

Gypsum

A technical report on the production and
use of gypsum from waste plasterboard

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Executive summary

Background

The Waste Protocols Project is a joint Environment Agency and WRAP (Waste & Resources Action Programme) initiative in collaboration with industry, funded by the Department for Environment, Food and Rural Affairs (Defra) as a business resource efficiency activity. The aim of the Waste Protocols Project is to provide guidance to business on a number of waste streams that will:

- define the point of full recovery from a waste back into a product or material that can be reused by the business or industry or sold into other markets; or
- confirm to the business community what legal obligations remain to control the reuse of the treated waste material.

Gypsum from waste plasterboard was chosen as one of the waste streams to be addressed by the Waste Protocols Project. A Technical Advisory Group (TAG) was set up to bring together representatives from the Environment Agency, WRAP and industry.

The Project Board asked the TAG to consider the feasibility of producing a Quality Protocol that would enable the point of recovery of gypsum to be moved closer to the point of production. The TAG was asked to consider the potential for using Publicly Available Specification PAS 109:2008 for producing gypsum from waste plasterboard as part of the Quality Protocol. PAS 109: 2008 was developed by WRAP in collaboration with the British Standards Institution (BSI).

Methodology

The TAG's remit was to produce a technical report setting out the process and controls necessary to determine at which point gypsum from waste plasterboard ceases to be waste. In doing so, the TAG:

- identified and quantified the major markets and appropriate end uses for gypsum from waste plasterboard;
- identified the current legislative framework that governs the production, handling, storage, transportation and use of gypsum from waste plasterboard;
- obtained and compared analytical data on the quality of gypsum from waste plasterboard produced to market specifications;
- identified and subjectively quantified the relative risk to human health and the environment, from the use of gypsum from waste plasterboard in the manufacture of plasterboard and gypsum-based construction materials and the agricultural application of gypsum as a soil treatment; and
- proposed appropriate mitigation measures and routes forward for each of the major markets.

Findings

- The scope of this technical report is restricted to the processing of plasterboard as defined in PAS 109:2008 (full definition reproduced in Appendix E of this report).
- There are a number of market uses for gypsum recovered from waste plasterboard. Many of these markets and manufacturing processes are well established. The TAG agreed the key markets for gypsum from waste plasterboard include:
 - as a raw material in the manufacture of new plasterboard and plasterboard products;
 - as a beneficial soil treatment agent for use in agriculture; and
 - as an additive in cement clinker.

Whilst the risk assessment did not quantitatively address the risks associated with the use of waste plasterboard as an additive in cement clinker, the TAG undertook a qualitative assessment. They considered that the use of gypsum from waste plasterboard posed no greater risk to human health and the environment than the use of virgin gypsum in cement. The TAG recommends including a question in the consultation to establish wider industry views on this end use.

Gypsum from waste plasterboard can be processed to a suitable, defined and consistent product specification as described in PAS 109:2008. Having reviewed the production process, quality control measures and product specifications in PAS 109:2008, the TAG agreed these should represent the minimum requirements for gypsum from waste plasterboard.

Risk assessment and management

Following a review of the outputs of the risk assessment, the TAG concluded:

- based on the comparative analysis of gypsum from waste plasterboard and natural and agricultural gypsum, it is apparent that the level of contamination with respect to potentially toxic elements in natural and agricultural gypsum is considerably higher than that for gypsum from waste plasterboard. This is used as an evidence of lower levels of total and potentially leachable metals from gypsum from waste plasterboard in comparison with gypsum from natural sources;
- the risk to human health, surface water quality and groundwater quality from gypsum from waste plasterboard applications for the scenarios assessed is considered to be low provided specific measures are followed;
- the rates of gypsum from waste plasterboard applied to agricultural land should comply with the *Code of Practice for Agricultural Use of Sewage Sludge* (the Sludge Code);
- provision of guidance to the agricultural industry on the number of applications of gypsum from waste plasterboard as an agricultural fertiliser, together with the standard good practice used in soil management, is sufficient to mitigate any environmental risks from its use;
- the risk to the workforce and the general population from exposure to gypsum from waste plasterboard during its use can be effectively mitigated by following good site practice and use of personal protective equipment; and
- to prevent any potential contamination of controlled water resources, 100 per cent gypsum should be stored in a contained area, under cover, protected from flooding and with protection against release to drains or surface water.

Suitability and certainty of use

By following the guidance and quality management systems detailed in PAS 109:2008, the TAG considers that gypsum from waste plasterboard can be produced in the UK to a suitable specification that enables it to compete with raw materials such as natural or synthetic gypsum.

The TAG believes there is a high demand in the chosen end use markets and therefore the material is certain to be used for such applications.

The TAG concluded that the specifications contained within PAS 109:2008 represent the minimum standards to be achieved by processors that supply gypsum from waste plasterboard for the manufacture of new plasterboard. It recognises that the specifications for gypsum from waste plasterboard are market-led and that customers using the material in the manufacture of new plasterboard may, in some cases, require it to meet an additional specification (e.g. such as the specification being developed by Eurogypsum).

Whilst PAS 109:2008 provides a quality standard, it does not consider the potential risk of harm to the environment. In order to be able to demonstrate that gypsum from waste plasterboard material ceases to be waste, this is an important issue. It is proposed that the maximum metal values in Table D4 are used to create an additional standard. These metal values have been risk assessed and demonstrated to pose acceptable risk of harm to human health and the environment. This means that any quality protocol would require producers to ensure the gypsum they produce meets both the maximum metal limits set out in Table D4 and the requirements of PAS 109:2008. It will also be necessary to agree test methods and frequency of testing, and it is proposed that this is done through the Quality Protocol consultation.

In the case of agricultural use of gypsum from waste plasterboard, batch analysis has demonstrated that the product specifications contained within PAS 109:2008 are suitable and can be met. The application of gypsum to land as a soil treatment agent should conform to the requirements set out in:

- *Codes of Good Agricultural Practice for Air, Water and Soil* (CoGAP) (or subsequent guidance);
- the Sludge (Use in Agriculture) Regulations 1989 (as amended); and
- *Code of Practice for Agricultural Use of Sewage Sludge* (the Sludge Code).

The TAG concluded there is a strong argument that gypsum from waste plasterboard that complies with PAS 109:2008 and quality assurance measures will give end users adequate confidence in the quality of the material to demonstrate that it is certain to be used.

The TAG propose that good practice should be adopted with respect to the record-keeping on the storage, production and supply of gypsum products in order to maintain customer confidence in product quality.

Requirements for no further processing

Evidence gathered during the development of this technical report demonstrates that gypsum from waste plasterboard leaving the site of production requires no further processing in order for it to be used in agricultural applications.

Further processing of the gypsum from waste plasterboard may be undertaken during the manufacture of new plasterboard. However, this processing is also applied to virgin raw material and, as such, does not prejudice the requirement for no further processing.

Recommendations

In recognition of these findings, the TAG recommends that there is adequate evidence to support development of a Quality Protocol. The Quality Protocol should adopt:

- the product standards and quality controls in PAS 109:2008 and a standard setting out maximum metal concentrations in Table D4 in order for gypsum from waste plasterboard processed to those standards not to be classified as a waste;
- test methods and frequencies which ensure compliance with the maximum metal concentrations standard;
- record keeping and supply documentation are retained; and
- the risk mitigation measures and recommendations for adoption of good practice highlighted in the technical report.

The TAG recommend that wider industry opinion is sought through the Quality Protocol consultation process on the following issues:

- whether the qualitative assessment of gypsum in cement clinker made is sufficient;
- whether the industry feels certification is required; and
- whether an agricultural tool should be developed to calculate suitable application rates for gypsum to soil.

It is also recommended that the Quality Protocol should be reviewed at least every two years or earlier if there are any changes to processing technology or material use.

