APPLICATION FOR AN ENVIRONMENTAL PERMIT UNDER THE ENVIRONMENTAL PERMITTING (ENGLAND AND WALES) REGULATIONS 2016 (AS AMENDED)

REQUEST FOR FURTHER INFORMATION

TDA
Wilton Centre - Pioneer Group
Wilton
Lazenby
Redcar
TS10 4RF

ECL Ref: DESC.01.01/RFI
Version: Issue 1
11/12/2025

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ACRONYMS/TERMS USED IN THE TEXT

ABFR	Aromatic Brominated Flame Retardants
ARGO	Argo Natural Resources
BAT	Best Available Techniques
BFR	Brominated Flame Retardants
BRef	Best Available Techniques Reference Document
CAPA	Corrective and Preventative Action
CInC	Commercially Confidential
DES	Deep Eutectic Solvent
EA	Environment Agency
ECL	Environmental Compliance Limited
EMS	Environmental Management System
EP	Environmental Permit
EPTR	Environmental Permitting Technical Requirements
ERA	Environmental Risk Assessment
ETFE	Polyethylene tetrafluoroethylene
FEP	Fluorinated ethylene propylene
MMH	Mixed Metal Hydroxides
NTS	Non Technical Summary
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
PCB	Printed Circuit Boards
PFA	Perfluoroalkoxy alkane
PFAS	Per- and Polyfluoroalkyl Substances)
POPs	Persistent Organic Pollutant
PVDF	Polyvinyldifluoride
SHEQ	Safety, Health, Environmental and Quality
TBBPA	Tetrabromobisphenol A
The Installation	Solvent-Based Metal Recovery Installation
The Site	Wilton Centre, Redcar, TS10 4RF

0. INTRODUCTION

0.1. Overview

0.1.1. Environmental Compliance Limited (“ECL”) have been commissioned Argo Natural Resources (“Argo”) trading as DEScycle to prepare a response to a request for further information (“RFI”) from the Environment Agency (“EA”)as part of the Environmental Permit (“EP”) application at their Solvent-based metal recovery installation, hereafter referred to as “the Installation”, located at the Wilton Centre, Redcar, TS10 4RF (“the Site”).

0.1.2. In addition to this response a number of documents submitted with the Environmental Permit application have been updated and included with this RFI response.

1. QUESTION 1 – COMMERCIAL CONFIDENTIALITY

1.1. EA Question

1.1.1. *Q1a - Confirm that you do not consider any part of your application to be commercially confidential.*

1.1.2. *Q1b - If you do consider all, or parts, of your application to be commercially confidential, please provide confirmation indicating which information should be considered as CInC and provide redacted documents.*

1.2. DEScycle Response

Q1a

1.2.1. Argo require parts of the application to be considered commercially confidential (“CInC”).

Q1b

1.2.2. Following a review of the documentation submitted it is considered that the following information be considered CInC:

- DESC.01.01/EPTR
  - Section 1.4.2. – Part of the EA’s Pre-App Advice that discussed the Process;
  - Para 4.2.3.;
  - Section 4.8 to 4.11 inclusive;
  - Figures 1-3 inclusive;
  - Table 4;
  - Notes to Table 5;
  - Appendix 1 – EA Pre-app Advice containing description of the process
  - Appendix II – DSEAR Assessment; and
  - Appendix III – Process Flow Diagrams.
- DESC.01.01/NTS
  - Section 4.8 to 4.11 inclusive;
  - Figures 1-3 inclusive;
  - Paragraph 5.1.1.; and
  - Notes to Table 3.
- DESC.01.01/WM3-SP (Liquid Waste)
  - Table 3;
  - Table 4; and
  - Table 5.
- DESC.01.01/RFI
  - Table 1;
  - Section 4.2.4;
  - Table 2;
  - Para 5.2.7.;
  - Para 5.2.14;
  - Para 5.2.15;
  - Section 6.2.2;

- Table 3;
- Para 6.2.10; and
- Appendix 1.

1.2.3. Redacted copies of the relevant documentation have been provided, a copy of the documents has been submitted to the EA with the CInC information highlighted in grey for ease of reference.

1.2.4. Information is considered commercially confidential as it contains detailed information on how the process can be replicated and the materials required. Its release would therefore prejudice DEScycle' s competitive position.

2. QUESTION 2 – ENVIRONMENTAL MANAGEMENT SYSTEM

2.1. EA Question

2.1.1. *Q2 - Confirm that a written environmental management system is in place or will be by the time of permit issue.*

2.2. DEScycle Response

2.2.1. An Environmental Management System ("EMS") will be in place at the time of permit issue. It is currently being drafted. The draft environmental policy currently states:

DEScycle, will maintain an Environmental Management System (EMS) which:

- *Recognises and addresses the existing and potential future environmental impacts of its operations both as a result of routine operations and in the case of unplanned events.*
- *Embodies the principle of continual improvement in prevention of pollution to air, land and water by elimination of use at source, recovery and reuse of solvents and reagents, or where this is not economically or technically feasible, the disposal of by-products by means which minimise the potential for damage to the environment.*
- *Aims to prevent air pollution and minimise the emissions of hazardous substances to atmosphere through adopting Best Available Technologies (BAT).*
- *Aims to minimise water consumption, prevent contamination of water, and to ensure efficient use of water resources through re-use / recycling.*
- *Aims to reduce energy consumption through efficiency improvements*
- *Aims to minimise the emissions of greenhouse gases and contribute to climate change mitigation in line with global and national targets.*
- *Complies with legislation, the requirements of our operating permits, and the principles of Responsible Care.*
- *Provides a framework in which limits are set and performance against these targets is measured.*
- *Ensures that all employees of the company who may have a direct environmental impact are aware of this policy and are sufficiently trained to operate within the letter and spirit hereof.*
- *Provides sufficient information to third parties who transport, use or dispose of materials produced by the company to enable them to be handled with minimum risk to the environment.*
- *Provides all stakeholders in our operation with sufficient information to enable them to understand the impact of the company's activities on the environment.*
- *Recognises change as an important feature of our activities and ensures that before implementation, the potential environmental impact of any change is carefully assessed.*
- *Promotes the evaluation of the best available technology for prevention of* environmental damage and to adopt it whenever financially feasible.

<u>This policy is communicated to all persons working for and on behalf of DEScycle</u>

<u>This policy is available to the public</u>

2.2.2. An EMS Manual is in the process of being drafted and can be provided if required. Documents that form part of the EMS will include:

- Safety, Health, Environmental and Quality ("SHEQ") Management Review;
- Environmental Aspect Significance Determination;
- Environmental Aspects;
- Training Guidelines;
- Approval of Documents (prior to issue to external organisations);
- Document Preparation, Approval and Implementation;
- Emergency Response Procedure;
- Environment Monitoring Requirements;
- Environmental and Regulatory Reporting Requirements;
- Environmental Notification;
- SHEQ Internal Auditing and Site Inspections; and
- Corrective and Preventative Action (CAPA) Tracking System.

3. QUESTION 3 – H1 RISK ASSESSMENT

3.1. EA Question

3.1.1. *Q3 - Submit a revised H1 for the assessment of substances released to air from point sources A1 and A2.*

3.2. DEScycle Response

3.2.1. The H1 assessment can be found as document DESC.01.01/H1 submitted with this response.

4. QUESTION 4 – CLARIFICATION OF ACTIVITIES

4.1. EA Question

4.1.1. *Q4a - Clarify the waste activities undertaken on site, including a site plan showing the location on the site where these activities will be taking place. Include waste reception areas, waste storage areas and waste processing activities. Indicate the types of wastes (EWC codes) and volumes of each waste type entering each of these activities.*

4.1.2. *Q4b - With reference to the waste codes EWC 20 01 35* and 20 01 36 to be accepted at the site, please give further descriptions of the waste.*

4.1.3. *Q4c - Confirm the number of opportunities in the process where "products" or "substances" are available to be sold for commercial gain with no further refining. That is, when the product or substance exits the process flow and undergoes no further processing*

4.1.4. *Q4d - Specify the name of the product/substance indicating if this is a metal, a metal salt or a metal hydroxide.*

4.2. DEScycle Response

Q4a

4.2.1. Drawing DESC.01.01-05 has been produced to describe where the various activities occur on site, including all waste reception, storage, DES1 and DES2 treatment, product storage and process wastes areas. Drawing DESC.01.01-05 may be found in Appendix 2 of this document.

