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Beyond quantity: Rio Tinto's focus on quality rehabilitation outcomes in the Pilbara region of Western Australia

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Abstract

Rio Tinto has responsibility for rehabilitation across its Pilbara operations, which include 18 mine sites, port facilities and an extensive rail network in Western Australia. As the operational disturbance footprint has grown, so has the need for increased progressive rehabilitation to offset it. In response, a rapid increase in rehabilitation delivery has been a focus across landforms of various complexity and size, achieving an average of 50% year-on-year uplift in hectares rehabilitated since 2019. With a continued pipeline of rehabilitation hectare outputs, the focus has now turned to quality and replication of successful outcomes.

Rio Tinto's investment in research, development and trials to improve rehabilitation performance in the Pilbara is informed by a rehabilitation strategic plan and performance framework endorsed by senior leadership. In 2022 the business established dedicated rehabilitation performance resourcing and technical expertise to support delivery of improved rehabilitation quality outcomes. Since this time, the rehabilitation performance team has managed an increasing portfolio ranging from seed forecasting and procurement through to rehabilitation monitoring and reporting, capturing knowledge gaps and identifying programs of work to resolve them. Central to this has been increasing the utilisation of rehabilitation monitoring data to: (1) develop digital tools to improve reporting and business understanding of rehabilitation quality; (2) develop proposed specific, measurable, achievable, relevant and time-bound (SMART) rehabilitation criteria; and (3) demonstrate the quality of previous rehabilitation outcomes against proposed rehabilitation criteria. This paper will describe the evolution of the program and provide insights of connected seed and species projects, replicated field trials, monitoring and reporting improvements, and collaboration with research institutions. The aim of the program is to move beyond simply hectares rehabilitated and towards developing evidence-based prescriptions to achieve quality rehabilitation outcomes.

Keywords: *mine closure, progressive rehabilitation, completion criteria, monitoring, performance indicators, Pilbara*

1 Introduction

Rio Tinto operates a network of iron ore mines, rail corridors and port facilities across the Pilbara region of Western Australia (Figure 1). Iron ore mining is conducted through open pits which results in an inevitable disturbance footprint. Progressive rehabilitation is conducted during operations to reduce the disturbance footprint, manage closure liabilities and demonstrate that disturbed land can be returned to proposed post-mining land uses. However, there are several challenges associated with rehabilitating landforms in the Pilbara region. High rates of evaporation and highly variable inter-annual rainfall characterise the region, and average daily maximum temperatures exceed 35°C from October to March (Sudmeyer 2016). In the eastern Pilbara, rainfall is predominantly influenced by tropical and monsoonal drivers which occur mostly in summer and autumn, while the western Pilbara also has frontal systems influencing rainfall during autumn and winter (Sudmeyer 2016). Tropical cyclones cause the most extreme rainfall events, though their inter-annual contribution to summer rainfall ranges from 0 to 86% (Sudmeyer 2016).

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The importance of rainfall quantity to germination and survival has been demonstrated in research trials where volumes around 120 mm over a week provided the best conditions to maximise germination (Erickson et al. 2023; Lewandrowski et al. 2018). While beneficial to seed germination, large volumes of rain can impact landform stability and trigger erosion events (Howard & Loch 2019). These challenges require informed planning for landform design, rehabilitation prescriptions and monitoring to determine success rates. For Rio Tinto, landform stability models inform landform design so that the requirement can be met for safe, stable and non-polluting landforms (e.g. see Chester et al. 2022; Worthington et al. 2019).