1. Introduction

- 1.1 The Waste Protocols Project is a joint Environment Agency and WRAP (Waste & Resources Action Programme) initiative in collaboration with industry, funded by the Department for Environment Food and Rural Affairs (Defra) as a business resource efficiency activity.
- 1.2 Uncertainty over the point at which 'waste' is fully recovered and ceases to be waste within the meaning of Article 1(1)(a) of the EU Waste Framework Directive (2006/12/EC) has inhibited the development and marketing of materials produced from waste which could be used beneficially without damaging human health and the environment. In some cases, this uncertainty has also inhibited the recovery and recycling of waste and its diversion from landfill.
- 1.3 Interpretation of EU legislation is ultimately a matter for the European Court of Justice and there is now a substantial body of case law on the interpretation of the definition of waste in Article 1(1)(a) of the Waste Framework Directive. Drawing on the principles established in this case law, it is possible to identify the point at which certain wastes cease to be waste and thus when the Directive's waste management controls no longer apply. This identification is the purpose of the Waste Protocols Project.
- 1.4 More specifically, depending on the circumstances of the waste stream concerned, the project seeks to achieve one of the following outcomes:
 - to produce a Quality Protocol defining the point at which waste, having been the subject of a complete recovery operation, may become a non-waste product or material that can be either reused by business or industry, or supplied into other markets, enabling such fully recovered products to be used without the need for waste management controls; and
 - to produce a statement that confirms to the business community what legal obligations they must comply with to use the treated waste material.
- 1.5 Gypsum from waste plasterboard is one of the waste streams addressed by the Waste Protocols Project. A Technical Advisory Group (TAG) was set up to bring together representatives from the Environment Agency, WRAP and industry. Appendix A contains a list of TAG members and Appendix B gives its terms of reference.
- 1.6 For the purposes of this technical report and the production of any future Quality Protocol, the TAG defined 'gypsum from waste plasterboard' as gypsum that has been processed from plasterboard materials that conform to the definition given in PAS 109:2008.¹
- 1.7 Any subsequent reference to waste plasterboard will only apply to the input materials specified in the definition of plasterboard in paragraph 3.12 of PAS 109:2008. The full definition is reproduced in Appendix E.
- 1.8 In summary, input materials include:
 - a gypsum plaster core encased in, and firmly bonded to, strong durable paper liner to form a flat rectangular board;
 - gypsum boards with mat reinforcement – a gypsum core bonded to a woven or non-woven sheet of inorganic or organic fibres located on or just below the surfaces;
 - gypsum fibre boards – set gypsum plaster reinforced with dispersed fibres, which may be inorganic and/or organic, to form flat rectangular boards; and
 - plasterboard cornice – pre-formed paper covered gypsum section with profiled face supported by shoulders.

¹ PAS 109: 2008 Specification for the production of recycled gypsum from waste plasterboard, BSI, 28 August 2008. Developed by WRAP in collaboration with the British Standards Institution (BSI). Available from BSI Customer Services (Tel: 020 8996 9001; cservices@bsigroup.com) or the WRAP website (<http://www.wrap.org.uk/document.rm?id=5761>).

- 1.9 Common sources of waste plasterboard include:
- plasterboard manufacturing waste;
 - plasterboard stripped out during refurbishment or demolition of buildings and facilities;
 - plasterboard arising from construction sites as a result of over-ordering or incorrect specification;
 - plasterboard that has been damaged and is unsuitable for installation; and
 - plasterboard off-cuts arising during the refurbishment or construction of buildings and facilities.
- 1.10 For gypsum from waste plasterboard to be considered as having ceased to be waste, it is necessary to demonstrate that:
- the material has been fully recovered; and
 - there is no further need for waste management controls.
- 1.11 Therefore the TAG considered in particular whether the waste has been made into a distinct product by meeting the following criteria:
- having a market and certainty of use;
 - meeting an appropriate publicly available standard (e.g. an identified specification) requiring no further processing before being used; and
 - capable of being used without undermining the aims of the Waste Framework Directive and the Water Framework Directive of protecting human health and the environment.
- 1.12 To investigate this last point, the TAG considered (when applicable) whether the waste-derived product can be used in the same way as the virgin material it replaces and with no worse environmental effects.
- 1.13 The objectives of this report are to:
- describe the progress of the TAG on this topic; and
 - set out the TAG's findings to the Project Board and the Environment Agency on what steps are needed to meet one of the project outcomes as stated in paragraph 1.4.
- 1.14 In developing this technical report, the TAG:
- identified and quantified the major markets and appropriate end uses for gypsum from waste plasterboard;
 - identified the current legislative framework that governs the production, handling, storage, transportation and use of gypsum from waste plasterboard;
 - obtained and compared analytical data on the quality of gypsum from waste plasterboard produced to publicly available specifications; and
 - identified and quantified the relative risk to human health and the environment from the use of gypsum from waste plasterboard in each individual market – namely agriculture, cement and plasterboard manufacture.
- 1.15 The following are excluded from the scope of this technical report:
- the use of gypsum from waste plasterboard in any end market use other than those explicitly stated in Section 4;
 - the processing of gypsum from input materials other than those covered by the definition of plasterboard in PAS 109:2008 (as reproduced in Appendix E of this report);
 - the paper or mat coating that is stripped off waste plasterboard – this will remain a waste;
 - any foreign materials removed from the waste plasterboard during the processing of waste plasterboard such as nails, screws, wood, metal beading, and sealing tape. These materials will remain a waste; and

- gypsum from any sources other than waste plasterboard, including gypsum that has been produced as a by-product of the flue gas desulphurisation (FGD) process commonly used as an emissions abatement technique on large combustion plant such as coal-fired power stations.

1.16 This scope of this technical report is limited to the processing of plasterboard as defined in PAS 109:2008. Having assessed the potential uses for gypsum from waste plasterboard, the TAG has identified and considered the following applications:

- as a raw material for use in the manufacture of new gypsum-based products (e.g. plasterboard and coving products);
- as a soil treatment agent for agricultural benefit; and
- as an additive in cement clinker.

2. Process description

- 2.1 This section considers the process applied to waste plasterboard to recover gypsum. Once processed, the resulting product is termed 'gypsum from waste plasterboard'. Sources of waste plasterboard and typical methods used for the capture, collection, transportation and processing of gypsum from waste plasterboard are outlined below.

Sources of waste plasterboard

Waste from the manufacture of plasterboard

- 2.2 Businesses that manufacture plasterboard generate waste plasterboard in the form of products that are damaged or do not meet the required standard. Rejected and scrap plasterboards are identified and rejected during the quality control (QC) process applied at various stages of the production process and logistics chain. Part of this waste plasterboard is sent for recycling depending on its suitability, which in turn depends on the characteristics of the recycling facility to which the rejected material is sent. The remainder of the waste plasterboard is sent for disposal.

Construction sites

- 2.3 Construction sites generate waste from new plasterboard that has not been used. The waste can be in the form of off-cuts, plasterboard damaged on-site and over-ordered plasterboard. This material is often uncontaminated and can be relatively easily separated for recycling.

Refurbishment and demolition projects

- 2.4 During refurbishment projects, waste plasterboard is produced when plasterboard products are removed at the 'strip out' stage. Those that are suitable can be separated and recycled.
- 2.5 As in the case of construction sites, waste plasterboard can also be generated from new plasterboard brought onto the site and never used. This waste plasterboard again takes the form of off-cuts, damaged and over-ordered material. It is often uncontaminated and can be relatively easy to separate for recycling.
- 2.6 Where buildings are being demolished, plasterboard products are identified during the tender process for the work. Plasterboard that is suitable for recycling can be removed and collected separately from unsuitable material destined for disposal.

Household waste recycling centres

- 2.7 The general public can take waste plasterboard – typically arising from DIY projects – to household waste recycling centres (HWRCs) for disposal. Some HWRCs provide separate containers for waste plasterboard that is suitable for recycling. The sites are supervised by trained staff who seek to ensure only suitable waste is put into the containers and contamination is kept to a minimum.

Waste transfer stations

- 2.8 Many waste transfer stations accept mixed construction waste. The waste is typically transported to the facility in skips that can range in size from 2 cu yd to 40 cu yd. The mixed waste is deposited in the sorting area where waste plasterboard suitable for recycling is identified by eye. It is either selected mechanically or by hand before being transferred to a dedicated bay or container for onward transport.

Capture, collection and transportation of waste plasterboard

- 2.9 The methods used to identify and separately collect waste plasterboard suitable for recycling at the place of production vary depending on the type of site and the scale of the activity. Typical capture methods include demountable skip loaders, wheelie bins and flexible bulk bags, and even wheelbarrows on smaller sites.
- 2.10 Waste plasterboard is picked up from site and transported in a number of ways depending on the container, quantity of waste plasterboard captured and proximity to the recycling facility. This can include the use of vehicles fitted with hydraulic grabs, or bulk transport using articulated vehicles with walking floor trailers for very large volumes.

Waste plasterboard processing and recycling facilities

- 2.11 Waste plasterboard is processed by crushing and screening to separate the gypsum from the paper facing or matting preceded or followed by the separation and removal of metals and other non-gypsum materials. The resulting gypsum powder is suitable for use in selected applications with no further processing. Some applications require gypsum from waste plasterboard to be subject to additional processes to grade it or transform it into an alternative form.
- 2.12 A generic process diagram for producing gypsum from waste plasterboard taken from PAS 109:2008 is reproduced in Appendix C.