Q4b

4.2.2. It is not the intention of Argo to accept municipal sources of PCBs – e.g. individual PCBs from households. The 20 codes were included to cover industrial and commercial PCBs arising from the following types of sectors/activities:

- electronics manufacturers;
- computer manufacturers;
- large scale commercial hardware upgrades to electronics system (e.g. server farm upgrades);
- legacy stock clearance, or removal of stored hardware;
- electronics retailers; and
- data destruction (direct from operators).

Q4c

4.2.3. Materials flows have been produced for the pre-processing, DES1 and DES 2 stages. These may be found as Appendix 1 to this RFI and are summarised in Table 1.

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5. QUESTION 5 – CHARACTERISATION OF INCOMING WASTE

5.1. EA Question

5.1.1. *Q5a - Consider the potential for PFAS substances and BFRs to be present within printed circuit boards entering each stage of the waste treatment activities and chemical recovery processes and assess the risks of PFAS passing into the environment (air, water, soil/groundwater, process wastes, effluent) providing a copy of the assessment.*

5.1.2. *Q5b - Where your risk assessment shows potential for POPs/PFAS or BFRs to be present in the incoming waste streams, provide a list of the analytes that would be part of the routine testing of incoming waste intended for shredding with reference to POPs, PFAS and brominated flame retardants.*

5.2. DEScycle Response

Q5a

Aromatic Brominated POPS in e-waste

5.2.1. Aromatic Brominated Flame Retardants (“ABFRs”) are widely used in electronics because they inhibit combustion, prevent ignition, and slow the spread of fire. However, many of these compounds are restricted and/or classified as persistent organic pollutants (“POPs”) due to their long-lasting environmental impact.

5.2.2. In printed circuit boards (“PCBs”), ABFRs typically appear in two ways:

- **Pathway 1** - Component in resin formation for PCB substrates: Epoxy resins are the most common base material for FR-4 PCBs[1], providing mechanical strength, electrical insulation, and thermal stability. As a reactive component in their manufacture, tetrabromobisphenol A (“TBBPA”) and structurally related molecules are often chemically bound into these epoxy resins during manufacture. As TBBPA is covalently bonded in the resin matrix, it is harder to extract, which reduces, but does not eliminate, safety and environmental concerns.
- **Pathway 2** - Additive polymers in plastics: In other cases, brominated flame retardants are added directly to polymers used in PCB manufacture, such as polybrominated diphenyl ethers (“PBDEs”) and polybrominated biphenyls (“PBBs”). These compounds are mixed into the polymer rather than chemically bound, making them more likely to leach out and therefore more hazardous. They are typically listed on restricted chemical lists.

5.2.3. Resins and polymers are intrinsic to PCB manufacture. Resins (epoxy, polyimide, PTFE blends) form the substrate or laminate of the PCB, which acts as the structural backbone. They provide mechanical support, electrical insulation, and resistance to heat and chemicals. Polymers are used in solder masks, coatings, and insulating layers. They protect copper traces, prevent short circuits, and improve durability.

[1] FR4 is a class of printed circuit board base material made from a flame-retardant epoxy resin and glass fabric composite.

5.2.4. Together, resins and polymers determine the PCB's thermal stability, dielectric properties, and mechanical durability, directly influencing performance and reliability.

5.2.5. Brominated flame retardants are found in most electronic products either as reactive components bound into epoxy resins or as additives blended into polymers used in plastics and coatings.

5.2.6. The Stockholm Convention, which came into force in 2008, restricted the use of many brominated compounds classified as persistent organic pollutants POPs, particularly those used as polymer additives (Pathway 2). As a result, the level of POPs in newly manufactured PCBs is assumed to be very low. However, the PCB waste stream still contains legacy boards produced before these restrictions, as well as imported boards manufactured in regions where banned POPs may still be present.

5.2.7. [redacted]

5.2.8. Consequently, ABFRs and TBBPA are not expected to be present in any of the non-PCB polymer/resin waste streams above EA permitted threshold levels (i.e. the salt and mixed-metal hydroxide).

5.2.9. For Pathway 2, the solubility profile of these chemicals in DEScycle's Deep Eutectic Solvent ("DES") is unknown. However, given that there is no molecular degradation of the PCB polymer in the DES processing, the only way that these particles would be extracted is from the surface of the milled particles, not from within the bulk material. This factor, combined with restrictions applied to the use of brominated materials in this way, makes it unlikely that significant quantities of brominated POPs would be extracted into the DES.

5.2.10. Although it is considered unlikely that POPs are present in the DEScycle waste streams, with the exception of the post treatment residue, DEScycle will undertake a programme of testing work to assess outputs from the process to build a dataset on the potential presence of POPs in each of the output streams. It is envisaged that this will be undertaken within the first 6-12 months of operation. This data set will then be used to determine the most appropriate post-process waste treatment and disposal approach for each output. During the analysis period, DEScycle will dispose of all solid residues produced from the processing of PCBs in high-temperature incineration.

PFAS in e-waste and expected leaching in DEScycle process

5.2.11. PFAS compounds are potentially present in many different areas from e-waste. Primarily, PFAS occur as perfluorinated polymers, such as polyfluoroethylene ("TEFLON") and polyvinyldifluoride ("PVDF"). These compounds have higher decomposition temperatures and increased chemical stabilities versus typical non-fluorinated polymers.

5.2.12. The polymers are used as flame retardants in PCBs, capacitors, wiring, lithium-ion batteries and plastics.

5.2.13. DEScycle have undertaken materials of construction testing of several construction materials that could be accepted as PCB Waste at the proposed Installation. These materials included PFAS compounds. Target compounds were immersed in DEScycle DES to understand if the DES would corrode the exposed surface of the compound. The construction materials tested were TEFLON, PVDF, perfluoroalkoxy alkane (“PFA”), fluorinated ethylene propylene (“FEP”) and polyethylene tetrafluoroethylene (“ETFE”). All displayed no discernible change upon being immersed in the two DES leaching formulations described in the permit application.

5.2.14. [redacted]

5.2.15. [redacted]

- [redacted]
- [redacted]
- [redacted]

5.2.16. During the first 6-12 months of operation, a testing plan for PFAS compounds in the PCB e-waste feedstock inputs as well as the process solvent, products and waste will be undertaken. All outputs will be disposed of in line with EA guidance.

Risks of PFAS Passing into the Environment

5.2.17. Acknowledging that PFAS are likely to be present within DEScycle’s PCB e-waste material, an assessment of potential emission points has been undertaken and can be found in DESC.01.01/ERA – Issue 2 – see Table 5.

5.2.18. Any emission is most likely to be in the form of fluorinated polymers that are both insoluble and stable across all stages of the DEScycle process meaning that they likely won’t leach into the solvent. Other types of PFAS compounds, e.g. liquid cleaning PFAS and dielectric fluids, are not anticipated to be present in the DEScycle input material in significant quantities, this will be evaluated through a PFAS testing program. The assessment of the risks of PFAS passing into the environment is predicated on these assumptions.

Q5b

Testing of Incoming Waste

5.2.19. The incoming waste PCBs will be from several suppliers with a range of different manufactured boards, potentially a mixture of board types. Section 5.2. above has identified the potential for POPs/PFAS and or BFRs to be present in the waste PCBs received.

5.2.20. In order to assess the presence of such substances, it is proposed to use handheld X-ray fluorescence ("XRF") to provide a chemical analysis of the PCBs, with particular focus on the bromine and antimony concentration. Samples can also be sent for energy-dispersive X-ray spectroscopy ("EDS") to quickly analyse for bromine.

5.2.21. The WM3 Technical Guidance will be used to develop a sampling plan based on the quantities received, potential variability of the PCB waste and taking into consideration the batch process activities.

