



GIVING VINYL A SECOND LIFE

Without Compromising Sound

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In partnership with:
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Overview

As part of efforts to improve the sustainability of vinyl record production, Warner Music Group (WGM) and GZ, a vinyl records pressing plant, partnered to evaluate whether unsold, obsolete records could be recycled and reintroduced into manufacturing while maintaining the audio fidelity and production performance expected of commercial vinyl.

Vinyl has experienced a sustained resurgence over the past two decades, becoming the dominant physical music product. According to IFPI, global physical music revenues reached US\$5.3 billion in 2025, representing 8.0% year-on-year growth. This increase was driven largely by vinyl, which grew by 13.7% and marked its nineteenth consecutive year of growth.¹ For the second time on record, physical formats outpaced digital growth, underscoring the continued cultural and commercial relevance of vinyl.

This growth has increased focus on the material intensity of vinyl production, particularly PVC use. Records are manufactured using polyvinyl chloride (PVC), a polymer derived primarily from fossil fuel-based feedstocks. At the same time, unsold inventory and obsolete records accumulate across the supply chain as a result of forecasting variability, product returns, and fluctuations in demand. These materials represent a potential secondary feedstock but have historically been difficult to reintegrate into production.

Reintroducing this material into manufacturing offers a potential pathway to reduce demand for virgin PVC and associated emissions, while also meaningfully extending the use of material that has already been produced. However, doing so presents technical challenges. Vinyl production requires tight control over compound composition and processing conditions, and there is longstanding concern within the industry that incorporating recycled material may affect audio fidelity or introduce variability in manufacturing performance.

For the purposes of this pilot, “mixed-origin pre-consumer vinyl” refers to obsolete records recovered from warehouse inventory prior to consumer use and recycled into a heterogeneous feedstock sourced from multiple production runs and suppliers. Throughout the report, this material may also be referred to as “mixed-origin feedstock.”

Against this backdrop, the project was designed around three core objectives:

1. Assess whether the introduction of mixed-origin pre-consumer material affects **audio performance**;
2. Evaluate the **environmental implications** of recycling pathways using lifecycle assessment principles; and
3. Determine whether such approaches are compatible with existing manufacturing systems and therefore **viable at scale**.



Assessment Framework & Key Results

The pilot examined **three dimensions** of incorporating obsolete vinyl material into record pressing compounds:

1. Audio Performance

Commercial playback standards maintained across tested blends.

2. Environmental Impact

Recycling obsolete vinyl reduced projected emissions by ~10%.

3. Production Feasibility

Lower inclusion rates integrated successfully into standard pressing workflows.

Testing was conducted under controlled, standard manufacturing conditions, and results should be interpreted within the materials, equipment, and parameters used in this study.

1. Audio Quality

This part of the pilot assessed whether incorporating mixed-origin pre-consumer vinyl from obsolete feedstock affected record audio quality. To support credible evaluation, the project implemented blind listening tests conducted by experienced audio engineers and mastering professionals. Test samples were anonymized using coded identifiers so that the evaluators were unaware of the blend composition of each sample during evaluation. The listening methodology included both physical pressings and standardized digital recordings to reduce variability associated with playback equipment and listening environments.

Under the conditions tested, incorporating mixed-origin recycled feedstock resulted in no consistently detectable differences in audio quality compared to virgin vinyl pressings. Across all variants, differences remained within a narrow range of approximately 0.5 points on a ten-point scale, with the top-3 performing variants within 0.2 points of each other. These findings suggest that mixed-origin feedstock can be reintroduced into vinyl production under controlled conditions without compromising expected commercial audio performance.

2. Environmental Impact

The second objective was to evaluate the potential environmental implications of recycling mixed-origin pre-consumer vinyl material into record production. Vinyl records are typically produced using PVC compounds derived from fossil fuel-based raw materials. Reintroducing unsold vinyl into production can reduce demand for virgin material inputs while extending the use of material already in circulation. However, recycling processes also introduce additional environmental impacts associated with warehousing, sorting, transport, shredding, and reprocessing.

To support a credible assessment, an independent environmental analysis was conducted with support from ClimatePartner. The analysis applies life-cycle assessment principles aligned with internationally recognized frameworks, including the Greenhouse Gas Protocol's Product Life Cycle Accounting and Reporting Standard. It also builds on the findings and methodologies established in the Vinyl Alliance and Music Climate Pact's Sustainable Supplier Programme in 2025.²

From an environmental perspective, the scenario analysis indicates an approximate 10.6% reduction in carbon emissions when obsolete records are reintroduced into vinyl record production rather than disposed of, driven primarily by reduced demand for virgin PVC.

3. Production Feasibility

The pilot also sought to assess whether mixed-origin pre-consumer vinyl material could be integrated into existing pressing operations without compromising production reliability or scalability. Vinyl pressing plants operate within narrow production tolerances, and variations in compound composition can influence factors such as: puck formation consistency, press cycle stability, defect rates, and production throughput.

From a production standpoint, mixed-origin feedstock introduced greater variability in material handling and pressing behavior, particularly at higher inclusion levels. While commercially acceptable records were produced across all variants, results indicate that lower inclusion rates are more compatible with stable operations in an automated pressing environment. Homogeneous recycled materials caused no operational issues during pressing. From a scalability perspective, integrating mixed-origin feedstock into standard production in smaller proportions is more effective than maintaining fully segregated recycled feedstock streams.

A close-up photograph of several vinyl records stacked on a production line. The records are in various stages of production, with some showing the characteristic grooves and others appearing as flat, metallic discs. The background is a blurred industrial setting with blue and green lighting.

Scope & Study Design

Scope of the Pilot

The results reflect the specific materials, equipment, and testing parameters used during the study and should therefore be interpreted as technical observations rather than definitive conclusions for industry-scale production.