3. Current legislative position

- 3.1 The following provisions apply to the collection, storage and processing of waste plasterboard into gypsum from waste plasterboard:
- the Environmental Protection Act 1990 (as amended) places a duty on those holding or discarding waste to ensure that it is transferred to an authorised person (such as a licensed waste management contractor or a waste collection authority);
 - the Environmental Protection (Duty of Care) Regulations 1991 (as amended) require the signed notification of waste transfers and the maintenance of records of wastes received and disposed of by an individual/company or site; and
 - the Environment Permitting (England and Wales) Regulations 2007 (EPR)² contain provisions concerning environmental permits. The regulations require a permit for the operation of a regulated facility. The term 'regulated facility' covers both a waste operation and an installation that carries out any activity listed in Schedule 1 of the regulations and activities that have a technical connection. These regulations include exemptions for certain types of waste operations.
- 3.2 In accordance with these regulations, waste plasterboard should only be collected and transferred to recyclers or the site of manufacture by a registered waste carrier (i.e. a haulier registered with the Environment Agency).
- 3.3 Table 3.1 summarises the current legislative controls on:
- transportation of waste plasterboard;
 - processing of waste plasterboard into gypsum from waste plasterboard;
 - delivery/receipt of final product once it has left the recycling site;
 - use of gypsum from waste plasterboard; and
 - landfilling of waste gypsum products.

The REACH Regulation

- 3.4 The REACH (Registration, Evaluation, Authorisation and Restrictions of Chemicals) Regulation³ came into force in the EU on 1 June 2007. It aims to improve protection of human health and the environment by making more information available about materials and products.
- 3.5 The regulation applies to 'substances', 'preparations' (mixtures of substances), and 'articles'. These are defined in Articles 3(1), (2) and (3) of the regulation as:
- '1) Substance: means a chemical element and its compounds in the natural state or obtained by any manufacturing process, including any additive necessary to preserve its stability and any impurity deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the substance or changing its composition;
 - 2) Preparation: means a mixture or solution composed of two or more substances;
 - 3) Article: means an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition;'
- 3.5.1 All these exclude waste as defined in the Waste Framework Directive. It follows that compliance with a Quality Protocol, while resulting in the removal of the need to apply waste management controls, could bring the material or product concerned within the scope of the REACH Regulation.

² These Regulations (SI 2007/3538) (http://www.opsu.gov.uk/si/si2007/uksi_20073538_en_1) introduced a new streamlined system of environmental permitting in England and Wales for certain installations, waste operations and mobile plants. They replaced over 40 pieces of legislation governing waste management licensing under the Environmental Protection Act 1990 and the Waste Management Licensing Regulations 1994 (SI 1994/1056) and the system permitting in the Pollution Prevention and Control (England and Wales) Regulations 2000 (SI 2000/1973), so that activities under these regimes are now covered by a single form of environmental permit governed by one set of regulations. These regulations also re-transposed into national law, the obligations in EU Directives 87/217/EEC, 92/112/EEC, 94/63/EC, 96/61/EC, 1999/31/EC, 2000/53/EC, 2000/76/EC, 2001/80/EC, 2002/96/EC and 2006/12/EC with regard to permits. These regulations came into force in 6 April 2008 and apply to England and Wales only.

³ Regulation (EC) No. 1907/2006 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No. 793/93 and Commission Regulation (EC) No. 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.

- 3.5.2 The main effect is that, unless the material falls within one of the exemptions in the REACH regulation, it may need to be registered by its manufacturer or importer in order to be marketed in the EU. Certain substances are eligible for phased registration over a 10-year period ('phase-in substances') but, to qualify, they must have been pre-registered with the new European Chemicals Agency between 1 June and 30 November 2008. Otherwise, substances new to the market will be required to be registered from 1 December 2008.
- 3.5.3 Further information on this and other processes relating to REACH is available from the UK REACH Competent Authority website at (<http://www.hse.gov.uk/reach>). Specific advice can be available from the Competent Authority Helpdesk on 0845 408 9575 or email ukreachca@hse.gov.uk

Table 3.1: Summary of current legislative controls

Activities	Current legislative control
Delivery of waste plasterboard for processing into gypsum from waste plasterboard	Waste plasterboard delivered for processing is considered to be a waste and must be handled according to the waste Duty of Care in the Environmental Protection Act 1990 and the Environmental Protection (Duty of Care) Regulations 1991. The waste plasterboard must be transported by a person who is registered as a waste carrier.
Storage of waste plasterboard	The storage pending disposal or recovery requires an environmental permit under EPR.
Processing of waste plasterboard into gypsum from waste plasterboard	The disposal or recovery of waste gypsum requires an Environmental Permit (as a waste operation) under EPR. If the gypsum from waste plasterboard is to be milled into a powder, the operation of an installation carrying out that activity will require an Environmental Permit as this falls within the list of activities in Schedule 1 of EPR.
Delivery of gypsum from waste plasterboard to end user (consumer)	Gypsum from waste plasterboard is currently viewed as waste and must be handled according to the waste Duty of Care in the Environmental Protection Act 1990 and the Environmental Protection (Duty of Care) Regulations 1991. The materials must be transported by a person who is registered as a waste carrier.
Use of gypsum from waste plasterboard by the consumer	Gypsum from waste plasterboard is currently viewed as a waste and its use requires an Environmental Permit under EPR unless the activity is an exempt waste operation as defined in Regulation 5 of EPR.
Use in agriculture	Treatment of land used for agriculture with gypsum is currently viewed as waste operation and will require an environmental permit under EPR unless the activity is an exempt waste operation as defined in Regulation 5 of EPR.
Manufacture of plasterboard from waste gypsum and associated storage	Manufacturing plasterboard from waste gypsum and storage of gypsum associated with this process requires an environmental permit under EPR unless the activity is an exempt waste operation as defined in Regulation 5 of EPR.
Storage of gypsum prior to use in certain construction works	Storage pending use of gypsum in construction works is currently viewed as waste operation and will require an environmental permit under EPR unless the activity is an exempt waste operation as defined in Regulation 5 of EPR.
Landfill of plasterboard and waste gypsum products	Landfilling of gypsum-based wastes is only allowed at sites that hold an Environmental Permit covering such an activity and in accordance with the requirements of the Landfill Directive (1999/31/EC).

4. Key markets

- 4.1 Gypsum from waste plasterboard can be used in a number of market applications. These have been considered by the TAG with regard to the criteria that must be met in order to redefine the point at which a material ceases to be a waste (see Section 1.11).
- 4.2 The market analysis within the Financial Impact Assessment⁴ identified the most significant markets for gypsum from waste plasterboard as:
- in plasterboard and plaster;
 - in cement; and
 - as an agricultural soil treatment.
- 4.3 The TAG identified a number of other potential end uses for gypsum from waste plasterboard. Examples of other end uses are described in PAS 109:2008 as follows:
- additive to horticultural growing media, including PAS 100 compost and mushroom compost;
 - hydraulically bound soil stabilisation and binding agent;
 - manufacture of construction products;
 - clarifying agent for aquatic environments; and
 - absorbent for liquid spillages.
- 4.4 Although these other end uses offer potential markets for gypsum from waste plasterboard, the TAG agreed there was insufficient information regarding their specification and use. As such, they had not been covered within the scope of the risk assessment work. This meant they could not be effectively judged against the criteria set out in Section 1.11. These other end uses are therefore excluded from the scope of this technical report.
- 4.5 The TAG further discussed the use of gypsum from waste plasterboard in the manufacture of cement, bearing in mind the established market size and low level of gypsum additions to the clinker (typically 2.5–4%). The TAG concluded that, given some qualitative assessment, this end use was likely to meet the criteria set out in Section 1.11. They considered that the use of gypsum from waste plasterboard posed no greater risk to human health and the environment than the use of virgin gypsum in cement, and was further safeguarded as the cement manufacturing process is regulated under EPR 2007. It therefore proposed raising the issue of whether their qualitative assessment of the potential environmental impact of the use of gypsum from waste plasterboard in the manufacture of cement is representative of wider industry views during the consultation process.
- 4.6 The Financial Impact Assessment report contains a detailed market analysis of the production and use of gypsum from waste plasterboard and assesses the potential impact of the Quality Protocol. The report concludes that the increased market value of gypsum from waste plasterboard resulting from the removal of waste management controls could total £10.9 million which compares favourably with the additional costs associated with complying with the Quality Protocol which have been estimated to be £2.42 million.

⁴ *Partial Financial Impact Assessment of the introduction of a Quality Protocol for the production and use of gypsum from waste plasterboard*, Environment Agency/WRAP, 2008.