5.2.22. A draft sample plan document, developed with reference to WM3, is provided in Appendix 3. Please note that this is very much in the draft stage.

The information gained from the sampling and analysis of the incoming waste PCBs will be used to inform the requirements of RFI question 6c.

6. QUESTION 6 – CHARACTERISATION OF RECOVERED MATERIAL

6.1. EA Question

6.1.1. *Q6a - Confirm if any of the identified recovered products or substances have been granted end-of-waste approval*

6.1.2. *Q6b - If end-of-waste status has not been granted, justify why your product or substance should not be considered as a waste or, provide details of the timeframes applicable to apply for end-of-waste status where needed for the products/substances from your activities.*

6.1.3. *Q6c - Where your risk assessment shows potential for POPs/PFAS or BFRs to be present in the recovered materials, wastes or residues, provide a list of the analytes that would be part of the routine testing with reference to POPs, PFAS and brominated flame retardants (e.g. PDBEs) which are likely present in this waste stream.*

6.2. DEScycle Response

Response to Q6a

6.2.1. None of the identified recovered products or substances have been granted end-of-waste approval.

Response to Q6b

6.2.2. [redacted]

6.2.3. End-of-waste status has not yet been formally granted for DEScycle's metal products. However, it is considered that the outputs listed above should be considered products rather than wastes, based on the following justification aligned with the Waste Framework Directive (2008/98/EC[2], Article 6) and EA guidance[3] (WM3):

- **Permit activities chosen**: the permit application includes a Section 2.2 Part A(1)(a) (production of non-ferrous metals from secondary raw materials) and a Section 4.2 Part A(1)(a)(v) (production of inorganic chemicals) regulated under The Environmental Permitting (England and Wales) Regulations 2016 (as amended)[4]. These activities were selected because they are associated with metal product outputs, not solely waste operations;
- **Process and outputs**: the feedstock consists of waste printed circuit boards. Through chemical treatment, DEScycle recover a consistent intermediate metal product. Although this material requires further refining to reach 99.99% purity

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098
[3] https://assets.publishing.service.gov.uk/media/6152d0b78fa8f5610b9c222b/Waste_classification_technical_guidance_WM3.pdf
[4] https://www.legislation.gov.uk/uksi/2016/1154/contents

and produce ingots, it is already a defined, stable output with a clear onward use in established refining processes to yield purified metals;

- **Market demand and acceptance**: The intermediate will be sold to established refiners. While many refiners hold permits to accept metals as waste, some only accept unrefined metal products. To ensure market reach and compliance, we classify our outputs as products, supported by their consistent quality and purity;
- **Technical requirements**: The outputs meet specifications required by refiners for further processing. They are comparable to other secondary raw materials already traded as products in the metals sector (e.g., scrap iron/aluminium under EU Regulation No. 333/2011[5]), EU No 715/2013[6] as retained UK law and relates to establishing criteria determining when copper scrap ceases to be waste under Directive 2008/98/EC of the European Parliament and of the Council;
- **Environmental and health impacts:** The recovered metals are chemically stable intermediates. Their onward use in refining does not introduce adverse environmental or health impacts beyond those already regulated under existing refining permits; and
- **Future refining steps:** Within three years, DEScycle plan to implement further refining on site, producing manufacture-ready metals equivalent to virgin metals.

6.2.4. There is existing precedent for scrap metal. Scrap metal can be regulated as a secondary raw material rather than waste through specific "end-of-waste" criteria, which define when a material has been recovered and can be used as a product. For example, processed iron, steel, and aluminium scrap, copper scrap, and glass cullet can fall under these criteria. This classification allows the material to be traded on a market, free from the more stringent regulations for waste.

6.2.5. A key regulation for handling and trading scrap metal, regardless of its classification, is the Scrap Metal Dealers Act 2013[7], which requires dealers to be licensed by the Local Authority.

6.2.6. Copper scrap can be classified as a product (end-of-waste) under Commission Regulation (EU) No 715/2013 if it meets strict criteria on quality, market demand, technical standards, and environmental safety. These criteria ensure that copper scrap is no longer considered waste but a usable raw material in manufacturing.

6.2.7. Under Regulation (EU) No 715/2013, to cease being waste and be treated as a product, copper scrap must meet the following conditions:

- Input material requirements:
  - scrap must come from lawful waste management operations; and
  - hazardous waste or residues containing persistent organic pollutants cannot be used.
- Quality of scrap:
  - scrap must be free from excessive foreign materials (plastics, oils, coatings, etc.);
  - must not contain hazardous properties (e.g., explosive, infectious, corrosive).
  - must meet industry specifications for copper and copper alloys.

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0333
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0715
[7] https://www.legislation.gov.uk/ukpga/2013/10

- Technical standards:
  - scrap must comply with recognised industry standards (e.g., EN 12861 for copper scrap); and
  - purity and composition must be consistent and suitable for direct use in metal production.
- Market demand and use:
  - there must be a proven market for the scrap as a raw material; and
  - scrap must be usable in non-ferrous metal production without further waste treatment.
- Environmental and health protection:
  - use of the scrap must not cause adverse impacts on human health or the environment; and
  - documentation and quality assurance systems must be in place to demonstrate compliance.
- Documentation requirements:
  - each consignment must be accompanied by a statement of conformity declaring compliance with the criteria; and
  - producers must implement a quality management system to ensure ongoing compliance.

6.2.8. It is therefore considered that a number of the DEScycle outputs should be treated as products as:

- there is legal precedent: copper scrap is one of the few materials with EU-wide end-of-waste criteria. This provides a strong precedent for arguing that other recovered metals (like copper cement or gold-on-carbon) can also be considered products if they meet similar conditions.
- market access**:** classifying outputs as products broadens the potential customer base, since not all refiners are permitted to accept waste.
- the use of materials in this manner aligns with the principles of a Circular economy alignment: recognising recovered metals as products supports EU/UK policy goals of resource efficiency and substitution of primary raw materials.

6.2.9. Table 3 considers this in more depth using the copper scrap regulation as a precedent.

Table 3: [redacted]

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Table3: [redacted]

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6.2.10. [redacted]

6.2.11. DEScycle's products are, like many other cases in the metals industry, where impure metallic inputs are clearly treated as products rather than waste. For example:

- copper concentrates are - even if they typically contain only 20-30% copper - treated as product, not as waste;
- copper blister typically contains 98–99% copper and is universally treated as a commercial product; and
- copper cathodes containing 99.99% copper are often produced from scrap-derived feedstock, yet the resulting cathodes are fully classified and traded as products, indistinguishable from primary cathodes in the market.

6.2.12. Various specifications, quality thresholds, and documentation will accompany the products, for example:

- DEScycle will agree with suppliers/customers on product specifications such as assays for copper concentrates, anodes, blister, etc;
- in some cases, recognised product standards (e.g., American Society for Testing and Materials ("ASTM")) apply.
- typically, a Certificate of Analysis from the supplier or an independent laboratory is provided to demonstrate compliance with the agreed specifications.