Our Approach

To evaluate the feasibility of incorporating mixed-origin recycled feedstock into record production, a controlled pilot was designed and conducted in collaboration between Warner Music Group and GZ.

The methodology was developed to isolate the effects of recycled mixed-origin feedstock content while minimizing other variables that could influence production outcomes or audio performance. Where possible, the pilot replicated conditions similar to those used in commercial vinyl manufacturing in order to ensure the observations would be relevant to real production environments.

The approach included the following stages:

- Selection of obsolete records suitable for recycling
- Sorting and screening of material
- Shredding and micronization of feedstock
- Controlled pressing across defined blend variants, representing different proportions of recycled mixed-origin material
- Blind audio evaluation and technical inspection

Throughout the pilot, steps were taken to document the process and maintain traceability of materials in order to support subsequent environmental and technical analysis.



Materials & Preparations

Selection of records for recycling

To ensure that the pilot reflected a realistic supply chain scenario while maintaining control over production variability, the study intentionally used mixed-origin pre-consumer vinyl records recovered from warehouse inventory. These records originated from multiple artists, pressing plants, production runs, and compound formulations, resulting in a heterogeneous material stream representative of obsolete inventory in distribution systems.

Because compound composition can vary between manufacturers and over time, specific exclusions were applied to ensure that the pilot material complied with current safety, regulatory, and manufacturing standards, and to reduce variability during processing.

The following materials were excluded:

- Records smaller than 12-inch format (7" and 10" records were excluded)
- Records that may have contained lead stabilizers, e.g. records produced outside the EU or records made in the EU before 2017
- Picture discs, which contain layered materials that differ from standard vinyl compounds
- Records with metallic, glitter, or pearlescent pigments, which may introduce particulate contamination during processing

These exclusions were implemented to reduce variability and avoid introducing materials that could compromise safety, processing performance, or test validity.

Approximately **10,000 obsolete records** were selected from Warner Music Group inventory stored in a European warehouse and transported to GZ's facility in the Czech Republic for processing and testing.

The initial pilot batch included five titles: three black vinyl pressings and two coloured vinyl pressings. This mix was selected to reflect the diversity of materials typically present in returned or obsolete inventory streams.

Unpacking and Sorting the Records

Upon arrival at the GZ facility, the records were manually unpacked and sorted by title, followed by a series of screening steps to confirm suitability for recycling.

These included:

1. Visual inspection, to verify compliance with material exclusions

Each title was visually assessed to confirm that it did not contain restricted formats, pigments, or material characteristics excluded from the pilot.

2. Audio screening, to assess baseline noise characteristics

Records were evaluated for baseline noise characteristics prior to processing. This provided an initial indication of compound quality and helped identify any anomalies that could influence downstream audio performance following reprocessing.

3. Thermal stability testing, to determine whether the material could withstand the temperatures required for further vinyl pressing

Material samples were subjected to thermal stability testing to assess whether the recovered vinyl feedstock could withstand the temperatures required for pressing without degradation. Records that did not meet thermal stability criteria were excluded from the feedstock.

During this screening process, both coloured titles were excluded. One was removed following thermal stability testing, which indicated potential degradation under reprocessing conditions. The second was excluded due to operational constraints associated with maintaining colour consistency during segregated processing.

As a result, the final recovered feedstock consisted of three black vinyl titles sourced from different pressing plants and production runs.

Shredding and Further Processing

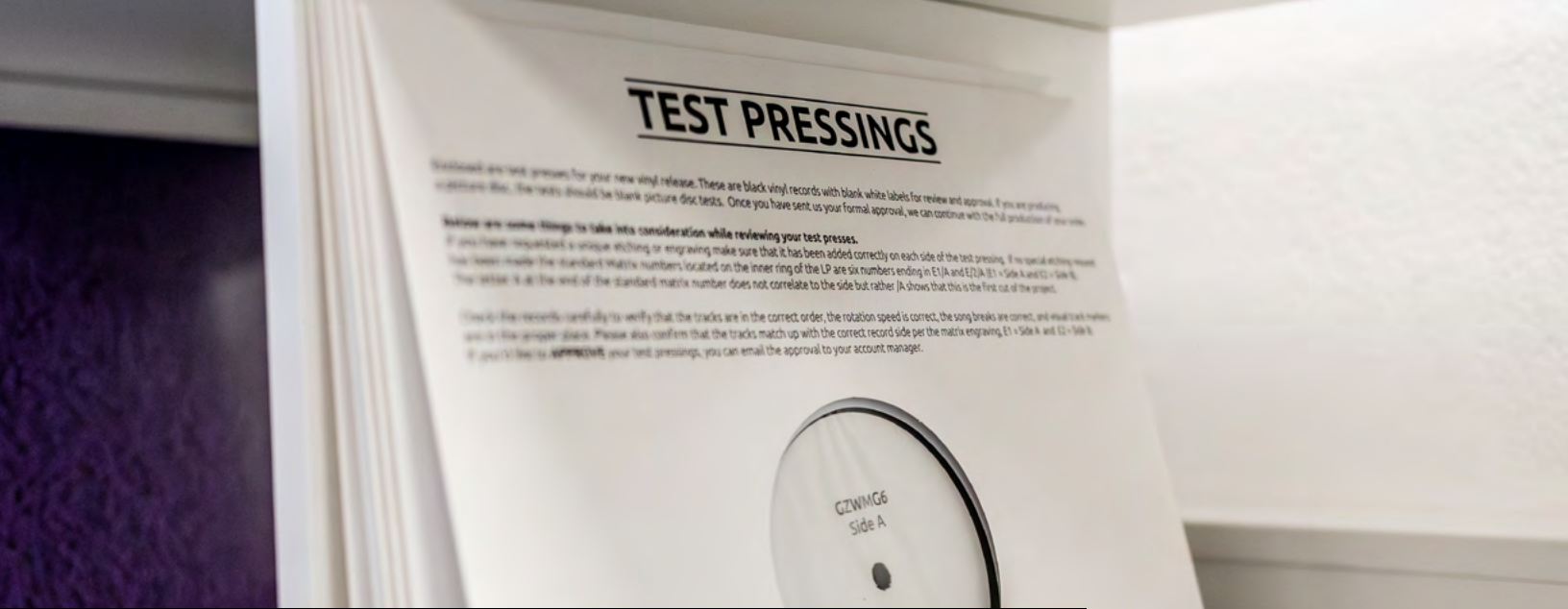
After sorting and inspection, the records were mechanically shredded and micronized to produce vinyl feedstock suitable for pressing.

