

# Mid-Stream Project Update

## SCOPING STUDY SUPPORTS POTENTIAL IN VALUE-ADDED PATH BEYOND SPODUMENE CONCENTRATES AT PILGANGOORA

### KEY POINTS

- Scoping Study completed for the Mid-Stream Project process pathway and potential Demonstration Plant.
- Scoping Study provides preliminary support for the construction of a demonstration scale chemicals facility at Pilgangoora, producing value-added lithium phosphate salts via an innovative refining process.
- Lithium phosphate salt selected as the preferred product, which is aiming to support a highly viable feedstock for a number of battery chemicals manufacturers, including the lithium ferro phosphate (LFP) battery cathode manufacturing industry, as well as lithium carbonate and lithium hydroxide production.
- Using Calix Limited's (ASX:CXL) flash calcination technology, test-work has confirmed high calcination conversion rates (>95% for alpha to beta spodumene phase transformation) using fine flotation spodumene concentrate<sup>1</sup> produced from Pilgangoora.
- The contained lithia content of the product is expected to increase from ~5.7-6.0% in spodumene concentrates to >36% in lithium phosphate salts, thereby optimising offshore product logistics, reducing associated carbon emissions, and minimising waste in the destination market.
- The Mid-Stream project has the potential to deliver significant sustainability benefits across the lithium supply chain via:
  - substantial reduction of carbon energy requirements by the complete electrification of the Mid-Stream process, including spodumene calcining, enabling the potential to power the project using up to 100% renewables sourced power;
  - rationalisation of the carbon footprint via reduced waste movement requirements across transport and logistics supply chains from a more lithium-dense, and near zero-waste final product; and
  - improved lithium recovery from the ore resource, as the proposed refining process should have the ability to treat very fine spodumene concentrates at lower lithia grades, which have traditionally been problematic for calcination in conventional direct-fired horizontal rotary calciners.
- Consistent with the previously announced MoU, Pilbara Minerals and Calix intend to move forward with negotiations to establish a Joint Venture (JV) to potentially develop a demonstration plant, and for the commercialisation of the Mid-Stream process technology globally.

Pilbara Minerals Limited (ASX: PLS) (**Pilbara Minerals** or **the Company**) is pleased to advise that its mid-stream value-added lithium growth strategy has taken another important step

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<sup>1</sup> Conversion rates vary as a function of concentrate properties (including particle size) and further testwork is underway.

forward, with the completion of a Scoping Study in conjunction with Calix Limited (ASX: CXL) (**Calix**).

The Scoping Study, which was undertaken by Lycopodium Minerals (ASX: LYL), provides preliminary support for the technical viability of constructing a demonstration-scale chemicals facility producing value-added lithium phosphate salts via an innovative refining process at Pilbara Minerals' Pilgangoora Operation ("**Pilgangoora**") in Western Australia.

The Scoping Study is the first economic evaluation of the Mid-Stream Project which has been prepared to an accuracy level of +/-40% (for Capital costs) and +/-30% (for Operating costs). It represents a preliminary study of the potential technical and economic viability of the proposed process path and demonstration scale facility development.

Any decision to proceed will be the subject of more definitive studies, as part of a proposed joint venture with Calix.

Studies to date are based on a low level of technical and economic assessments that are not yet sufficient to support a business case to proceed with the construction and development of the demonstration plant, or to provide certainty that the conclusions of the study will be realised. Further, more definitive studies, including on operating costs and whether there is a viable market for lithium phosphate will be required as part of the proposed joint venture with Calix, before any final investment decision can be made to proceed with the development of the demonstration plant.

## **PROJECT BACKGROUND**

Following execution of a Memorandum of Understanding (**MoU**) in May 2021 (refer ASX Announcement dated 11 May 2021) between Pilbara Minerals and Calix, a Scoping Study has been completed by Lycopodium Minerals in conjunction with the Pilbara Minerals and Calix teams. The study's purpose was to assess the technical viability of developing a demonstration scale chemicals facility at Pilgangoora to produce lithium salts from fines-flotation spodumene concentrate produced at Pilgangoora. Thereby supporting a potential pathway towards future commercial production of value-added lithium products (refer ASX Announcement dated 21 December 2021).

