

**ASX & Media Release**

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**ASX Symbol**

ARL

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Shares  
80,711,168

Unlisted options  
12,310,022

Loyalty options  
25,165,791

ABN 30 614 289 342

## Flowsheet selection for KNP Cobalt Zone

Fifth generation high-pressure acid leach (HPAL) will combine financial and processing efficiencies with engineering certainty to enable production of battery-grade cobalt sulphate and nickel sulphate at Goongarrie

- Simulus Engineers completed bench-scale testwork on three flowsheets:
  - › sulphuric High-Pressure Acid Leach (HPAL),
  - › sulphuric Atmospheric Acid Leach (AL) and
  - › hydrochloric Atmospheric Acid Leach
- All flowsheets had comparable capital costs, but HPAL was selected:
  - › Cobalt and nickel leach recoveries are 95-97%.
  - › Significantly lower acid consumption.
  - › Substantially lower operating costs.
  - › Interim Mixed Sulphide (MS) precipitation process to ensure high purity products can be manufactured on site.
  - › Provides an internationally recognised and commercially successful non-proprietary flowsheet likely to be acceptable to debt financiers.
  - › Fifth generation HPAL to incorporate latest advances.
- The base case flowsheet is set at 1Mtpa. Scoping is being undertaken for 2Mtpa and 4Mtpa throughputs.
  - › KNP Cobalt Zone to support multiple-decade production optimised on cobalt.
  - › Overall KNP to support many, many more decades of nickel-focussed production.
- An elegant flowsheet comprises milling, sulphuric acid leach in an autoclave, mixed sulphide precipitation, redissolve and crystallise cobalt and nickel sulphate for sale to lithium ion battery sector.
- Pre-feasibility study is on schedule for delivery in first quarter 2018.

## Selection of HPAL–MS flowsheet

Ardea Resources is pleased to announce that a high-pressure acid leach (HPAL) flowsheet has been selected to process the cobalt-nickel deposits of the Goongarrie Line of the KNP Cobalt Zone. Through exhaustive analysis and comparison of HPAL using sulphuric acid and two atmospheric leach options (sulphuric and hydrochloric acid), HPAL is clearly the most suitable. An elegant “off-the-shelf” flowsheet is being developed, involving:

- Crushing (low energy consumption SAG mill),
- sulphuric acid leach in an autoclave (HPAL),
- mixed sulphide (MS) precipitation (for removal of impurities),
- redissolution of MS,
- crystallisation of cobalt sulphate and nickel sulphate,
- modular processes that can be added later to recover various accessory materials if and when desired.

By combining HPAL with the MS precipitation technique into the one flowsheet, it is expected that Ardea will be able to produce battery-quality materials on-site at Goongarrie.

The selected flowsheet will provide a clear set developmental pathway that will enable Ardea to become a significant producer of high purity cobalt sulphate, nickel sulphate, scandium oxide, and other accessory products to supply the increasingly important battery mineral and high-tech metal sectors.