All records were shredded together rather than separated by title or source batch. This approach was chosen to replicate a realistic scenario in which obsolete inventory from multiple production runs is processed collectively.

The resulting feedstock was used to produce records across a range of recycled mixed-origin content blends.

To avoid bias during subsequent evaluation stages, the feedstock and resulting pressings were anonymized using coded identifiers referred to as GZWMG codes.

These codes were used throughout the remainder of the pilot to track the material while preventing listeners participating in the audio evaluation from knowing the blend composition of each record.



Test Record Design

Music Selection and Cutting

A bespoke test record was produced specifically for the pilot to enable controlled audio evaluation.

Audio Input and Selection

The test record consisted of two sides chosen to represent different audio characteristics commonly encountered in commercial releases.

Side A: Acoustic Post-Rock

This recording was selected because it contains a wide dynamic range, including low level passages alongside louder peaks. Such recordings are particularly sensitive to surface noise and pressing defects.

To further support the evaluation, a 20-second silent section was intentionally inserted after the lead-in groove and before the music begins. This section provides a clear reference point for detecting background noise characteristics during listening tests.

Side B: Modern Rock

These tracks represent a more typical pop/rock mastering profile with a narrower dynamic range. A 20-second silent section was inserted between tracks 2 and 3. Both sides also included a few seconds of silence at the end of the recording before the run-out groove, allowing for assessment of additional audio impurities.

The combination of these two recordings allowed the pilot to evaluate the performance of the test variants under both challenging and typical audio conditions.

Both sides were cut specifically for this project using lacquer masters prepared by Miles Showell at Abbey Road Studios.



Pressing Process & Test Conditions

To ensure that the test results reflected the influence of recycled mixed-origin feedstock rather than other production variables, several manufacturing controls were implemented during pressing.

Metalwork

All test record variants were produced using the same metalwork components.

Using identical metalwork ensured that differences in audio performance could not be attributed to variations in cutting or plating.

Pressing Equipment

Records were primarily produced on a manual pressing machine in order to monitor consistent operating conditions across the tested blend variants. The same press was used for all manually pressed variants. In addition, one blend variant was produced using an automated pressing machine to evaluate material behavior under automated production conditions.

Sample Selection

Following each stamper change, the press requires a stabilization period. GZ confirmed that approximately 15 initial records are typically discarded during this process. To reflect realistic production conditions, test samples were selected from records pressed between numbers 30 and 50.

Test Variants

To evaluate the performance of mixed-origin recycled feedstock under different production conditions, the pilot was conducted in two rounds of pressing trials. The second round was designed to refine the methodology based on observations from the initial production run, allowing the project team to better understand how the material behaved during pressing and across different blend ratios.

Across both rounds, each pressing variant was assigned a coded identifier. These identifiers allowed the records to be tracked internally while maintaining anonymity throughout the blind listening evaluations.

Round 1

The first round of testing evaluated whether recycled mixed-origin feedstock could be incorporated into pressing compounds at varying proportions while maintaining acceptable production performance and audio quality.

All records in Round 1 were pressed using manual pressing equipment, allowing the production team to closely monitor material behavior and make adjustments throughout the pressing process.

Four variants were produced in the first round:

- **GZWMG1:** 100% recycled mixed-origin feedstock.
- **GZWMG2:** 50% recycled mixed-origin feedstock blended with 50% virgin vinyl compound.
- **GZWMG3:** 25% recycled mixed-origin feedstock blended with 75% virgin vinyl compound.
- **GZWMG4 (Control):** 100% homogenous virgin compound

The inclusion of a control variant allowed the project team to compare recycled mixed-origin pressings against a baseline representing virgin compound only.

Production observations indicated that material handling characteristics varied depending on the proportion of recycled mixed-origin feedstock included in the blend. The 25% mixed-origin variant pressed with minimal operational issues. At higher inclusion levels, however, maintaining consistent puck weight required increased operator adjustment. In the 50% blend, this variability required repeated correction of puck size during pressing, while the 100% variant proved most difficult to stabilize, increasing the risk of pressing defects and reducing overall production efficiency.

This variability is likely attributable to the heterogeneous nature of the mixed-origin feedstock. Because the material originated from obsolete records recovered from warehouse inventory prior to consumer use and produced across different pressing plants, compound formulations, and stabilizer systems, the resulting blend was more difficult to balance and stabilize during pressing. The absence of clear provenance for individual records also made it more difficult to predict melt behavior and puck formation characteristics during production.

Taken together, these observations suggest that processing mixed-origin feedstock from multiple production sources as a segregated material stream may present operational challenges at higher inclusion levels and could limit scalability within standard high-volume pressing environments. However, despite these operational challenges, the pilot successfully produced pressings considered suitable for commercial release, with evaluators noting only minor differences in audio performance compared with the virgin control variant.

These observations highlight the importance of identifying practical inclusion thresholds for recycled mixed-origin feedstock that maintain stability, efficiency, and compatibility with existing pressing equipment and production workflows.

These findings informed adjustments to the Round 2 methodology, including the introduction of two additional blend ratios. A 10% mixed-origin variant was tested under automated pressing conditions to evaluate how the material performs at scale. In addition, a 100% post-industrial reused vinyl compound from GZ, referred to as Eco Mix, was included.

