m^3/s)	Velocity (m/s)	Temperature (°C)
	X (m)	Y (m)					
Main stack	304170	184500	9 / 12.7	0.1	0.118	15	45

The pollutants considered in the assessment are set out in Table 2. The modelling assessment was based on estimations of peak emission rates for each pollutant, which were provided by Purolite Ltd and Briggs.

Table 2: Emission rates

Pollutant	Peak emissions (g/s)
Acetic Acid	0.058
Allyl glycidyl ether (AGE)	0.38
Epichlorohydrin*	0.13
Ethanol	0.069
Ethanol (as IMS)	1.08
Hydrogen	0.88
Methanol	2.23
Toluene	1.14

The impact of these emissions was assessed by comparing the maximum ground level concentrations against their respective EALs, as set out below. Odour concentrations were calculated by dividing pollutants by their applicable published odour threshold values, and summing the total to provide the total impact in odour unit per cubic meter, which has then been assessed against an odour benchmark of 3 OU_E/m^3 as a 98th%ile, as per the Environment Agency’s “H4 Odour Management”[2] Guidance.

Table 3: Environmental Assessment Levels and Odour Threshold Values

Pollutant	ST EAL (µg/m^3)	LTEAL (µg/m^3)	Odour threshold (mg/m^3)	Odour benchmark
Acetic Acid	3,700[1]	250[1]	0.043[3]	3 OU_E/m^3 as a 98th%ile
Allyl glycidyl ether (AGE)	No EAL		44[4]	
Epichlorohydrin	No EAL		3.52[5]	
Ethanol	576,000[6]	19,200[6]	0.28[3]	
Hydrogen	No EAL		N/A	
Methanol	33,300[1]	2,660[1]	4[3]	
Toluene	8,000[1]	1,910[1]	0.644[3]	

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[3] Woodfield, M. and Hall, D. (1994) Odour measurement and control – An update. AEA Technology National Environmental Technology Centre.

[4] Ruth, J.H.; Am Ind. Hyg. Assoc. J 47: A-142-51 (1986) Odor thresholds and irritation levels of several chemical substances: a review.

[5] https://www3.epa.gov/airtoxics/hlthef/epichlor.html

[6] https://www.sepa.org.uk/media/61377/ippc-h1-environmental-assessment-and-appraisal-of-bat-updated-july-2003.pdf

It is important to note that the estimation of odour concentration is based on an amalgamation of the individual compounds. The odour threshold values listed in Table 3 represent the thresholds for each substance individually, and it is possible that through their interaction, the point of detection could be different when emitted in combination.

2.2.4 Buildings affecting stack dispersion

Nearby buildings can influence the dispersion of pollutants from a stack. In order to address this, the dimensions of the main process building and the proposed tank farm, including to the height of the gantry and the tanks themselves, have been factored into the model. The parameters of these are summarised in Table 4.

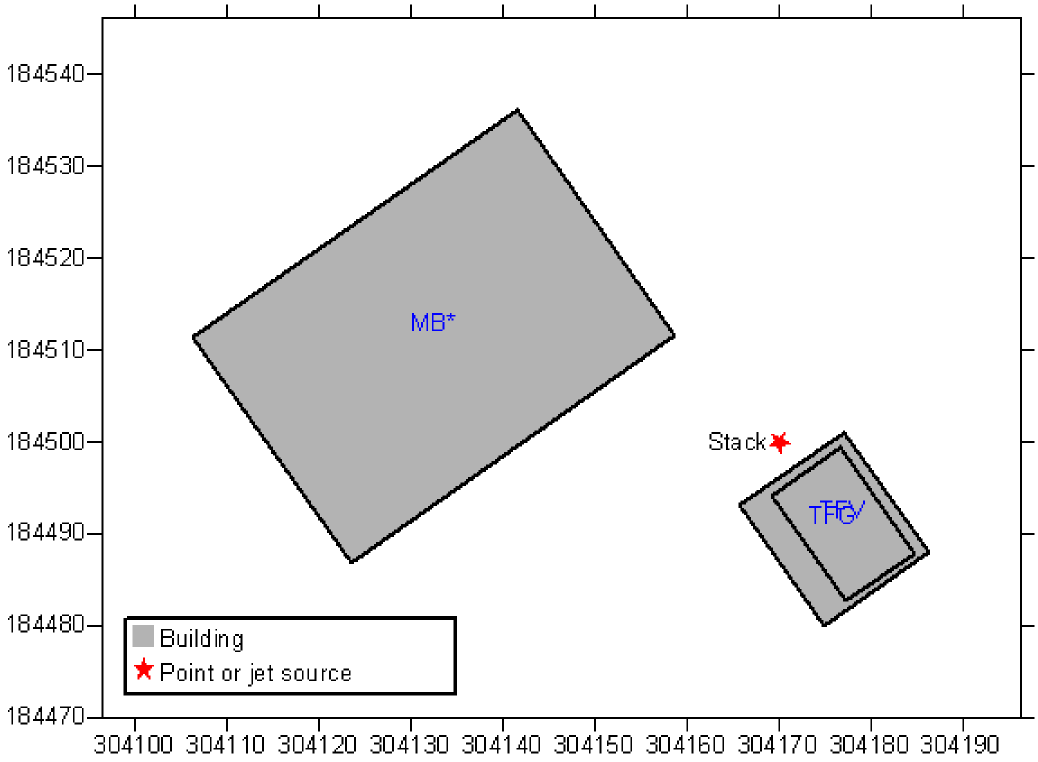
Table 4: Building parameters

Ref	Building	Centre-point		Height (m)	Length (m)	Width (m)	Angle (°)
		x (m)	y (m)				
MB	**Main building**	304133	184512	9.7	43	30	55
TFG	**Tank farm gantry**	304176	184491	6	14	16	55
TFV	**Tank farm vessels**	304177	184491	10	9	14	55

Figure 2 provides an illustration of the layout of the buildings factored into the modelling. The emission stack has been illustrated by a red star.

A screening assessment was carried out to determine which building, when identified as the “Main Building” in ADMS resulted in the highest ground level concentrations. This was found to be the main process building and as such, this was considered to be the “Main Building” for the remainder of the modelling.

Figure 2: Visualisation of buildings and emission point



2.2.5 Surface roughness and terrain

The proposed Purolite facility is located on an industrial estate in a semi-rural area to the north of the town of Llantrisant. Although there are not significant gradients in the immediate vicinity of the site, for the avoidance of doubt, the effects of terrain on dispersion of emissions from the proposed facility were considered in the assessment. Local terrain data was incorporated into the modelling study at the highest appropriate resolution.

Local land use patterns can affect the structure of the atmosphere. For example, the presence of high-rise buildings in an industrial or city centre area can result in increased turbulence in the atmosphere. Conversely, areas with low vegetation or open water may have less influence on the atmosphere, and tend to result in a more stable atmosphere. This is represented in the dispersion model using a parameter known as the “surface roughness length”. The surface roughness length used in this study was 0.2 metres, representative of the minimum surface roughness for agricultural areas.

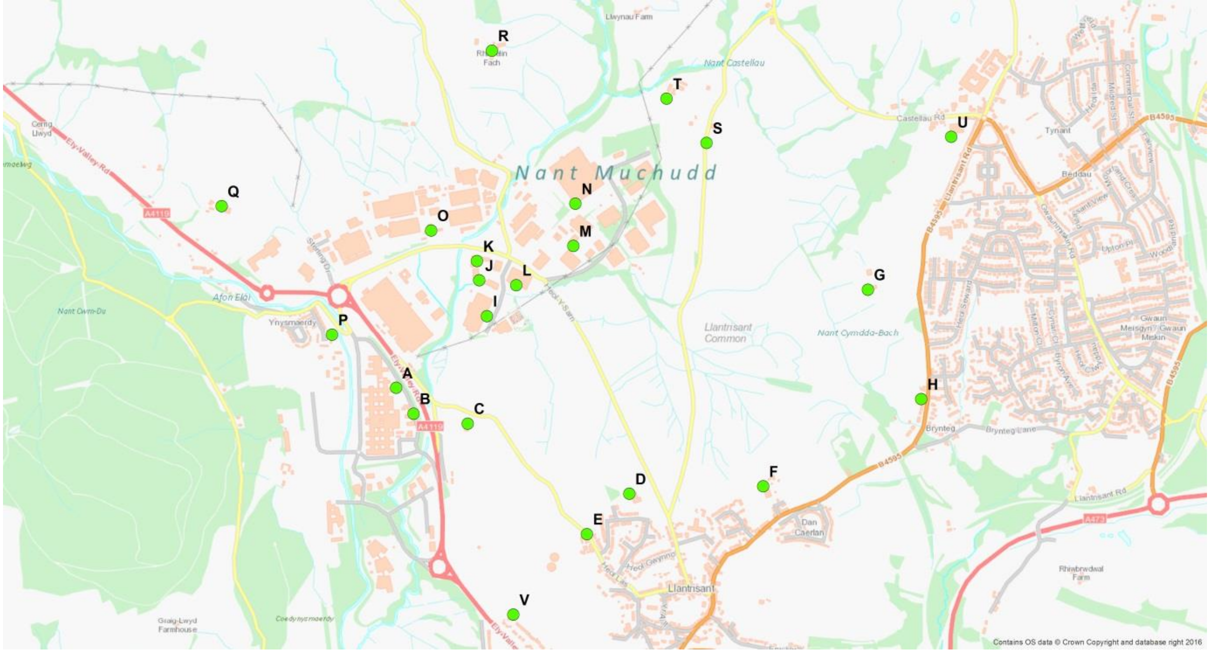
2.2.6 Discrete receptors

A selection of nearby receptor locations, including residential properties and commercial premises, have been identified to assess the impact of emissions from the proposed facility, and factored into the model as discrete receptors at 1 m above ground level. Details of the positions of the specified discrete receptor points are provided in Table 5 and illustrated in Figure 3, where the receptors are marked by green circles accompanied by their reference.