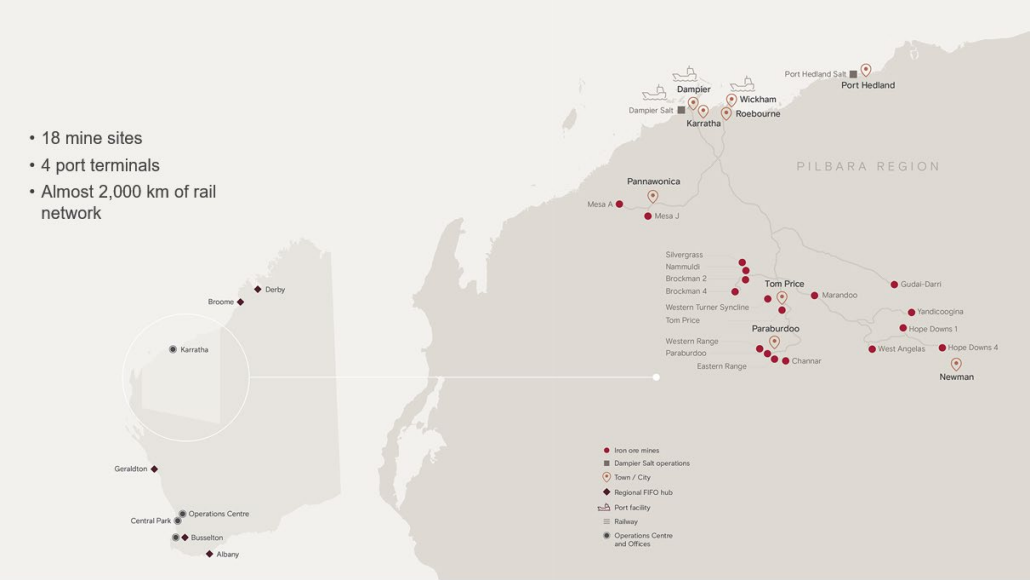

Figure 1 Location of Rio Tinto Pilbara operations

With demonstrated ability to plan and execute rehabilitation landforms with a high degree of conformance to design, the company's progressive rehabilitation program expanded rapidly from 2019, with an average 50% year-on-year uplift of area rehabilitated (Figure 2) and a forecast to rehabilitate 4,000 hectares over the next 5 years. This scale-up was supported by expanded delivery capacity, including increased engagement of Pilbara Aboriginal businesses (PABs) for rehabilitation earthworks and construction activities (Chester et al. 2022). While maintaining the area of rehabilitated hectares as a key delivery target remains important to retain a pipeline of work for PABs and to reduce closure liability during the life of mine, it is the quality of the rehabilitation outcomes that determines long-term rehabilitation success. Furthermore, if rehabilitated hectare delivery increases without good predictability of quality and the likelihood of future relinquishment, there is potential for costly rework, delayed relinquishment and uncertainty when forecasting closure schedules.

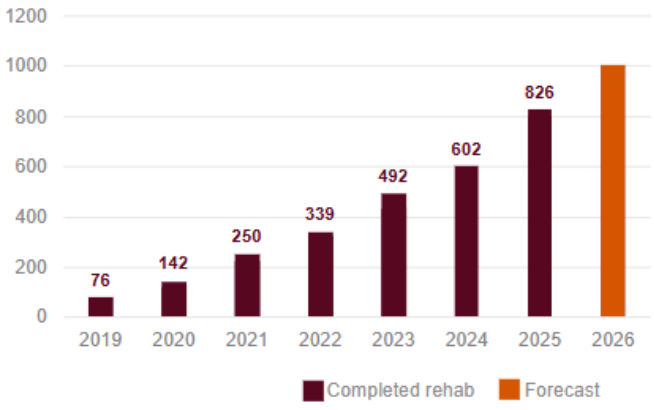

Figure 2 Number of hectares rehabilitated annually across Rio Tinto's Pilbara mining operations from 2019 to 2025, and the forecast for 2026

Learnings from Rio Tinto's experience across diverse Pilbara land systems have been embedded into rehabilitation design and planning processes that support early establishment outcomes (e.g. erosion resistance, germination and vegetation recruitment) across landforms, seasons and operational practices. Now that a level of maturity has been built for planning and designing 'how much' rehabilitation is delivered, focus has pivoted to 'how well' it performs. This shift is supported by senior leadership within the organisation to develop an evidence-based approach that defines and measures quality, identifies performance constraints and implements improvement actions through alignment with the Rio Tinto Iron Ore environment strategy. Understanding how well rehabilitation performs requires targets to measure against (Young et al. 2019). The Western Australian Government through the Department of Mines, Petroleum and Exploration (2025) has developed a series of standard closure outcomes which represent the objectives, goals or outcomes to be achieved at the completion of the decommissioning of a mine and the rehabilitation of the land. Mine closure plans must state the closure outcomes and the associated completion criteria which are justified by evidence such as trials and research findings and the criteria must be measurable and defensible.

This paper documents Rio Tinto's recent organisational and technical progression to focus on quality rehabilitation outcomes via: (1) establishment of central planning capability to sustain progressive rehabilitation delivery; (2) development of proposed quantitative completion criteria and early-phase performance indicators to define, measure and report rehabilitation quality; and (3) prioritisation of targeted research, development and trials to address identified constraints. Establishment of the rehabilitation performance framework to establish a rigorous feedback loop will be detailed and described using examples to demonstrate the importance of continuous improvement for rehabilitating Pilbara landscapes.

2 Program evolution: from hectare delivery to a focus on quality

Rio Tinto's progressive rehabilitation program has progressed through 2 overlapping phases: (1) increasing the area being rehabilitated; and (2) improving rehabilitation quality. Increasing the rehabilitation area has been achieved through improving linkages between the mine planning and rehabilitation and closure teams over several years. Rehabilitation planning now includes a 5-year forecast identifying rehabilitation sites and when they will become available. This paper focuses on the second phase of improving rehabilitation quality, which is underpinned by standardising the monitoring and assessment processes for completed rehabilitation, identifying constraints to achieve quality outcomes, identifying research and trials, and translating research findings into operational practice. The phases overlap because rehabilitation delivery must continue while the knowledge base and work practices mature. More detail on the steps taken to evolve this program are described below.

2.1 Step 1: maintaining a delivery pipeline while acknowledging rehabilitation quality must improve

Progressive rehabilitation of the mine disturbance footprint is a key management action for Rio Tinto in the Pilbara. Business decisions were made to develop targets for annual rehabilitation hectares with an objective to increase rehabilitation area year-on-year across all operations where land was available. Rehabilitation planning now includes annual updates to a 5-year progressive rehabilitation plan which includes all mine sites and is integrated into the annual business planning processes. This process has led to more certainty when maintaining pipelines of work for PAB contractors and resulted in more contractors with the skills for completing earthworks safely and to a high standard. However, vegetation growth and rehabilitation performance have been variable and not linked to quantitative metrics. While the quality of earthworks associated with landform rehabilitation has improved, knowledge gaps remained with respect to long-term rehabilitation performance. Rather than cease all earthwork operations to acquire the knowledge, an adaptive management strategy was internally endorsed to continue increasing the progressive rehabilitation area while rehabilitation quality knowledge gaps were investigated.