Round 2

The second round of testing was designed to build on the operational observations from the first round by evaluating additional blend ratios and production scenarios under conditions more representative of commercial manufacturing. In addition to refining the mixed-origin blend ratios tested in Round 1, the second phase introduced automated pressing conditions and included evaluation of a post-industrial reused vinyl compound ("Eco Mix") already used internally by GZ.

The GZ Eco Mix material represents leftover trimmed flash and defective records generated during vinyl manufacturing processes rather than obsolete finished records. Because this post-industrial vinyl compound originates from the same production compound stream, it is homogeneous in composition compared to the mixed-origin feedstock recovered from obsolete warehouse inventory. Eco Mix was therefore included as a reference point for comparison with the mixed-origin feedstock.

Six variants were produced in the second round:

- **GZWGM1:** 50% recycled mixed-origin feedstock blended with 50% virgin compound.
- **GZWGM2:** 100% recycled mixed-origin feedstock.
- **GZWGM3 (Control):** 100% homogenous virgin compound.
- **GZWGM4:** 10% recycled mixed-origin feedstock blended with 90% virgin compound (pressed on automated equipment).
- **GZWGM5:** 25% recycled mixed-origin feedstock blended with 75% virgin compound.
- **GZWGM6:** 100% Eco Mix material from GZ (post-industrial feedstock).

The inclusion of the automated press scenario was intended to evaluate whether mixed-origin feedstock could be incorporated into production processes compatible with high-volume pressing operations.

Across all variants, the same metalwork, stampers, and audio masters were used to ensure that differences observed during evaluation could be attributed to material composition rather than other production variables.

Purpose of the Variant Structure

The variant structure was designed to test three core conditions:

1. High mixed-origin-content scenarios:

To understand the technical limits of incorporating recycled mixed-origin feedstock and compare its performance with a homogeneous recycled compound.

2. Moderate mixed-origin-content blends:

To evaluate whether recycled mixed-origin feedstock could be incorporated while maintaining stable production conditions.

3. Baseline production conditions:

To establish a control reference point against which all pressings could be compared. The baseline variant was made of 100% virgin material produced specifically for the purpose of this pilot.

This structured approach enabled the project team to compare production performance, audio characteristics, and operational considerations across multiple blend scenarios.



Evaluation & Methodology

The listening evaluation was intended to provide qualitative insight into whether recycled mixed-origin pre-consumer vinyl feedstock introduced audible differences in record playback.

Where possible, observations from the listening panel are considered alongside production observations and technical inspection of the records.

Blind Listening Protocol

To evaluate whether the incorporation of recycled mixed-origin feedstock affected perceived audio performance, a structured blind listening protocol was implemented.

Listeners conducted evaluations using their own playback setups, including both speakers and headphones, and documented their equipment as part of the process. To introduce consistency, evaluators were instructed to assess the same individual track across all variants before proceeding to the next track. Each track was evaluated independently using a structured checklist, with attributes scored on a scale of 1 to 10 and accompanied by a pass/fail determination. No overall record rating was assigned; results were aggregated and analyzed centrally following completion of the listening process.

Two listening rounds were conducted. In Round 1, evaluation was based solely on physical records. In Round 2, evaluators assessed standardized digital rips of the test records, prepared by Miles Showell at Abbey Road, while also providing the corresponding physical discs for reference.

Because audio perception inherently involves subjective interpretation, the listening methodology was designed to reduce bias through anonymized samples, standardized playback references, and consistent evaluation framework. These measures ensured that observed differences reflected the records themselves rather than variability in playback environments or listener expectations.

Physical Records and Digital Rip Standardization

All the evaluators received 3 pieces of randomly chosen physical records (in Round 1) from each variant for their evaluation.

Regarding the digital rips (Round 2), all test variants were first produced as physical listening test records. These physical pressings were subsequently digitized using a controlled recording process to produce standardized digital reference files. A noise fingerprint was also measured and documented for each blend prior to evaluation.

Digitization was conducted using identical playback equipment and recording parameters to ensure that differences observed during analysis could be attributed to the test records themselves rather than playback system variability.

"Caring for the world in which we live is something that has been important to me for decades, so I was delighted to be invited to contribute to this test project. My role was to cut the master discs for the test records, and then later to listen to and make digital files from the six separate test LP pressings. The digital files I made were used by the panel charged with evaluating the reproduction quality of the different recycled vinyl blends. This was to remove the many variables that different turntable/ tonearm and cartridge combinations would have introduced and to create a level playing field so that everyone was listening to the same thing. In my opinion, the discs were remarkably consistent, with the level of recycled PVC not making much of a difference to the quality of the end product."

Miles Showell

Mastering Engineer, Abbey Road Studios

During the digital capture process, each track was individually recorded from the physical pressings and precisely aligned to consistent start and end points before export.

Standardizing the digital capture process allowed evaluators to:

- Listen to recordings under consistent conditions
- Compare variants directly using identical playback systems
- Perform detailed A/B comparisons of individual tracks rather than listening sequentially to full record sides

The listening evaluation in Round 2 itself was conducted using these standardized digital recordings derived from the physical pressings. The digital recordings also provided a standardized reference archive for consistent track-level comparison across listeners, helping reduce variability in subjective assessment.

Expert Listening Panel

The listening tests were conducted by a panel of seven experienced audio engineers and technical specialists from Abbey Road, GZ, and WMG Studio Services. The evaluation was led by Miles Showell of Abbey Road, who performed an initial technical review prior to the broader assessment. The panel's combined expertise in mastering, vinyl production, and audio quality control ensured representation across multiple stages of the production process.

Panel members shared details on their audio equipment and whether they listened on speakers or headphones. They were then instructed to evaluate the pressings independently and by listening to the same individual track on each record before proceeding to the next track. All observations were recorded without discussing results with other listeners during the evaluation stage.