### **Mid-Stream Project Objective – Pursuing a superior lithium carrier product**

The lithium-ion battery supply market is rapidly evolving with large scale development occurring through all segments of the supply chain. Several prominent themes are shaping the industry including product cost (per lithia unit), product quality (purity), carbon energy reduction and waste management (particularly for the European market).

The objective of the Mid-Stream Project is to deliver a superior value-added lithium raw material that outperforms across the key metrics of product cost, quality, carbon energy reduction and waste reduction/handling.

The project work completed to date has consisted of work to explore alternative solutions to achieve these aims, including reviewing and testing alternate process paths, equipment selection and end-product types.

The Scoping Study undertaken by Lycopodium Minerals has confirmed the technical viability of the Mid-Stream project to deploy a novel calcination technology and integrated chemical concentration process at the Pilgangoora Operation to produce a new end-product, with the preferred product at this stage of study being lithium phosphate salt.

## SCOPING STUDY OUTCOMES

### Process Design

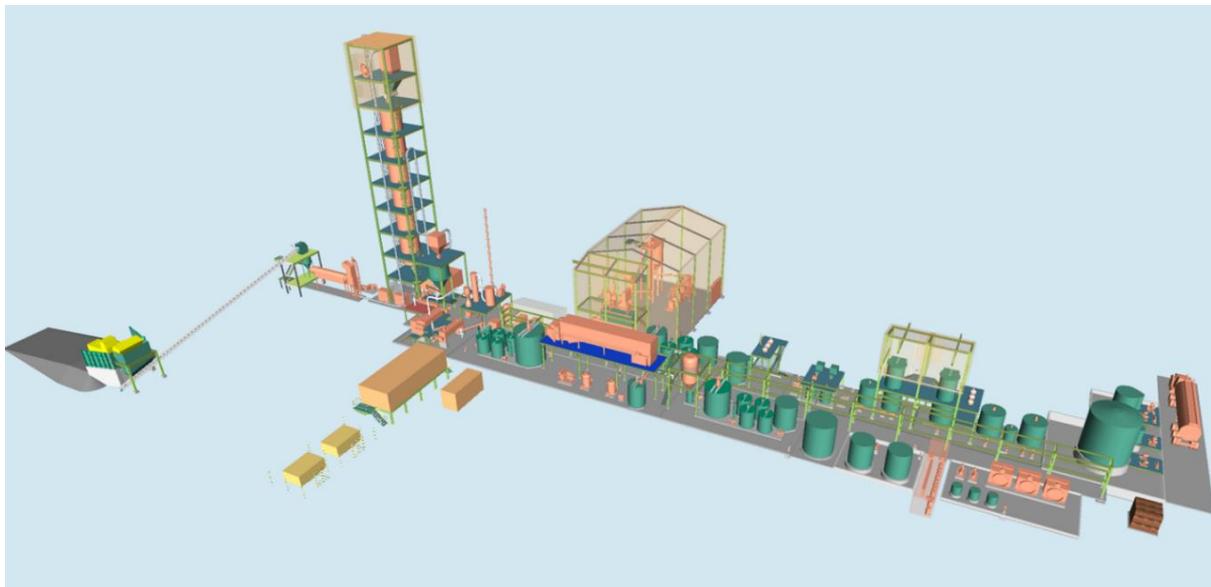
The Scoping Study has confirmed the technical capability of Pilbara Minerals' innovative flowsheet, which is capable of producing lithium phosphate salt from fines flotation spodumene concentrate from the Pilgangoora Operation. Initial test-work programmes to confirm the flowsheet were undertaken using a produced synthetic lithium sulphate leach solution to produce small quantities of lithium phosphate precipitate.

Subsequent test-work phases further developed the flowsheet to produce high purity lithium phosphate precipitates from Calix-calcined Pilbara Minerals fine flotation spodumene concentrate.