Table 5: Receptor locations used in this study

Ref.	Location	Type	X (m)	Y (m)	Approximate distance to site (km)
A	Royal Glamorgan Hospital 1	Hospital	303682	184247	0.54
B	Royal Glamorgan Hospital 2	Hospital	303747	184150	0.54
C	Farmhouse 1	Residential	303950	184113	0.44
D	Llantrisant Primary School	School	304556	183850	0.76
E	House - Heol Las	Residential	304397	183699	0.83
F	Llantrisant Rugby Football Club	Leisure	305058	183878	1.09
G	Farmhouse 2	Residential	305451	184615	1.29
H	House - B4595	Residential	305651	184205	1.52
I	RPC Containers	Commercial	304022	184516	0.14
J	The Kite Brewery	Commercial	303993	184650	0.23
K	Three Saints Hotel / The Red Mint	Hotel	303985	184722	0.29
L	Balmoral Tanks	Commercial	304132	184632	0.14
M	Euro Performance	Commercial	304346	184779	0.34
N	Universal Engineering	Commercial	304354	184937	0.48
O	The Royal Mint	Commercial / Leisure	303813	184837	0.49
P	Ynysmaerdy Terrace	Residential	303441	184446	0.72
Q	Farmhouse 3	Residential	303027	184928	1.22
R	Farmhouse 4	Residential	304041	185511	1.02
S	Farmhouse 5	Residential	304846	185165	0.96
T	Farmhouse 6	Residential	304696	185331	0.99
U	Ysgol Gymraeg Castellau	School	305764	185188	1.74
V	Dan Y Graig Heights	Residential	304121	183397	1.10

Figure 3: Illustration of discrete receptors selected around the proposed facility



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2.2.7 Model scenarios considered

For the purpose of this study a series of modelling scenarios have been considered. The model runs set out in Table 6 consider the long and short-term impacts associated with emissions from the stack at a height of 9 m and 12.7 m. These stack heights have been selected as they are 3 m above the height of the Tank Farm Gantry and Main Building respectively. Pollutant concentrations have been modelled as annual average concentrations (long-term) and as maximum hourly concentrations (short-term). Odour concentrations have been modelled as a 98th%ile of 1 hour averages. This expresses the odour concentration at the worst 176th hour of the 8760 hours per year (i.e. 2% of the time).

Table 6: Modelling scenarios

Scenario	Substance	Stack height	Averaging period
1	Pollutants (individual VOCs)	9 m	Annual average
2		12.7 m	
3		9 m	Max. hourly mean
4		12.7 m	
5	Odour	9 m	98th%ile of hourly means
6		12.7 m	

2.2.8 Guideline values and benchmarks

There are no mandatory or statutory numeric standards for determining whether the level of odour perceived at a specific location is acceptable or not. Numeric standards have been established by custom and practice. For example:

- A 5 OU_E/m^3 as a 98^{th}%ile 1 hour average criterion was first used at the Newbiggin-on-Sea waste water treatment works planning inquiry in 1993. The main application of this criterion is in the evaluation of statutory nuisance.
- According to the Chartered Institution of Water and Environmental management[7] *"CIWEM considers that the following framework [when dealing with sewage type odour] is the most reliable that can be defined on the basis of the limited research undertaken in the UK at the time of writing:*
  - *>10 OU_E/m^3 as a 98^{th}%ile 1 hour average - complaints are highly likely and odour exposure at these levels represents an actionable nuisance;*
  - *>5 OU_E/m^3 as a 98^{th}%ile 1 hour average - complaints may occur and depending on the sensitivity of the locality and nature of the odour this level may constitute a nuisance; and*
  - *<3 OU_E/m^3 as a 98^{th}%ile 1 hour average - complaints are unlikely to occur and exposure below this level are unlikely to constitute significant pollution or significant detriment to amenity unless the locality is highly sensitive or the odour highly unpleasant in nature."*

The Environment Agency has published guideline criteria for Agency permitted / regulated sites at 1.5, 3 and 6 OU_E/m^3 as 98^{th}%ile 1 hour averages for the most, moderate and least offensive process emissions[2]. In presenting this information the Environment Agency provides example processes which fall within each offensiveness category as shown in the following table.

Table 7: Odour benchmarks published by the Environment Agency

Offensiveness	Processes	Criterion
Most offensive	• Decaying animal or fish remains • Involving septic effluent or sludge • Biological landfill odours	1.5 OU_{E}/m^3 98th%ile 1 hr
Moderately offensive	• Intensive livestock rearing • Fat frying (food processing) • Sugar beet processing • Well aerated green waste composting	3 OU_{E}/m^3 98th%ile 1 hr
Less offensive	• Brewery • Confectionary • Coffee roasting • Bakery	6 OU_{E}/m^3 98th%ile 1 hr

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[7] CIWEM (2012) Position Policy Statement – Control of Odour

The odour from the proposed process probably falls within the less offensive category and thus for this study we propose that a benchmark of 3 OU_E/m^3 as a 98^{th}%ile 1 hour average should be applied. The unit OU_E signifies “European Odour Units”, however the odour thresholds applied in this study (see Table 3) are not European designated units, therefore the odour concentrations in this assessment are described as “OU” not “OU_E”.

The prediction that a particular receptor location will experience odour concentrations above the EA thresholds does not necessarily imply that unreasonable annoyance will follow. However, it is suggested that the probability of such an occurrence is increased in proportion to the exceedance of the guideline.

2.3 Conservative approach

This study has assumed that the facility will operate continuously, whereas in practice there will be some process down-time. Furthermore, the assessment has assumed peak emissions will occur throughout the year, which again is likely to be an overestimate. Also, the assessment conditions do not include the effect of in-line process abatements (e.g. such as condensers on reaction vessels) which will almost certainly reduce emission concentrations. The assessment has also been based on the meteorological year which resulted in the highest impacts. This approach was adopted in order to ensure that modelled concentrations and impacts are more likely to be over-estimated than under-estimated.

3 Results

3.1 Maximum ground level concentrations

The following provides the maximum ground level concentrations found to occur across the 3 x 3 km gridded area, centred on the stack, applied in the modelling assessment. The results represent the maximum value from each of the five years of meteorological data used in the assessment.

3.1.1 Pollutant concentrations

Table 8 and Table 9 provide the results under Scenarios 1 – 4, including the short and long-term pollutant concentrations with a stack height of 9 m and 12.7 m.

Table 8: Maximum pollutant concentrations – 9 m stack

Pollutant	ST EAL (µg/m³)	LT EAL (µg/m³)	Annual mean	as % of LT EAL	100th%ile of hourly means	as % of ST EAL
Acetic Acid	**3,700**	**250**	14.4	6%	120.4	3%
Allyl glycidyl ether (AGE)	**No EAL**	**No EAL**	92.8	No EAL	774.1	No EAL
Epichlorohydrin	**No EAL**	**No EAL**	31.6	No EAL	263.8	No EAL
Ethanol	**576,000**	**19,200**	17.2	0.09%	143.4	0.02%
Ethanol (as IMS)	**576,000**	**19,200**	267.5	1.39%	2230.6	0.39%
Hydrogen	**No EAL**	**No EAL**	218.6	No EAL	1823.5	No EAL
Methanol	**33,300**	**2,660**	551.4	21%	4598.9	14%
Toluene	**8,000**	**1,910**	283.3	15%	2362.5	30%

Table 9: Maximum pollutant concentrations – 12.7 m stack

Pollutant	ST EAL (µg/m³)	LT EAL (µg/m³)	Annual mean	as % of LT EAL	100th%ile of hourly means	as % of ST EAL
Acetic Acid	**3,700**	**250**	3.6	1%	88.5	2%
Allyl glycidyl ether (AGE)	**No EAL**	**No EAL**	23.1	No EAL	569.0	No EAL
Epichlorohydrin	**No EAL**	**No EAL**	7.9	No EAL	193.9	No EAL
Ethanol	**576,000**	**19,200**	4.3	0.02%	105.4	0.02%
Ethanol (as IMS)	**576,000**	**19,200**	66.6	0.35%	1639.7	0.28%
Hydrogen	**No EAL**	**No EAL**	54.5	No EAL	1340.4	No EAL
Methanol	**33,300**	**2,660**	137.4	5%	3380.5	10%

Toluene	**8,000**	**1,910**	70.6	4%	1736.6	22%

The results presented in Table 8 and Table 9 show that, with stacks heights of both 9 m and 12 m, all pollutants for which EALs are available (EALs for AGE, epichlorohydrin and hydrogen are not available), fall within both the short and long-term EALs. The highest pollutant contributions, when compared with the relevant EAL, were found to be methanol for long-term contributions (21% of the LT EAL @ 9 m) and toluene for short-term contributions (30% of the ST EAL @ 9 m). With a stack height of 12.7 m the maximum long-term methanol contribution, as a percentage of the EAL, was found to fall by 16%, whilst short-term contributions of toluene were found to fall by 8%. In all cases the greatest contribution to the overall odour contribution comes from alcohol. In the event that in-line process abatement in the form of condensation is applied, then the pollutant contributions would be reduced.