This approach helped minimize group bias and allowed for independent interpretation of the listening experience.

Evaluation Framework

To introduce structure into the listening evaluation, each participant was provided with a standardized evaluation checklist.

The checklist was designed to guide listeners toward specific audio characteristics relevant to vinyl pressing quality while allowing space for qualitative observations.

Audio and Physical Evaluation Criteria

To enable consistent comparison across pressing variants, listeners evaluated each record using a structured set of audio and physical assessment criteria. These criteria were designed to capture both perceived sound performance and observable pressing characteristics that may influence playback quality. A list of these criteria are presented in the appendix. And, to ensure consistency in interpretation, definitions of evaluation criteria were provided to the panel.

Audio Evaluation Criteria

Evaluators were asked to listen for specific characteristics such as background surface noise audible during silent passages or lead-in grooves, as well as crackle, clicks, pops, and "swooshing." Contributing factors may include compound impurities, specifics of the lacquer cut, metalwork anomalies, pressing conditions, or groove contamination.

Listeners also assessed the ability of the record to reproduce both quiet and loud passages without loss of clarity or stability, analysing whether variants maintained consistent playback performance across recordings with varying dynamic range.

Evaluators were asked to test for distortion, and end-of-side distortion, as well as over-polishing, and non-fill, where the PVC compound does not fill the grooves of the stampers during pressing and is often audible as crackling or small pops.

Overall Audio Quality

The overall listening experience was assessed qualitatively, reflecting the combined impact of noise distortion, and dynamic performance. Evaluators also recorded a pass/fail judgment indicating whether the pressing would meet typical commercial quality expectations for a vinyl release.

Physical Evaluation Criteria

In addition to audio evaluation, records were visually inspected for physical characteristics that may affect playback or product quality.

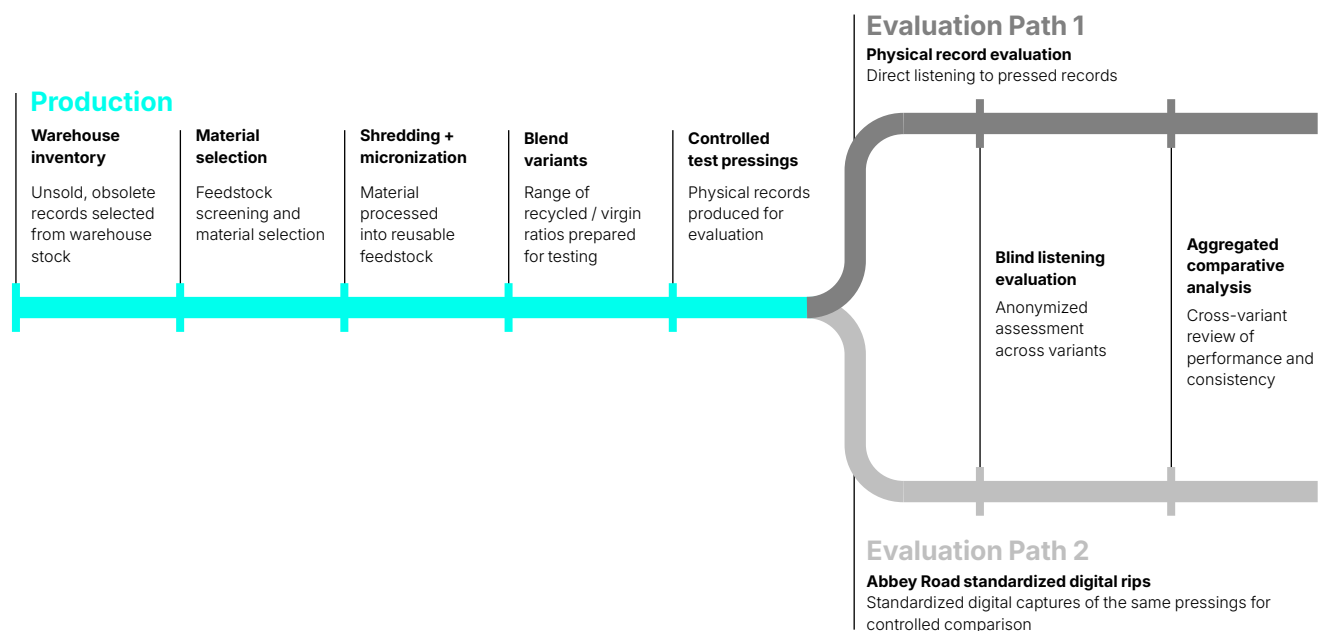
Observed attributes included:

- Weight(g) and color
- Off-center pressings
- Dishing or warping
- Orange peel texture
- Pits or dimples
- Non-fill
- Overpolishing
- Dirt, dust, or paper debris
- Debris within grooves

These observations were recorded to determine whether visible manufacturing characteristics corresponded with any audible artifacts identified during playback.

"Vinyl demand is growing, but the industry was never designed to bring unsold records back into production. Waste is a design problem we have not solved yet. This pilot is about doing the real work to understand whether recovered vinyl can meet the audio quality, manufacturing, and environmental standards the format demands under real production conditions."

Miriam Lessar
VP, Global Release Management





Results & Evaluation

Following the completion of the pressing trials and blind listening protocol, the results of the pilot were evaluated across three primary dimensions:

- Audio performance
- Environmental considerations
- Operational feasibility within commercial vinyl production

Audio Performance

The blind listening evaluation was conducted to determine whether the incorporation of recycled mixed-origin pre-consumer material introduced perceptible differences in audio playback when compared with pressings produced using virgin vinyl compound.

Overall, the listening panel did not identify evidence suggesting that recycled mixed-origin feedstock inherently compromises perceived audio quality under the conditions of this pilot.