Following laboratory scale test-work, lithium phosphate salts has been selected as the preferred product, having demonstrated superior performance to those other alternatives evaluated to date; however, the Mid-Stream flowsheet is able to incorporate the production of other lithium-bearing salts, with minor modification to process flow (however additional equipment would likely be required). This will continue to be evaluated in future study works.

Flowsheet test-work to-date (comprising pilot-scale calcination and laboratory-scale chemical processing) has demonstrated >90% overall lithium recovery to a final high purity lithium phosphate salt product.

**Figure 1** – Mid-stream product demonstration plant design model.



### Calcination

A series of spodumene flotation concentrate samples from Pilbara Minerals' Pilgangoora Operation were sent to Calix's test facility in Bacchus Marsh - Victoria, for processing through their BATMn reactor. These samples were processed under a range of operating conditions to determine whether successful calcination of Pilgangoora spodumene flotation concentrate could be achieved using the Calix Flash Calciner ("**CFC**") and if so, what the optimal conditions for this calcination would be.

Testing undertaken at the BATMn reactor was considered as a pilot scale initiative, given

the scale of the facilities in use.

Calcination test work during the Scoping Study demonstrated a >95% conversion (alpha to beta spodumene phase transformation) using fine spodumene concentrate, which is regarded as a competitive result compared to industry norms utilising conventional rotary kiln technology.

Further, the Calix flash calcination technique is particularly well-suited to the finer fraction of the fines flotation concentrate at Pilgangoora (less than 75 $\mu$ m). This is very encouraging as it has the potential to solve an existing challenge for the industry when dealing with fine flotation products through conventional calcining technology.

**Figure 2** – Calix flash calciner and electric pilot scale plant (BATMn Reactor)



### **Summary of key Scoping Study demonstration plant parameters**

As part of the Scoping Study, Pilbara Minerals commissioned several value engineering assessments to quantify the impact of varying feed lithia grade, decreasing feed spodumene size distribution, increasing spodumene throughput rates and optimising reagent selection.

The optimised value engineering scenario selected via the Scoping Study is the processing of ~27,000 tpa of fine, lower-grade spodumene concentrate, to produce in excess of 3,000

tpa<sup>2</sup> of high purity (>98% purity) lithium phosphate salt. Further, more definitive engineering studies will include this scenario as a base-case for the proposed development of the Pilgangoora demonstration plant.

The key parameters for the proposed Demonstration Plant, as confirmed by the Scoping Study and value engineering assessments, are outlined in Table 1.

**Table 1** – Mid-Stream Scoping Study key process plant parameters.

| Key parameter                              | UoM                                   | Scoping Study Outcomes |
|--|---------------------------------------|------------------------|
| Concentrate feed                           | dmt/a                                 | ~27,000                |
| Concentrate feed grade                     | % w/w Li <sub>2</sub> O               | 5.00                   |
| Overall lithium recovery                   | %                                     | 91                     |
| Li <sub>3</sub> PO <sub>4</sub> production | dmt/a                                 | >3,000                 |
| Li <sub>3</sub> PO <sub>4</sub> purity     | % w/w Li <sub>3</sub> PO <sub>4</sub> | ~>98                   |

While Pilbara Minerals is encouraged by the results to date from the Scoping Study outcomes, contributing engineering is still considered to be at an early stage of development.

### Scoping Study Economic Assessment

At a Scoping Study level of assessment, the estimated capital development cost of the envisaged demonstration plant is between A\$50-70M. These are preliminary assessments and further study work is to be undertaken to develop the underlying engineering and refine the expected capital development costs.

Key operating cost drivers to the production of lithium phosphate at Pilgangoora include the cost (or transfer price) of spodumene feed, power supply and the supply cost of phosphate sources. At this early stage of the project's development, the cost of production is still under review, and will be subject to further optimisation (among other capital and operating costs) in subsequent engineering studies.

### NEXT STEPS AND TIMELINE

Pilbara Minerals is encouraged by the results of the Scoping Study, potentially supporting an innovative new refining process at the Pilgangoora Operation.