These results indicate that the proposed facility is not forecast to have a detrimental impact on ambient concentrations of the substances assessed at either stack height.

3.1.2 Odour concentrations

The following table provides the results of Scenario 5 and 6, illustrating the maximum estimated odour concentrations (98th%ile of 1 hour averages) with a stack height of 9 m and 12.7 m.

Table 10: Maximum odour concentrations – 9 m stack

Averaging period	Odour threshold (mg/m^3)	98th%ile of hourly means	OU/m^3
Acetic Acid	**0.043**	48.9	1.1
Allyl glycidyl ether (AGE)	**44**	314.2	0.0
Epichlorohydrin*	**3.52**	107.1	0.0
Ethanol	**0.28**	58.2	0.2
Ethanol (as IMS)	**0.28**	905.3	3.2
Hydrogen	**-**	740.1	No DDT
Methanol	**4**	1866.5	0.5
Toluene	**1**	958.9	1.5
Total odour concentration (OU/m^3)		6.6	
as % of odour benchmark (3 OU/m^3)		219%	

Table 11: Maximum odour concentrations – 12.7 m stack

Averaging period	Odour threshold (mg/m^3)	98th%ile of hourly means	OU/m^3
Acetic Acid	**0.043**	18.5	0.4
Allyl glycidyl ether (AGE)	**44**	118.9	0.0

Epichlorohydrin*	**3.52**	40.5	0.0
Ethanol	**0.28**	22.0	0.1
Ethanol (as IMS)	**0.28**	342.6	1.2
Hydrogen	**-**	280.1	No DDT
Methanol	**4**	706.3	0.2
Toluene	**1**	362.9	0.6
Total odour concentration (OU/m^3)		2.5	
as % of odour benchmark (3 OU$_E$/m^3)		83%	

The results in Table 10 show that with a stack of 9 m maximum ground level odour concentrations are forecast to exceed the odour benchmark of 3 OU$_E$/m^3 by 3.6 OU/m^3. However, with a stack height of 12.7 m, as shown in Table 11, maximum odour concentrations would fall below this threshold, at 2.5 OU/m^3. In all cases the greatest contribution to the overall odour contribution comes from alcohol. In the event that in-line process abatement in the form of condensation is applied, then the odour contribution would be reduced.

It is therefore recommended that, based on worst case emissions, a stack height of 12.7 m be adopted to ensure odour concentrations in ambient air around the facility remain below this benchmark, to avoid the potential for environmental nuisance at local receptors.

3.2 Dispersion plots

The following figures provide dispersion plots for:

- Odour arising from the proposed facility with stack heights of 9 m and 12.7 m;
- Annual mean emissions of methanol with stack heights of 9 m and 12.7 m; and
- Maximum hourly mean emissions of toluene with stack heights of 9 m and 12.7 m.

Projected pollutant and odour concentrations, under each Scenario, at all of the sensitive receptor sites listed in Table 5 are provided in Appendix 1.