5. Product standards and specification

Product standards for the receipt, production, storage and supply of gypsum from waste plasterboard

- 5.1 For gypsum from waste plasterboard to be considered a non-waste product, processors need to follow a recognised standard in order to produce a consistent product of suitable quality. This would give the regulator confidence that the material can be taken out of waste management control and end users adequate confidence in the quality of the material.
- 5.2 Compliance with the Quality Protocol would require producers to ensure they operate to product standards that include, as a minimum:
- a requirement to achieving the minimum specifications for the product types produced as detailed within this technical report;
 - a requirement to establish and carry out a sampling and testing regime to ensure and demonstrate consistent product quality;
 - a requirement to fulfilling customer requirements for the products that are specified to their needs or produced in accordance with the specifications detailed in this technical report;
 - a clearly identified scope of application; and
 - documentation of the process and its subsequent implementation by, and communication to, all those whose activities affect quality management and the quality of output products.
- 5.3 PAS 109:2008 was identified as being the most suitable product standard containing a series of requirements that detail industry good practice. Following a review of the sections setting out the procedures that manufacturers should follow, the TAG concluded that PAS 109:2008 currently represents the benchmark industry standard with regard to the receipt, production, storage and supply of gypsum from waste plasterboard.
- 5.4 At present, the requirement to process waste plasterboard according to PAS 109:2008 is voluntary.
- 5.5 The TAG suggest that if a Quality Protocol is produced it should state that in order to produce gypsum from waste plasterboard that is Quality Protocol compliant, processors should follow the requirements set out in Sections 4–11 inclusive of PAS 109:2008.
- 5.6 However, PAS109:2008 does not fully consider potential risks of harm to the environment. This will need to be considered and evaluated in order to demonstrate that the material has ceased to be waste.

Specifications for gypsum from waste plasterboard

- 5.7 The specifications agreed by the TAG aim to support the implementation of a Quality Protocol by:
- identifying the relevant specifications that recyclers of gypsum from waste plasterboard will be required to follow in order to demonstrate compliance with the Quality Protocol;
 - providing end users with increased levels of confidence that sources of gypsum from waste plasterboard will be manufactured to the same standard by different recyclers; and
 - providing a high degree of transparency for third party stakeholders (public regulators, companies).
- 5.8 The TAG concluded that the specifications in PAS 109:2008 with regard to the production of gypsum from waste plasterboard were representative of end user requirements.
- 5.9 The TAG recommends that the specifications in PAS 109:2008 should be the standard to which gypsum from waste plasterboard should comply with to be regarded as a quality product and therefore cease to be a waste at the point it is despatched to the customer. These specifications can be split into the identified end use applications as set out on page 13.

Gypsum from waste plasterboard for use in the manufacture of new plasterboard and gypsum-based products

- 5.10 Where gypsum from waste plasterboard is used as a raw material in the manufacture of new plasterboard, the TAG believes major plasterboard manufacturers will be committed to accepting gypsum from waste plasterboard that has been processed to a product specification defined by the European Federation of National Associations of Producers of Gypsum Products (Eurogypsum). The Eurogypsum specification is currently under development and thus the TAG has been unable to assess its suitability as a reference standard for the Quality Protocol.
- 5.11 The TAG recognises that customers may wish to apply additional requirements to those in the Quality Protocol such as the forthcoming Eurogypsum specification or bespoke specifications to meet their particular requirements.

Gypsum from waste plasterboard for use in the manufacture of cement

- 5.12 At present, there are no agreed standard or specifications for gypsum from waste plasterboard which is used as an additive to cement clinker in the manufacture of cement.

Gypsum from waste plasterboard for use as a beneficial treatment agent for soils in agricultural applications

- 5.13 At present, there are no agreed standard specifications for gypsum from waste plasterboard sold for beneficial use as a soil improver. The specifications are defined by the requirements of the end user. The TAG concluded that gypsum from waste plasterboard meeting the product specifications in PAS 109:2008 can (on the basis of the figures submitted) meet the product specifications given for agricultural gypsum (natural gypsum).
- 5.14 Analytical test results showed little fluctuation over time. There is therefore a high degree of certainty that gypsum from waste plasterboard can repeatedly meet a designated standard.
- 5.15 The TAG concluded that the application rate of gypsum from waste plasterboard to land as a soil treatment agent must conform to the requirements set out in:
- *Codes of Good Agricultural Practice* (for Air, Water and Soil CoGAP) (or subsequent guidance);⁵
 - the Sludge (Use in Agriculture) Regulations 1989 (as amended);⁶ and
 - *Code of Practice for Agricultural Use of Sewage Sludge* (the Sludge Code).⁷
- 5.16 Application rates will be limited by the levels of Potentially Toxic Elements (PTEs) present in the gypsum from waste plasterboard. PTEs in soil has to be taken into consideration on site by site basis.
- ### **Independent certification and material verification**
- 5.17 There needs to be a balance between a requirement for independent certification and the benefits of not requiring certification. Any certification requirement should mirror existing arrangements as closely as possible as these have been developed in conjunction with industrial customers receiving gypsum from waste plasterboard as a product.
- 5.18 Processors of gypsum from waste plasterboard wishing to comply with the requirements of the Quality Protocol would have to meet the product standards and quality assurance procedures set out in PAS 109:2008. These product standards define the ultimate quality and consistency of the end material and the process used. This supports the argument for not requiring an independent certification mechanism that may be costly and onerous to administer and is unlikely to provide significant benefits to industry.

5 See <http://www.defra.gov.uk/FARM/environment/cogap/index.htm>

6 See <http://www.defra.gov.uk/farm/waste/sludge/index.htm>

7 See <http://www.defra.gov.uk/environment/water/quality/sewage/sludge-report.pdf>

- 5.19 Processing of gypsum from waste plasterboard for sale into agriculture will be undertaken in accordance with defined product standards which require quality control measures including batch testing. In practice this is often supplemented by independent verification of analysis results by agronomists. This further supports the case that further independent certification would not offer any substantial benefits for either the manufacturer or the customer.
- 5.20 For gypsum from waste plasterboard going into agricultural applications, there are mechanisms where parallels could be drawn, such as compost, where there is an interactive on-line tool which farmers and agronomists can use to calculate application rates of compost to land – helping safeguard soil health. The TAG discussed the applicability of a similar tool for gypsum from waste plasterboard. It was recognised that the practicalities of maintaining such an electronic reference, and which organisation might be suitable or willing to do so, are unclear. However, the TAG recognised the usefulness of such a web tool in helping guide farmers and proposed that this be included as an option in the Quality Protocol, and wider industry views gauged as part of the consultation process.
- 5.21 Given the level of uncertainty regarding independent certification and the limited benefit (gypsum from waste plasterboard is already required to be processed in accordance with defined product standards and meet a customer-driven specification), the TAG recommends raising this issue during the consultation. A specific question should ask whether stakeholders foresee benefits in a certification system that would balance or outweigh its cost and administrative burden.

6. Risk assessment and management

- 6.1 A risk assessment was commissioned by the Environment Agency on behalf of the TAG. Its purpose was to assess the relative levels of risk to human health and the environment arising from the use of gypsum from waste plasterboard in the following market applications:
- plasterboard manufacture; and
 - agricultural application as a soil improver.
- 6.2 The risk assessment study was carried out by environmental consultants. Consult the associated risk assessment report⁸ for details of the methods used and the results.
- 6.3 The risk assessment did not look at the risks to human health and environment from the manufacture of plasterboard from gypsum from waste plasterboard as this is regulated under EPR.
- 6.4 The risk assessment applied a source–pathway–receptor methodology in determining risks from the two market applications for gypsum from waste plasterboard.
- 6.5 The source data used included material composition and liquid to solid ratio (10:1) for leachability for parameters with existing environmental and/or human health benchmarks including Soil Guideline Values,⁹ drinking water standards and Environmental Quality Standards. These benchmarks are widely accepted as reference figures in assessing the potential impacts of a material in different environmental compartments.
- 6.6 An assessment of available compositional and leachability data sources questioned the quality and relevance of existing data, and their suitability for use in the risk assessment models. The TAG therefore commissioned test sampling and analysis in 2007 from a series of representative producers of gypsum from waste plasterboard. The results of this analysis are given in full in Chapter 1 of the risk assessment report. The compositional analysis concentrations results were compared with the concentrations found in natural gypsum (reported by WRAP, 2007). The results of the comparative analysis of gypsum from waste plasterboard and natural and agricultural gypsum has demonstrated that the level of contamination with respect to potentially toxic elements in natural and agricultural gypsum is considerably higher than that for gypsum from waste plasterboard. This was used as an evidence of lower levels of total and potentially leachable metals from gypsum from waste plasterboard in comparison with gypsum from natural sources.
- 6.7 The results of the risk assessment are summarised below.
- Soils**
- 6.8 With the exception of mercury, the concentrations of metals and metalloids in gypsum from waste plasterboard are lower than those typically found in rural and urban natural soils.¹⁰
- 6.9 Mercury concentrations in the samples from the tests commissioned by the TAG varied from <2 mg/kg to 0.05 mg/kg. Data from analysis of natural mined gypsum¹¹ show mercury concentrations to be 2 mg/kg, which is consistent with the data collated during the risk assessment.