2.2 Step 2: establishing the rehabilitation performance team and the rehabilitation strategic plan

In 2022 the company introduced dedicated rehabilitation performance capability into the rehabilitation and closure team which is responsible for identifying, designing, implementing and monitoring of rehabilitation projects. By 2026 the rehabilitation performance team had grown to 8 team members with a variety of skill sets, bringing expertise from academia, mining and non-mining backgrounds with complementary skills such as agricultural science and geospatial intelligence. The team manages an integrated portfolio spanning monitoring and reporting, rehabilitation criteria development, seed management, field trial planning and delivery, data systems, and external research partnerships. Work is guided through alignment to a rehabilitation strategic plan with 5 focus pillars: 'landscapes and landforms', 'driving revegetation success', 'progressive rehabilitation,' 'two-way science' and 'performance monitoring' (Figure 3).

The rehabilitation strategic plan (Figure 3) was revised in 2025 to help structure the workflows that will lead to maintaining or increasing the area of land being rehabilitated but also to improve quality to achieve long-term performance outcomes. The current focus is on identifying factors that drive revegetation success and improvements in performance monitoring, specifically in relation to development of proposed quantitative performance indicators and digital tools to display and summarise monitoring data. Investment in research, development and trials is informed by the strategic plan, which also provides clear structure and justification for proposed research and development (R&D) work.

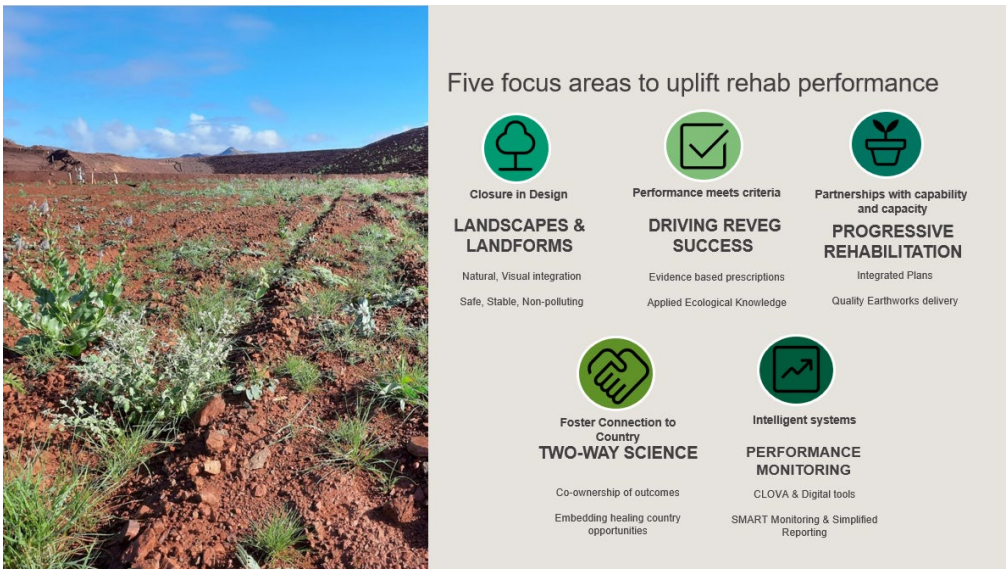

Figure 3 The rehabilitation strategic plan focuses on 5 key areas to improve rehabilitation performance outcomes. Priority focus areas include 'driving revegetation success' and 'performance monitoring'

2.3 Step 3: developing quantitative completion criteria as the basis for measuring rehabilitation quality

Monitoring of historical rehabilitation had taken place across the sites for many years. However, in the absence of quantitative rehabilitation success criteria, the results were not being used critically to inform how rehabilitation outcomes could be improved. The pivotal enabler for the company's assessment of rehabilitation quality has been the development of proposed quantitative completion criteria and particularly early-phase performance indicators, with reference to the Western Australian Biodiversity Science Institute completion criteria framework (Young et al. 2019). Prior to this work, rehabilitation was assessed against undisturbed analogue landforms which had inherent variability through time and between sites. The development of proposed quantitative completion criteria (initiated in 2021 and planned for completion across all Pilbara assets by end of 2028) links closure intent to measurable targets and defines what is achievable at a site and landform level. Criteria are designed to be specific, measurable, achievable, relevant and time-bound (SMART) and include 3 time-related phases. Phase 1 relates to landform planning and construction, ensuring all inputs are considered to design a safe, stable and non-polluting landform. Phase 2

provides leading indicators that can be assessed early (within 1–3 years of landform construction and rehabilitation) and phase 3 provides lagging indicators (beyond 3 years) to confirm that rehabilitation is on a desired trajectory or is meeting the completion criteria. Phase 1 is a checklist of planning considerations, while thresholds in phases 2 and 3 are informed by analysis of the best-performing rehabilitation against analogue sites, and have been developed from historical monitoring data (i.e. are evidence-based). The framework used for developing criteria and performance indicators for vegetation and fauna habitat on rehabilitation sites is shown in Figure 4. Together, the criteria and indicators provide the basis to assess rehabilitation quality, support consistent reporting and direct improvement actions where performance falls below target.