Response to Q6c

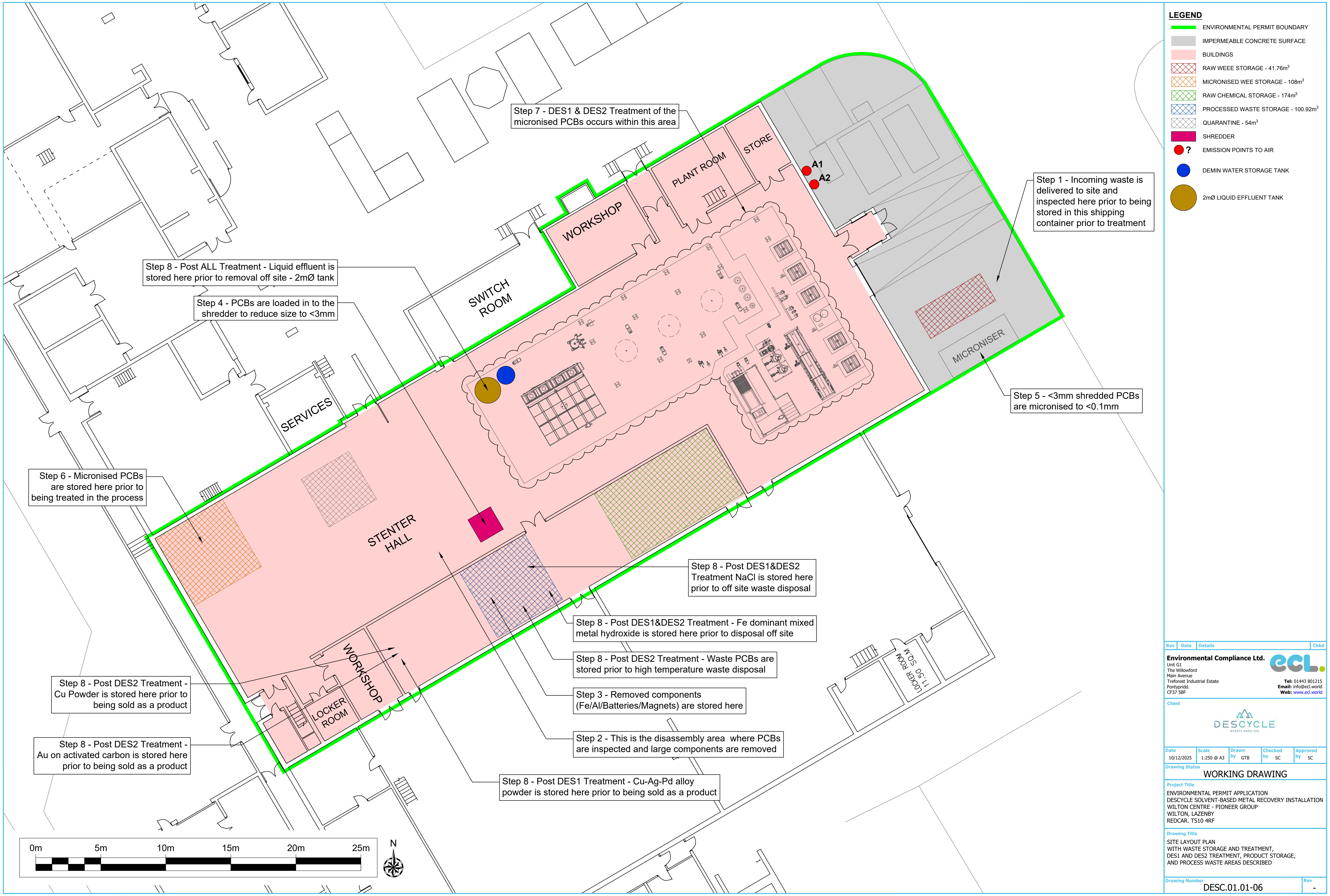
6.2.13. As discussed in section 5.2. above, it is proposed that all outputs from the process will be assessed for the potential presence of POPs/PFAS and BFRs. In addition to the input material (see question 5b) handheld XRF will be used as an initial screen to identify the presence of bromine and antimony (particularly for the post treatment residue which is to be sent for high temperature incineration). Analysis in accordance with the Sampling Plan (Incoming Waste PCB) in Appendix 3 will be used to characterise the incoming PCB waste. The outcome of such analysis will inform the sampling regime for process outputs (solids).

6.2.14. The sampling methodology for the various outputs will be developed through reference to the WM3 Technical Guidance with sample plans being developed for each output having regard to the nature of the output, i.e. solid, liquid, powder etc.

6.2.15. An example sample plan is provided in Appendix 4 relating to a draft plan for the liquid waste streams of liquid condensate, and liquid wastes with residues of DES. A sampling plan for the solid waste streams will be developed once the incoming PCB waste has been characterised.

APPENDIX 1
OUTPUT MATERIAL FLOWS

APPENDIX 2
DRAWING DESC.01.01-05



Rev	Date	Details	Chkd

Environmental Compliance Ltd.
Unit G1
The Willowford
Main Avenue
Treforest Industrial Estate
Pontypridd.
CF37 5BF

Tel: 01443 801215
Email: info@ecl.world
Web: www.ecl.world

Client
DESCYCLE
metals made new

Date	Scale	Drawn by	Checked by	Approved by
10/12/2025	1:250 @ A3	GTB	SC	SC

Drawing Status
WORKING DRAWING

Project Title
ENVIRONMENTAL PERMIT APPLICATION
DESCYCLE SOLVENT-BASED METAL RECOVERY INSTALLATION
WILTON CENTRE - PIONEER GROUP
WILTON, LAZENBY
REDCAR. TS10 4RF

Drawing Title
SITE LAYOUT PLAN
WITH WASTE STORAGE AND TREATMENT,
DES1 AND DES2 TREATMENT, PRODUCT STORAGE,
AND PROCESS WASTE AREAS DESCRIBED

Drawing Number: DESC.01.01-06
Rev: -

APPENDIX 3
DESC.01.01/WM3-SP (Incoming Waste PCBs)

E-WASTE (PRINTED CIRCUIT BOARDS) TREATMENT - METALS RECOVERY INCOMING WASTE WM3 – SAMPLING PLAN

For the confirmation of the correct waste code

DEScycle,
Wilton Centre,
Redcar,
Cleveland,
TS10 4RF

ECL Ref: DESC.01.01/WM3 SP (Incoming Waste PCBs)
Version: DRAFT
11/12/2025

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ACRONYMS / TERMS USED IN THIS REPORT

BCC	**Basic (Comprehensive) Characterisation**
BFRs	**Brominated Flame Retardants**
DES	**Deep Eutectic Solvent**
EA	**Environment Agency**
ECL	**Environmental Compliance Limited**
LOD	**Limit of Detection**
LoW	**List of Wastes**
PCBs	**Printed Circuit Boards**
POPs	**Persistent Organic Pollutants**
SWP	**Safe Working Procedure**
TBC	**To be confirmed**
UKAS	**United Kingdom Accreditation Service**
WM3	**Waste Management Classification Guidance**
XRF	**X-Ray Fluorescence**

1. INTRODUCTION

1.1. Overview

1.1.1. Environmental Compliance Limited ("ECL") have been commissioned by Argo Natural Resources trading as DEScycle to author a WM3 Sampling Plan to assist with the appropriate assessment for the classification and confirmation of the waste code assigned to incoming e-waste ("Waste Electrical and Electronic Equipment") in the form of printed circuit boards ("PCBs"). The PCBs are consigned from known industrial sources such as waste treatment facilities and multi-national companies seeking to improve their sustainability credentials. The PCBs are received at the site, having been approved through pre-acceptance procedures, and validated through acceptance procedures prior to being moved to secure storage at the Wilton Centre, Redcar site.

1.1.2. DEScycle will receive hazardous e-waste PCBs, for the purpose of undertaking trials, that will be subject to various processing activities. This can be summarised as shredding followed by micronisation, and then selective metals recovery through the use of Deep Eutectic Solvent ("DES") chemistry.

1.1.3. This Sample Plan relates to the incoming PCBs only. Waste generated through the site activities are subject to a separate sample plan.

1.2. Site Location

1.2.1. This Sampling Plan details the process of developing an appropriate sampling regime for the Basic (Comprehensive) Characterisation ("BCC") of the process incoming waste stream of PCB's that will be subject to metals recovery activities as a scale up trial to assess feasibility of introducing the processing techniques and equipment on a commercial basis. The PCBs will arrive at site under List of Wastes ("LoW") codes 16 02 13*, 16 02 14, 16 02 15*, 16 02 16, 20 01 35*, and 20 01 36. The site is shown in the Indicative Site Location Plan in Appendix I.

2. STEP 1 - PREPARATORY STEPS

2.1. Step 1.1: Identify the Parties Involved

2.1.1. The parties 'involved' with the development of the sampling plan and that may have specific roles to play are detailed in Table 1 below.