8 *Risk assessment for applications of gypsum from recycled plasterboard*, Environment Agency, 2008, pp.14–18.

9 As given in the Sludge (Use in Agriculture) Regulations 1989.

10 Data from UK Soil and Herbage Pollutant Survey published by the Environment Agency in 2007 [see <http://www.environment-agency.gov.uk/science/922254/923462/>].

11 *Gypsum products developed from gypsum based wastes*, Roy Hatfield Ltd Quality Protocol v3.0, 2006.

6.10 Based on worst case concentrations of metals and metalloids and taking account of the limits set out in the Sludge Code,¹² the TAG put forward the following guidelines regarding applications to land of gypsum from waste plasterboard:

‘any dosage to land of this beneficial treatment agent should be made having consideration to the nutrient requirements of the soil and should not be applied at a total frequency (or dose equivalent) exceeding once per annum at an application rate of 20 tonnes/hectare to meet sulphur deficiency and provide soil improvement benefits’.

This conclusion was informed by the maximum selenium concentrations in gypsum from waste plasterboard. These limit applications to this dose rate and frequency so as to comply with the Sludge Code.

6.11 To maintain a consistent approach with existing Quality Protocols, the TAG recommends that a Quality Protocol for gypsum from waste plasterboard should highlight the following good practice in relation to soil treatment:

- carry out routine testing of gypsum from waste plasterboard to ensure concentrations of metal and metalloid elements do not exceed the values used in the risk assessment (for which the results of the risk assessment are valid). These values should be used as an environmental standard against which all gypsum from waste plasterboard should be measured;
- comply with relevant codes of practice and regulations such as:
 - *Fertiliser recommendations for agricultural and horticultural crops* (RB209);¹³
 - *Codes of Good Agricultural Practice* (CoGAP);
 - *Code of Practice for the Agricultural Use of Sewage Sludge (the ‘sludge code’)*; and
 - membership of farm assurance schemes;
- record all applications of gypsum from waste plasterboard made to agricultural or other land (including date, quantity and source); and
- arrange independent auditing.

Surface water

6.12 An initial screening exercise for dissolved determinands resulted in the exclusion of a number of determinands from further assessment.

6.13 Gypsum powder (whether from waste plasterboard or natural sources) was found to have the potential to cause breaches of Environmental Quality Standards (EQS) for a number of determinands, if accidentally released in large quantities to small volumes of surface water. This is particularly the case for soft waters (<50 mg/l CaCO₃) where EQS values are most stringent.

6.14 Agricultural application at a typical rate of 6 tonnes per hectare poses no risk to surface water quality in hard water or moderately hard water catchments. The risk of contamination by certain determinands in very soft water catchment (<50 mg/l CaCO₃) is considered to be negligible. Only two-fold dilution is required to prevent more than 10 per cent contribution to the EQS for these determinands. This finding is based on one application of 6 tonnes per hectare.

6.15 Based on this evidence, the TAG agreed that the overall risk to surface water is low provided the following good practice measures (which are comparable to those appropriate to the use of virgin gypsum) are adopted:

- do not use gypsum from waste plasterboard within 10 metres of surface water (including ditches);
- do not release gypsum from waste plasterboard to drains or surface water;
- store gypsum from waste plasterboard under cover and protect it from flooding; and
- manage run-off from field-heaps to prevent any potential breach of EQS.

¹² The limits in the Sludge Code are intended to complement the Sludge (Use in Agriculture) Regulations 1989.

¹³ See <http://www.defra.gov.uk/farm/environment/land-manage/nutrient/fert/rb209/index.htm>

Groundwater

- 6.16 Screening exercises were undertaken to exclude parameters unlikely to impact on relevant standards.
- 6.17 Gypsum powder (whether from waste plasterboard or natural sources) was found to have the potential to cause a breach of groundwater benchmarks for a number of determinands.
- 6.18 The assessment for 100 per cent gypsum powder identified potential issues with certain determinands (including List 1 substances) when the maximum concentration and the current minimum reporting value (MRV) were used.
- 6.19 The scenario involving 100 per cent gypsum was not considered to be an actual application scenario, but rather an assessment of potential risk from the accidental release or submergence of powdered gypsum. Good practice is therefore required to ensure dry storage in conditions where there is no risk of exposure to rainfall or flood waters.
- 6.20 The groundwater risk assessment for agricultural applications indicated that levels of contaminants are below even the most stringent benchmarks and represent no significant risk to groundwater. This finding is based on one application of 6 tonnes per hectare.
- 6.21 The TAG assessed the main assumptions of the groundwater risk assessment model¹⁴ and agreed they are appropriate.
- 6.22 Based on the evidence from the risk assessment, the TAG concluded that the use of gypsum from waste plasterboard in the proposed end uses represents a low risk to groundwater provided the following good practice measures (which are comparable to those appropriate to the use of virgin gypsum) are adopted:
- do not use gypsum from waste plasterboard within 50 metres of a potable groundwater borehole;
 - do not use gypsum from waste plasterboard below the groundwater table or at a depth where there is a reasonably foreseeable risk of the material coming into contact with groundwater during seasonal variations; and
 - adopt good practice in areas prone to poor drainage or at high risk from flooding.

Human health

- 6.23 Following a review of the findings of the risk assessment, the TAG concluded that any potential human health risks can be effectively mitigated through the use of the good practice measures (which are comparable to those appropriate to the use of virgin gypsum).
- 6.24 These should include the use of suitable personal protective equipment (PPE) in accordance with the requirements of all relevant health and safety regulations when handling or working with gypsum from waste plasterboard.

14 The risk assessment model used was: *Remedial Targets Methodology – Hydrogeological Risk Assessment for Land Contamination*, Environment Agency, 2006 (see <http://publications.environment-agency.gov.uk/pdf/GEH00706BLEQ-e-e.pdf>).

7. Findings and recommendations

- 7.1 The scope of this technical report is restricted to the processing of plasterboard as defined in PAS 109:2008 *Specification for the Production of Recycled Gypsum from Waste Plasterboard*.
- 7.2 There are a number of market uses for gypsum recovered from waste plasterboard. Many of these markets are well-established and the benefits of using a waste material as a substitute or supplement to natural or synthetic raw materials are considered to be obtainable without additional risk to the environment or to human health, based on available information in terms of the composition of the gypsum from waste plasterboard and in comparison to the composition of other natural and synthetic gypsum.
- 7.3 The key markets for gypsum from waste plasterboard include:
- as a raw material in the manufacture of new plasterboard and plasterboard products;
 - as a beneficial soil treatment agent for use in agriculture; and
 - as an additive in cement clinker.
- 7.4 Gypsum from waste plasterboard can be processed to defined standards, the most suitable of which has been identified as PAS 109:2008. The TAG agreed that use of these production standards and the quality control measures within PAS 109: 2008 can produce a product that meets a standard and requires no further processing.

Risk assessment and management

- 7.5 The risk assessment demonstrated that the risk to human health, surface water and groundwater from the applications considered in the risk assessment modelling is low provided specific measures are followed:
- ensure appropriate PPE is worn during the application of gypsum to mitigate against the potentially irritant nature of the material;
 - to prevent any potential contamination of controlled water resources, 100 per cent gypsum should be stored in a contained area, under cover, protected from flooding and with protection against release to drains or surface water;
 - follow all relevant good practice including RB209, CoGAP, the sludge code and membership of farm assurance schemes;
 - do not use within 10 metres of surface water (including ditches);
 - do not use within 50 metres of a potable groundwater borehole;
 - do not use below the groundwater table or at a depth where there is a reasonably foreseeable risk of the material coming into contact with groundwater during seasonal variations; and
 - operate good practice with respect to applications in areas prone to poor drainage or at high risk from flooding.
- 7.6 Guidance should be provided to the agricultural industry on the number of applications to land of gypsum from waste plasterboard as an agricultural fertiliser. Provision of such information, together with the standard common good practice used in soil management, is sufficient to mitigate any potential environmental risks.
- 7.7 Whilst the risk assessment did not quantitatively address the risks associated with the use of waste plasterboard as an additive in cement clinker, the TAG undertook a qualitative risk assessment in relation to the use of gypsum in cement clinker. They concluded that the use of gypsum from waste plasterboard as a cement additive posed no greater risk to human health and the environment than virgin gypsum. However, they recommend that wider industry views are sought on this end use during consultation.