Figure 4: Odour concentrations (98th%ile of hourly means) - 9 m stack

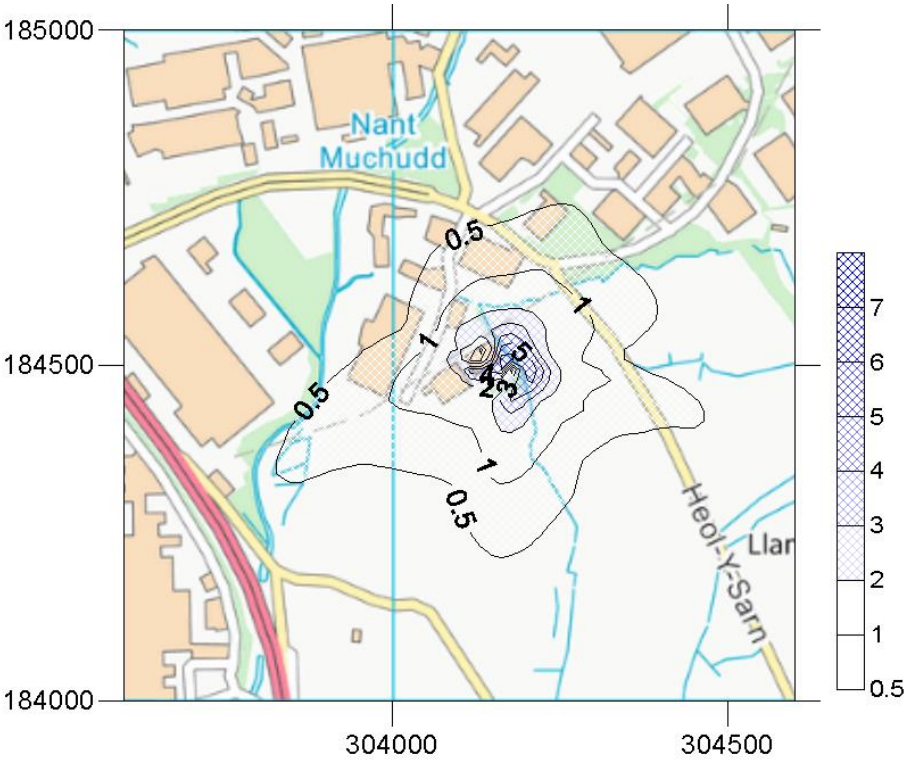


Figure 5: Odour concentrations (98th%ile of hourly means) – 12.7 m stack

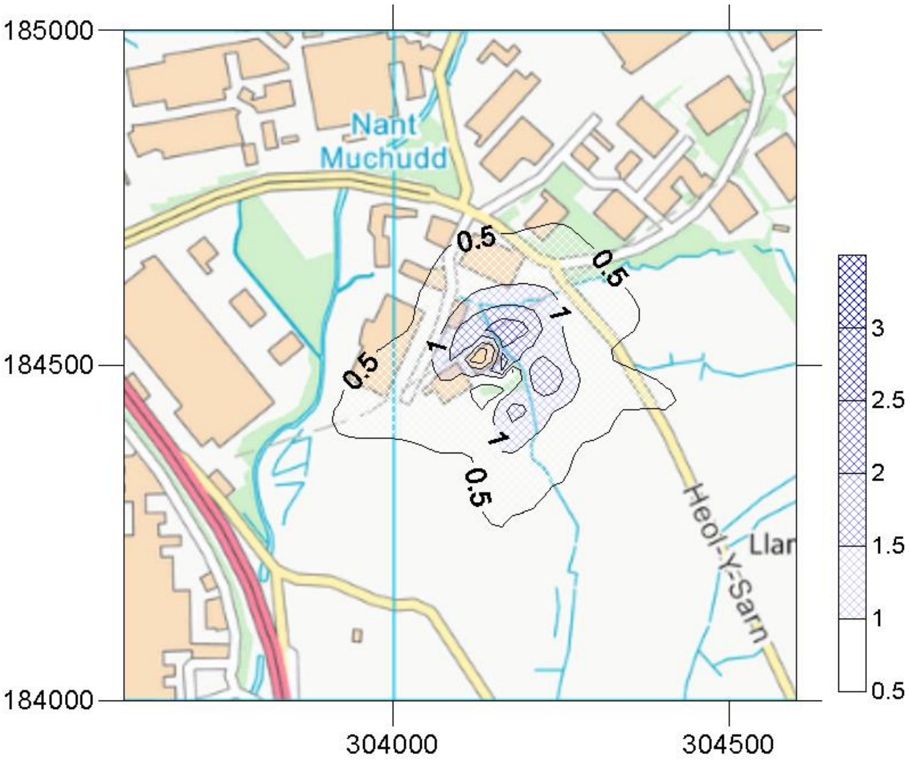


Figure 6: Methanol concentrations (annual mean) – 9 m stack

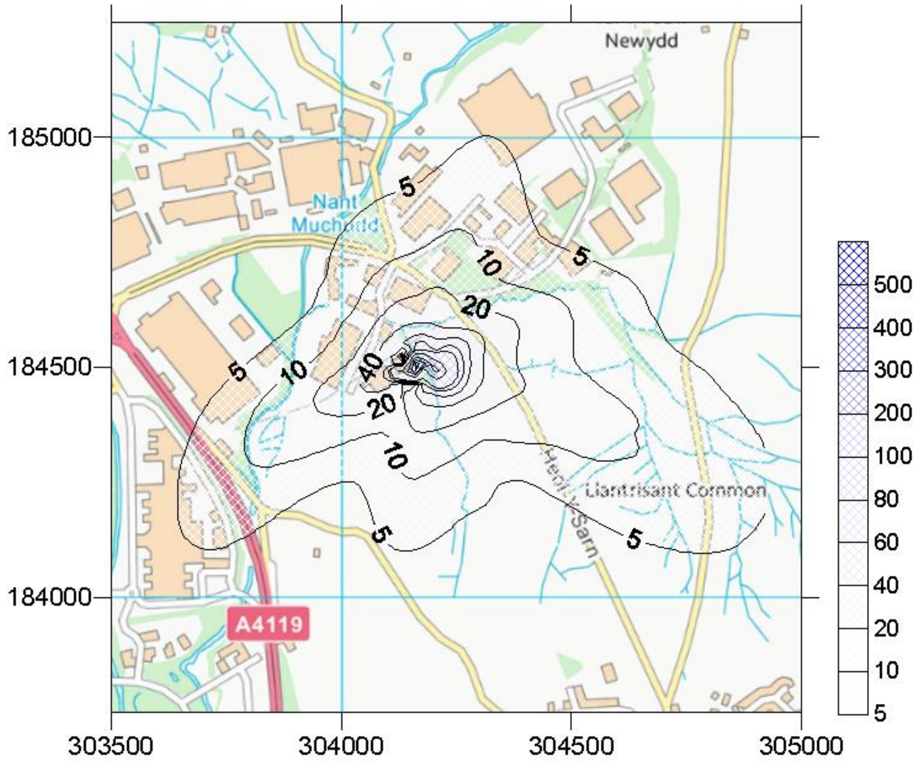


Figure 7: Methanol concentrations (annual mean) – 12.7 m stack

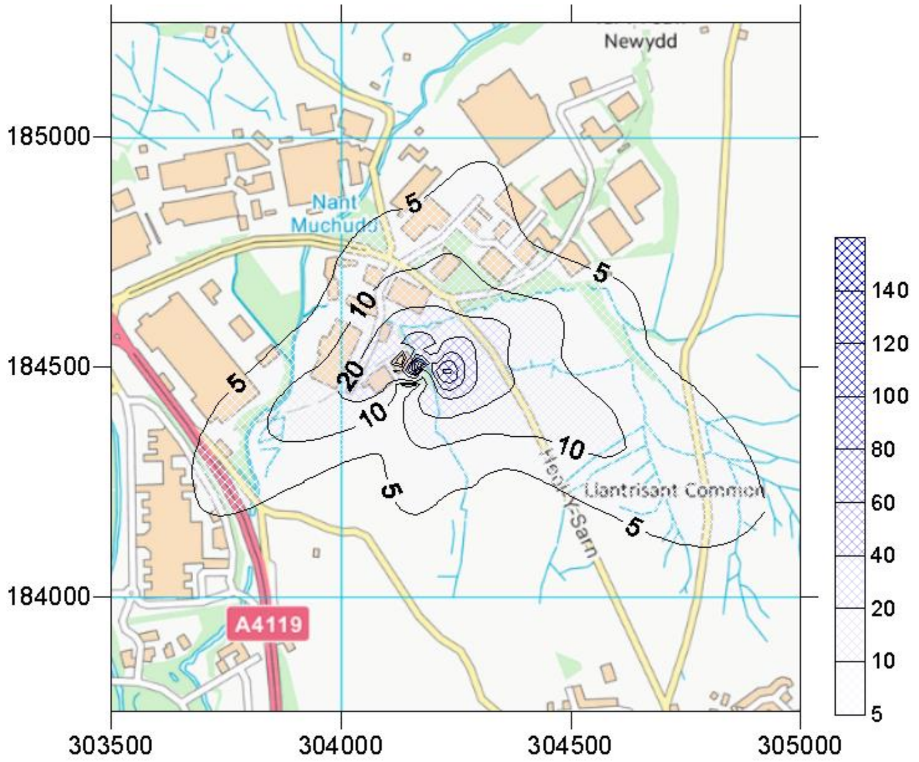


Figure 8: Toluene concentrations (maximum hourly means) – 9 m stack

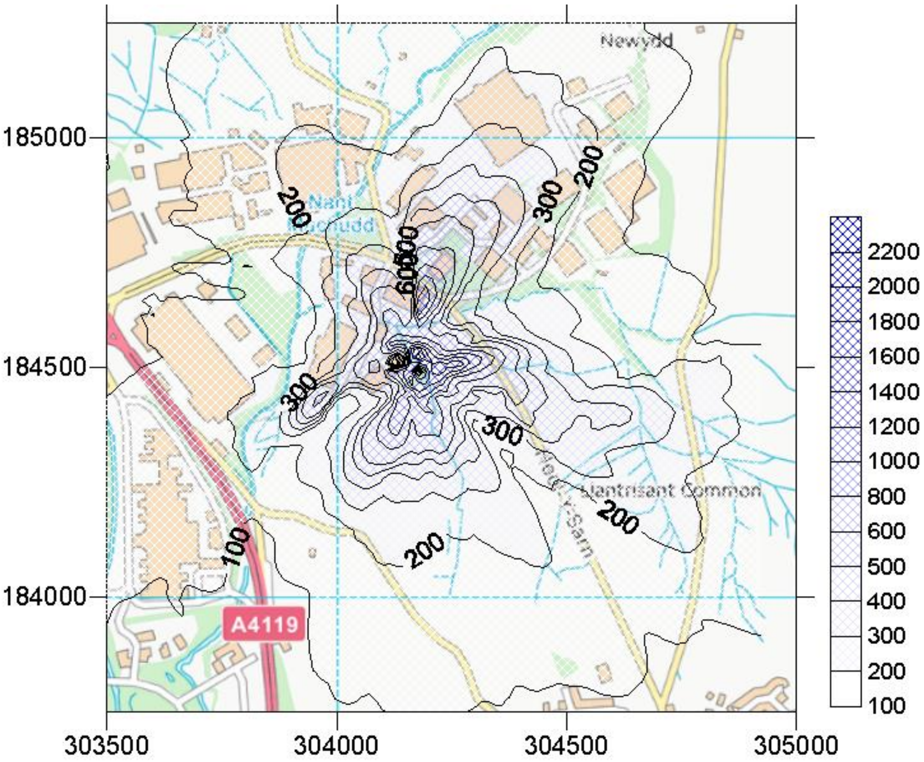
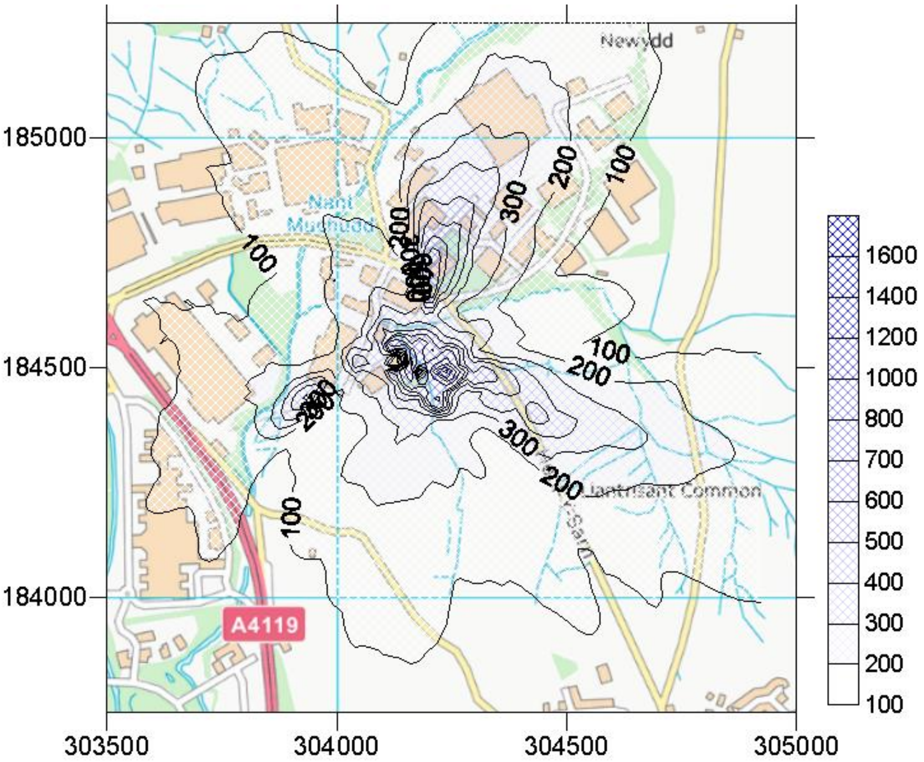


Figure 9: Toluene concentrations (maximum hourly means) – 12.7 m stack



4 Findings

1. This study provides an assessment of the likely impact on air quality and odour resulting from emissions arising from the proposed fine chemical manufacturing facility, at the Llantrisant Business Park. The study has combined estimated peak pollutant emissions data, provided by Purolite Ltd, with Environmental Assessment Levels, and published data on odour thresholds, applicable to the compounds identified in the flue gases.
2. The dispersion modelling itself has considered a range of scenarios, reflecting the long and short-term impacts of emissions with stack heights of 9 m and 12.7 m.
3. The study has shown that emissions of the substances assessed would not result in the exceedance of EALs in ambient air around the facility, or at any of the sensitive receptor sites included in the model, with a stack height of either 9 m or 12.7 m. However, by increasing the stack height to 12.7 m the level of impact would be reduced by up to 16%.
4. The study found that with a stack height of 9 m, emissions exceeded the Environment Agency's odour threshold value of 3 OU_E/m^3, for "moderately offensive" odours. Whereas a stack height of 12.7 m resulted in a maximum ambient odour concentration of 2.5 OU_E/m^3. It is therefore recommended that a stack of 12.7 m be adopted to minimise the potential for nuisance odour at sensitive receptor sites around the facility.
5. The point of maximum process contribution, for all long-term concentrations, was found to occur to the south east of the facility, close to the boundary of the site, in an area of open agricultural land, and that the impact at sensitive receptor sites (e.g. houses, the Royal Glamorgan Hospital etc.) was found to be considerably lower.
6. It should also be noted that had the effect of in-line process abatement, such as condensers on reaction vessels, been taken into account then the impact concentration predicted in this report would be lower.
7. The findings of this study are very dependent on the odour concentration estimates and subsequent odour emission rates assigned to the emission sources and the discharge characteristics provided by Purolite Ltd and Briggs. If for any reason the data used in this study is unrepresentative of the proposed facility this may influence the results of this study.