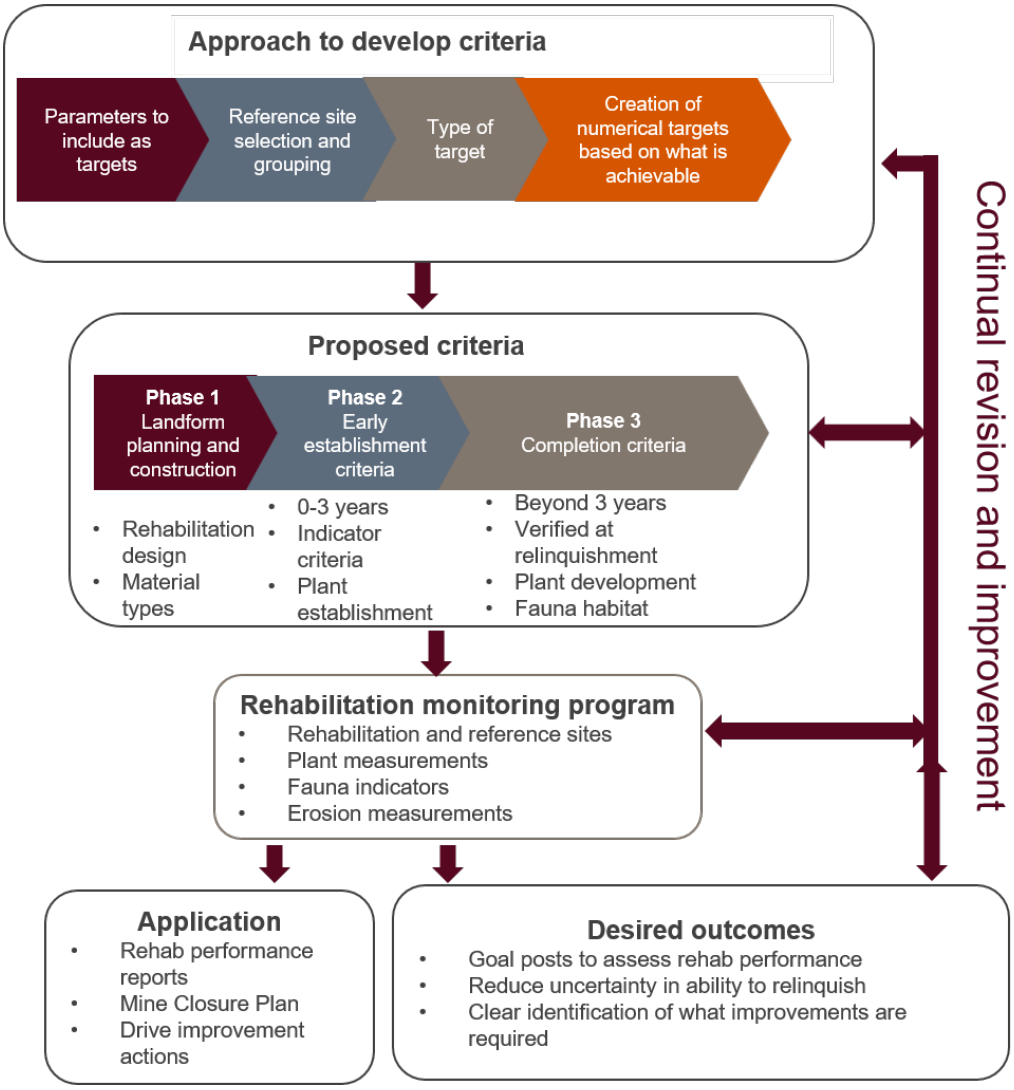

Figure 4 Rehabilitation vegetation and fauna habitat criteria framework linking monitoring, the approach to develop criteria and time-bound phases for criteria assessment: phase 1 landform planning and construction; phase 2 early establishment indicators (0–3 years); phase 3 completion criteria verified at relinquishment)

2.4 Step 4: Standardising monitoring procedures and improving data management and visibility

Standardised monitoring is essential to collect high-quality and comparable data across sites. Data has been collected from monitoring sites in the same way for decades, and this remains one of the strengths of Rio Tinto's rehabilitation program. A 2024 internal review of monitoring and reporting processes identified no significant changes that were needed to the on-ground monitoring procedures. Data governance has also been strong, with storage in a dedicated database which holds all environmental data across the business.