Table 1: 'Involved Parties' to the Sampling Plan

Involved Party	Role / Involvement
DEScycle	Operator of the metals production and recovery activities and consignee of the waste PCBs received at the Wilton Centre site, legally responsible for confirming waste classification for waste materials received. [Direct involvement]
Environmental Compliance Limited ("ECL")	Consultant providing advice for waste classification processes. [Direct involvement]
Waste Sampling - DEScycle	Collection of samples in an appropriate manner in compliance with the WM3 guidance. [Direct involvement]
Suitably Accredited Laboratory - TBC	Analysis of samples received and provision of the results from analysis. [Direct involvement]
Appropriately Permitted Carrier and Consignee of the waste - TBC	Ensuring that the waste transfers are accompanied by correctly completely paperwork, that the waste is transported accordingly, and that it is disposed of / recovered appropriately and legally. [Direct involvement]
Environment Agency ("EA")	Involved through their regulatory role, both as advisor and through compliance checking. [Direct and indirect involvement]

2.1.2. The interested parties and roles performed may change over time due to various circumstances. Therefore, as part of ongoing review, this document and the contents of Table 1 above should be updated, as necessary, to reflect any changes that have taken place. The significance of the changes may impact on the following sections within this Sampling Plan.

2.2. Step 1.2: Objectives and Technical Goals

2.2.1. The objective of the sampling plan is to identify whether the incoming waste PCBs are as described through pre-acceptance agreements and consignment documentation, along with identification of the composition of the PCBs in order to track the fate of brominated flame retardants ("BFRs") and persistent organic pollutants ("POPs") present in the waste stream.

2.2.2. To achieve the objective, there are several technical goals, which are:

- Identify if the waste is a mixture of two or more wastes or subpopulations.
- Identify if there are any hazardous substances within the waste.
- If so, determine the concentration of any hazardous substances present.
- Direct testing for certain hazardous properties if present (such as HP3 Flammable).

2.2.3. Delivering the technical goals will require further considerations which are detailed through this Sampling Plan document, and which will address the following aspects as detailed within the WM3 Guidance:

- Defining the population to be sampled.
- Assessing the variability within the waste streams.
- Selection of sampling approach.
- Identification of the constituents to be assessed.
- Identifying the scale of sampling.
- Selection of statistical approach.

2.3. Step 1.3: Determine the Level of Testing Required

2.3.1. The PCB waste is likely to be subject to some form of assessment by the suppliers of the waste PCB which should have identified the main characterisation of the waste stream. The waste is transferred as hazardous due to presence of BFRs / POPs, however, confirmation of contamination and the fate of hazardous contaminants is required to be identified. Therefore, the level of testing will need to identify incoming hazardous substances and thus determine potential transfer of such substances to all process outputs.

2.4. Step 1.4: Research

2.4.1. The purpose of the Installation is to trial a scaled-up version of a research pilot for metals production and recovery from PCB waste to ascertain the commercial viability of the equipment and production/recovery techniques. The trial will require 32.5 tonnes of PCB waste in order to undertake the necessary steps of commissioning, validation and optimisation.

2.4.2. The wastes that are proposed to be accepted at the site are classified as hazardous and non-hazardous and fall under Chapters 16 and 20 of the LoW.

2.4.3. Pre-acceptance criteria and agreements are in place and each consignment received will be assessed against the agreement criteria. As part of waste acceptance checks, the waste PCBs will be sampled and assessed by way of x-ray fluorescence (“XRF”) analysis to confirm the main characteristics of the waste PCB, specifically bromine and antimony.

2.5. Step 1.5: Identify the Constituents to be Tested

2.5.1. PCB are manufactured using a large range and number of substances, often in small quantities. The waste PCB are the feedstock for the processes that will be undertaken and therefore, the feedstock composition will change through the various process stages. It is not intended that the waste PCB will be subject to vigorous analytical assessment but to confirm the main characteristics of what is being received to remain compliant with waste regulations. Typical composition of PCB is detailed below in Table 2.

Table 2: PCB Typical Composition

Metals	Non-Metallic
Aluminium	Antimony trioxide
Arsenic	Brominated Flame Retardants
Beryllium	Ceramics
Cadmium	Cerium
Chromium	Epoxy Resins
Copper	Glass Fibres
Gold	Phenolic Resins
Iron	Scandium
Lead	
Mercury	
Nickel	
Palladium	
Platinum	
Silver	
Selenium	
Tin	
Zinc	

2.5.2. In order to assess the presence of such substances, it is proposed to use handheld X-ray fluorescence (“XRF”) to provide a chemical analysis of the PCBs, with particular focus on the bromine and antimony concentration. Samples can also be sent for energy-dispersive X-ray spectroscopy (“EDS”) to quickly analyse for bromine.

2.6. Step 1.6: Health and Safety Precautions

2.6.1. The sampling of the waste PCBs will be assessed and will be subject to a specific safe working procedure (“SWP”), titled ‘SWP Sampling In-coming Waste PCBs’, and will be provided in Appendix II [*procedure is still in development*].

2.6.2. The SWP will consider the use of eye protection, protective gloves, protective clothing, safety boots and high visibility clothing etc.

3. STEP 2: DEVELOP TECHNICAL GOALS FROM OBJECTIVE

3.1. Step 2.1: Define the Population to be Sampled

3.1.1. For this initial trial, the volume of waste PCBs will be 32.5 tonnes. This is considered to be the overall population. The overall population will have inherent variability due to variability in the composition of the waste PCB materials received on site.

3.1.2. The waste PCBs will come from various waste streams, and the original purpose or use of the PCB will be wide ranging. There is likely to be significant variation in PCB component content, potential age of PCB received, and overall composition.

3.1.3. Variability of the population is governed by the waste throughput volumes of particular types of PCB, the age of PCBs in respect of how the actual boards may have been manufactured and the substances used in manufacturing, along with the age and size of components on the PCBs. Electronic component design, manufacture and composition have been continually evolving.

3.2. Step 2.2: Assess Variability

3.2.1. As discussed in Step 2.1 above, there is inherent variability of the PCB waste that will be received at site, but the number of bags or overall volume of waste received does not determine the variability within the waste. This is driven by the composition of boards at the manufacturing stage, the population of boards with electronic components (number of them, type, age, means of attaching to the board) and the purpose or nature in which individual PCB were designed for use.

3.2.2. Some of this variability may be minimised through careful source selection of PCB waste. Receiving waste from a specific supply of PCB where the board purpose is known and historical composition is understood could help reduce variability. However, such limitations in supply may affect the longer-term viability of commercial upscaling of the process.

3.2.3. There will be spatial variation associated with the contributing sources of PCBs, their frequency of supplying waste PCBs, and their overall contribution to the quantity received for processing. This will link into the volume of each of the supplies and the volumes of the specific coded wastes that are to be processed. However, this will be somewhat dependant on how the PCB waste is received to site, such as only one, or limited, type of board in each 1 tonne woven poly bag.

3.2.4. Temporal variation is unlikely to be a factor in this assessment as it is limited to the trial based on the 32.5 tonnes of waste PCBs.

3.2.5. Within stratum variability could potentially be introduced through greater volume of one particular source of PCB waste being received for the trial, compared to other sources.

3.2.6. It is quite possible that between stratum variation will exist between the bags received for the trial, however, the purpose of the exercise is confirmation of the waste being received and as part of waste acceptance checks. Any variation in the materials received is likely to be diminished as part of processing steps.

3.2.7. For the purposes of this assessment, it is not considered that cyclic temporal variability within the waste PCBs will be possible to determine.

3.3. Step 2.3: Scale of Sampling

3.3.1. For this confirmation exercise of characterisation, the scale of sampling is considered best assessed against the volume of waste PCB material being received and the potential variation of the received materials.

3.3.2. The study period will be the period of time taken to undertake the trial and satisfy the objectives of the trial. This period will be sufficient to collect the number of samples that provide confidence in the classification that has been provided and to identify the main composition of the PCB waste and confirm BFRs/POPs are present.

3.3.3. At this time, it is unknown what the waste PCB streams will be comprised of, in terms of size of boards, type, use, and quantity by type. It is also not known if the incoming waste will contain only one type of PCB or whether they will be mixed loads. These details will determine the level of sampling and volume / quantity of PCB sampled for analysis. The more variability in the received waste stream, the more sampling and analysis is required.