Suitability and certainty of use

- 7.8 By following the guidance and quality management systems detailed in PAS 109:2008, the TAG considers that gypsum from waste plasterboard can be produced in the UK to a suitable specification that enables it to compete as a raw material with raw materials such as natural or synthetic gypsum.
- 7.9 The TAG concluded that the specifications contained within PAS 109:2008 represent the minimum standards to be achieved by processors that supply gypsum from waste

plasterboard for the manufacture of new plasterboard. It recognises that the specifications for gypsum from waste plasterboard are market-led and that customers using the material in the manufacture of new plasterboard may, in some cases, require it to meet an additional specification (e.g. such as the specification being developed by Eurogypsum).

- 7.10 Whilst providing a useful quality standard, PAS 109:2008 does not consider the potential risk of harm to the environment. In order to be able to demonstrate that the material ceases to be waste, this is an important factor. It is proposed that the maximum metal values in Table D4 are used to create a standard. These metals have been risk assessed and demonstrated to pose acceptable risk of harm to human health and the environment comparable to virgin gypsum. This means that any quality protocol would require producers to ensure the gypsum they produce meets both the maximum metal limits set in Table D4 the environmental standard and the requirements of PAS 109:2008. It will also be necessary to agree test methods and frequency of testing. It is proposed that this is done through the Quality Protocol consultation.
- 7.11 In the case of agricultural use of gypsum from waste plasterboard, batch analysis has demonstrated that the product specifications contained within PAS 109:2008 are suitable and can be met. The application of gypsum from waste plasterboard as a soil treatment agent should conform to the requirements set out in:
- *Codes of Good Agricultural Practice for Air, Water and Soil* (CoGAP) (or subsequent guidance);
 - the Sludge (Use in Agriculture) Regulations 1989 (as amended); and
 - *Code of Practice for Agricultural Use of Sewage Sludge* (the Sludge Code).
- 7.12 Application rates will be determined by the levels of Potentially Toxic Elements (PTEs) in the gypsum from waste plasterboard and the receiving soil.
- 7.13 The TAG concluded there is a strong argument that gypsum from waste plasterboard will have certainty of use by compliance with PAS 109:2008 product standards and quality assurance measures.

Requirements for no further processing

- 7.14 From the evidence gathered during the development of this technical report, the TAG concluded that gypsum from waste plasterboard leaving the site of production requires no further processing in order for it to be used in agricultural applications.
- 7.15 Further processing of the gypsum from waste plasterboard may be undertaken during manufacture of new plasterboard. However, natural and synthetic raw materials would be handled in the same manner. The requirement for no further processing is therefore not prejudiced.

Recommendations

- 7.16 The TAG find that there is adequate evidence to support development of a Quality Protocol. The Quality Protocol should adopt:
- the product standards and quality controls in PAS 109:2008 in order for gypsum from waste plasterboard processed to those standards not to be classified as a waste;
 - record keeping and supply documentation are retained; and
 - the risk mitigation measures and recommendations for adoption of good practice highlighted in the technical report.
- 7.17 The TAG recommend that wider industry opinion is sought through the Quality Protocol consultation process on the following issues:
- whether the qualitative assessment of gypsum in cement clinker made is sufficient;
 - whether the industry feels certification is required; and
 - whether an agricultural tool should be developed to calculate suitable application rates for gypsum to soil.
- 7.18 It is also recommended that the Quality Protocol should be reviewed at least every two years or earlier if there are any changes to processing technology or material use.

Appendix A Technical Advisory Group (TAG) Membership

Organisation	Representative	Type of member
Waste Protocols Project Team	Suzanne Laidlaw Sarah Clayton Hana Leithgoe Michelle Steer	Attending Attending Attending Attending
WRAP	Dave Marsh	Attending
Entec (Technical Support to Project Team)	Keith Lawton	Attending
Soils Policy Advisor (Environment Agency)	Victoria Sturt	Attending
Gypsum Recycling UK Ltd (GRUK)	Roger Meaden	Attending
Roy Hatfield Ltd	Mark Hatfield	Attending
Plasterboard Recycling UK (PBRUK)	Matthew Purdie	Attending
Mid UK Recycling Ltd	Chris Mountain	Attending
Recyclet Ltd	Warren Fothergill	Attending
Gypsum Products Development Association (GPDA)	Crispin Dunn-Meynell	Attending
Lafarge (on behalf of GPDA)	Steve Hemmings	Attending TAG 1
British Gypsum (on behalf of GPDA)	Heidi Barnard	Attending
Knauf Drywall	Amanda Owen	Attending
Sustainable Business Solutions (on behalf of NWGR)	Rob Enticott	Attending TAG 1
New West Gypsum Recycling (UK) Ltd	Bob Curd	Attended TAG 3 on behalf of Rob Enticott
RPS (Technical Support to Project Team)	Ahlim Hashm	Attending
BCA	Mike Taylor	Corresponding
Coast to Coast Recycling	David Coning	Corresponding
Environment Agency (Policy Advisor)	Chris Deed	Corresponding
Environment Agency (Policy Rep)	Clare McCallan	Corresponding
Environment Agency (Legal Rep)	Kathryn Harriss	Corresponding
Environment Agency Wales (Policy Rep – Wales)	Becky Favager	Corresponding
SEPA (Policy/Strategy Rep – Scotland)	Mark Heggie	Corresponding
NIEHS (Policy Rep – Northern Ireland)	Tony Osborne	Corresponding
NFU	Aarun Naik	Corresponding

Appendix B TAG terms of reference

B1. Mission statement

- B1.1 To produce a technical report, recognised by (and produced with the support of) industry. The technical report will contain sufficient information to determine when gypsum from waste plasterboard has been processed to such a level that it can be considered to be fully recovered and no longer subject to the requirements of the regulatory waste regime.
- B1.2 If this is unachievable, the technical report will contain sufficient information to enable the Environment Agency to:
- determine whether gypsum from waste plasterboard is recovered to a state where its use is acceptable in accordance with their low risk regulatory principles; or
 - confirm to the business community what legal obligations remain to control the re-use of the treated waste material.