Improvement opportunities that were identified included the use of remote sensing as an additional monitoring process, and development of a dedicated digital interface to bring monitoring and rehabilitation data together. A barrier to assessing rehabilitation quality in the past was the inability to access information in a timely manner or in a format that clearly displayed quality metrics. Therefore, a digital program was developed to draw monitoring data out of storage and into an easy-to-use system to display rehabilitation features at each site and the status of each performance indicator. The closure verification and assessment (CLOVA) system permits users to review rehabilitation quality data at a range of scales (from transect level up to mine site level) and has given more visibility to the importance of considering rehabilitation performance during operations. CLOVA now provides outputs (example in Figure 5) that translate monitoring results into operationally meaningful signals (e.g. pass/fail against leading or lagging indicators), enabling timely decisions about corrective actions and prioritisation of improvement initiatives.

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Assessment criteria	Pass	T1 2008	T2 2008	T3 2008	T4 2008	Meeting
Last monitored		Sep 2022	Aug 2016	Aug 2019	Jun 2024	
Landform stability						
Gully depth	≤ 40	No Encap	No Encap	No Encap	No Encap	100%
Vegetation and habitat						
Perennial cover	≥ 19%	↘ 18.6%	↗ 39.8%	↘ 31.2%	↘ 28.0%	75%
Spinifex cover	≥ 15%	↘ 2.8%	↗ 22.1%	↘ 20.4%	↗ 10.0%	50%
Flowering &/or fruiting	True	✓	✓	✓	✓	100%
Native recruitment	True	✓	✓	✗	✓	75%
Weed cover	≤ 5%	→ 0.0%	↗ 0.5%	↘ 0.0%	→ 0.0%	100%
Vegetation strata	≥ 2	→ 4.0	→ 4.0	↘ 3.0	→ 4.0	100%
Rocks, logs &/or leaf litter	True	✓	✓	✓	✓	100%
Total matching criteria met		6 of 8	8 of 8	7 of 8	7 of 8	5 of 8

Figure 5 Example reporting output from the closure verification and assessment system showing the criteria measurement and status for each transect on a rehabilitation feature (transects indicated by columns T1, T2, T3, T4) and the percentage of transects passing each performance indicator for the rehabilitation feature ('Meeting' column)

2.5 Step 5: identifying knowledge gaps, underperforming rehabilitation metrics and research priorities

As completion criteria and early performance indicators are developed on a site-by-site basis they can be compared against monitoring results to identify which criteria are, or are not, meeting expectations. This helps identify where knowledge gaps and research priorities exist either at a site level, or potentially across all sites. Analyses that come from this work can identify where rehabilitation has underperformed, highlight which leading or lagging indicators are passing and failing, and pinpoint persistent or common metrics that are underperforming. This focus on quality helps identify rehabilitation performance issues from which knowledge gaps and research priorities can be derived. This process is explained in more detail in Section 3.1.

The evolution of Rio Tinto's rehabilitation program to focus on the quality of outcomes aligns with the Mine Closure Completion Guideline (Department of Energy, Mines, Industry Regulation and Safety 2021), which sets out guidance on the evidence required to receive formal acceptance from the Western Australian Government that rehabilitation and closure obligations have been met under the *Mining Act 1978* (Government of Western Australia 1978). Submission of a Mine Closure Completion Report under the Act requires evidence that rehabilitation actions are effective, not merely completed, by demonstrating that completion criteria have been achieved via appropriate monitoring. The 5 steps outlined above demonstrate a clear path towards building internal capability to assess performance, identify knowledge gaps, and implement research and trials to improve outcomes.

3 Beyond quantity: improving quality through adaptive management

Conducting progressive rehabilitation during operations is important for reducing the amount of land area under disturbance and being able to learn and improve prior to closure. Mining iron ore in the Pilbara results in a disturbance footprint that includes waste rock dumps that can be hundreds of hectares in size and consist of millions of cubic metres of material. These novel landforms cannot be returned to what was previously in their place (i.e. cannot be restored), but they can be designed and rehabilitated to become functioning ecosystems that blend with their natural surroundings. Because of their size, and the size of the overall disturbance footprint, rehabilitating areas as soon as practicable is a good ecological and economical strategy. However, if the rehabilitation is of poor quality, it does not serve an ecological outcome; nor is it a good economical decision, due to the potential for costly rework.

The implementation of rehabilitation performance measurements to understand the quality of historic rehabilitation is an essential step towards determining the value of progressive rehabilitation. It also identifies opportunities for improvement work and R&D to get better outcomes, thereby reducing closure liability. This is one of the key outcomes of this initiative: to quantify the problem and identify some of the key metrics that are consistently underperforming. Improvement initiatives to elevate these metrics can be justified from this work, and the outcomes can be fed back into operations to develop a process of adaptive management.

3.1 The rehabilitation performance framework

A conceptual depiction of the rehabilitation performance framework is shown in Figure 6. The outer ring forms the core components of planning, conducting, monitoring and improving rehabilitation over time. This corresponds to the 'plan–do–check–act' cycle of continuous improvement (Deming et al. 1982; Shewhart 1939) and is described below:

- The rehabilitation management plan sets out the core steps and considerations across all stages for completing a rehabilitation project.
- Rehabilitation works are conducted on site by implementing the earthworks and seeding (where applicable) according to the rehabilitation design and scope of works.
- Monitoring of rehabilitated sites is undertaken to obtain time series data for key metrics.
- Performance assessment is conducted using results from the monitoring program to examine performance issues, identify knowledge gaps, and implement R&D as required.