Appendix 1: Pollutant and odour concentrations at sensitive receptors

Scenario 1: Long-term pollutant concentrations (µg/m^3) – 9 m stack

Pollutant		Sensitive receptor ref.																					
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Acetic Acid		0.16	0.15	0.08	0.04	0.03	0.05	0.03	0.04	0.53	0.18	0.14	0.62	0.19	0.15	0.06	0.05	0.02	0.02	0.03	0.03	0.01	0.04
Allyl glycidyl ether (AGE)		1.01	0.98	0.50	0.25	0.19	0.32	0.21	0.28	3.40	1.16	0.91	4.00	1.24	0.94	0.35	0.29	0.12	0.16	0.18	0.22	0.08	0.23
Epichlorohydrin*		0.34	0.33	0.17	0.08	0.06	0.11	0.07	0.10	1.16	0.39	0.31	1.36	0.42	0.32	0.12	0.10	0.04	0.05	0.06	0.08	0.03	0.08
Ethanol		0.19	0.18	0.09	0.05	0.04	0.06	0.04	0.05	0.63	0.21	0.17	0.74	0.23	0.17	0.07	0.05	0.02	0.03	0.03	0.04	0.01	0.04
Ethanol (as IMS)		2.91	2.82	1.43	0.71	0.55	0.91	0.60	0.81	9.79	3.33	2.63	11.5	3.56	2.70	1.02	0.84	0.36	0.46	0.52	0.63	0.23	0.65
Hydrogen		2.38	2.31	1.17	0.58	0.45	0.75	0.49	0.67	8.00	2.73	2.15	9.42	2.91	2.21	0.83	0.69	0.29	0.38	0.43	0.52	0.19	0.53
Methanol		5.99	5.82	2.94	1.47	1.12	1.88	1.23	1.68	20.1	6.88	5.42	23.7	7.34	5.58	2.10	1.74	0.73	0.95	1.08	1.31	0.47	1.34
Toluene		3.08	2.99	1.51	0.76	0.58	0.97	0.63	0.86	10.3	3.53	2.79	12.2	3.77	2.86	1.08	0.89	0.38	0.49	0.55	0.67	0.24	0.69
	LT EAL	As % of LT EAL																					
Acetic Acid	250	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Allyl glycidyl ether (AGE)	No EAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epichlorohydrin*	No ELA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethanol	19,200	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ethanol (as IMS)	19,200	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hydrogen	No ELA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methanol	2,660	0.2%	0.2%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	0.8%	0.3%	0.2%	0.9%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Toluene	1,910	0.2%	0.2%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.5%	0.2%	0.1%	0.6%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Scenario 2: Long-term pollutant concentrations (µg/m^3) – 12.7 m stack

Pollutant		Sensitive receptor ref.																					
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Acetic Acid		0.13	0.12	0.06	0.03	0.03	0.05	0.03	0.04	0.43	0.16	0.13	0.49	0.17	0.13	0.05	0.04	0.02	0.02	0.03	0.03	0.01	0.03
Allyl glycidyl ether (AGE)		0.85	0.75	0.37	0.22	0.16	0.30	0.20	0.27	2.74	1.05	0.83	3.15	1.07	0.81	0.33	0.27	0.11	0.14	0.17	0.21	0.08	0.19
Epichlorohydrin*		0.29	0.25	0.13	0.07	0.06	0.10	0.07	0.09	0.93	0.36	0.28	1.07	0.36	0.28	0.11	0.09	0.04	0.05	0.06	0.07	0.03	0.06
Ethanol		0.16	0.14	0.07	0.04	0.03	0.06	0.04	0.05	0.51	0.19	0.15	0.58	0.20	0.15	0.06	0.05	0.02	0.03	0.03	0.04	0.01	0.03
Ethanol (as IMS)		2.45	2.15	1.08	0.62	0.47	0.86	0.56	0.77	7.89	3.02	2.40	9.07	3.07	2.33	0.96	0.77	0.33	0.41	0.49	0.61	0.22	0.54
Hydrogen		2.01	1.76	0.88	0.51	0.39	0.70	0.46	0.63	6.45	2.47	1.97	7.41	2.51	1.90	0.79	0.63	0.27	0.34	0.40	0.50	0.18	0.44
Methanol		5.06	4.43	2.23	1.29	0.97	1.77	1.16	1.58	16.2	6.23	4.96	18.6	6.33	4.80	1.98	1.58	0.68	0.85	1.00	1.25	0.46	1.11
Toluene		2.60	2.28	1.14	0.66	0.50	0.91	0.60	0.81	8.36	3.20	2.55	9.60	3.25	2.46	1.02	0.81	0.35	0.44	0.51	0.64	0.24	0.57
	LT EAL	**As % of LT EAL**																					
Acetic Acid	**250**	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Allyl glycidyl ether (AGE)	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epichlorohydrin*	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethanol	**19,200**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ethanol (as IMS)	**19,200**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hydrogen	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methanol	**2,660**	0.2%	0.2%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.6%	0.2%	0.2%	0.7%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Toluene	**1,910**	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.2%	0.1%	0.5%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Scenario 3: Short-term pollutant concentrations (µg/m^3) – 9 m stack

Pollutant		Sensitive receptor ref.																					
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Acetic Acid		7	7	7	6	4	4	3	3	20	17	14	39	23	19	8	4	3	4	5	4	1	3
Allyl glycidyl ether (AGE)		46	45	48	37	26	27	21	18	128	110	87	250	149	123	52	28	18	24	30	27	8	20
Epichlorohydrin*		16	15	16	13	9	9	7	6	44	37	30	85	51	42	18	10	6	8	10	9	3	7
Ethanol		8	8	9	7	5	5	4	3	24	20	16	46	28	23	10	5	3	4	5	5	1	4
Ethanol (as IMS)		132	130	138	107	76	79	61	52	368	316	250	721	430	353	150	80	51	69	85	78	22	58
Hydrogen		108	106	113	87	62	64	50	43	301	258	205	589	352	289	123	66	42	56	70	64	18	48
Methanol		272	268	285	220	157	162	125	107	758	651	516	1486	887	729	310	166	106	142	176	161	45	120
Toluene		140	138	146	113	81	83	64	55	390	335	265	763	456	374	159	85	54	73	90	83	23	62
	ST EAL	**As % of ST EAL**																					
Acetic Acid	**3,700**	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.5%	0.5%	0.4%	1.1%	0.6%	0.5%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Allyl glycidyl ether (AGE)	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epichlorohydrin*	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethanol	**576,000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ethanol (as IMS)	**576,000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hydrogen	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methanol	**33,300**	0.8%	0.8%	0.9%	0.7%	0.5%	0.5%	0.4%	0.3%	2.3%	2.0%	1.6%	4.5%	2.7%	2.2%	0.9%	0.5%	0.3%	0.4%	0.5%	0.5%	0.1%	0.4%
Toluene	**8,000**	1.7%	1.7%	1.8%	1.4%	1.0%	1.0%	0.8%	0.7%	4.9%	4.2%	3.3%	9.5%	5.7%	4.7%	2.0%	1.1%	0.7%	0.9%	1.1%	1.0%	0.3%	0.8%

Scenario 4: Short-term pollutant concentrations (µg/m^3) – 12.7 m stack

Pollutant		Sensitive receptor ref.																					
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Acetic Acid		7	6	5	4	3	3	3	3	15	12	11	18	15	20	6	4	3	3	3	5	1	2
Allyl glycidyl ether (AGE)		46	37	33	28	19	22	17	19	100	79	71	114	93	130	39	23	20	18	22	30	6	16
Epichlorohydrin*		16	13	11	9	6	8	6	6	34	27	24	39	32	44	13	8	7	6	7	10	2	5
Ethanol		8	7	6	5	3	4	3	3	18	15	13	21	17	24	7	4	4	3	4	6	1	3
Ethanol (as IMS)		131	107	96	80	54	65	49	54	287	229	203	329	269	373	111	66	56	53	63	87	17	45
Hydrogen		107	87	79	65	44	53	40	44	235	187	166	269	220	305	91	54	46	43	52	71	14	37
Methanol		270	220	198	164	111	133	100	110	592	472	419	678	554	770	230	135	116	108	130	180	36	93
Toluene		139	113	102	84	57	68	52	57	304	242	215	349	285	395	118	70	60	56	67	93	18	48
	ST EAL	**As % of ST EAL**																					
Acetic Acid	**3,700**	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%	0.3%	0.3%	0.5%	0.4%	0.5%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Allyl glycidyl ether (AGE)	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epichlorohydrin*	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethanol	**576,000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ethanol (as IMS)	**576,000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hydrogen	**No ELA**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methanol	**33,300**	0.8%	0.7%	0.6%	0.5%	0.3%	0.4%	0.3%	0.3%	1.8%	1.4%	1.3%	2.0%	1.7%	2.3%	0.7%	0.4%	0.3%	0.3%	0.4%	0.5%	0.1%	0.3%
Toluene	**8,000**	1.7%	1.4%	1.3%	1.1%	0.7%	0.9%	0.6%	0.7%	3.8%	3.0%	2.7%	4.4%	3.6%	4.9%	1.5%	0.9%	0.7%	0.7%	0.8%	1.2%	0.2%	0.6%