3.3.4. At this stage, the proposed scale of sampling is based on Option (I) detailed in the WM3 guidance for 'Step 2.3 Scale of Sampling', and random probabilistic sampling.

4. STEP 3: DETERMINE THE PRACTICAL INSTRUCTIONS

4.1. Step 3.1: Choose the Statistical Approach

4.1.1. At the time of writing there are no sample results to validate a particular statistical approach.

4.1.2. The sampling regime, once known, will hopefully help to identify whether there is limited variability in results and inform sampling going forward. A review of all results, both individually and in combination will be undertaken once available.

4.2. Step 3.2: Select the Sampling Approach

4.2.1. The incoming waste PCB will be from several sources, but all deliveries will be in appropriate waste containers. It is not known at this stage whether the bags will contain only one type of waste PCB, or whether there will be a mix of different types and sizes of PCB. These details would determine how many PCB would be sampled for analysis ensuring there was a sufficient number of the different types to have confidence in the results obtained.

4.2.2. However, the sampling and analysis is for confirmation of what is being received, rather than full characterisation and classification for onward transfer of the waste PCB. Sampling will take place as part of acceptance procedures on site. Acceptance is not reliant on analysis results, therefore, if all other acceptance checks are validated, the waste PCBs can be transferred to storage.

4.2.3. Whilst the specific details of the waste PCB that will be received on site, the 'consistency' of materials to be received and relevant quantities from suppliers, are not yet known, it is considered the sampling approach will be random. Therefore, the sampling pattern would be considered to be Simple Random Sampling (probabilistic).

4.2.4. This sample plan document will be updated once further details are known and the sampling approach confirmed.

4.3. Step 3.3: Determine the Type, Number and Size of Samples Required

4.3.1. As a minimum, each consignment received should be sampled. However, depending on the quantities received as separate consignments, this may not be feasible. A pragmatic approach that ensures a sufficiently wide range of samples from across the population is sampled and analysed is required to confirm the waste is as described by consignors.

4.3.2. The sample size must be sufficient for the laboratory to undertake the XRF analysis. The quantity supplied to the laboratory is yet to be confirmed. The laboratory will then undertake any necessary sample preparation on each sample received for the analysis.

4.3.3. The samples will be physically taken from the waste containers by picking PCB from the waste bag. The sample taken will be placed into a sample bag which is pre-labelled with sample details and the consignment from which it has been taken for audit purposes.

4.4. Step 3.4: Identify Sampling Techniques

4.4.1. The waste PCB sampling methodology has been based on the guidance provided in the WM3 Technical Guidance (Waste Classification – Guidance on the classification and assessment of waste (1st Edition v1.2 GB)) [October 2021].

5. STEP 5: DEFINE AND DOCUMENT THE SAMPLING PLAN

5.1. Documented Sampling Plan

5.1.1. The preceding sections describing the development and rational of the sampling plan, based on the WM3 guidance, are summarised in a Sample Plan Document Record which will be produced and can be found in Appendix III [*TBC*].

6. STEP 6: SUBSEQUENT STEPS

6.1. Taking the Samples

6.1.1. Sampling is undertaken by DEScycle employees in accordance with the sampling SWP. The document contains a sample record sheet to identify each sample event, and the sample details for each event.

6.1.2. Eye protection, protective gloves and clothing, safety boots and high visibility clothing are all required for the sampling which takes place from within the waste storage container.

6.1.3. The samples are physically removed and placed into sample bags. The sample bags are labelled and referenced, with the same details also being logged on the sample record sheet for traceability. Samples are then dispatched to the laboratory for analysis.

6.2. Analytical Methods

6.2.1. The laboratory arranging the analytical analysis of PCB waste is yet to be confirmed.

6.3. Sample Records

6.3.1. The sample records comprise of:

- Sample Plan (this document)
- Sample Plan Document Record (Appendix III)
- Sampling Record (for each sample taken)
- Chain of Custody Form (for each set of samples)
- Sample Analysis Report (for each sampling event)

6.3.2. Analysis results supplied by the laboratory to be commissioned will conform to the requirements of their UKAS accreditation, along with their in-house protocols and procedures. The results reports will include details on the specific test methods, the substances analysed, the limit of detection (“LOD”), the units of measurement and the analysis results. The reports also include details of any deviations, where appropriate, the laboratory number, the sample identification number/reference, type of sample, sampling date and the sampling time.

APPENDIX I

DESCYCLE

INDICATIVE SITE LOCATION PLAN

ECL Ref: DESC.01.01/WM3 SP (Incoming Waste PCBs)
Version: DRAFT
11/12/2025

APPENDIX II

DESCYCLE

SAFE WORKING PROCEDURE [TBC]

APPENDIX III

DESCYCLE

SAMPLE PLAN DOCUMENT RECORD [TBC]

APPENDIX 4
DESC.01.01/WM3-SP (Liquid Waste)

E-WASTE (PRINTED CIRCUIT BOARDS) TREATMENT - METALS RECOVERY
LIQUID WASTE WM3 – SAMPLING PLAN

For the identification of the correct waste code

DEScycle,
Wilton Centre,
Redcar,
Cleveland,
TS10 4RF

ECL Ref: DESC.01.01/WM3 SP (Liquid Waste)
Version: DRAFT
11/12/2025

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APPENDIX II: Safe Working Procedure – TBC
APPENDIX III: Sample Plan Document Record - TBC

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ACRONYMS / TERMS USED IN THIS REPORT

BCC	**Basic (Comprehensive) Characterisation**
BFRs	**Brominated Flame Retardants**
DES	**Deep Eutectic Solvent**
EA	**Environment Agency**
ECL	**Environmental Compliance Limited**
LOD	**Limit of Detection**
LoW	**List of Wastes**
PCBs	**Printed Circuit Boards**
POPs	**Persistent Organic Pollutants**
SWP	**Safe Working Procedure**
TBC	**To Be Confirmed**
UKAS	**United Kingdom Accreditation Service**
WM3	**Waste Management Classification Guidance**

1. INTRODUCTION

1.1. Overview

1.1.1. Environmental Compliance Limited ("ECL") have been commissioned by Argo Natural Resources trading as DEScycle to author a WM3 Sampling Plan to assist with the appropriate assessment for the classification and the waste code assigned to liquid waste generated on site through the processing of incoming e-waste ("Waste Electrical and Electronic Equipment") in the form of printed circuit boards ("PCBs"). The waste PCBs are consigned from known industrial sources such as waste treatment facilities and multi-national companies seeking to improve their sustainability credentials. The PCBs are received at the site, having been approved through pre-acceptance procedures, and validated through acceptance procedures prior to being moved to secure storage at the Wilton Centre, Redcar site.

1.1.2. Some parts of this Sampling Plan are considered to be Commercially Confidential. Redacted copies of all application documents have been provided to the Environment Agency ("EA"), however, for ease of review, any text considered confidential has also been highlighted in grey.

1.1.3. DEScycle will receive hazardous e-waste PCBs, for the purpose of undertaking trials, that will be subject to various processing activities. This can be summarised as shredding followed by micronisation, and then selective metals recovery through the use of Deep Eutectic Solvent ("DES") chemistry.

1.1.4. This Sample Plan relates to the liquid wastes only. Resin and solid waste generated through the site activities are subject to separate sample plans.

1.1.5. This document is a draft containing details of what will be progressed as further work is undertaken to establish the trial activities. Some information relevant to the development of a formal sampling plan is not yet known. This document has been developed using the WM3 Technical Guidance for waste classification.

1.2. Site Location

1.2.1. This Sampling Plan details the process of developing an appropriate sampling regime for the Basic (Comprehensive) Characterisation ("BCC") of the liquid waste stream from PCB's that will be subject to metals recovery activities as a scale up trial to assess feasibility of introducing the processing techniques and equipment on a commercial basis. The PCBs will arrive at site under List of Wastes ("LoW") codes 16 02 13*, 16 02 14, 16 02 15*, 16 02 16, 20 01 35* and 20 01 36. The site is shown in the Indicative Location Plan in Appendix I.