Prior to developing the rehabilitation performance framework, the 'act' component of the cycle (conducting performance assessments) was infrequent and could not be conducted against clear targets. As described above, the rehabilitation performance team has now developed methods for completing performance assessments, which are depicted in the inner circle of Figure 6. These include the following steps:

- Identify the underperforming metric(s). Because these metrics are linked to proposed completion criteria, they must be investigated.

- Develop a problem statement related to the metric. The statement outlines a non-controversial observation based on fact (the data) and is likely to represent an impediment to achieving a long-term closure objective. The purposes of the problem statement are to capture the current processes and outcomes and identify short-comings or knowledge gaps, which help define work that needs to be done to improve outcomes. Hypotheses are then considered as a way to solve the problem.
- From these hypotheses, potential projects are listed and detailed to test the hypotheses.
- Projects are prioritised by the rehabilitation performance team for inclusion in annual works programs. Governance of prioritisation occurs through the annual planning process.
- Projects are initiated and may form field trials, investigations, literature reviews or collaborative research with academia.

Once the project is completed (or during the work, if early findings warrant it), outcomes are fed through to the planning phase via changes to the rehabilitation management plan. Updates to the plan can occur at any time when findings warrant a change in process. Further direct communication to the affected teams (e.g. rehabilitation delivery team) occurs through memorandums and/or information sessions as needed.

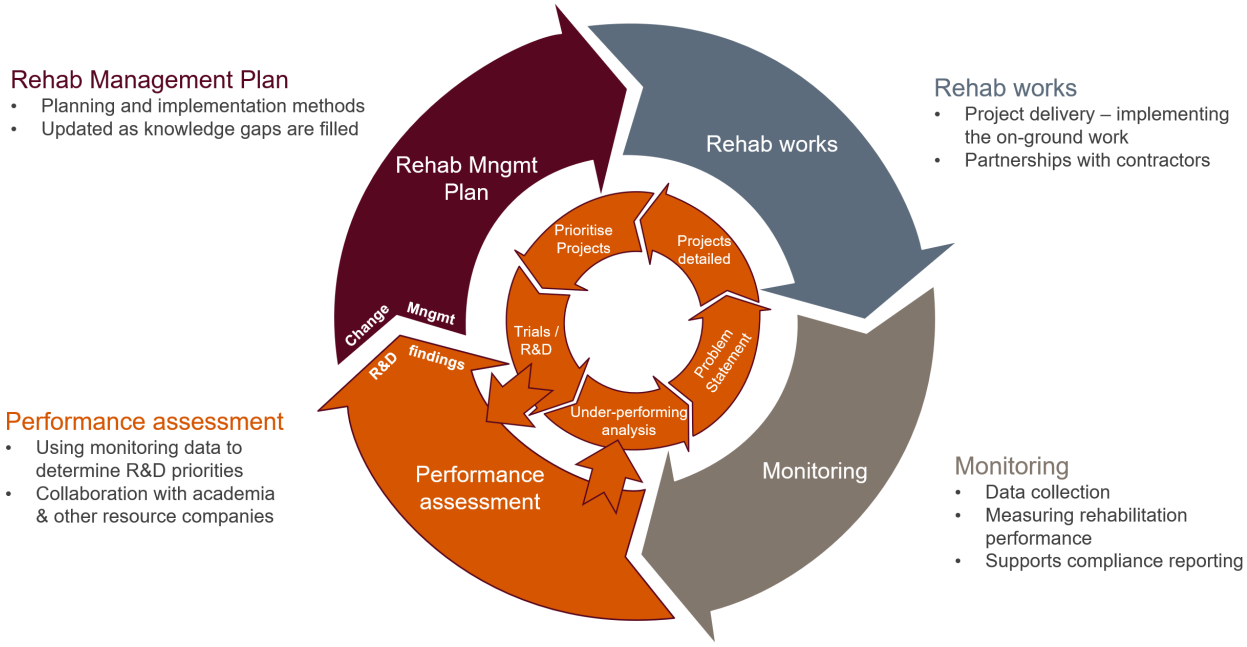

Figure 6 The rehabilitation performance framework consisting of the outer loop demonstrating key work to complete rehabilitation projects, and the inner performance assessment focusing on improving rehabilitation quality, trials, research and development

A key initiative of the rehabilitation performance framework has been to design field trials that are replicated and include controls to quantify background contributions to observed data. This is essential to have confidence in findings and develop evidence-based prescriptions for methods. Replication of treatments on a specific rehabilitation feature allows for any spatial variation in soils or waste materials on the feature which may affect results. Replication of the same trial across more than one mine site (where possible) also demonstrates the applicability or otherwise of results at multiple sites. Building up this evidence by implementing replicated and controlled field trials is an important step to fill in knowledge gaps and have corroboration to change or improve an implementation method.

Rio Tinto is now also developing partnerships with academia and industry to fund R&D opportunities to investigate specific problems. Structuring and planning these research opportunities is a key part of being

able to rapidly solve problems on multiple work fronts simultaneously. Obtaining results from trials on rehabilitation improvement inevitably takes time. Therefore, commencing many work items and having several teams working on different problems will permit a faster understanding of knowledge gaps and faster uptake of new information.