Scenario 5: Odour concentrations (98th%ile of hourly means OU/m^3) – 9 m stack

Pollutant	Sensitive receptor ref.																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
OU/m^3	0.25	0.24	0.16	0.08	0.05	0.07	0.03	0.06	0.87	0.31	0.24	0.98	0.31	0.21	0.09	0.07	0.03	0.04	0.05	0.05	0.02	0.08
As % of Odour Threshold Value	8.4%	7.9%	5.4%	2.5%	1.6%	2.4%	0.9%	1.9%	29.0%	10.2%	8.2%	32.6%	10.5%	7.0%	2.9%	2.4%	1.0%	1.3%	1.5%	1.7%	0.6%	2.7%

Scenario 6: Odour concentrations (98th%ile of hourly means OU/m^3) – 12.7 m stack

Pollutant	Sensitive receptor ref.																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
OU/m^3	0.21	0.17	0.13	0.07	0.04	0.07	0.03	0.05	0.70	0.28	0.23	0.83	0.27	0.19	0.09	0.07	0.03	0.04	0.04	0.05	0.02	0.07
As % of Odour Threshold Value	7.0%	5.8%	4.4%	2.3%	1.5%	2.2%	0.9%	1.7%	23.4%	9.3%	7.6%	27.6%	9.1%	6.4%	2.9%	2.3%	1.0%	1.2%	1.5%	1.6%	0.6%	2.3%

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Appendix D Drainage Philosophy

CIVIL & STRUCTURAL ENGINEERS

DRAINAGE PHILOSOPHY

PUROLITE
CDGA-9021-REP01-R4

December 2017

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1 INTRODUCTION

1.1 Purolite are proposing to expand pharmaceutical processing into an existing industrial unit in Llantrisant Business Park.

1.2 CD Gray & Associates Ltd have been appointed as Civil and Structural Consulting Engineers to provide a high level drainage philosophy to support Purolite's planning application and subsequent NRW licencing application(s). This report has been informed by consultation with statutory undertakers, known site constraints, mindful of existing infrastructure and current best practice and industry standards.

2 EXISTING SITE & DRAINAGE PROVISION

2.1 The site is located within Llantrisant Business Park, immediately adjacent to Purolite's existing premises, It consists of a currently vacant industrial unit, understood to have formerly been associated with the production of orange juice, car park and rear service yard, set within approximately 0.5ha.

2.2 Dwr Cymru Welsh Water (DCWW) public sewer records have been obtained and show the existing drainage infrastructure in the area to be separate in nature.

2.3 With reference to Figure 1 below, the DCWW asset database identifies a 150mm diameter foul public sewer running north-south parallel to the Business Park's distributor road and serves the proposed development unit and those of the surrounding area. The system upsizes to a 300mm diameter at the former Sogefi Filtration factory some 250m downstream.

2.4 The DCWW surface water network running south-north parallel to the foul sewer is 450mm diameter and outfalls into an unnamed watercourse / drainage ditch, culverted in part, to convey flows to the Nant Muchudd to the west.

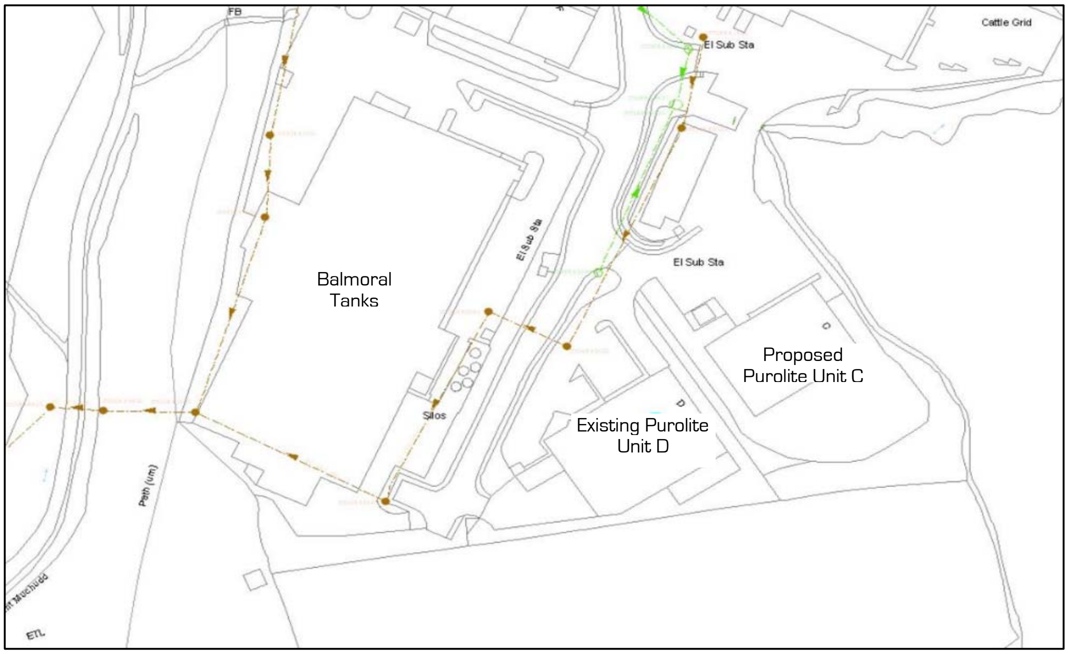


Figure 1 – Extract from DCWW Public Sewer Records

2.5 The site itself is served by separate foul and surface water drainage infrastructure.

2.6 Foul Water

2.6.1 The existing foul network runs parallel to the frontage of the existing unit in a southwesterly direction. The network continues through the adjacent existing Purolite unit before connecting to the recognised DCWW public sewer shown in Figure 1 to lie within the carpark of the existing Purolite unit. However, as part of the recent sewer transfer legislation, ownership of the off-site sewer would have transferred to DCWW on the basis that the network serves more than one land owner.

2.6.2 The on-site foul sewer is 100mm diameter pipe laid at a gradient of 1:205 which has a full bore capacity of 3.6l/s. The foul loading (domestic / trade effluent) associated with the building's former use is unknown.

2.7 Surface Water

2.7.1 The site consists wholly of hardstanding areas comprising the building of approximately 1,350m^2 with surrounding tarmac / concrete slab access road, car park and service yard. The existing surface water run-off sources are rainwater downpipes and external gullys.

2.7.2 There is a traditional three stage petrol interceptor serving the rear service yard area.

2.7.3 There are two offsite surface water conveyances to the DCWW surface water public sewerage network. The rear building and service yard run-off runs through the unit's access road and off-site to make connection via a 225mm diameter pipe. The front of the building and car park area has a separate 150mm diameter pipe which makes connection to the DCWW network approximately 30m downstream.

2.7.4 A drainage CCTV survey has been commissioned to inform the condition of the existing network and its suitability for reuse.

3 PROPOSED DEVELOPMENT

3.1 Proposals are largely limited to internal refurbishment of the existing industrial unit.

3.2 Minor re-configuration is proposed to the front car park area which includes a new dedicated turning off the access road to segregate front and back of house vehicular movements.

3.3 More significant changes are proposed to the rear service yard area where a tank farm of above vessels is to be located to the southeastern corner along with an associated tanker offload area, pump house, new sprinkler system housing and general waste and IBC storage areas.