2. STEP 1 - PREPARATORY STEPS

2.1. Step 1.1: Identify the Parties Involved

2.1.1. The parties 'involved' with the development of the sampling plan and that may have specific roles to play are detailed in Table 1 below.

Table 1: 'Involved Parties' to the Sampling Plan

Involved Party	Role / Involvement
DEScycle	Operator of the metals production and recovery activities and consignee of the waste PCBs received at the Wilton Centre site, legally responsible for confirming waste classification for waste materials received. [Direct involvement]
Environmental Compliance Limited ("ECL")	Consultant providing advice for waste classification processes. [Direct involvement]
Waste Sampling - DESCYCLE	Collection of samples in an appropriate manner in compliance with the WM3 guidance. [Direct involvement]
Suitably Accredited Laboratory - TBC	Analysis of samples received and provision of the results from analysis. [Direct involvement]
Appropriately Permitted Carrier and Consignee of the waste - TBC	Ensuring that the waste transfers are accompanied by correctly completely paperwork, that the waste is transported accordingly, and that it is disposed of / recovered appropriately and legally. [Direct involvement]
Environment Agency ("EA")	Involved through their regulatory role, both as advisor and through compliance checking. [Direct and indirect involvement]

2.1.2. The interested parties and roles performed may change over time due to various circumstances. Therefore, as part of ongoing review, this document and the contents of Table 1 above should be updated, as necessary, to reflect any changes that have taken place. The significance of the changes may impact on the following sections within this Sampling Plan.

2.2. Step 1.2: Objectives and Technical Goals

2.2.1. The objective of the sampling plan is to identify whether the liquid waste generated through the processing of the waste PCBs results in transfer of brominated flame retardants ("BFRs") or any persistent organic pollutants ("POPs") into the liquid waste stream, or if the waste stream contains any other hazardous substances / properties.

2.2.2. To achieve the objective, there are several technical goals, which are:

- Identify if the waste is a mixture of two or more wastes or subpopulations.
- Identify if there are any hazardous substances within the waste.
- If so, determine the concentration of any hazardous substances present.
- Direct testing for certain hazardous properties if present (such as HP3 Flammable).

2.2.3. Delivering the technical goals will require further considerations which are detailed through this Sampling Plan document, and which will address the following aspects as detailed within the WM3 Guidance:

- Defining the population to be sampled.
- Assessing the variability within the waste streams.
- Selection of sampling approach.
- Identification of the constituents to be assessed.
- Identifying the scale of sampling.
- Selection of statistical approach.

2.3. Step 1.3: Determine the Level of Testing Required

2.3.1. The liquid waste generated through the process activities may potentially leach substances from the waste PCBs into the liquid waste. Whilst it is believed this is unlikely, the liquid waste would still require classification before it can leave site for disposal or recovery in accordance with WM3 guidance. Therefore, the level of testing will be to satisfy a Basic (Comprehensive) Characterisation ("BCC") of the liquid waste.

2.4. Step 1.4: Research

2.4.1. The purpose of the Installation is to trial a scaled-up version of a research pilot for metals production and recovery from PCB waste to ascertain the commercial viability of the equipment and production/recovery techniques. The trial will require 32.5 tonnes of PCB waste in order to undertake the necessary steps of commissioning, validation and optimisation. The PCB waste will be delivered to site in various containers. The trial will require processing 130 batches in total. Each batch will comprise 250kg of shredded and micronised PCB waste, and each batch will generate some liquid waste

2.4.2. The trial steps and associated batch quantities are detailed in Table 2.

Table 2: Trial Steps and Batches

Trial Steps	Number of Batches
Initial commissioning and set-up	20
Verify baseline conditions	20
Test various process optimisations	80
Define optimised standard operating procedure	10

2.4.3. The wastes that are proposed to be accepted at the site are hazardous and non-hazardous and fall under Chapters 16 and 20 of the LoW. These relate to the waste streams delivered to site in waste containers.

2.4.4. Following waste acceptance checks, the PCBs are subject to pre-processing which involves the removal of aluminium and steel components (usually associated with heat sinks and structural components), and removal of any batteries and magnets. The PCBs are then shredded to less than 3mm particle size and then micronized to less than 100µm.

2.4.5. Various metals recovery stages are then undertaken through two main processing cycles, described as DES 1 and DES 2, which generate process wastes. There are two liquid waste streams from the process cycles which are liquid condensate and liquid with residual DES.

2.4.6. The wastewater streams are comprised mainly of water with chemical residues associated with the DES process steps. There is potential for some leaching of metals from the waste PCBs, and those known to be present in the processing. Previous research of PCB composition by DEScycle has not identified arsenic, cadmium or mercury. The substances that may potentially be in the liquid waste are provided below in Table 3.

Table 3: [redacted]

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

2.5. Step 1.5: Identify the Constituents to be Tested

2.5.1. As the liquid waste streams have not been subject to sampling and analysis previously, it is considered appropriate to utilise a wide sweep of substances, typical wastewater analytical suite, along with additional substances that have the potential to be present. PCBs are known to have a wide and varied composition; therefore, initial analysis should seek to encompass as much as possible. A potential analytical suite is provided in Table 4.

Table 4: [redacted]

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

2.5.2. The analysis suite requires consultation with the laboratory to determine which determinants can be analysed and how. Not all of those listed in Table 4 may be appropriate or necessary.

2.5.3. Any analysis suite utilised will have to assess for POPs/PFAS and BFRs. Discussions are underway with various laboratories. Liaison and further communication will be required to ascertain if the various waste streams can be tested and also if accreditation is available. From an initial review of potential testing suites, a PFAS wastewater suite seems a reasonable starting point.

Table 5: [redacted]

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

2.6. Step 1.6: Health and Safety Precautions

2.6.1. The sampling of the liquid waste will be assessed and is subject to a specific safe working procedure (“SWP”), titled ‘SWP Sampling Liquid Waste’, and will be provided in Appendix II [*procedure is still in development]*.

2.6.2. The SWP will consider the use of eye protection, protective gloves, protective clothing, safety boots and high visibility clothing.

3. STEP 2: DEVELOP TECHNICAL GOALS FROM OBJECTIVE

3.1. Step 2.1: Define the Population to be Sampled

3.1.1. The population relates to the liquid waste generated from the process steps associated with the DES metal recovery stages undertaken on the waste PCBs delivered to site in various types of waste containers. For this trial, the volume of liquid waste will be that generated through the processing of the 32.5 tonnes of waste PCBs is yet to be quantified. However, the overall population of the liquid waste will be the total volume associated with the 130 batches processes over the duration of the trial.. The overall population will have inherent variability due to variability in the composition of the waste PCB materials received on site within the waste containers.

3.1.2. Pre-processing activity on the incoming PCBs involves the removing of aluminium and steel components that become a waste stream sent for recycling off site. In addition, batteries and magnets are removed which become additional waste streams for offsite recycling. The pre-processing steps have no influence on the population under assessment.

3.1.3. Variability of the population, after pre-processing, is governed by the waste throughput volumes of particular types of PCB, the age of PCBs in respect of how the actual boards may have been manufactured and the substances used in manufacturing, along with the age and size of components on the PCBs. Electronic component design, manufacture and composition have been continually evolving.

3.1.4. However, pre-processing is followed by shredding and micronisation which effectively blends the PCB composition for the batch being processed. Each batch is a volume of 250kg and comprised of PCBs removed from the waste containers. The liquid waste from each batch processed is effectively a subpopulation of the overall population. A number of sampling events generating results for subpopulations are required to produce an initial Basic (Comprehensive) characterisation.

3.2. Step 2.2: Assess Variability

3.2.1. As discussed in Step 2.1 above, there is inherent variability of the PCB waste that will be received at site, but the number of waste containers or overall volume of waste received does not determine the variability within the waste. This is driven by the composition of boards at the manufacturing stage, the population of boards with electronic components (number of them, type, age, means of attaching to the board) and the purpose or nature in which individual PCB were designed for use.