4 Developing integrated work plans for quality uplift

Several key projects have been instigated through development of the rehabilitation performance framework to uplift rehabilitation quality.

4.1 Example 1: the seed value chain

Seed is recognised as a constraint to meeting the goals for increased rehabilitation hectares. Developing a problem statement on the seed value chain identified several key projects that require effort. Some of these projects are listed below:

- seed forecasting to quantify the number and size of rehabilitation areas by mine site over the next 5 years and how much (and which species) of seed is required
- increased seed procurement each season and setting up processes that allow for additional seed to be purchased when seasons are plentiful
- improving seed-use efficiency by developing partnerships in R&D to investigate seed dormancy alleviation, seed processing methods and direct seeding methods
- planting tubestock of those species that do not return from seed and investigating tubestock survival.

Projects such as seed forecasting have now become essential business-as-usual processes to inform seed collection partners of our needs and mitigate any seed-related constraints via Rio Tinto's 5-year rehabilitation plan. This has been formalised through inclusion in the rehabilitation management plan.

Other works, such as those to improve seed-use efficiency, are longer-term projects that will likely have several small improvements along the way as knowledge gaps are filled but, overall, are considered the most essential for improved outcomes in the long term. These currently sit in the trials/R&D phase of the rehabilitation performance framework (Figure 6). However, rather than wait for all project outcomes before enacting change, the rehabilitation performance framework permits any small findings to be included through the rehabilitation management plan at any time to allow incremental improvements.

4.2 Example 2: monitoring and reporting efficiencies

Rio Tinto manages a large and complex monitoring program for rehabilitation across its sites. Monitoring results are reported through compliance mechanisms and a variety of formats. Following the development of proposed quantitative completion criteria, opportunity existed to improve the efficiency of performance reporting. Development of a digital product to display monitoring results became a focus through 2025, allowing data to be displayed, summarised and extracted for a variety of purposes. Ultimately, the goal of this project is to use outputs for direct inclusion in compliance reports, but also for ad hoc data requests, stakeholder engagements and internal key performance indicator reporting. This CLOVA product was discussed earlier, in Section 2.5.

A parallel workstream involved investigating remote sensing technologies to capture and quantify data. Given the size of Rio Tinto operations and an increase in rehabilitated area annually, remote monitoring was deemed a required improvement. Work is continuing to determine the methods and data to use, as well as data pipelines to incorporate into the new digital program.

4.3 Example 3: spinifex growth and the seed use chain

Benchmarking against proposed quantitative completion criteria has highlighted recurring constraints that are not consistently addressed through business-as-usual practices, particularly those influencing vegetation establishment. Variable establishment of *Triodia* hummock grasses (commonly known as spinifex) has been a common finding across all sites in the analyses conducted so far. Spinifex is ubiquitous in Pilbara landscapes and its germination ecology is complex (Erickson et al. 2016; Lewandrowski et al. 2018). For some rehabilitation features, poor performance is more broadly related to early vegetation density or, for older sites, low perennial plant cover. On most occasions this also means variable spinifex success.

By developing a problem statement, identifying knowledge gaps and listing out the known challenges, the seed use chain was identified as the basis for developing projects to help solve the issue. The aim of the work was: 'To identify a reliable and scalable seed use chain for *Triodia* that results in greater long-term recruitment in rehabilitation sites.' Concentrating on the seed use chain identified seed availability as a key constraint in achieving acceptable spinifex outcomes and that there is a need to conduct research and trials into all aspects of the seed use chain, from procurement and storage to pre-treatments and using the seed on ground.

This led to questions and hypotheses around 2 main themes:

1. How can more spinifex seed be procured to meet the higher demands based on increasing rehabilitation hectares and the potential need to increase seeding rates?
2. How can spinifex seed use efficiency be increased (i.e. Can more plants be achieved in the rehabilitation areas from fewer seeds via pre-treatment or other means)?

This approach highlighted the potential for additive benefits: if more seed can be procured, and efficiency of seed use can be increased, the constraint associated with having enough seed can be significantly reduced or eliminated. Addressing the procurement of more seed involved internal (Rio Tinto) processes, while the investigation of the seed use efficiency was outsourced to Curtin University through sharing of the problem statement, and determination of 'easy wins' compared with other work that might take more time and effort. Work related to easy wins included investigation of seed processing for storage and to remove non-viable florets and other trash from seed lots. Significant advances were made in seed processing (work yet to be published) which can reduce the storage volume of spinifex by around two-thirds. Other work which will provide longer-term benefits includes investigating germination and dormancy; these are ongoing but have already yielded key insights. A key next step from this work program is to investigate ways that the processing of spinifex seed can be scaled up to handle the large volumes that Rio Tinto procures annually. This will achieve benefits to alleviate seed storage constraints in the short term and, in combination with other treatments, potentially lead to increased seed germination rates in rehabilitation.