The most commonly reported audio issues across all variants included:

- Background noise
- Clicks
- Crackle

These characteristics are commonly observed in vinyl playback and were present across both mixed-origin pre-consumer and virgin compound pressings.

Analysis of the listening results indicated that some differences emerged between specific material blends tested during the evaluations. In particular, the 25% recycled mixed-origin feedstock / 75% virgin compound blend consistently received the highest overall audio quality scores from the listening panel, while the 100% recycled mixed-origin variant received the lowest average ratings.

The table below summarizes the relative performance of the test variants evaluated during the second pilot round. The variant produced entirely from mixed-origin pre-consumer vinyl received the lowest average rating among the test samples and presented greater operational challenges during pressing. However, the differences across the listening tests were relatively small overall. The three highest-rated variants fell within a narrow range of roughly 0.2 points on a ten-point scale, and the full set of samples spanned only about half a point.

Variant ID	Material Composition	Relative Audio Performance	Key Observations
GZWGM5	25% recycled mixed-origin feedstock blended with 75% virgin	Highest overall rating	Most consistent audio performance across listeners
GZWGM6	100% GZ Eco Mix	High	Some variability observed across listeners
GZWGM3	100% virgin compound	Baseline control	Used as a reference for comparison
GZWGM4	10% recycled mixed-origin feedstock blended with 90% virgin	Moderate	Performance comparable to control
GZWGM1	50% recycled mixed-origin feedstock blended with 50% virgin	Moderate	Greater variation between A-side and B-side performance
GZWGM2	100% recycled mixed-origin feedstock	Lowest overall rating	Increased reports of crackle, clicks, and background noise

Further analysis of the listening data indicated that B-sides generally performed slightly better than A-sides across several variants. As Miles Showell, master cutting engineer at Abbey Road, noted, the audio selected for the B-side consists largely of louder, more compressed material, which can mask low-level vinyl noise and minor pressing artifacts. Conversely, the audio selected for the A-side features quieter, more dynamic content, making such artifacts more readily audible. As a result, differences in perceived performance between the two sides likely reflect the interaction between vinyl surface noise and the dynamic profile of the program material, rather than a systematic difference in the recycled material blends themselves.

In addition, sensitivity analysis was conducted to determine whether the results were disproportionately influenced by any individual listener. When the ratings from a single listener were excluded, the relative ranking of the variants did not change meaningfully. The 100% mixed-origin material variant remained the lowest rated, while the 25% mixed-origin vinyl blend remained the highest rated.

The results indicate that blends incorporating recycled mixed-origin feedstock can be used in pressing compounds without consistently detectable impacts on perceived audio quality. However, higher mixed-origin content levels may introduce additional variability that warrants further investigation.

While this pilot focused on pre-consumer material, these findings provide initial insight into how mixed-origin recovered feedstock may behave in production, including alongside post-industrial sources.

Overall, the listening panel did not identify evidence suggesting that recycled mixed-origin feedstock inherently compromises perceived audio quality under the conditions of this pilot.

Environmental Impact

Alongside the technical testing, the pilot included an environmental assessment to examine the lifecycle implications of recycling mixed-origin pre-consumer vinyl records.

The analysis was conducted with support from ClimatePartner, a firm specializing in emissions measurement, reduction, and climate project implementation. ClimatePartner was selected due to its prior experience with vinyl records supply chain from similar assessments.

The approach applies the life-cycle assessment principles aligned with the Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard. The objective was to evaluate whether incorporating recycled feedstock results in a net environmental benefit compared with conventional production using virgin PVC.

Vinyl record manufacturing relies on PVC compounds derived primarily from fossil fuel-based feedstocks, which contribute to 39% of cradle-to-gate emissions for average vinyl record production in Europe.² Reintroducing obsolete vinyl into production reduces demand for virgin PVC material inputs but introduces additional processes, including transportation, storage, sorting, shredding, and reprocessing. The assessment therefore evaluates the net impact of these trade-offs within a defined system boundary.

System Boundary and Data Approach

The system boundary applied in this calculation is “Cradle-to-Gate” plus “End-of-life,” capturing emissions associated with raw material extraction, production, recycling processes, and disposal of the product and its packaging.

This approach expands on the ‘Cradle-to-Gate’ methodology in the Vinyl Alliance and Music Climate Pact’s ‘Sustainable Supplier Programme’ in 2025. The inclusion of end-of-life emissions is necessary in this case, as the pilot specifically evaluates vinyl-to-vinyl recycling pathways in which obsolete material is recovered and diverted from disposal.

Use-phase emissions and outbound distribution were excluded due to variability and limited control within the scope of the pilot. Similarly, outbound distribution was excluded to maintain consistency with prior industry studies and due to the early-stage nature of this analysis.

Emissions not directly attributable to a specific product but required for production, such as facility-level energy use and supporting activities (e.g., employee commuting and business travel), were included as general emissions where relevant.

The analysis was conducted using a combination of primary data provided by Warner Music Group and GZ, and secondary data sourced from ClimatePartner’s database as part of their work with the Vinyl Alliance and Music Climate Pact’s ‘Sustainable Supplier Programme.’

Scenario Design and Functional Unit

In both scenarios, emissions associated with storing obsolete records at a contracted warehouse in France for one year were included. The records are then either transported to GZ for recycling (Scenario 1) or sent for disposal (Scenario 2). The quantity of obsolete records modelled corresponds to the material required to press 1,000 new records.

Because this vinyl never reached an end-consumer, its lifecycle is treated as extended through reprocessing in manufacturing rather than producing new records from virgin PVC. As a part of this extended life-cycle, the emissions associated with each obsolescent record's original production are included in the analysis. To account for this, an average emission factor for a European-produced vinyl record was applied to each obsolescent record in both scenarios.