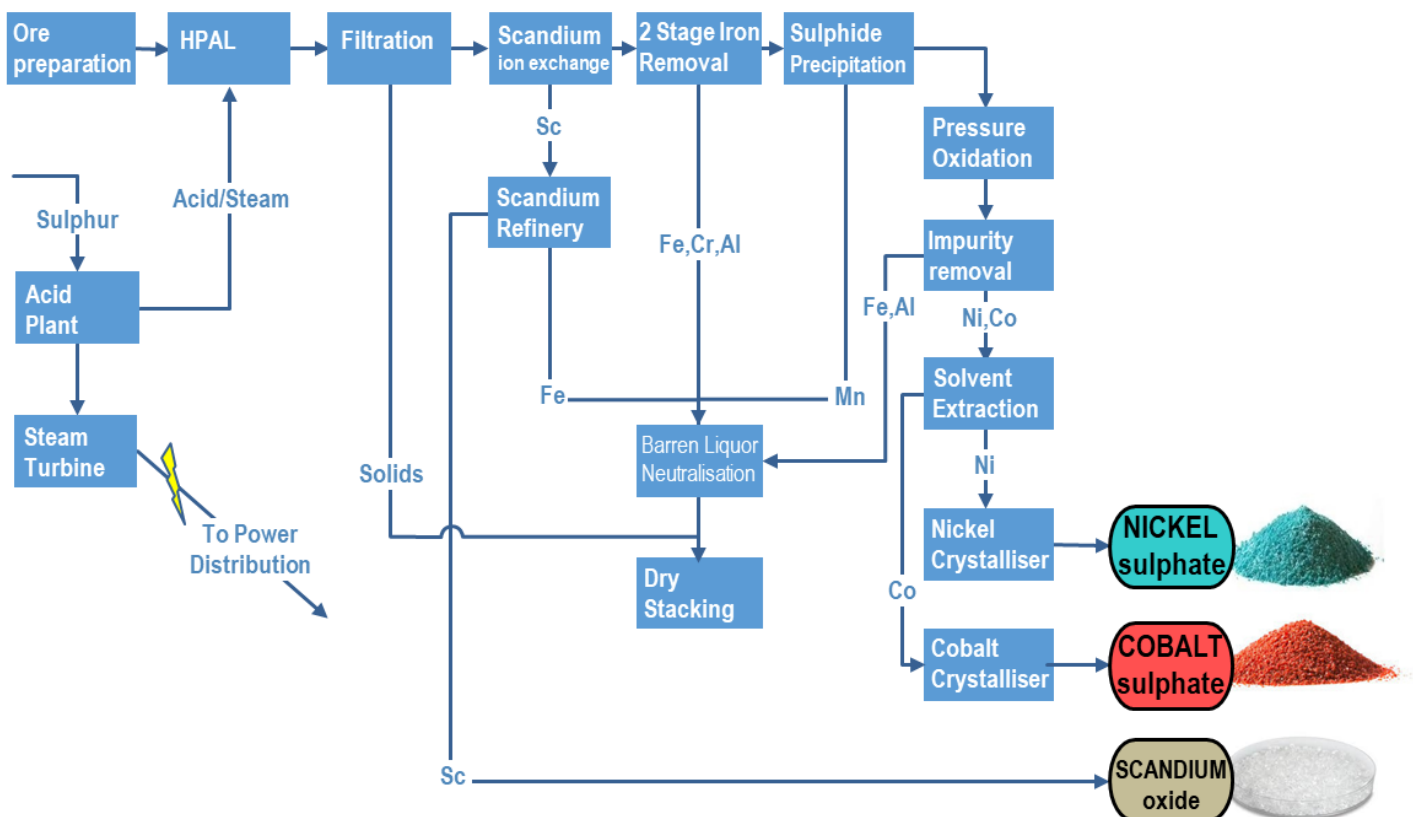


Figure 1 – High-level flowsheet for the processing of cobalt-nickel mineralisation from the KNP Cobalt Zone at Goongarrie. The flowsheet indicates commercially proven extraction processes for impurity removal prior to nickel and cobalt crystallisation. Bench scale test work is still in progress, but it is expected that the final flowsheet will not differ greatly to this.

## Comparison of HPAL to other leaching technologies

To select and define a commercially and technically viable flowsheet to process the KNP mineralisation, numerous tests were undertaken focussing on HPAL and atmospheric acid leaching. The quality of the mineralisation on the Goongarrie Line is such that exceptional recoveries were obtained from every test.

The benefits of the grade and reactivity of the mineralisation of the Goongarrie Line also resulted in unforeseen effects such as near complete dissolution of iron which, if incorrectly handled, could swamp and/or inhibit cobalt and nickel recovery. It is HPAL-MS that has proven best able to deal with these effects.

In selecting HPAL, many factors were considered, including:

- Capital expenditure (CAPEX) to develop HPAL and atmospheric leach are very similar, with HPAL actually lower cost than most variations of atmospheric leach considered (reflecting the additional reagent consumption and recovery requirements of atmospheric leaching).
- Operational expenditure (OPEX) is considerably lower for HPAL than for atmospheric alternatives.
- HPAL offers considerably lower acid consumption, which is significant in terms of cost and environmental considerations.
- Without impinging upon cobalt and nickel production, HPAL offers flexibility to recover by-products such as scandium, aluminium and manganese from the Goongarrie Line.
- Plant development times will be significantly shorter using “off-the-shelf” HPAL components rather than developing new plant and processes.

Work continues on refining financial and flowsheet models. Finalised costings and detailed flowsheets will be published in the forthcoming Pre-Feasibility Study.

*Table 1 – Comparison of recent successful HPAL-MS plants, and comparison to possible scenarios at the KNP Cobalt Zone which are still being formulated. Under the Staged scenario, an initial base-case 1 Mtpa plant would be built, followed by a second 1 Mtpa plant. Under the Alternate scenario, a larger scale but more expensive 4 Mtpa plant would be constructed. These and several other possibilities are being modelled for the PFS.*