B2. Desired outcomes/outputs

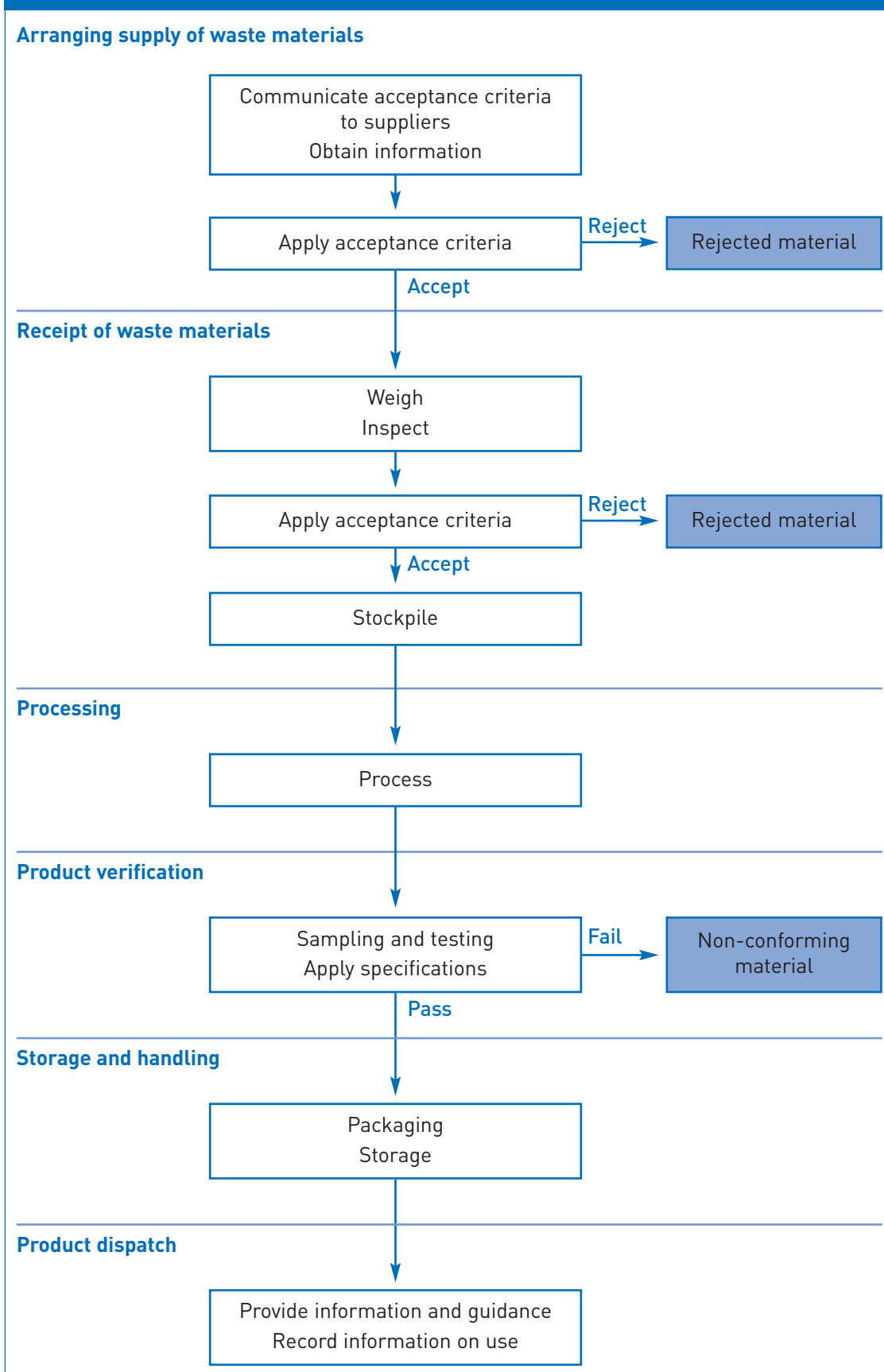
- B2.1 The Technical Advisory Group (TAG) will produce a technical report that will identify and establish the point where:
- contaminants present by virtue of the nature of the waste have been eliminated or reduced so much that their presence is immaterial;
 - the waste will be fully suitable as a substitute for a non-waste and can be considered a 'recovered product';
 - there is a market for the recovered product and it is certain to be used; and
 - the use of the recovered product will not result in harm to human health or the environment.
- B2.2 To do this the TAG will consider:
- the current or future markets for gypsum from waste plasterboard; and
 - existing standards and specifications relevant to the production or use of gypsum from waste plasterboard. If they do not exist, the TAG will identify alternatives and/or scope out projects for producing a new standard or specification.
- Alternatively, the TAG will consider developing existing ones if required;
- whether there are any potential human health and environmental impacts associated with the use of gypsum from waste plasterboard and identify any necessary mitigation methods; and
 - the requirement for certification and auditing/monitoring.
- B2.3 The TAG will provide input into a financial impact assessment (FIA) that will determine the costs and benefits of a change in the point that waste ceases to be waste (with the aid of the project economist).
- B2.4 The TAG will also contribute to the delivery of a communications plan.

B3. Limitations

- B3.1 Knowledge from the industry is vital in the production of the technical report and financial impact assessment. By being a member of the TAG it is expected that participants will willingly share information from their sector and be prepared to participate in writing and reviewing elements of the report. If this help is not forthcoming, it may not be possible to fully develop a technical report in the timescale available.
- B3.2 The technical report will provide sufficient evidence to the Environment Agency to support moving the point at which waste ceases to be waste. However, it is ultimately the Environment Agency that will decide this point.

Appendix C Process diagram

Figure C1 Generic process in producing PAS 109 recycled gypsum, and minimum scope of factory control procedures (reproduced from PAS 109: 2008)



Appendix D Material composition

D1. Chemical composition

- D1.1. Calcium sulphate is a crystalline, colourless to white, widely occurring mineral found in deposits as both hydrated and anhydrous forms. It is formed as a by-product of the evaporation of seawater and occurs in beds or nodular masses up to several metres thick. The dihydrate form ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is known as gypsum and is formed by the hydration of anhydrite at or near the Earth's surface.
- D1.2. Natural gypsum has a molecular weight of 172.17 and contains only four basic elements (Table D1).¹⁵

Table D1: Percentage elemental composition of natural gypsum

Element	Percentage
Oxygen	55.76
Calcium	23.28
Sulphur	18.62
Hydrogen	2.34

Source: <http://www.webmineral.com>

- D1.3. Gypsum is slightly soluble in water and readily soluble in hydrochloric acid.
- D1.4. Gypsum consists of the following compounds:¹⁶
- CaO – 32.57%
 - H₂O – 20.93%
 - SO₃ – 46.50%.
- D1.5. To prepare gypsum for use in plasterboard, it must first be partially dehydrated by application of heat to reduce the water content to below 0.5 per cent weight/weight (w/w). This process changes the chemical formula of the gypsum slightly to reflect its hemihydrated state ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$). After significant dehydration to produce a material known as stucco, the gypsum is ready for incorporation into a finished plasterboard sheet.
- D1.6. To produce a product of suitable specification for its application, the gypsum slurry used to manufacture the plasterboard contains a number of additives to enhance its performance characteristics. Although many of these additives are specialist chemicals added in minute quantities, they are present in gypsum from waste plasterboard.
- D1.7. The TAG discussed this issue and the possibility of obtaining supporting data. However, the additions made to plasterboard during its manufacture vary widely and are part of commercially confidential specifications. Given the lack of data, the TAG could not consider the extent of these additives or the environmental risk they pose. It concluded that existing regulatory controls on chemical inputs, together with REACH, form an appropriate management mechanism for the downstream risks (if any) associated with additives.
- D1.8. Plasterboard can become waste via a number of mechanisms (e.g. structural demolition, off-cuts, damaged boards, over-ordering and contamination). The composition of waste plasterboard is highly dependent on the level of segregation employed at the site where it arises.
- D1.9. Clean plasterboard that may be physically damaged or off-cuts that are well segregated will typically retain the exact composition of that of a new board. Waste plasterboard that arises from clearance, demolition or renovation may be contaminated with a number of different materials and substances. These are typically removed during the recycling process.

¹⁵ In naturally occurring gypsum, small concentrations of contaminant oxides and elements may be found.

¹⁶ Figures taken from information available on <http://www.webmineral.com>

D1.10. Plasterboard recyclers have agreed quality specifications for gypsum from waste plasterboard powder, which may vary depending on the recycler and the end use of the gypsum powder. Table D2 gives an example specification.

Table D2: Standard quality specification for gypsum from waste plasterboard powder (Gypsum Recycling UK Ltd)

Parameter	Typical value
Chloride	0.01% w/w
pH	7–9
Free moisture	<10.00% w/w
Magnesium oxide	<0.19% w/w
Di-sodium oxide (Na ₂ O)*	<0.06% w/w
Total organic carbon (TOC)	0.84%

* Na₂O exists as a sodium silicate and is isolated through analysis

D1.11. Once waste plasterboard has been processed to recover the gypsum, its composition is likely to be closely representative of natural or synthetic gypsum powder.

D1.12. To perform a suitable risk assessment, a number of sources were examined to obtain the typical composition of gypsum from waste plasterboard. Table D3 presents X-ray fluorescence (XRF) compositional data compiled on behalf of WRAP by Coventry University.

Table D3: Composition of gypsum from waste plasterboard

Oxide	Typical values (w/w %)	Element	Typical values (mg/kg)
Al ₂ O ₃	0.81	Aluminium	4,287
CaO	37.30	Calcium	266,581
Fe ₂ O ₃	0.36	Iron	2,518
K ₂ O	0.24	Potassium	1,992
MgO	0.40	Magnesium	2,412
Na ₂ O	0.03	Sodium	223
PsO ₅	0.02	Phosphorous	87
SiO ₃	2.43	Silicon	11,362
SO ₃	53.70		
TiO ₂	0.03	Titanium	180
Loss on Ignition (LOI)	4.09		

Source: *Use of recycled gypsum in road foundation construction*, WRAP, 2007.

D1.13. In the absence of publicly available test data, the TAG requested the commissioning of new compositional data (principally aqua regia metals) together with an analysis of organic compounds. Table D4 presents composition data for gypsum from waste plasterboard gathered during the course of the development of this technical report.

Table D4: Composition of gypsum from waste plasterboard

Analyte	Mean contaminant values (mg/kg)	Maximum contaminant values (mg/kg)
Aluminium*	4,287	4,287
Antimony**	<10	<10
Arsenic	2	5.23
Barium	42	70.3
Calcium	22,7191	26,6581
Cadmium	0.123	0.30
Chromium	9	17.9
Copper	9	32.8
Iron*	2,518	2,518
Lead	10.01	31.9
Magnesium*	2,412	2,412
Mercury	1.88	<2
Molybdenum	3.09	7.68
Nickel	3.20	7.31
Phosphorous*	87	87
Potassium*	1,992	1,992
Selenium	2.4	7.37
Sodium*	223	223
Silicon*	11,362	11,362
Titanium*	180	180
Zinc	10.5	40.3
Sulphur*	209,200	20,9200
SO ₄ *	628,000	628,000
Dry solids @ 30°C	93%	99.1%

Source: *Risk assessment for applications of gypsum from recycled plasterboard*, Environment Agency, 2008.
 * only one sample
 ** all readings below the detection limits

- D1.14. These data confirm that gypsum from waste plasterboard is primarily composed of calcium sulphate. The remaining elements in the risk assessment data are contaminants likely to have been present in minute quantities in the natural gypsum.
- D1.15. Assessment of the organic compounds present shows that, with the exception of methylene chloride (CH₂Cl₂), the majority of determinands are present below 5 µg/kg, with many at their Limit of Detection (LOD).