3.4 An extract of the proposed site layout is shown in Figure 2 below;

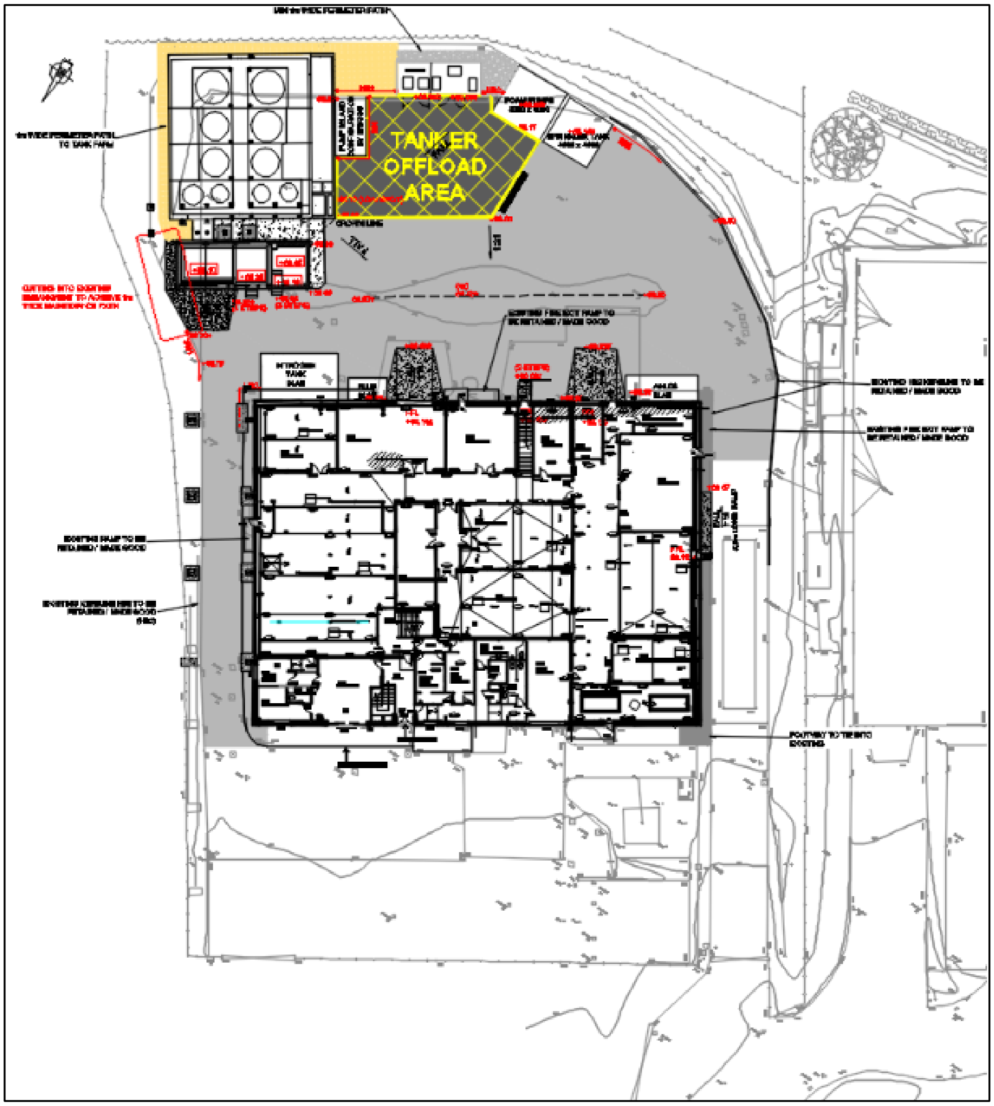


Figure 2 – Proposed Site Layout

(Source: CDGA-9021-106-C3)

3.5 Tanker Offloading Procedure

3.5.1 The proposed tanker offload area has been designed with a high level / ridged crown line on its outside edge with falls created to direct run-off within this area towards the crash tank inlet holes on the surface.

3.5.2 The crash tank has been designed with a containment volume suitable to cater for tanker deliveries with a maximum load of 28,000 litres.

3.5.3 **Tanker offloading should only be commenced when the tanker is stationary and positioned wholly within the designated tanker offload hatched area.**

3.5.4 Ordinarily, the penstock within the crash tank's receiving chamber will direct run-off to the surface water network. **Prior to tanker offloading, the penstock valve must be closed** so that there is no risk of run-off or spillage entering the surface water network during offloading activity.

3.5.5 Should a spillage occur, the escaped effluent will be contained within the below ground crash tank. From this location, Purolite have the option to pump to holding tanks within the tank farm, discharge to the foul network if within licensing limits or remove by specialist disposal methods off-site as required to suit the nature of the spillage.

3.5.6 Once the off-loading procedure is complete and without incident the penstock valve should be switched back to its default position to allow run-off to be directed to the surface water network.

3.5.7 This procedure will form part of Purolite's formal Operation and Management procedures.

3.6 Drainage - General

3.6.1 It is intended to reuse, as far as reasonably practical, the existing drainage infrastructure and mimic the existing drainage regime.

3.6.2 Pre-planning advice has been sought from DCWW, their feedback has been incorporated into the proposals presented.

3.6.3 It is understood that S106 agreements are required in addition to a trade effluent license. Statutory approvals will be sought as part of the design development.

3.7 Foul Water

3.7.1 Foul water discharge has been considered as two separate elements to cover domestic flow and that associated with trade effluent arising from the industrial processing.

3.7.2 <u>Domestic Flow</u>

3.7.2.1 Peak flow loadings arising from domestic flow sources is approximated at 0.08l/s based on a maximum of 20 persons over a standard 8 hour shift (as advised by Bryan Griffiths, Purolite, email 11.03.16) in accordance with British Water, Flows and Loads 3 for a factory without canteen. See Appendix B for calculations.

3.7.2.2 The domestic loadings for the former building usage are unknown however, based on the existing office space, number of toilets and parking spaces it is anticipated that the staff numbers and thereby domestic loading are comparable pre and post development.

3.7.2.3 The proposed toilets, staff changing and canteen areas are located near the existing foul drainage infrastructure. Gravity connection to the existing system is therefore considered achievable.

3.7.2.4 The existing foul drainage run (100mm diameter @ 1:205) does not achieve self cleansing guidance in compliance with Building Regulations, Document H. The sewer may therefore be prone to holding / build-up of solids. Roddable access is provided for maintenance and blockages should therefore be readily cleared should they occur.

3.7.2.5 There is no hot food preparation intended and therefore no inclusion for grease treatment in the current drainage proposals.

3.7.3 Trade Effluent

3.7.3.1 Purolite are in consultation with DCWW to establish agreeable limits of daily discharge volume, COD and solids levels.

3.7.3.2 All discharge from processing operations will be treated internally and regulated within above ground holding tanks in the tank farm, tested for pH and TOC prior to direct release to the below ground drainage network.

3.7.3.3 DCWW have advised that pH values within the range of 6-11 are acceptable to be received by the foul network. In the event of exceedance of the pH and TOC testing thresholds, flows will be retained within the holding tank and either regulated by Purolite operators and retested for release, or held for removal by specialist waste carrier.

3.7.3.4 Connection to the existing foul sewerage network from the holding tanks / crash tank will require pumping and forms part of the mechanical / process engineering package. A pump rate of 3l/s is proposed which allows ample tolerance below the DCWW agreed limit of 3.5l/s for the domestic flow element.

3.7.3.5 Flow monitoring will be required to verify the volume communicated to the public sewerage network. A metering device will therefore be introduced to the foul network for this purpose.

3.7.4 Spillage / Containment Events

3.7.4.1 The tank farm is not to have any positive, gravity drainage provision. In the event of vessel rupture within the tank farm, liquid will be held within the above ground bund (wall height approximately 1.2m) and dealt with on the surface rather than below ground. The bund has been designed in accordance with CIRIA Report C736 – Containment Systems for the Prevention of Pollution and appropriate allowances for rainfall events have been incorporated in the containment capacity – calculations available within Appendix B. Surface water run-off collected within the bunded area will be tested and pumped out periodically. Contaminated or stagnant water is to be discharged to the foul network via a gully located on the outside of the perimeter bund or by specialist disposal if levels are outside of acceptable limits. This will form part of the operational management procedures.

3.7.4.2 A secondary 'crash tank' is provided below ground to cater for emergency spillages primarily associated with spillage within the building or during tanker offloading activity. This has been sized based on the same principles as the tank farm bund, to Ciria C736, as the largest of 25% complete volume or 110% of the largest tank.

3.7.4.3 Conveyance of surface water run-off from external areas designated 'high risk' has been avoided as far as practically possible. Design measures have included covering the bin store and IBC waste storage area, removing positive drainage provision to the bunded tank farm and operationally managing the tanker offload area so that ordinarily the area drains to the surface water network and switched (via penstock or similar mechanism) to close this outlet during offloading activity only.

3.7.4.4 On the basis that spillage / rupture will be dealt with on occurrence, the tanker delivery is considered the worst case source in terms of volume by a substantial margin when compared with the significantly smaller volumes associated with materials held internally in storage racking, IBC waste storage and so on.

3.7.4.5 The crash tank has therefore been sized on the on the following contributing factors;

Table 1: Volume of Crash Tank Required

Area / Scenario		Storage Criteria	Required Storage Volume (m^3)
Emergency Spillage / Rupture Scenario	Tank Farm	No positive drainage provision – if rupture occurs spill to be held within above ground bund but option to over pump to crash tank as an overflow / alternative if required.	
	Tanker Delivery	110% complete volume (28,000litres)	30.8
Process Waste		Internally tested - bypass holding tank	
Rainfall / Storm Event Contribution	Contributing areas designed out – tank farm area not to be drained whilst tanker offloading activity is in progress.		

3.7.4.6 A crash tank of providing minimum storage volume of 31m^3 has therefore been determined to be required.

3.7.4.7 On the basis that rainfall run-off from the tanker offload area will ordinarily continually discharge to the surface water network there will be no accumulation of rainwater within the crash tank. Tanker offloading will not be permitted or realistic during an extreme rainfall event and should a spillage occur the penstock valve should be shut once the escaped effluent has been captured so that in instance of an extreme rainfall event occurring immediately after a spillage, run-off would be directed to the surface water drainage network or held on the surface and not have any contribution to the crash tank capacity requirements. That being said, with reference to the calculations contained within Appendix B, the provided crash tank volume totals 35m^3 and is in excess of the minimum 31 m^3.

3.8 Surface Water

3.8.1 Pre and post development hardstanding areas are comparable and therefore no additional run-off will be generated by the proposed development. There will be a small reduction in contributing area due to the introduction of some soft landscaping.

3.8.2 The building footprint and rainwater downpipe positions are to remain. Similarly, the front carpark is limited to minor reconfiguration and the majority of gully positions are to remain as is.