Operation	Stage	Gen	Flowsheet	Start Up	Status	Design Cobalt (tpa)	Design Nickel (tpa)
Moa Bay Revitalisation		1st	HPAL-MS	1995	• Ramp up within a year, currently operating at 32,000tpa Nickel and 3,800tpa Co	3,000	25,000
Murrin Murrin		2nd	HPAL-MS-Hydrogen Reduction	1999	• Currently operating at approximately 85%	5,000	45,000
Coral Bay	1	3rd	HPAL-MS	2004	• Achieved 90% capacity in 15months. Currently operating at 120% of design capacity	750	10,000
	2	3rd	HPAL-MS	2009	• Achieved 100% capacity in 9 months. Currently operating at 120% of design capacity	750	10,000
<i>Coral Bay Total</i>						<i>1,500</i>	<i>20,000</i>
Taganito		4th	HPAL-MS	2013	• Achieved 90%+ nameplate within 3 years.	2,600	30,000
Ambatovy		4th	HPAL-MS-Hydrogen reduction	2012	• Achieved 80% nameplate in 4 years	5,600	15,000
KNP Cobalt Zone, Staged	1	5th	HPAL-MS-Crystallisers	Early 2020s	• 1 Mtpa. Target: Ramp up to 100% in 15 months	1,700	10,000
	2	5th	HPAL-MS-Crystallisers	Later 2020s	• 1 Mtpa Target, Ramp up to 100% in 9 months	1,700	10,000
<i>Proposed KNP Cobalt Zone Total (Staged scenario)</i>						<i>3,400</i>	<i>20,000</i>
KNP Alternate: 4 Mtpa		5th	HPAL-MS-Crystallisers	2020s	• High-production scenario, more expensive.	6,800	40,000

## HPAL benchmarking

The use of HPAL on the KNP Cobalt Zone will follow on from the successful implementation of HPAL-MS at numerous deposits globally (Table 1).

Ardea has reviewed in detail the most recent operations globally that have used HPAL and MS precipitation flowsheet. Successful operations at Moa Bay, Coral Bay 1 & 2 and the Taganito operations produce nickel and cobalt via the HPAL and MS route, and their operations are being scrutinised to ensure best practice will be followed at Goongarrie.

Table 1 shows the production and the ramp up time for these operations. It can be seen from this data that the 3<sup>rd</sup> and later generation operations improved from the 1<sup>st</sup> and 2<sup>nd</sup> generation counterparts.

## Forward strategy for the KNP Cobalt Zone

It is recognized that the third and fourth generation HPAL processing plants have largely succeeded due to learnings, through success, failure, and working issues from previous generation HPAL operations. The most successful operations adopted a **lower CAPEX modular approach, achieving their target production in two stages.**

Ardea's strategy is to develop the HPAL-MS process flowsheet to:

1. Produce target cobalt and nickel products (sulphates) for the rapidly expanding battery industry.  
The flow sheet will:
  - a. Be based on proven technology that is financially successful for laterite ores.
  - b. Be supported by continuous test work results on the Goongarrie Line deposits
  - c. Provide opportunities for production of valuable by-products such as scandium, aluminum and manganese. *(Aluminium and manganese have similar growth opportunities to nickel and cobalt products within the battery industry).*
2. Select key personnel for the engineering and owners team that have been involved in previous generation HPAL design, commissioning and ramp up.
3. Assess and adopt successful implementation components of third and fourth generation laterite operations such as low capex modular two stage approach, *that is starting with a single stream, and adding a second stream based on operating experience.*

## Ongoing bench-scale testwork at Simulus Engineers

Drill core from Ardea drill holes AGSD0001 to 0004 were composited on the basis of geo-metallurgical interpretations (KNP mineralised style CUGZR – Clay Upper regolith with Goethite-Asbolite-Chromite mineralogy). This cobalt and nickel mineralisation style shows remarkable consistency in all drill holes, suggesting a premium input in terms of chemical uniformity for a hydrometallurgical feedstock.

Initial optimisation testwork was completed on drill core from AGSD0002 (16.0-56.9m), averaging 0.126% cobalt and 1.5% nickel. Following HPAL flowsheet selection, the remaining 250kg of core was composited and 400 litres of Pregnant Liquor Solution (PLS) generated from a bench-scale autoclave.

Bench scale tests to process PLS are currently being carried out to remove scandium via ion exchange or solvent extraction process and then to recover nickel and cobalt as a mixed sulphide. Initial results indicate that the ore can be treated economically using the commercially successful HPAL and mixed sulphide (MS) flowsheet.

Alongside bench-scale testwork, Simulus are completing engineering design work and obtaining vendor quotes for an HPAL plant located at Goongarrie South on granted Mining Lease M29/272.

A consulting group has been retained to assist with water and environmental studies. It is planned to use dry-stacked tailings and in-pit mullock dumping to reduce the overall project footprint.

## Delivery of the Pre-Feasibility Study

The definition of a HPAL-MS flowsheet provides direction for the final leg of the Pre-Feasibility Study (PFS).

With test work on schedule to be completed by Simulus before Christmas, interrogation and analysis of the data generated, followed by detailed refinement of the proposed flowsheet will be undertaken in the New Year. These final results will be incorporated into the PFS document for release in the first quarter of 2018.