4.4 Example 4: snappy gum return in rehabilitation

Snappy gum (*Eucalyptus leucophloia*) is an iconic tree species in the Pilbara. However, the return of this species to rehabilitation sites is variable and is often in very low densities despite the seed being plentiful and easily germinated. The problem statement identified many issues that may cause this outcome, including the seeding depth, method of seed delivery and soil-water factors, many of which are likely interacting with the very small size of the seed to result in low plant densities. The potential for planting the species as tubestock was trialled at two sites in 2024–2025 and results have indicated this could be a successful method to establish the species. The trials compared different planting treatments including soil additives and different watering regimes. The intent of the trial was to determine if this method could produce results worth pursuing. The next stage of problem-solving involves logistical issues such as where seedlings would be raised, how they would be transferred and stored at the mine sites, how water can be obtained and the method of planting large numbers of tubestock in a safe manner. Demonstrating the viability of planting first allows effort to then be directed towards solving the next key logistical challenge. Outcomes are intended to

inform when tubestock is warranted, how it should be specified in scopes of work and how success should be assessed relative to seeding-only approaches.

5 Future state: developing evidence-based rehabilitation prescriptions

Developing the rehabilitation performance framework has led to several work fronts to improve rehabilitation outcomes. Performance assessments of completed rehabilitation have provided clear insights into common problems that require effort to manage and improve. The intention of improvement work is to develop a list of techniques and options to use for completing rehabilitation activities that are evidence-based. Feeding these through to management plans provides the governance framework for the planning and delivery teams to draw from to develop their prescriptions based on the known attributes of the final rehabilitation feature.

It will take time to gather the evidence and improve confidence through implementation. The benefits of instilling the rehabilitation performance framework into the ways of working include:

- providing transparency on areas that still have knowledge gaps. These should be visible in the framework, associated problem statements and work plans
- providing opportunities for the continuation of rehabilitation activities while improvement works are ongoing. This adaptive management approach also provides opportunities to monitor the effectiveness of changes that have been made to rehabilitation methods based on trial results. This builds further evidence that can reinforce the change or identify further knowledge gaps, thus leading to continuous improvement
- developing a clear but flexible work plan on priorities for improvement works
- clear delineation of improvement projects that can be worked on simultaneously to accelerate the uplift in rehabilitation quality
- building internal knowledge and the capability of staff and contractors in technical aspects of rehabilitation implementation for quality outcomes
- the ability to accurately ascertain and monitor the rehabilitation quality across operations or at individual mine sites. This is important for considerations of closure liability, costs and the need for rework or maintenance
- the ability to provide timely reports and transparency on rehabilitation quality through the improved data platform.

Through this continuous improvement and adaptive management process, the overall intention of the rehabilitation performance framework is to set our teams up to do rehabilitation once and do it well. This will lead to a reduction in future spend for maintenance or rework; and increased confidence in meeting completion criteria.

6 Conclusion

Rio Tinto has moved beyond placing importance on the ‘quantity’ of rehabilitation being performed to developing processes for improving the ‘quality’ of outcomes. Following the rapid scale-up in progressive rehabilitation, the focus has shifted from hectares delivered to the ‘quality, consistency and replicability’ of outcomes across diverse Pilbara landforms. This has occurred through:

- Senior leadership engagement and investment are critical. Senior leaders of such organisations must be engaged in and supportive of the significant investment in rehabilitation. The rapid increase in hectares and focus on quality outcomes would not have been possible without clear goals, direction and alignment with the Rio Tinto Iron Ore environment strategy, and integration across business governance, decision-making and annual planning forums.

- A dedicated capability was created to operationalise performance. The rehabilitation performance team (growing to a multidisciplinary group) has taken ownership of an integrated portfolio of monitoring/reporting, criteria development, seed forecasting/procurement, trials, data systems and research partnerships.
- Quality is defined through quantitative, time-bound criteria. The phases 1–3 completion criteria framework translates closure intent into specific, measurable, achievable, relevant and time-bound requirements.
- Monitoring data is being turned into decision-making tools. Standardised monitoring remains the backbone, while digital reporting (closure verification and assessment) turns datasets into accessible pass/fail status against indicators, supporting timely intervention, prioritisation of work and broader awareness of rehabilitation quality across the business.
- A structured adaptive management loop links evidence to action. The rehabilitation performance framework formalises plan–do–check–act by identifying underperforming metrics, translating them into problem statements and hypotheses, prioritising projects and feeding outcomes back into business-as-usual processes through updates to the rehabilitation management plan.
- Benchmarking highlights repeat constraints that matter for closure confidence. Comparing monitoring results to criteria makes persistent weaknesses visible (particularly around vegetation establishment), helping target effort where variability would otherwise drive rework, extended closure schedules and increased liability.
- Seed and species programs are central to the quality uplift. Integrated work plans show how strengthening the seed value chain (forecasting, procurement, processing/storage and improved seed use efficiency) and testing alternative establishment approaches (including tubestock for selected species) directly supports indicator performance and repeatable revegetation outcomes.
- Replicated trials and partnerships accelerate defensible prescriptions. Controlled, replicated field trials supported by collaborations with research institutions are being used to close key knowledge gaps and develop scalable, evidence-based rehabilitation prescriptions that can be adopted across sites.

Development of the rehabilitation performance framework has been a key enabler for Rio Tinto to close the loop on the plan–do–check–act model. Through dedicated and prioritised improvement work plans, the intent is to provide the rehabilitation team with evidence-based prescriptions to do rehabilitation once and do it well.

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