Treatment of Pre-Consumer Material and Mass-Balance Approach

Because the pre-consumer material in this study consists of pre-consumer vinyl that has not reached an end user, its lifecycle is treated as extended through reprocessing rather than replaced by new production. As part of this extended lifecycle approach, emissions associated with the original production of the obsolete records are included in both scenarios. To account for this, an average emission factor for European-produced vinyl records, 0.75 Kg CO₂e, was applied to each unit of obsolescent material. Rather than calculating a product-level carbon footprint for an individual record, the analysis applies a mass-balance comparison across the two scenarios. This reflects that the same pre-consumer inventory exists in both cases, regardless of whether it is recycled or disposed of. The comparison therefore isolates the environmental impact of the treatment pathway (recycling vs. disposal), rather than differences in initial production.

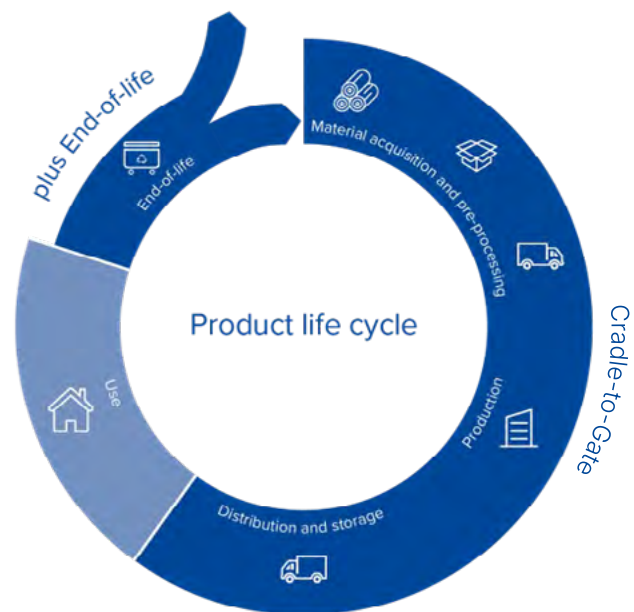
As a result, the outputs of this analysis are not directly comparable to previously published vinyl product carbon footprints, which are typically calculated on a per-unit basis under different system boundaries.

Emissions Accounting

All emissions are reported as carbon dioxide equivalents (CO₂e), referred to in this report as "CO₂".

This includes all relevant greenhouse gases as defined by the IPCC Assessment Report:

- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Hydrofluorocarbons (HFC)
- Perfluorocarbons (PFC)
- Sulfur hexafluoride (SF₆)
- Nitrogen trifluoride (NF₃).



Under the conditions modeled, Scenario 1 demonstrated a 10.6% reduction in total emissions compared with Scenario 2.

This reduction is primarily driven by:

- Lower demand for virgin PVC inputs
- Reduced material sent to end-of-life disposal

These benefits are partially offset by emissions associated with recovering, storing, transporting, and processing the obsolete material. In this pilot, incorporating mixed-origin recovered feedstock reduced overall emissions compared with producing records entirely from virgin material.

The mixed-origin material evaluated in this study was derived from a limited and screened set of obsolete records and may not fully represent variability across broader supply chains or manufacturing environments. These findings should therefore be interpreted within the defined system boundary and pilot conditions and are not intended to represent all vinyl production systems.

Production Feasibility

The pressing trials showed that mixed-origin material can be reprocessed into new, high-quality pressings. However, at higher inclusion rates, achieving consistent results required careful control of processing conditions, including increased operator oversight and adjustment. Lower inclusion levels (10%, 25%) performed more consistently, while higher-content blends (50%, 100%) introduced greater variability in material handling and pressing behavior.

These observations highlight the importance of identifying practical inclusion thresholds for mixed-origin material that remain compatible with existing pressing equipment and production workflows. This consideration applies specifically to mixed-origin material streams and should not be interpreted as applying to homogeneous recycled compounds produced through controlled compounding processes.

The homogeneous recycled compound Eco Mix, produced from internal manufacturing scrap did not present the challenges observed with the mixed-origin pre-consumer material. Eco Mix ranked among the top-performing variants, demonstrating that reusing controlled production waste does not compromise record quality.

Material Accounting Considerations

Taken together, these observations suggest a practical constraint: while higher proportions of mixed-origin pre-consumer recycled vinyl inputs may be technically achievable, segregated processing becomes less stable and production less efficient as the proportion of mixed-origin inputs increases.

In this context, plant-level mass balance accounting represents a more scalable pathway for incorporating these inputs. Under a mass balance framework, recycled inputs are introduced into the overall production system and allocated proportionally in smaller ratios across output through accounting, rather than through physical segregation throughout the whole process.

From a manufacturing perspective, this approach reduces the impact of feedstock variability by distributing heterogeneous material across a larger production volume, enabling more consistent compound behavior and press conditions. It also removes the need for segregated handling of mixed-origin material, which was observed in this pilot to introduce operational constraints. GZ already operates ISCC PLUS mass balance systems for certain materials, confirming that the infrastructure required to support this approach is in place.

Mass balance accounting reflects system-level material flows and does not imply that individual products contain a defined proportion of recycled material. Any future implementation would require appropriate documentation, verification, and alignment with environmental claims guidance.



Limitations

As with any controlled pilot study, the findings presented in this report should be interpreted within the specific experimental conditions under which they were generated. The pilot was designed to evaluate technical feasibility rather than to establish industry-wide performance benchmarks. Consequently, the results reflect the materials, equipment, and testing protocols used in this study and may not fully represent outcomes across other manufacturing environments, compound formulations, or production scales.