**For further information regarding Ardea, please visit [www.ardearesources.com.au](http://www.ardearesources.com.au) or contact:**

**Ardea Resources Limited:**

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### **Compliance Statement (JORC 2012)**

*A competent person's statement for the purposes of Listing Rule 5.22 has previously been announced by the Company for:*

- 1. Kalgoorlie Nickel Project on 21 October 2013 and 31 June 2014, October 2016, 2016 Heron Resources Annual Report and 6 January 2017;*
- 2. KNP Cobalt Zone Study on 7 August 2017*

*The Company confirms that it is not aware of any new information or data that materially affects information included in previous announcements, and all material assumptions and technical parameters underpinning the estimates continue to apply and have not materially changed. All projects will be subject to new work programs following the listing of Ardea, notably drilling, metallurgy and JORC Code 2012 resource estimation as applicable.*

*The information in this report that relates to KNP exploration and metallurgical results is based on information originally compiled by previous and current full time employees of Ardea Resources Limited and Heron Resources Limited. The exploration and metallurgical results and data collection processes have been reviewed, verified and re-interpreted by Mr Ian Buchhorn who is a Member of the Australasian Institute of Mining and Metallurgy and currently a director of Ardea Resources Limited. Mr Buchhorn has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the exploration activities undertaken to qualify as a Competent Person as defined in the 2012 Edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. Mr Buchhorn consents to the inclusion in this report of the matters based on his information in the form and context that it appears.*

*The exploration and industry benchmarking summaries are based on information reviewed by Dr Matthew Painter, who is a Member of the Australian Institute of Geoscientists. Dr Painter is a full-time employee and a director of Ardea Resources Limited and has sufficient experience, which is relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2012 edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. Dr Painter has reviewed this press release and consents to the inclusion in this report of the information in the form and context in which it appears.*



**CAUTIONARY NOTE REGARDING FORWARD-LOOKING INFORMATION**

*This news release contains forward-looking statements and forward-looking information within the meaning of applicable Australian securities laws, which are based on expectations, estimates and projections as of the date of this news release.*

*This forward-looking information includes, or may be based upon, without limitation, estimates, forecasts and statements as to management's expectations with respect to, among other things, development and business plans, capital and exploration expenditures, the effect on the Company of any changes to existing legislation or policy, government regulation of mining operations, the length of time required to obtain permits, certifications and approvals, the success of exploration, development and mining activities, the geology of the Company's properties, environmental risks, the availability of labour, the focus of the Company in the future, demand and market outlook for metals and the prices thereof, progress in development of mineral properties, the Company's ability to raise funding privately or on a public market in the future, the Company's future growth, results of operations, performance, and business prospects and opportunities. Wherever possible, words such as "anticipate", "believe", "expect", "intend", "may" and similar expressions have been used to identify such forward-looking information. Forward-looking information is based on the opinions and estimates of management at the date the information is given, and on information available to management at such time. Forward-looking information involves significant risks, uncertainties, assumptions and other factors that could cause actual results, performance or achievements to differ materially from the results discussed or implied in the forward-looking information. These factors, including, but not limited to, fluctuations in currency markets, fluctuations in commodity prices, the ability of the Company to access sufficient capital on favourable terms or at all, changes in national and local government legislation, taxation, controls, regulations, political or economic developments in Australia or other countries in which the Company does business or may carry on business in the future, operational or technical difficulties in connection with exploration or development activities, employee relations, the speculative nature of mineral exploration and development, obtaining necessary licenses and permits, diminishing quantities and grades of mineral reserves, contests over title to properties, especially title to undeveloped properties, the inherent risks involved in the exploration and development of mineral properties, the uncertainties involved in interpreting drill results and other geological data, environmental hazards, industrial accidents, unusual or unexpected formations, pressures, cave-ins and flooding, limitations of insurance coverage and the possibility of project cost overruns or unanticipated costs and expenses, and should be considered carefully. Many of these uncertainties and contingencies can affect the Company's actual results and could cause actual results to differ materially from those expressed or implied in any forward-looking statements made by, or on behalf of, the Company. Prospective investors should not place undue reliance on any forward-looking information.*

*Although the forward-looking information contained in this news release is based upon what management believes, or believed at the time, to be reasonable assumptions, the Company cannot assure prospective purchasers that actual results will be consistent with such forward-looking information, as there may be other factors that cause results not to be as anticipated, estimated or intended, and neither the Company nor any other person assumes responsibility for the accuracy and completeness of any such forward-looking information. The Company does not undertake, and assumes no obligation, to update or revise any such forward-looking statements or forward-looking information contained herein to reflect new events or circumstances, except as may be required by law.*

**No stock exchange, regulation services provider, securities commission or other regulatory authority has approved or disapproved the information contained in this news release**