The near-term activities to progress the Mid-Stream project that are expected to be completed before the end of CY2022 are:

- JV Development and Cost Optimisation - negotiation and formation of a JV between Pilbara Minerals and Calix to undertake further, more definitive, engineering studies to further assess the operating and capital costs for the Demonstration Plant to support the parties making a final investment decision to move forward with developing the Demonstration Plant and for the commercialisation of the Mid-Stream technology across industry globally.

<sup>2</sup> For reference, the lithium content of one tonne of lithium phosphate is ~95% of the lithium contained in the same mass of lithium carbonate, or ~108% of the lithium in the same mass of lithium hydroxide monohydrate.

- Market Samples - a continuous pilot test-work program to produce lithium phosphate samples in lots of 10kgs for a detailed market engagement program to help inform the project of the likely marketability and selling price outcomes of the lithium phosphate salt product being produced; and
- Demonstration Plant FID - development of the demonstration Plant will be subject to an investment decision being made by the JV parties which will be targeted to be assessed prior to the end of CY2022.

Following progression of the near-term activities and further updates to the market, the parties are indicatively targeting a timeline which comprises Demonstration Plant construction commencement in Q2 CY2023, with construction completion in Q1 CY2024. Following completion of construction and commissioning, a period of process optimisation would follow.

*Release authorised by Ken Brinsden, Pilbara Minerals Limited's Managing Director.*

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## MORE INFORMATION

### ABOUT PILBARA MINERALS

Pilbara Minerals is the leading ASX-listed pure-play lithium company, owning 100% of the world's largest, independent hard-rock lithium operation. Located in Western Australia's resource-rich Pilbara region, the Pilgangoora Operation produces a spodumene and tantalite concentrate. The significant scale and quality of the operation has attracted a consortium of high quality, global partners including Ganfeng Lithium, General Lithium, Great Wall Motor Company, POSCO, CATL and Yibin Tianyi.

While it continues to deliver a low-cost, quality spodumene to market, Pilbara Minerals is pursuing a growth and diversification strategy to become a sustainable, low-cost lithium producer and fully integrated lithium raw materials and chemicals supplier in the years to come.

Through execution of this strategy, Pilbara Minerals is positioned to become a major player in the rapidly growing lithium supply chain, underpinned by increasing demand for clean energy technologies such as electric vehicles and energy storage as the world pursues a sustainable energy future.

### ABOUT CALIX

Calix is a team of dedicated people who are urgently developing great businesses, leveraging our patented technology, that deliver positive global impact.

The core technology is being used to develop more environmentally friendly solutions for water treatment, CO<sub>2</sub> mitigation, biotechnology, advanced batteries, and more sustainable mineral and chemical processing.

Calix develops its technology via a global network of research and development collaborations, including governments, research institutes and universities, some of world's

largest companies, and a growing customer base and distributor network for its commercialised products and processes.

Because there's only one Earth – Mars is for Quitters.

Website: <https://www.calix.global/>

Twitter: @CalixLimited Youtube: CalixLimited

## FORWARD LOOKING STATEMENTS AND IMPORTANT NOTICE

This announcement may contain some references to forecasts, estimates, assumptions, and other forward-looking statements. Although the Company believes that its expectations, estimates, and forecast outcomes are based on reasonable assumptions, it can give no assurance that they will be achieved. They may be affected by a variety of variables and changes in underlying assumptions that are subject to risk factors associated with the nature of the business, which could cause actual results to differ materially from those expressed herein.

All references to dollars (\$) and cents in this announcement are to Australian currency, unless otherwise stated.

Scoping and other technical studies in respect of the Mid-Stream Project have been undertaken to determine the potential viability of the demonstration plant and to reach a decision to proceed with more definitive studies and enter into a joint venture agreement. Each scoping study has been prepared to an accuracy level of +/-40% (for Capital costs) and +/-30% (for Operating costs). Each scoping and technical study is based on low-level technical and economic assessments and is insufficient to provide assurance of an economic development case at this stage or provide certainty that the conclusions of the studies will be realised. The results of the studies should not be considered a profit forecast or production forecast.