D1.16. The results of batch testing of the gypsum from waste plasterboard were compared with an industry 'benchmark' product specification for agricultural gypsum (natural gypsum) and the specification in PAS 109: 2008 to demonstrate that industry accepted specifications for a non-waste material applied to land can be met by gypsum from waste plasterboard. Table D5 summarises the results of this comparison.

Table D5: Comparative compositional data		
Parameter	Gypsum from waste plasterboard ¹	Agricultural gypsum (BPB) ²
Particle size	<16 mm	150–600+ µm
Purity (CaSO ₄ ·2H ₂ O)	85% minimum	85% minimum
pH	7.94	8
Cadmium	0.26 mg/kg	N/A
Copper	9.43 mg/kg	N/A
Chromium	9.60 mg/kg	N/A
Nickel	1.72 mg/kg	N/A
Lead	4.45 mg/kg	N/A
Zinc	20.8 mg/kg	N/A
Mercury	0.05 mg/kg	N/A
Arsenic	0.99 mg/kg	N/A
Selenium	0.51 mg/kg	N/A
Molybdenum	0.98 mg/kg	N/A
Fluoride	82 mg/kg	N/A

¹ Analysis results taken from recycled gypsum batch analysis, January 2008, Recyclet Ltd.
² Agricultural gypsum (natural gypsum) specifications taken from BPB Formula website using agricultural gypsum 171/TD3/UR.

D1.17. The primary specifications for gypsum from waste plasterboard for agricultural use are:

- high purity of product (CaSO₄·2H₂O content);
- low free-moisture levels;
- neutral to slightly alkaline pH (~8); and
- a particle size suitable for the intended application, i.e. <30 µm to 2mm range of particle capture using sieve analysis.

D2. Physical characteristics

D2.1. Natural gypsum is the most commonly occurring sulphate mineral and is usually found in marine evaporates, in caves where the air is dry enough to allow it to be deposited, in fumaroles and occasionally in the oxidised zones of sulphide deposits. It is found as a monoclinic colourless to white crystalline solid exhibiting tabular to lenticular shaped crystals, which can sometimes be prismatic. The mineral is given a Mohs Hardness Scale rating of 2.

D2.2. The unique physical properties of the hemihydrated or anhydrous mineral forms mean that, when re-combined with water, gypsum will quickly revert to its preferred chemical state of dihydrate in an exothermic reaction that results in a physical change of state from liquid to gypsum crystal lattice. These properties have been exploited for many centuries and find uses in a wide range of sectors from art and sculpture through to medical and construction.

D2.3. Gypsum from waste plasterboard powder shows similar physical characteristics to the natural or synthetic gypsum powder. The gypsum from waste plasterboard powder is sized in the range 0.063–13 mm, with approximately 70 per cent of the powder being <1 mm in diameter.¹⁷

Appendix E Definitions

Term	Description
Controlled waste	Controlled waste is household, commercial and industrial waste. Controlled waste is defined in section 30 of the Control of Pollution Act 1974, section 75 of the Environmental Protection Act 1990 and the Controlled Waste Regulations 1992 (as amended). Paragraph 9(2) of Schedule 4 to the Waste Management Licensing Regulations 1994 provides that any reference to 'waste' in Part II of the 1990 Act includes a reference to Directive waste.
Duty of Care	<p>The Duty of Care is set out in section 34 of the Environmental Protection Act 1990 and associated regulations. It applies to anyone who is the holder of controlled waste.</p> <p>Persons concerned with controlled waste must ensure that the waste:</p> <ul style="list-style-type: none"> ■ is managed properly; ■ recovered or disposed of safely; ■ does not cause harm to human health or pollution of the environment; and ■ is only transferred to someone who is authorised to receive it. <p>The duty applies to any person who produces, imports, carries, keeps, treats or disposes of controlled waste or, as a broker, has control of such waste.</p>
Environment Agency	The Environment Agency is the leading public body for protecting and improving the environment in England and Wales. Its job is to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.
Environmental permit	<p>Environmental permits or exemptions issued under the Environmental Permitting (England and Wales) Regulations 2007, which came into force on 6 April 2008, or low risk waste activities in accordance with Environment Agency guidance.</p> <p>From 6 April 2008, the following automatically became environmental permits:</p> <ul style="list-style-type: none"> ■ PPC permits issued under the Pollution Prevention and Control (England and Wales) Regulations 2000 (as amended); and ■ Waste Management Licence (WMLs) issued under the Environmental Protection Act 1990 (as amended). <p>Exemptions from the need for a Waste Management Licence, registered under Regulation 18 and Schedule 3 of the Waste Management Licensing Regulations 1994 (as amended) now come under Schedule 3 of the Environmental Permitting (England and Wales) Regulations 2007.</p>
Gypsum from waste plasterboard	For the purposes of this technical report and any future Quality Protocol, gypsum from waste plasterboard is defined as plasterboard consistent with the definition in PAS 109:2008 that has been processed to produce a gypsum product suitable for use in a number of end use applications.
PAS 109:2008	This is one of a series of publicly available specifications (PAS) produced by the British Standard Institution (BSI) in collaboration with WRAP. PAS 109:2008 is concerned with the processing of waste plasterboard into gypsum for use as a recovered material.
Plasterboard	<p>Section 3.12 of PAS 109:2008 defines plasterboard as a product composed of:</p> <ol style="list-style-type: none"> a. a gypsum plaster core encased in, and firmly bonded to, strong durable paper liner to form a flat rectangular board. The paper surfaces may vary according to the particular type of board and the core may contain additives to impart additional properties. The longitudinal edges are paper-covered and profiled to suit the application [BS EN 520:2004 definition 3.1]; or b. gypsum boards with mat reinforcement: a gypsum core firmly bonded to a woven or non-woven sheet of inorganic or organic fibres located on or just below the surface. The sheet may consist of single or multiple layers and may be reinforced by filaments or webs of fibre strands. The surfaces may vary according to the use and the core can also contain fibres, additives and/or fillers to impart additional properties. The surfaces and edge profiles vary according to the use of the particular type of board. [EN 15283-2:2008, definition 3.1]; or

Term	Description
Plasterboard (continued)	<p>c. gypsum fibre boards: set gypsum plaster reinforced with dispersed fibres, which may be inorganic and/or organic, to form flat rectangular boards. They may contain additives and/or fillers to impart additional properties. The surfaces may vary according to the use. The edges and ends may be profiled to suit the application [EN 5283-2:2008, definition 3.1]; or</p> <p>d. plasterboard cornice: preformed paper covered gypsum section with profiled face supported by shoulders [EN 14209:2005, definition 3.1]</p>
Potentially Toxic Element (PTE)	Chemical element that has the potential to cause toxicity to humans, flora and/or fauna. The majority are also known as 'heavy metals' or 'transition metals' (e.g. lead, cadmium, mercury, copper, zinc, nickel).
Quality Protocol	A Quality Protocol sets out criteria for the production of a product from a specific waste type. Compliance with these criteria is considered sufficient to ensure that the recovered product may be used without risk to the environment or harm to human health and therefore without the need for waste management controls. In addition, the Quality Protocol indicates how compliance may be demonstrated and points to good practice for the use of the recovered product.
REACH	This Regulation aims to control and limit the risk to human health and the environment from the use of chemical substances and preparations in materials that are available to purchase on the open European market. Its full title is 'Regulation (EC) No. 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC'.
Waste carrier	A person who transports controlled waste, within Great Britain, including journeys into and out of Great Britain.
Waste carriers licence	The Waste Framework Directive requires that establishments and undertakings that collect or transport waste on a professional basis or which arrange for the disposal or recovery of waste (dealers or brokers) must be registered. This is implemented in domestic legislation by the Control of Pollution (Amendment) Act 1989. Persons who carry waste as part of their business are required to be registered with the Environment Agency/SEPA/Northern Ireland Environment Agency (as appropriate).
Waste management controls	Controls under legislation that govern the treatment, handling, containment, transportation and storage of waste.
WRAP (Waste & Resources Action Programme)	WRAP helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change.

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**Waste & Resources
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