Notable limitations include:

- **Feedstock variability:** The mixed-origin pre-consumer material used in this pilot was derived from a limited set of obsolete records that met specific screening criteria. The composition of feedstock may vary across different supply chains and production histories.
- **Production Environment:** The pressing trials were conducted within a defined production environment. Results may differ when obsolete recovered vinyl materials are introduced into other manufacturing contexts.
- **Audio Evaluation Methodology:** The listening evaluation relied on expert panel assessment rather than comprehensive instrumental measurement of groove geometry or noise spectra across all variants. As such, the results should be interpreted as observational findings rather than definitive measurements of audio performance. Prior to initiating the listening panel, a preliminary average noise analysis was conducted to confirm that the pressings were of sufficient quality for evaluation. This analysis indicated that general noise fingerprints were broadly similar across the tested blends, with marginal variation, while random noise was more prone to variability. The noise analysis served as a quality gate before the listening tests but was not intended to provide a full acoustic characterization of the pressings.
- **Environmental Impact:** The environmental analysis associated with the pilot is limited to the processes evaluated within the project scope. Broader lifecycle impacts associated with distribution, retail, and consumer use were not included in this pilot study.
- **Product Level Claims:** These findings relate to the performance of physical blend variants and do not extend to product-level claims regarding recycled content or labeling. This is particularly relevant where mass balance approaches are applied, as such systems allocate inputs at a system level rather than to individual products.

These findings are intended to inform further technical and environmental evaluation rather than to establish industry-wide performance benchmarks.



Implications for the Vinyl Industry

The continued growth of vinyl as a format presents both an opportunity and a responsibility for the music industry. As production volumes increase, stakeholders across the supply chain are examining how the environmental footprint of physical media can be better understood and managed.

This pilot was undertaken to explore whether warehoused obsolete vinyl records can be safely and effectively reintroduced into vinyl manufacturing. While the findings represent observations from a controlled feasibility study, they contribute to a growing body of work aimed at improving transparency around the environmental and operational characteristics of vinyl production.

Previous research has identified the PVC compound used in record pressing as the second largest contributor to manufacturing emissions. As a result, material efficiency and compound innovation are key levers for reducing environmental impact. This includes the use of recycled and alternative feedstock pathways, though benefits may be limited or highly dependent on accounting methodology, system boundaries, and energy use in any given factory.²

In parallel, further work is needed to understand how recycled mixed-origin pre-consumer feedstock performs across different pressing environments and to define recycled content thresholds that can be integrated into commercial production without compromising manufacturing stability or audio quality. Results from this pilot indicate that higher proportions of mixed-origin material introduce increased variability during pressing, highlighting the need to balance recycled content with operational consistency. Further research is required to evaluate repeated thermal processing, long-term material performance, supply chain scalability, and environmental impacts across multiple facilities.

The vinyl industry has historically demonstrated a strong capacity for innovation, and some pressing plants and suppliers are already exploring new compound formulations, alternative materials such as PET, and process improvements.

While price, collectability, and artist affinity remain the primary drivers of vinyl purchasing decisions, environmental considerations are emerging as a secondary factor for some consumer segments. However, their own purchasing behavior remains limited and context-dependent.^{3,4}

For this reason, sustainability discussions around vinyl production should be grounded in transparent data and careful analysis. The purpose of publishing this pilot is to contribute practical insight and support continued research within the vinyl manufacturing ecosystem.

This work represents one step toward building that knowledge base. Continued collaboration between record labels, pressing plants, suppliers, and industry organizations will be essential to developing the data and technical solutions needed to support the long-term resilience of the vinyl ecosystem.



References and Sources

This report draws on publicly available research, industry data, and internally-generated observations from the pilot project described herein. The sources listed below provide context for the environmental characteristics of vinyl production, consumer demand trends, and broader developments within the recorded music industry.

Recorded Music Market Data

1. International Federation of the Phonographic Industry (IFPI). (2026). *Global Music Report 2026: State of the Industry*.

The IFPI report provides global data on recorded music revenue trends, highlighting continued industry growth driven by streaming and sustained demand for physical formats such as vinyl records.

Industry Environmental Research

2. Music Climate Pact, & Vinyl Alliance. (2025). *Sustainable Supplier Programme: Phase 1 Insights Report*.

This report presents a standardized, industry-wide assessment of the carbon footprint of vinyl record manufacturing, quantifying emissions across raw materials, production processes, and packaging components.

Consumer Research

3. Vinyl Alliance. (2025). *Gen Z Report Preview*. Vinyl Alliance Research Initiative.

The report provides qualitative and quantitative insights into Gen Z vinyl consumers, including purchasing behavior, motivations for collecting vinyl records, and the growing role of environmental considerations in purchasing decisions.

4. McKinsey & Company. (2020). *Consumers care about sustainability—and back it up with their wallets*. McKinsey & Company.

Research from McKinsey & Company shows that while consumer interest in sustainability is increasing, its influence on purchasing decisions remains secondary to factors such as price, quality, and brand affinity, and is often context-dependent.

Standards and Methodological Frameworks Referenced

Greenhouse Gas Protocol.

Corporate Accounting and Reporting Standard and Product Life Cycle Accounting and Reporting Standard.

International Organization for Standardization (ISO).

ISO 14040 / ISO 14044 – *Life Cycle Assessment: Principles and Framework*.



Appendix:

Physical and Audio Evaluation Criteria

The following criteria were used to assess both the physical integrity and audio performance of records produced during the pilot. These indicators reflect common manufacturing and playback considerations used within vinyl pressing environments to identify defects, evaluate consistency, and determine overall product quality. Physical attributes focus on visual and structural characteristics that may affect handling and playback, while audio attributes capture audible artifacts and distortions experienced during listening.

Physical Evaluation Criteria

- Surface defects (scuffs, scratches)
- Weight consistency
- Colour consistency
- Off-centre pressing
- Warping / dishing
- Surface texture irregularities (e.g., orange peel)
- Pits / dimples
- Non-fill
- Groove contamination (e.g., debris, dust, paper)
- Overpolishing

Audio Evaluation Criteria

- Distortion (including end-of-side distortion)
- Crackle
- Clicks
- Swooshing
- Overall Sound Quality
- Background Surface Noise
- Skipping/Jumping
- End of Side Distortion