3.2.2. Not all of this variability may be relevant for the liquid waste. The purpose of processing is to extract certain metals with chemistry designed to achieve that. It is not believed that many substances will be extracted from the board themselves. However, that possibility is not discounted. The process steps themselves may create variability in respect of the chemistry and how well aligned to the assay results used to determine the DES to be used for each batch processed. In the absence of analysis results, it is difficult to determine if process variability will influence assessment and characterisation of the waste stream.

3.2.3. It is difficult to determine if spatial variation associated with the contributing sources of PCBs, their frequency of supplying waste PCBs, and their overall contribution to the quantity received for processing will impact variation on liquid waste generated. The shredding and micronising will have some 'blending' effect on the PCB waste streams received and effectively provides some level of homogenisation and reducing the variability of substances that may be present. However, this will be somewhat dependant on how the PCB waste is received to site, such as only one, or limited, type of board in each waste container.

3.2.4. Temporal variation is unlikely to be a factor in this assessment as it is limited to the trial based on the 32.5 tonnes of waste PCBs.

3.2.5. Within stratum variability could potentially be introduced through greater volume of one particular source of PCB waste being received for the trial, compared to other sources.

3.2.6. It is highly likely that between stratum variation would be found through sampling liquid waste from every single batch that is processed for the trial, however, this would be very costly and not representative of how the liquid waste would leave site.

3.2.7. For the purposes of this trial assessment, it is not considered that cyclic temporal variability within the waste PCBs will need to be given any regard.

3.3. Step 2.3: Scale of Sampling

3.3.1. For the BCC characterisation, the scale of sampling is considered best assessed against the volume of liquid waste generated from the batches processed for the trial purposes.

3.3.2. The study period will be the period of time taken to undertake the trial objectives detailed in Table 2 above. This period should be sufficient to generate enough samples that provide confidence in the classification assessment and to identify the composition of the liquid waste and whether BFRs / POPs are present.

3.3.3. Although sampling and analysis of liquid waste from every batch may not be feasible or practicable, there may be merit in sampling at the process cycle level to determine any significant variation between the two cycle outputs. This information may help inform commercial scale operations and any benefit in splitting the liquid waste streams by cycle.

3.3.4. The liquid waste storage tank is still under detailed design, and the quantity of liquid waste generated from each batch, and the condensate volume is yet to be quantified.

3.3.5. The sampling rate and quantities are to be confirmed once it is known how much liquid waste is generated from the process and over what time frame or number of batches. Sample volumes will need to be sufficient to undertake all analysis scheduled.

3.3.6. A review of each individual sample results will be undertaken as they are received to generate an indicative classification of the waste stream. The results will be collated together with a review of the results and full WM3 assessment undertaken. This will hopefully confirm the appropriate waste classification through an initial BCC assessment.

3.3.7. The sample volume for each of the composite / sample required will be placed into different types of sample containers for the different analysis to be undertaken, with containers securely sealed for transportation within a cool box. A total volume sample over the study period will be calculated.

3.3.8. At this stage, it is considered the proposed scale of sampling is likely to be based on Option (I) detailed in the WM3 guidance for 'Step 2.3 Scale of Sampling', and random probabilistic sampling.

4. STEP 3: DETERMINE THE PRACTICAL INSTRUCTIONS

4.1. Step 3.1: Choose the Statistical Approach

4.1.1. At the time of writing there are no sample results to validate a particular statistical approach.

4.1.2. The proposed sampling regime, once defined, will hopefully help to identify whether there is limited variability in results and inform sampling going forward. A review of all results, both individually and in combination will be undertaken.

4.1.3. The statistical approach will be looked at further once all sample results have been received, however, it is considered at this stage that Parametric method A or Non-parametric method B will be used to identify whether the sampling undertaken is likely to have been sufficient to determine the liquid waste is non-hazardous, with confidence.

4.2. Step 3.2: Select the Sampling Approach

4.2.1. There are four sources of liquid waste associated with the processing of waste PCBs. These relate to liquid condensate and liquid with residual DES from both DES 1 and DES 2 cycles. These will be combined within the liquid waste storage tank before transferring off site for disposal or treatment. It is not believed that the condensate contains much contamination, but it could be worthwhile checking specifically for the presence of contaminant concentrations to ascertain whether it is worth segregating the condensate from the liquid with residual DES.

4.2.2. As the four sources of process liquid waste all end up in the liquid waste storage tank, it is from this tank that samples for analysis should be taken and used for the WM3 assessment.

4.2.3. The waste PCB processing is not a continuous process, and the process equipment is used for a number of process steps. The process is a batch process with each batch subject to both DES 1 and DES 2 process steps. There is likely to be variation of substance composition from each of the liquid waste sources, but the variation will be masked through homogenisation within the liquid waste storage tank. Each addition of liquid waste from one of the four sources is a subpopulation of the overall population. This assumes there is no layering effect within the liquid waste storage tank. It may be advantageous to identify whether all four sources are non-hazardous or if different waste controls should be applied to any of them.

4.2.4. The specific sampling regime and pattern are to be determined.

4.3. Step 3.3: Determine the Type, Number and Size of Samples Required

4.3.1. The nature of activities has been considered and in the context of how the activities 'generate' the liquid waste and the composition of the liquid waste, and how they may change with the processing of different types of PCBs being processed.

4.3.2. The number of individual sample containers will be confirmed by the Laboratory for each sample taken from the liquid waste storage tank on each occasion of sampling for a number of consecutive sampling events [*TBC*].

4.3.3. The sample size must be sufficient for the laboratory to undertake the necessary analysis. The quantity supplied to the Laboratory will be confirmed. The Laboratory will then undertake sample preparation on each sample received for the analysis of different substances to be undertaken.

4.3.4. The samples will be physically taken from the liquid waste storage tank via a drain point. The equipment used for removing samples from the tank and transferring to the appropriate sample containers is yet to be confirmed. Care will be taken in ensuring the containers are as full as possible to provide adequate volumes of samples and to minimize headspace for the respective necessary analysis.

4.4. Step 3.4: Identify Sampling Techniques

4.4.1. The liquid waste sampling methodology has been based on the guidance provided in the WM3 Technical Guidance (Waste Classification – Guidance on the classification and assessment of waste (1st Edition v1.2 GB)) [October 2021].

5. STEP 5: DEFINE AND DOCUMENT THE SAMPLING PLAN

5.1. Documented Sampling Plan

5.1.1. The preceding sections describing the development and rationale of the sampling plan, based on the WM3 guidance, are summarised in the Sample Plan Document Record in Appendix III [*TBC*].

6. STEP 6: SUBSEQUENT STEPS

6.1. Taking the Samples

6.1.1. Sampling is undertaken by DEScycle employees in accordance with the sampling SWP. The document contains a sample record sheet to identify each sample event that is used to produce a composite sample.

6.1.2. Eye protection, protective gloves and clothing, safety boots and high visibility clothing are all required for the sampling.

6.1.3. The samples are physically removed and placed into the appropriate containment. Containers are labelled and referenced, with the same details also being logged on the sample record sheet for traceability. Samples are then dispatched to the laboratory for analysis.

6.2. Analytical Methods

6.2.1. The laboratory arranging the analytical analysis of PCB waste is yet to be confirmed.

6.3. Sample Records

6.3.1. The sample records comprise of:

- Sample Plan (this document)
- Sample Plan Document Record (Appendix III)
- Sampling Record (for each sample taken)
- Chain of Custody Form (for each set of samples)
- Sample Analysis Request

6.3.2. Analysis results supplied by the Laboratory conform to the requirements of their UKAS accreditation, along with their in-house protocols and procedures. The results reports include details on the specific test methods, the substances analysed, the limit of detection ("LOD"), the units of measurement and the analysis results. The reports also include details of any deviations, where appropriate, the laboratory number, the sample identification number/reference, type of sample, sampling date and the sampling time.

APPENDIX I

DESCYCLE

INDICATIVE SITE LOCATION PLAN

APPENDIX II

DESCYCLE

SAFE WORKING PROCEDURE [TBC]

APPENDIX III

DESCYCLE

SAMPLE PLAN DOCUMENT RECORD [TBC]