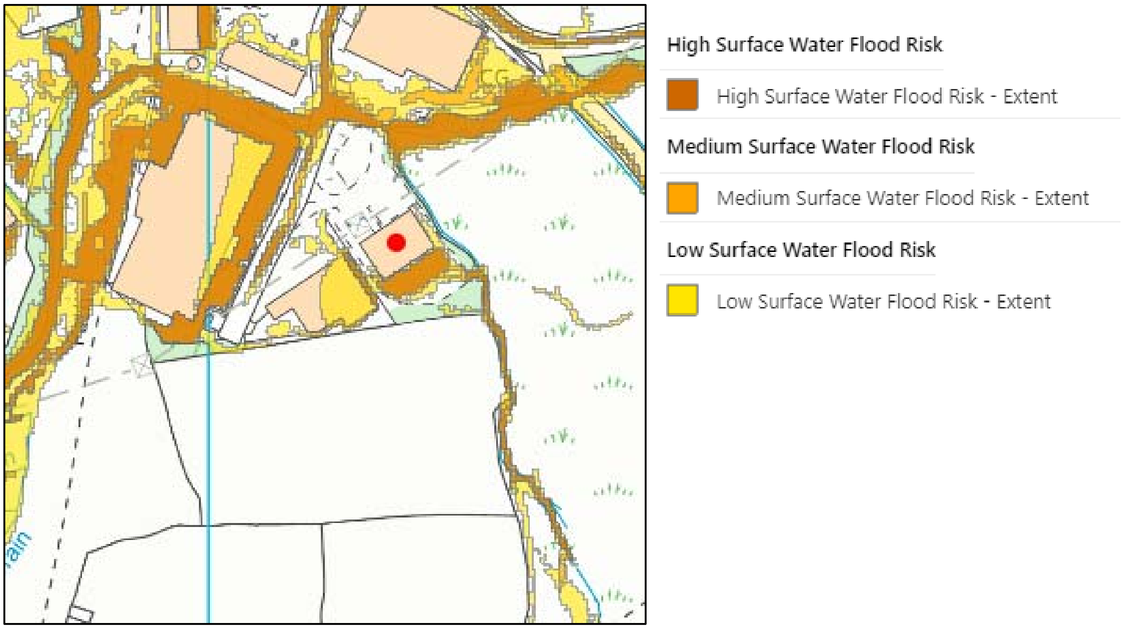
3.8.3 The front car park area is below the threshold (by number of spaces and contributing area) to require a petrol interceptor in accordance with PPG3. It is however, intended to retain the existing petrol interceptor serving the rear service yard as a precautionary measure.

3.8.4 NRW have been consulted and the principles of the drainage philosophy were agreeable.

3.8.5 <u>Surface Water Flood Risk</u>

3.8.5.1 NRW mapping indicates a low to medium surface water risk affecting the rear service yard only which appears to originate from the ordinary watercourse on the site's eastern boundary which is a tributary to the Nant Muchudd. A medium risk corresponds to an annual event probability of occurrence between 1 in 30 and 1 in 100.

Figure 3 – NRW Mapping: Surface Water Flood Risk



3.8.5.2 Should a storm event of sufficient magnitude occur which results in channel exceedance, flows would escape the bank and an overland flow path would be generated, governed by local topography, channelled by physical / obstructive above ground features. In this instance floodwaters propagating in the rear service yard would be directed initially toward the linear drain where a valleyed low spot exists in the profile of the existing service yard at a topographical survey level of 68.42m. Here flows would either re-enter the network if capacity allowed or begin ponding on the surface at this location.

3.8.5.3 Should ponding spread, the levels are such that flows would be directed around the building rather than inundating the main building through its threshold positions on the rear elevation. The existing building's lowest finish floor level for the rear thresholds is 69.127m therefore affording the building protection at a level of 700mm higher than the external service yard low spot.

3.8.5.4 Similarly, the slab levels of the pump house, IBC storage, foam pumps and sprinkler tanks are all higher in their relative surroundings. The tank farm, which is bunded, would remain protected from inundation in the most extreme of flood events.

4 CONCLUSIONS

4.1 It is intended to mimic the existing drainage regime and reuse the existing drainage infrastructure and off-site connections where condition and position is suitable.

4.2 All discharge from processing operations will be regulated internally and the above ground holding tanks / vessels located in the tank farm will be tested for pH and TOC prior to release to the below ground drainage network in accordance with the agreed trade effluent licence. The tank farm is appropriately bunded to cater for the eventuality of a rupture in this area.

4.3 A below ground crash tank will be introduced to cater for spillages within the building or during tanker offloading activity. The detailed tanker offload procedure should form part of Purolite's operational management procedures and should be strictly observed.

4.4 The trade effluent portion of the foul contributing discharge will be restricted to a pump rate of 3l/s to the existing private network.

4.5 Surface water infrastructure is to remain largely unaltered with gullys positioned to suit the minor reconfiguration to the front car park.

4.6 The design philosophy is presented for illustrative purposes within drawing referenced CDGA-9021-101-C7, within Appendix A.

4.7 Consultations are ongoing with DCWW and NRW. Appropriate Section agreements, discharge consents and trade effluent licensing will be sought as necessary.

APPENDIX A – DRAWINGS

APPENDIX B – CALCULATIONS

Appendix E Draft Trade Effluent Consent

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Managing Director
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Llantrisant
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CF72 8LF

DRAFT COPY ONLY

Date 7th September 2016

Dear Mr Horton,

Ref:- Authorisation for Temporary Disposal of Wastewater from the manufacture of pharmaceutical grade resins at Purolite Limited, Unit C Llantrisant Business Park to the Public Foul Sewer

Thank you for your recent enquiry regarding an authorisation to discharge trade effluent to the public foul sewer from the above address.

Based on the information provided, I can confirm that authorisation is given to discharge the trade effluent into the public foul sewer, subject to the following conditions and not otherwise:

1. The premises from which the trade effluent may be discharged is: Purolite Limited, Unit C Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff CF72 8LF.

2. The maximum volume of trade effluent that may be discharged shall not exceed 100 cubic metres per day at a flow rate of no more than 3 litres/second.

3. The trade effluent to be discharged is derived from;
   - the manufacture of agarose based resin for pharmaceutical use, i.e. aqueous process waste from two waste holding tanks within the bunded area at the tank farm; and each tank tested for pH and Total Organic Carbon (TOC) prior to discharge into the underground tank.
   - potentially contaminated surface water from the tank farm bund, and from the underground storage tank.

   All the trade effluent from these sources is to be combined and stored within the underground storage tank, and each batch tested for pH and Total Organic Carbon (TOC) prior to discharge to ensure compliance with the consent limits outlined below.

Commented [d1]: Added "aqueous".

Commented [d2]: Bryan Griffiths Comment

4. The trade effluent is expected to contain traces of:
   COD, Solids (fine agarose particles), Ethanol, Sodium Hydroxide, Epichlorohydrin, Acetic Acid, Sodium Sulphate, Glycidyltrimethylammonium chloride (GMAC).

glas
Glas Cymru Cyfyngedig

We welcome correspondence in Welsh and English
Rydym yn croesawu gohebiaeth yn y Gymraeg neu yn Saesneg

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Dŵr Cymru Cyf, cwmni cyfyngedig wedi'i gofrestru yng Nghymru rhif 2366777. Swyddfa gofrestredig: Heol Pentwyn, Nelson, Treharris, Morgannwg Ganol CF46 6LY.

5. The combined trade effluent discharge from Unit C will be subject to the following consent limits:
   - Settled Chemical Oxygen Demand load of 100 kilograms per day;
   - Total Suspended Solids limit of 100 milligrams per litre;
   - Ammonia (as N) 10 milligrams per litre;
   - Ethanol load of 10 kilograms per day;
   - Toluene 1.0 milligram per litre;
   - Total Sulphate 1800 milligrams per litre.

6. Compliance with consent limits will be determined by spot samples taken from the trade effluent monitoring point.

7. A flow meter must be installed downstream of the underground storage tank, and daily flow meter readings taken and recorded whilst discharging to provide cumulative volumes both for compliance purposes (i.e. determining daily loads), and for charging purposes according to Dwr Cymru's current Scheme of Charges.

8. This permission is given on the understanding that:
   a) it may be reviewed from time to time in accordance with the frequency applying in respect of a trade effluent consent issued under the Water Industry Act 1991, section 124.
   b) Dwr Cymru-Welsh Water may review its Trade Effluent Policy and require a review of this permission subject to the restrictions in a) above.
   c) If the nature of the discharge is changed then Dwr Cymru-Welsh Water must be informed of this and shall be entitled to review the permission.

9. This permission is valid for 6 months only from the date of this letter. After this initial 6 month period, it will be a requirement to replace this authorisation with a full trade effluent discharge consent, to be based on the volume and effluent quality data collected during the initial authorised period.

Commented [d3]: Clarify whether date from commissioning or issue. When would issue come?

The standard trade effluent consent application fee of £321 (zero rated for VAT) is payable in respect of this application. You will be sent an invoice for this amount in due course.

In the meantime, if you have any queries or should the operation change in any way so as to affect the nature and volume of wastewater for disposal, please contact Heather Pepper, Trade Effluent Officer on (029) 20 478822 or on e-mail at heather.pepper@dwrcymru.com.

Yours sincerely

Richard Ingles
Process Scientist